Lake Charles LNG export project partners file FERC application

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By OGJ editors

Trunkline LNG Co. LLC and Trunkline LNG Export LLC, both wholly owned subsidiaries of Energy Transfer Equity LP and Energy Transfer Partners LP, have submitted an application with the US Federal Energy Regulatory Commission seeking its authorization for the siting, construction, ownership, and operation of the proposed Lake Charles LNG export project.

The FERC filing represents the culmination of significant front-end engineering and design (FEED) work and pre-filing consultations with FERC and other federal, state, and local agencies that have been under way since mid-2012, said BG Group, which will oversee the construction and operation of the proposed facility under a long-term agreement with Energy Transfer.

Pending final investment decisions and the receipt of all necessary approvals expected in 2015, construction is planned to start shortly afterwards, with first LNG exports expected in second-quarter 2019.

The US Department of Energy in August 2013 conditionally granted authorization to export as much as 2 bcfd of LNG from the existing Trunkline LNG import terminal to non-free trade agreement nations (OGJ Online, Aug. 8, 2013).

The proposed project will include the construction of three liquefaction trains and use the existing LNG storage and marine berthing facilities owned by Trunkline LNG Co. LLC. Energy Transfer has secured all property rights required for the site of the proposed liquefaction facility.

Energy Transfer will own and finance the proposed facility while BG Group will be responsible for the offtake. Trunkline Gas will provide pipeline transportation services to supply gas to the proposed facility.

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Large scale export of East Coast Australia natural gas: Unintended consequences

A study of the national interest effects of the structure of the Australian gas industry.

A report to
The Australian Industry Group and the Plastics and Chemicals Industries Association

Prepared by the
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October 2012

While the National Institute endeavours to provide reliable forecasts and believes the material is accurate it will not be liable for any claim by any party acting on such information.

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Executive summary

"*One molecule of natural gas is chemically the same as another, but where it is found has enormous implications for global politics.*

The price of gas in the US following the shale drilling boom is now a third of that in western Europe and a fifth of that in Asia."

Financial Times, 17 July 2012

"Gas prices on the eastern seaboard will follow the big rises already hitting downstream industrial users in Western Australia, says Santos chief executive David Knox.

At a Sydney forum on the future of gas, Mr Knox stated that prices in the east of between $3 and $4 a gigajoule would rise to between $6 and $9 for new domestic customers as increasing volumes were exported.

That is the range we are talking about for anyone coming to us now," he said. "We are actively negotiating with a number of buyers … and you are going to see an increase in prices."

Australian Financial Review, 23 August 2012

Natural gas is a fundamental source of energy for power generation, industry, consumers, hospitals and institutions generally. In today's world of transition to greater use of renewable energy it plays an important role in facilitating cost effective peaking power to fill the gaps when renewable supply is not available. It is both an efficient relatively clean fuel source and a critical feedstock for conversion by industry into value-added consumer products. Its value to the domestic economy is very significant as the alternatives are less efficient and, in the case of coal and oil, have significantly higher greenhouse gas emissions.

Many major projects to export Liquefied Natural Gas from Eastern Australia have been approved and will start to operate over the next several years. This will significantly impact the domestic supply of natural gas. In this report we do not argue against the export of LNG but emphasise that the benefits from exporting LNG should be weighed against the benefits of ensuring competitive supply to the domestic gas-dependent manufacturing sector. In a market where there are sufficient reserves of the resource, as appears to be the case in Australia, the typical response would be for additional supply to be made available to meet domestic demand. However, due to the nature of the gas resources, their location, limitations in infrastructure and the way in which we manage these resources, there is a serious risk that this will not be the case. Even a temporary period without secure access to domestic gas would have significant unintended consequences, as would a shift to LNG-linked gas pricing. As such, it is prudent to look at the implications of these developments for consumers and industry.

The National Institute of Economic and Industry Research (NIEIR) has made such an assessment, reviewing the literature and conducting its own assessment of the sectoral and macroeconomic implications of these developments. The findings are concerning.

NIEIR has found that:

- if existing plans proceed, gas exports from eastern Australia will rise from 2 million tonnes in 2015 to 20 million tonnes in 2018, and possibly 24 million tonnes in 2023;

- the current policy framework and market settings for the Australian gas industry favour export of LNG without a subsequent assurance of reliable, competitively priced supplies of gas for domestic industry. Such supplies have historically been a competitive advantage for Australian industry, and gas export revenue is insufficient to compensate Australia for the loss of this advantage;

- natural gas is essential to a range of industries, particularly non-ferrous metals and basic chemicals, but also plastics, pharmaceuticals, paints and cosmetics. Secure local supply at competitive prices is a fundamental requirement for the continuation of a significant part of production and the development of new investment in these industries;

- contracts for the long term supply of gas to domestic industry have 'evaporated' as a consequence of export commitments;

- Australia has only a few years before significant economic loss is likely to be felt from the failure to secure an affordable supply of natural gas to domestic users;

- domestic gas users are increasingly being offered "surplus" gas volumes and prices that do not reflect domestic supply, demand or extraction costs, but are instead linked to East Asia's LNG market – the highest-priced gas in the world. This is a radical reshaping of the domestic gas market, constraining supply (in the near term at least) and driving prices to high (and for many industries uneconomic) levels;

- current gas production and proven reserves will need to expand dramatically in order to support the LNG expansion without significant large scale suppression of gas use on the domestic economy. While the total gas resource is thought to be very large, proving up additional resources and developing them will take time and faces community opposition and other barriers. To ensure gas availability for domestic users, the management of reserves and their supply to market needs attention if domestic needs are not to be overlooked in the rush to export this valuable resource;

- there are important opportunities to expand use of gas in industrial production and electricity generation, but even so domestic consumers cannot make use of the whole gas resource. There are worthwhile benefits to pursue from exporting gas production beyond these needs. But each petajoule of natural gas that is shifted **away** from industrial use **towards** export, whether because of tight supply or uneconomic pricing, means giving up $255 million in lost industrial output for a $12 million gain in export output. That is, for every dollar gained $21 is lost. This increases to $24 when economy-wide impacts are taken into account;

- the dramatic shift in the domestic gas market will have wider impacts well beyond the gas intensive industries:

    - increased operating costs for gas-fired electricity generators due to high gas prices. Such generators would see cost increases three times greater than those currently resulting from the carbon tax. Wholesale electricity prices would thus rise, and the viability of new gas-fired generation would suffer. These plants already play an important role in the electricity market for both peak power and

base load. That role is expected to grow to meet emissions reduction targets and provide backup for expanding renewable generation;

- some substitution away from gas towards electricity by business and households, to reduce their exposure to rising gas prices. This would still leave their costs higher than at present, and would raise greenhouse emissions;

- a slow-down of general economic activity resulting from impacts of the tighter gas supply and higher costs for gas and electricity;

- the expected economic response to the East Coast LNG expansion will involve a combination of the adjustments above. As a result, modelling indicates that, by 2040 the gross production benefit for East Coast LNG expansion will be $15 billion annually, in 2009 prices. However, taking into account the negative effects of adjustment on other sectors, annual GDP will be $22 billion lower than it would be with secure and affordable gas. An alternative 'benefit indicator' used for this study, which combines private consumption, tax receipts and net national product, will be reduced by $46 billion;

- under current policy settings and market structures, the unwanted consequences of the significant boom in LNG exports will persist even if, as is likely, adequate natural gas reserves exist and are brought to market; and

- there are substantial further risks that would lead to even greater costs if realised. These risks include:

  (i) LNG prices may be lower than currently expected. While this would reduce the extent of domestic price rises, it would also reduce gross export benefits while leaving domestic supply constrained in the short-to-medium term by contracted export commitments; and

  (ii) industry will likely be unable to grow without secure affordable gas supplies, leading to additional damage.

The rules of thumb developed in this study for these additional effects are:

- for every 1 per cent reduction in the LNG price the economy-wide benefits from LNG exports will be reduced by approximately 2 percentage points. This stems mainly from the fact that tax receipts and domestic profits will be disproportionately impacted. Foreign interest payments and repayment of debt will still have to be paid; and

- for every $1m of existing chemical industry output that is saved by increased natural gas supply there is another $1m of output that can be obtained by using the competitive advantages for domestic natural gas availability in general, and natural gas liquids in particular.

The likely consequences of the current policy and industry settings on natural gas export are serious for both industry and households. There is an urgent need for more recognition of these impacts, and for a debate on how they can be prevented, alleviated or adapted to. LNG export is a positive for Australia as long as it proceeds without significant harm to the domestic sector and with confident assurance of domestic supply.

1. Background and study objective

1.1 Background

Natural gas is an essential input to value creation and productivity in many of Australia's key industries. If the supply of natural gas is threatened or, short of this, confidence in its ready availability at competitive prices is weakened, so too are the industries that use the gas as a raw material or fuel. Current developments in Queensland, focusing on LNG exports, are threatening Eastern Australia's gas-dependent industries by weakening confidence that gas will be available at competitive cost.

In this report we do not argue against the export of LNG but emphasise that the benefits from exporting LNG should be weighed against the benefits of ensuring competitive supply to the domestic gas-dependent manufacturing sector. Our work indicates that the national benefit from the supply of gas to the many industries that are involved is many times the gain due to export of the same quantity of gas.

Taking these benefits into account, from the beginning the Western Australian Government was active in ensuring that domestic use of the offshore North West Shelf gas resource was to be protected. The Government explicitly committed to actively ensuring that this would be the case. The provisions of the original LNG Act drafted in the 1970s to pave the way for Australia's first LNG export project are specific in the way the reserves are to be used for both export and domestic users. Two sections of the Act indicate this.

*"**Notification of additional reserves of natural gas***

20. If the Joint Venturers discover reserves of natural gas additional to those required for their commitments contemplated in recitals (c) and (d) of this Agreement during their exploration programme in the offshore Dampier region (carried out under the provision of the Petroleum (Submerged Lands) Acts), which in the opinion of the Joint Venturers are capable of commercial development the Joint Venturers shall –

(a) notify the Minister of the extent and nature of such additional reserves;

(b) having regard to the State's desire for the petrochemical industry to be established in Western Australia, investigate the processing of all or part of such natural gas for use as petrochemical feedstock; and

(c) enter into discussions with the Minister concerning the utilisation of such natural gas."

"Marketing authorisation

42. The State authorises the Joint Venturers and each of them subject to the provisions of this Agreement and pursuant to recital (c) hereof to sell gas to the State Energy Commission and pursuant to such gas agreements with the State Energy Commission –

(a) to market gas in the Pilbara to each of their affiliated companies and to major industrial customers who use more than 28 000 cubic metres of gas per day;

> *(b) to sell or supply gas to each of their affiliated companies anywhere in Western Australia;*
>
> *(c) to construct, finance and operate gas transmission pipelines to each of their customers in the Pilbara."*

The benchmark price for domestic sales from the Joint Venture was set with a high weight given to domestic cost levels and competitiveness.

In terms of new fields in this century, the Western Australian Government has imposed a reservation policy where 15 per cent of the natural gas reserves are required to be used for domestic purposes.

The case is very different for Queensland. As of 2012 three major LNG plants are under construction in Gladstone on the Queensland central coast. These projects have been approved to proceed without any conditions or arrangements being put in place to generate supply at competitive prices to domestic gas users, whether they are heavy industrial users, commercial business, electricity generators or households.

With the advent of LNG projects the situation changed quickly for Queensland domestic gas customers and increasingly for large users across the east coast. Previously users were offered long-term contracts with predictable price settings. They could undertake long-term investments underpinned by a secure and cost-stable energy supply.

Currently, long-term contracts have "evaporated" as the first priority of gas producers is to secure supply for their LNG plants. Domestic customers feel the domestic market is now the residual sector, allocated what is surplus to requirements for the LNG plants, a reality which will become obvious once existing gas contracts end. Medium-term, let alone long-term, security of supply is no longer guaranteed. Domestic customers are now faced with the expectation having to pay the "net back" LNG price for natural gas, involving most probably a significant increase in price and, more importantly, the introduction of considerable price uncertainty derived from the unpredictability of the world gas market.

Admittedly, it is difficult to be precise about the calculation of 'net back' prices. Because of the variation in contract arrangements between LNG projects, the concept of a world LNG price is difficult to apply and actual prices will be determined by specific contract provisions. The provisions may or may not relate to LNG prices from other sources, either in Australia or overseas.

However, the concept of a domestic gas price based on a 'net back' price for LNG may not be the only factor leading to increased and more variable prices. Domestic consumers expect that the large impact of LNG demand on reserves will force domestic supply to be sourced from fields with higher extraction costs and, therefore, higher domestic cost. Since the majority of gas reserves are leased by interested parties focussed on LNG, it now appears likely that the domestic customers will be matched to the marginal increment in gross supply costs.

This is an extraordinary state of affairs given the scale of the projects and scale of the impact on the existing Australian identified reserves of natural gas. In the application of the national interest test to the projects which governments are obliged to do as manager of the resource on behalf of the community, it appears unlikely that the impacts of the LNG projects on domestic gas using industries have been considered to any great extent. This has been done in private sector reports, such as "*Carbon Market Economics – The Impact of Liquefied Natural Gas on Queensland Gas markets and Gas Users*", March 2010, with to date little impact in changing arrangements.

Australian natural gas (identified and potential) reserves are owned by the Crown which obliges the government of the day to determine when and how the resources are to be used. In exercising this duty, the government has a responsibility to optimise the benefit which current and future generators obtain from the extraction of the resources. Under the Australian constitution there are Federal/State Government jurisdiction issues as to who is responsible, but the reality is that all areas of Government need to cooperate to solve the problem.

1.2 Study objective

Accordingly, the study objective is to:

(i) outline a framework for testing the national interest benefit of Eastern Australian LNG projects that should be applied by the responsible Governments;

(ii) apply the framework to assess the net benefits that are likely to be obtained from the current projects under the current terms and conditions of their approval; and

(iii) evaluate the impact of alternative terms and conditions, in terms of assessing whether or not the net benefits assessed in (ii) can be significantly increased.

In short, this report complements the *Carbon Market Economics* (CME) report by quantifying the macroeconomic costs of a less than satisfactory (that is deficient) national interest evaluation and appropriate complementary policy design.

1.3 The LNG industry evaluated by this study

The LNG industry evaluated by this national interest evaluation is LNG exports from Queensland. The question at issue is whether Australia will obtain a net benefit from expected exports of LNG from Queensland. The expansion profile assumed in the quantitative analysis of the issue is:

Exports of LNG from Queensland
(million tonnes)

2015	2
2016	15
2017	18
2018	20
2019	20
2020	20
2021	20
2022	20
2023	24

In simple terms, therefore, the study will attempt to answer the question of whether or not Australia will obtain a net benefit from 24 million tonnes per annum of natural gas export from Queensland.

1.4 Why the focus on East Coast LNG?

The focus on East Coast LNG is because:

(i) the Western Australian market is not connected to the integrated gas market of the Eastern Australian states (which for this purpose include South Australia but not the Northern Territory) and

(ii) Western Australia has a domestic reservation policy for natural gas and the eastern states do not.

Because of the inter-connection between the eastern states' markets, the East Coast LNG plants will affect the majority of the Australian economy.

In short, given the conditions under which the Queensland projects were allowed to proceed, it is these projects that are most likely to fail a comprehensive national interest test.

1.5 Construction impacts

This study focuses on the production impacts on the economy. The construction impacts of new capacity required to support the changes is ignored as there is no suggestion that the LNG projects should not proceed but the focus should be on ensuring there is ample gas for the domestic sector.

2. The national interest evaluation framework, indicators and methodology

Under Australian law, Australia's petroleum (including natural gas) resources (and mineral resources) are owned by the Crown, in some cases in the right of the states and territories and in some cases in the right of the Commonwealth. In the words of the Productivity Commission, governments should exercise stewardship over Crown resources, managing them to achieve maximum overall benefits for the community. As the Productivity Commission notes, management should not simply be focussed on economic benefits but should also take into account objectives such as the protection of health, the environment and heritage. In general terms, the governance requirement is expressed as the Government's responsibility to make decisions on:

- how;
- when; and
- on what terms,

the petroleum resources are extracted, in terms of maximising the national interest.

Although the national interest test is required in legislation, for example, for assessing foreign investment proposals, Australian Governments have not explicitly stated what guidelines should be applied in balancing the economic, environment, strategic or social interests that constitute the national interest. While this allows regulatory bodies to operate with maximum flexibility, it also shields their decisions from evaluation in terms of explicit criteria.

2.1 The national interest test

The latest statement on the national interest test was made on behalf of the Australian Government by the Treasurer.[1] The statement applies to foreign investment but would be equally relevant to resource management decisions, and not only for the reason that most resource management decisions have a foreign investment component. The statement runs as follows.

2.1.1 What are the characteristics of investment proposals that are likely to be approved

The Government is making sure investments are not contrary to the national interest. If an investment is contrary to the national interest, the Government will intervene. This occurs infrequently.

What is contrary to the national interest cannot be answered with hard and fast rules. Attempting to do so can prohibit beneficial investments and that is not the intention of our regime. Australia's case-by-case approach maximises investment flows while protecting Australia's national interest.

[1] The Treasurer of Australia, "*Australian Foreign Investment Policy*", January 2012.

2.1.2 What are the national interest considerations

Assessing the national interest allows the Government to balance potential sensitivities against the benefits of foreign investment.

The Government determines national interest concerns case-by-case. We look at a range of factors and the relative importance of these can vary depending upon the nature of the target enterprise. Investments in enterprises that are large employers or that have significant market share may raise more sensitivities than investments in smaller enterprises. However, investments in small enterprises with unique assets or in sensitive industries may also raise concerns.

The impact of the investment is also a consideration. An investment that enhances economic activity – such as by developing additional productive capacity or new technology – is less likely to be contrary to the national interest.

The Government typically considers the following factors when assessing foreign investment proposals.

National Security

The Government considers the extent to which investments affect Australia's ability to protect its strategic and security interests. The Government relies on advice from the relevant national security agencies for assessments as to whether an investment raises national security issues.

Competition

The Government favours diversity of ownership within Australian industries and sectors to promote healthy competition. The Government considers whether a proposed investment may result in an investor gaining control over market pricing and production of a good or service in Australia. For example, the Government will carefully consider a proposal that involves a customer of a product gaining control over an existing Australian producer of the product, particularly if it involves a significant producer.

The Government may also consider the impact that a proposed investment has on the make-up of the relevant global industry, particularly where concentration could lead to distortions to competitive market outcomes. A particular concern is the extent to which an investment may allow an investor to control the global supply of a product or service.

The Australian Competition and Consumer Commission (ACCC) also examines competition issues in accordance with Australia's competition policy regime. Any such examination is independent of Australia's foreign investment regime.

Other Australian Government Policies (Including Tax)

The Government considers the impact of a foreign investment proposal on Australian tax revenues. Investments must also be consistent with the Government's objectives in relation to matters such as environmental impact.

Impact on the Economy and the Community

The Government considers the impact of the investment on the general economy. The Government will consider the impact of any plans to restructure an Australian enterprise following an acquisition. It also considers the nature of the funding of the acquisition and what level of Australian participation in the enterprise will remain after the foreign investment occurs, as well as the interests of employees, creditors and other stakeholders.

The Government considers the extent to which the investor will develop the project and ensure a fair return for the Australian people. The investment should also be consistent with the Government's aim of ensuring that Australia remains a reliable supplier to all customers in the future.

Though the national interest is defined broadly, possible negative spillover effects of any specific investment on other industries are not explicitly considered.

2.2 A qualification of the national interest test: The guidelines used for this study

(i) Net economic benefit

The project should make a significant net benefit to cumulative economic activity over its life including the construction phase.

(ii) Significant medium-term benefits

In order to ensure that the benefits are not delayed beyond the living spans of a significant proportion of the current living population, at least one third of the net benefits should be achieved within the first 10 years of the life of the operations of the project.

(iii) Strengthening the skill base of the economy

The project should, net, strengthen the skills base of the economy as measured by the skill intensity of demand for labour.

(iv) There is a significant net impact on Government revenues

In order for the benefits of resources to be distributed to the broader community, Governments need a significant revenue base to distribution. Therefore, a necessary requirement would be that the discounted Government revenue from the project be greater than what would be achieved from an expansion in the general economy.

(v) Australia's economic security

One requirement here, in general terms, would be for the economy to be able to withstand negative economic shocks better than would have been the case in the absence of the project. Australia's relatively secure open economy is subject to shocks in the form of sudden and adverse movements in terms of trade (commodity prices) and the exchange rate. It is desirable, therefore, that the project should reduce the economic costs of adverse commodity prices and exchange rates.

(vi) Australian political security is enhanced

It is desirable that the project should not promote economic dependence on any particular trade partner or closely-allied group of partners.

2.3 The national interest evaluation: Its importance in optimising national benefits

The decision to allow an individual LNG project to proceed or not, in terms of the national interest test, would depend on whether or not the expected net economic, environmental and security outcomes are significantly positive. The project would only be allowed to proceed if it was deemed likely to yield greater national benefit compared to denial of approval.

In most cases, however, it will not be a simple case of a go/no go decision. The national interest evaluation process will frequently identify negative outcomes which can be remedied either by changes in the particular project or by more general policy changes, unrelated to the particular project, which will increase the benefits generated by the project. These complementary policies or other changes may change the status of a project from 'no go' to a strong positive national interest return, and will frequently include strategies to minimise the costs which the project imposes on other industries. A rigorous national interest evaluation process is therefore in itself an instrument to maximise national benefit.

2.4 The benefit indicator

After the design of the national interest evaluation framework, the next most important decision is the selection of the core indicator for evaluating net benefits. In general terms the benefit indicator selected should measure that part of the flow of production that is available to support expenditures in the national economy that directly contribute to welfare/happiness. In the absence of direct measures of welfare, it is usual to concentrate on the flows of funds available to citizens for expenditure on meeting their needs and wants. We are therefore seeking within the constraints of available data for a benefit indicator of sustainable consumption.

A range of indicators is commonly used when measuring the impact of an investment on economic activity, including:

- gross domestic product;
- gross national product (gross domestic income); and
- net national product (net domestic income).

The bracketed name is what the series is now called in the Australian National Accounts. The original names are retained in this study because they clearly signal that the indicators have the same status as GDP whereas the new names imply a lower status. Gross domestic product is the value added generated in a given jurisdiction, irrespective of where the income is distributed. Gross national product (gross domestic income) is GDP less that part of GDP that is distributed to foreign residents or companies in the form of interest, dividends and undistributed income. Net national product is gross national product less that part of value added that is allocated to depreciation expenses. The last is the most appropriate to use in evaluating the benefits of investments in the gas industry for two reasons.

- high foreign ownership in the industry (one of the three LNG export terminals currently under construction at Gladstone is wholly overseas owned and the other two are joint ventures with substantial overseas participation); and

- very high depreciation charges (the bulk of depreciation expense occurs in the first half of the project life and much of it is returned overseas to repay debt).

Because of overseas ownership and high depreciation, the GDP indicator gives a very misleading indication of the benefits of LNG plants.

Given a regard for national welfare, the benefit indicator on which all national interest evaluations should be based should be either net national product (net disposable income) or direct estimates of sustainable private and public consumption expenditure impacts, which can be approximated by consumption expenditure plus total taxation revenue. Both NNP and consumption plus tax revenue are reasonably good proxies for sustainable consumption. Accordingly, for this study, the benefit indicator is taken to be an average of the two measures, that is, the sum of NNP plus private consumption expenditure plus taxation revenue divided by two.

2.5 A probability approach needs to be built into the evaluation framework

A probability approach is required for this study and for testing the implications of a project's approval by regulators. For this study a range of parameters have to be quantified with values around which there is a great deal of uncertainty not only in terms of current settings but also what the values may be over a 20 to 30 year time horizon.

Regulators are able to assess more accurately current information in regard to particular projects if only for the reason that it will be contained in the supporting documentation required for the approval process. In terms of the future values of required parameters, this will require judgement based on the best available current information. In this case, it would be useful for regulators to adopt a probability approach which requires the explicit setting of the characteristics of the probability distribution around key parameters.

This also fits into the general bottom line reality of assessments. Because of uncertainty, the best that any national interest assessment can conclude is that "*on the balance of probabilities it is concluded that .....*". By specifying probability distributions of the key parameters that determine the overall outcomes, the degree of uncertainty surrounding a decision for a project to proceed or not, or surrounding the conditions imposed on project approval, can be communicated to the general public. This eliminates the need for regulators to have a non-transparent and flexible definition of how the national interest is to be assessed.

Further, it can be more difficult to interrogate modelling results, and minor differences in assumptions can lead to big differences in outcomes. This worry is blunted if a probabilistic framework is adopted since, if results are sensitive to certain parameter specifications, this will be indicated by a high probability distribution range around the bottom line evaluation indicators.

In the present study, all relevant data and relationships used in the calculations for the national interest evaluation are included to readers to cross check the conclusions.

2.6 The quantification of risk – the Trigen distribution

For this study the probability distribution selected to quantify risk is the Trigen distribution. This distribution is selected because its parameters are easily related to the conditions that the probability distribution is describing.

To apply a Trigen probability distribution five parameters have to be specified. They are:

(i) the lower bound of the parameter/indicator;

(ii) the mode value of the parameter/indicator;

(iii) the upper bound value of the parameter/indicator;

(iv) the probability that values less the lower bound values will be taken; and

(v) the probability that values less than the upper bound value will be taken.

The approach will be illustrated for perhaps the most important input indicator for this study which has a high level of uncertainty. This indicator is the total remaining identified and undiscovered reserves of natural gas. As shorthand, these reserves are often referred to as remaining reserves. Chapter 6 below nominates the lower bound and upper bound values based on the estimates of others.

Figure 2.1: Trigen probability distribution for remaining reserves

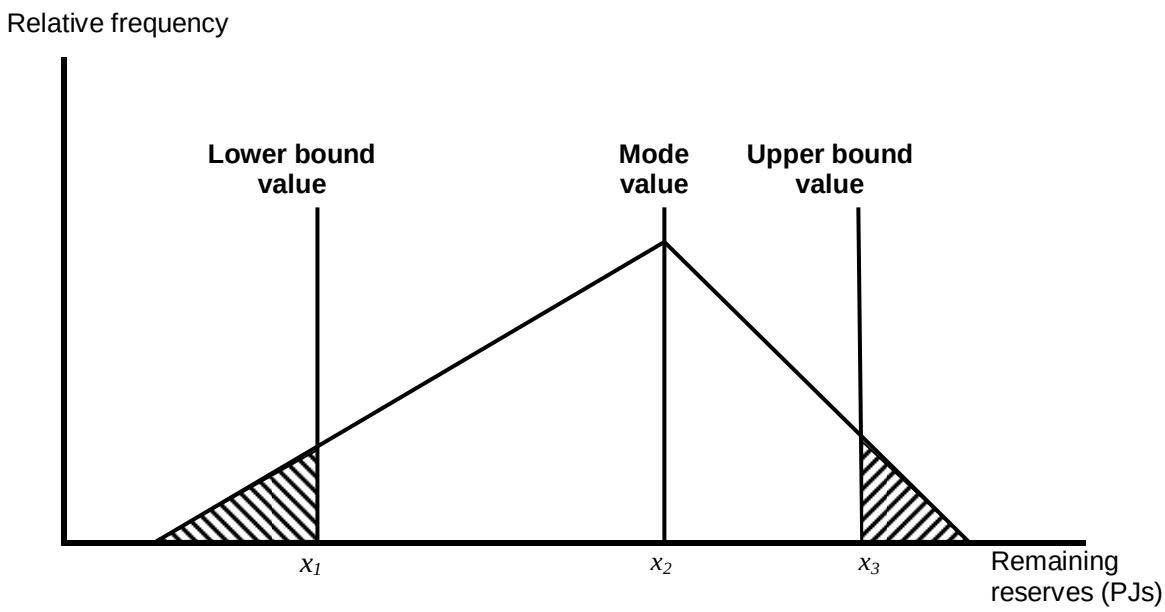


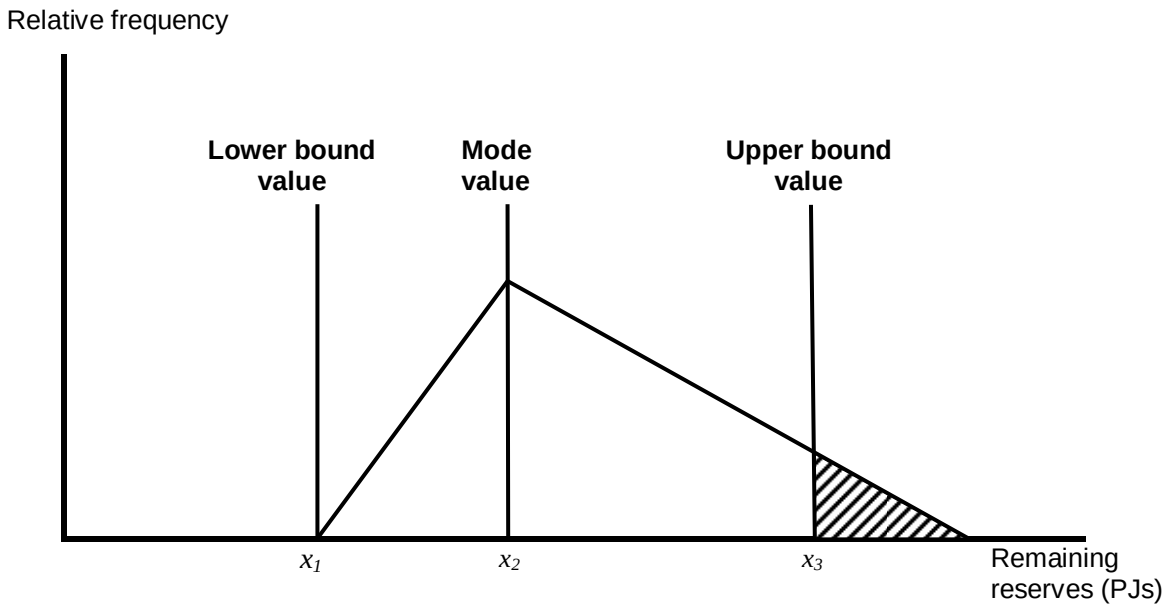
Figure 2.1 illustrates this case. Remaining reserves are measured in petajoules (PJs). The remaining reserves, in terms of lower bound (x_1), mode (x_2) and upper bound values (x_3) are selected on the best available information. If the upper bound probability is set at 100, then there will be no shaded area for the upper bound value. However, if it was considered that the probability of finding more reserves than the upper bound value, then the upper bound probability might be set at 80 per cent with the shaded area in the figure representing a probability of 20 per cent.

The same concepts apply to the lower bound values. For this study the lower bound probability is set at zero, meaning that there is no probability of the lower bound value taking lower values.

The mode can be selected on the basis of whether an upward or downward bias is to be imposed after consideration of upside and downside risks.

Figure 2.2 illustrates the case where the downside risks are considered dominant. Also, the lower bound probability is set at zero.

Figure 2.2: Trigen probability distribution for remaining reserves



2.7 The spillover impacts on other industries

A deficient national interest test would focus on the value of a project with little or no testing of the implications for other industries.

Comprehensive economic national interest testing examines how the project will impact other industries both positively and negatively. Comprehensive national interest testing, therefore, focuses not on the gross benefit of a project but the net impact after taking into account both negative and positive impacts on other industries.

3. LNG export expansion – channels of costs imposed on non-resource industries

LNG expansion can impose costs on other industries. Although a range of transmission channels may be relevant, the costs generally take the form of reductions in the level of output in other industries, sometimes referred to as crowding out. In a fully-employed economy some level of crowding out is inevitable if new projects are to proceed; the question is then whether the benefits from the new project exceed those lost through crowding out. In economies which are less than fully employed opportunities may exist to resource the new project without crowding out, in which case the potential benefits are considerable. However, there is also a possibility that projects will be implemented in ways which cause unnecessary crowding-out.

The discussion here is in qualitative terms and takes LNG expansion as a particular case of resource industry expansion. Although agriculture is also a resource industry, in the context of this chapter the term exclusively applies to the resource extraction industry. In ABS terminology the resource extraction industry is called mining and includes all activities which extract subsurface mineral resources other than water.

3.1 Macroeconomic resource (labour) constraints: Non-resource industry crowding out

Macroeconomic resource constraints apply to any LNG project planned for an economy which would otherwise be operating with full utilisation of resources, or which would reach full resource utilisation in the event of the project proceeding. Full utilisation can apply in both the construction and production phases of the project, and may apply to the economy as a whole or to particular inputs or geographic areas. If the project is to divert inputs from other uses the following tests must return positive answers if the project is to yield net benefits at the national level. (The tests are specified in terms of labour, but can be re-phrased to apply to any other diverted inputs such as office space). The first test is relatively simple: gross product, real wages and Government tax per hour worked by marginal workers transferred into the project are greater than gross product, real wages and taxes per hour worked by marginal workers in the industries from which they are displaced. The second test recognises that labour displacement will be accompanied by a gradual process of capital displacement, particularly during the construction phase, during which capacity-enhancing investment in the non-resource industries will be crowded out by resource project investment. The second test requires that the foregone productivity-enhancing effects of the crowded out investment does not reverse the first test.

Though these tests are conveniently specified in terms of labour, it should be remembered that Australia has a long history of alleviation of labour shortages through increased immigration. The chief concern, therefore, has to be crowded-out investment.

3.2 The drivers of manufacturing expansion

Relative costs are important in the sense that manufacturing will contract if there is too great a gap between domestic and foreign costs of production. However, even if relative costs are comparable and Australian products have a price edge (as when the actual $A/$US exchange rate is below its Purchasing Power Parity level) manufacturing expansion still depends on producers' ability to gain a competitive edge by product differentiation in terms of the design, functionality, durability, etc. of their products. This requires years of lead time in research and development and marketing efforts and also requires time to finance innovation and new capacity involving the latest technology and so on. The efforts of a firm to adopt best practice production technology, innovate via research and development expenditures and develop new markets are all part of either achieving competitive edge product differentiation or identifying opportunities for greater exploitation of existing advantages.

In the typical manufacturing industry the individual producer creates or maintains a market while in the resource extraction industry the producer responds to the market. This is why differentiated product manufacturing is riskier than most other industries. An important aspect of this higher level of risk is that differentiated product manufacturers have to create their own finance for expansion whereas in resource extraction industries this finance is delivered by the market.

At the macroeconomic level the different drivers of the resource extraction industry versus manufacturing expansion can lead to a conflict between manufacturing expansion and equivalent resource extraction industry expansion that is unrelated to issues of national resource availability. This is because the higher terms of trade effect associated with resource extraction industry expansion crowds out manufacturing activity through exchange rate impacts. The converse negative impact on the resource extraction industry from manufacturing expansion is much weaker because manufacturing expansion does not influence the terms of trade.

The most important dynamic is one of cumulative causation. Success in sustained manufacturing expansion depends on an uninterrupted sequence of steps that are resourced adequately and are consistent with market requirements.

Periods of highly over-valued exchange rates associated with elevated resource extraction industry activity intensity are very destructive for manufacturing. This is because high relative costs, in conjunction with already high risks, lead producers to curtail or end new development initiatives. Research and development (R&D) is scaled back and capacity expansion and replacement decisions are postponed, which leads to producers falling further behind their competitors in other countries. When the period of elevated resource extraction investment ends and the exchange rate falls back to cost parity levels domestic competitors are too far behind to restart R&D programs or even, in some cases, to undertake the replacement investment required to ensure long term business sustainability. The same adjustment process occurs, though less severely in terms of the long run negative outcomes, for other trade-exposed industries such as differentiated agriculture, high value business services industries, tourist industries and export-oriented segments of the health and education industries.

In general, a floating exchange rate protects the resource extraction industry in both the expansion and stability phase of the resource price cycle. For manufacturing and other trade exposed industries, positive stimulus to growth mainly comes in periods of low resource prices and hence low exchange rates. However the strength of this positive stimulus to growth is likely to be weak under the following conditions:

(i) if the period of low commodity prices corresponds to a period of relatively low world growth and low expectations of future growth; and

(ii) if a history of high exchange rates during past mining booms has generated expectations of future episodes, leading potential investors to discount the benefits of a current relatively low exchange rate heavily when they calculate the expected future returns on investment. They will not expect the exchange to remain low for very long.

Repeated episodes of resource extraction industry expansion lead to expectations of increasing volatility and the requirement of high short-term returns on investment.

National interest testing of a project's impact on economic security should cover a number of components, including, inter alia trade dependency and resilience to economic shocks.

3.2.1 Economic security: Trade dependency

It is not in an exporting country's national interest to become over-dependent for its exports on any other country. Over-dependence means that if the importing country's economic prospects decline rapidly it will force a significant decline in economic activity on the exporting country. There is also a risk that such trade dependency might be used by the importing country to force political and economic decisions on the exporting country even when they are costly in terms of the latter's national interest.

3.2.2 Economic security and the national interest: Resilience to economic shocks

One of the economic security components of national interest evaluation is the resilience to economic shocks test. If project proceeds, the project should not increase the security risk of the economy to a negative economic shock and, in particular, an exchange rate shock.

The one thing that is certain about any period of strong expansion in resource development is that it will end. More often than not the ending will be characterised by a rapid fall in commodity prices, closely followed by a fall in the exchange rate. This will lead to a widening of the current account deficit which in the Australian case is likely to be unsustainable given that, even with relatively high terms of trade, Australia's current account deficit is likely to be around 5-8 per cent of GDP circa 2016-2020.

The national interest evaluation would require that the following questions be answered.

(i) What is a plausible lower limit for commodity prices at the end of the current resource extraction industry expansion?

(ii) Assuming that the exchange rate falls in proportion to the commodity price fall, what would be the direct impact on:

- domestic inflation rates; and
- the current account deficit?

(iii) How much will national economic activity have to contract to return the inflation rate to desired levels? (The assumption here is that increases in unemployment rates are required to reduce the rate of growth of nominal wages and hence of costs and prices.)

(iv) In terms of (iii), does the project under consideration increase or reduce the contraction in economic activity necessary to bring inflation under control during a period of falling exchange rates?

(v) To what extent are import and export responses to the exchange rate devaluation likely to reduce the initial current account deficit after a reasonable time, say three years? What will be the contribution of the project to these responses?

(vi) Given the outcome of (v), what is the contraction in output required to restore the current account deficit to sustainable levels?

(vii) Given the outcome of (vi) does the go-ahead of the project under evaluation add to or reduce the contraction in economic activity required to restore the current account deficit to acceptable levels?

The national interest test would then compare the calculations from (iv) and (vii). If one or both answers were negative the project would fail the national interest test because it reduced the resilience of the economy to economic shocks. Failure of these tests means that the project could increase the contractions in the level of general economic activity required to achieve satisfactory inflation or balance of payments outcomes during the last phase of an episode of elevated resource expansion, the period of the return to stability.

3.3 Microeconomic resource constraints: Industry crowding out

As distinct from macroeconomic resource constraints, microeconomic resource constraints, resulting from projects proceeding, can impose costs on specific industries by limiting the growth in, or reducing the availability of, key resource inputs which cannot be effectively substituted with other inputs. In this case the industries affected have no option but to reduce actual or planned output in proportion with the actual or expected reduction in key input supply – a process which can easily lead to unemployment of other inputs.

For the case of LNG projects requiring large scale access to natural gas reserves, the impact on the future availability of gas will affect actual and expected investment, output and employment decisions in directly affected industries, especially heavy industry and electricity generation.

The chemical and alumina industries depend on the availability of gas at competitive prices. One or two LNG projects may not undermine confidence in the future availability of gas provided that expected gas reserves are adequate. However, with three and perhaps four additional LNG plants to come online over the next few years, along with projected expansion in the capacity of these plants, it is becoming clear that the combined claims on gas resources may lead to gas supply constraints in the eastern Australian gas market which will almost certainly lead to increasing expectations of real gas cost rises as higher costs of extraction are encountered in exploiting Australia's remaining resources of natural gas. The expectation of rising gas prices will reduce the willingness of producers in the chemical and alumina industries both to maintain the competitiveness of their current plants and to invest in additional capacity. This change in expectations could trigger a long-term decline in these industries which will be accelerated if expectations of gas shortages to domestic users take hold.

Because of the importance of the downstream gas-user industries in Australia's industrial structure and their recent growth performance, the impact of LNG export proposals on domestic users would have to be at the centre of any national interest evaluation for any

valid determination of net project benefits. The critical indicator to focus on in this component of the national interest test is the ratio of annual natural gas demand (including all approved LNG plans) to estimated remaining reserves. If this ratio falls below acceptable levels then substantial microeconomic crowding out is likely to eventuate at some point over the project's life.

Microeconomic crowding out is analysed in Chapters 4 to 7 below.

3.4 Electricity price impacts

A further avenue of impact from LNG expansion lies in the implications for wholesale electricity prices that result from greatly elevated natural gas prices. Gas powered generation already plays a significant role in the electricity market, particularly in meeting peak demand, and its role is expected to grow both to provide backup to variable renewable generation and to provide relatively low-emissions base load. At peak times highly responsive Open Cycle Gas Turbines (OCGT) frequently set the wholesale price in the National Electricity Market and increased fuel costs can be expected to flow directly through to higher prices in that market. A 2010 AGL study found a $35 per megawatt hour difference in the marginal running costs of OCGT between a gas price scenario of $3.60 per GJ and one at $6.75.[2] These increases will flow through to almost all consumers, while those businesses who have moved to insulate themselves from rising electricity prices by installing highly efficient gas-fired cogeneration systems in recent years will find themselves subject to the same fuel price pressures.

[2] Paul Simshauser, Tim Nelson and Thao Doan, *The Boomerang Paradox, Part 1* (October 2010) http://www.aglblog.com.au/wp-content/uploads/2010/10/No.17-Boomerang-Paradox-Final-Oct-20101.pdf.

4. The natural gas usage trade-off: Domestic allocation versus export use – the case of natural gas dependent industries

Central to the application of the national interest test will be the direct economic value of a given quantity of natural gas from LNG exports versus the economic value of the same quantity of gas produced from domestic use. The net value of this comparison is a key estimate because:

(i) it indicates the cost of supply shortages if the export of gas has supply preference over domestic users; and

(ii) a high economic value for gas for domestic use entails that it is in the national interest that confidence in the adequacy of future domestic gas supplies at competitive prices ought not to be undermined by inappropriate exports.

The value of the trade-off will be assessed from two perspectives, namely:

(i) gas dependent industries; and

(ii) the non-resource economy excluding agriculture and mining.

The case of natural gas dependent industries is considered in this chapter and the broader economy-wide industry effects will be considered in the next chapter.

Natural gas dependent industries are industries where a large part of total output depends on the availability of natural gas at relatively low prices. These industries are the chemical sector and the non-ferrous basic metals industries (particularly alumina production).

To calculate the net value trade off for a given quantity of natural gas we estimate the value of current output of these industries that, in the long-term, would be curtailed if the supply of natural gas to these industries ended, or alternatively if supply was available only at such prohibitive prices that the industries became uncompetitive and retreated offshore.

4.1 Natural gas dependent industries: The direct value of natural gas availability

The chemical sector consists of the following major industries:

- basic chemicals;
- paints;
- pharmaceuticals;
- soap and detergents;
- cosmetics;
- other chemicals;
- rubber products; and
- plastic products.

There are other industries where the dependency on natural gas is high enough to justify the assumption that a substantial part of these industries, in the current environment, would not exist without reliable supplies of natural gas at competitive prices. These industries include glass and cement. The electricity sector is also becoming dependent on natural gas for peak power generation and increasingly for base load; this dependence will likely increase with the growth of renewables. The concentration of the present study on non-ferrous metals and chemicals to assess the cost of diversion of gas to LNG exports does not imply that other industries are unaffected. As long as the other affected industries have smaller economic values for gas the marginal cost of gas diversion is determined by the analysed industries.

The assumption in this study is that if natural gas was no longer available, the bulk of the basic chemicals industry would cease to operate, not necessarily overnight, but over time. The basic chemical industry was established in Australia before adequate supplies of natural gas became available. However, this was driven by factors including security objectives arising during and from World War II and high levels of tariff protection and subsidies. These no longer exist. More importantly, it was established at a time when other countries with large scale chemical industries also had limited or no supply of natural gas. The widespread availability of natural gas over the last half century has meant that the technological base of the industry has changed radically so that now a world competitive industry perforce relies on natural gas.

Other industries in the chemical sector rely on the presence of a local basic chemicals industry at the head of their supply chain and part of these industries would not exist without the availability of domestic basic chemical products. Accordingly the basic chemical industry generates a supply multiplier through the rest of the chemical sector. The question is how big is this multiplier effect? This multiplier effect was estimated by the following steps:

(i) using input-output table $m flows to calculate the share of product from the basic chemical industry used in the other seven chemical industries listed above as a percentage of output of each industry;

(ii) find the industry with the highest share of basic chemical products and nominate that share of this industry that would not exist in the long-run without the local availability of supply from the basic chemical industry. This nomination is termed the maximum basic chemical industry dependency ratio;

(iii) extend this nomination to the other chemical industries dependent on the basic chemical industry as the maximum basic chemical industry dependency rate multiplied by the basic chemical input share of the industry being estimated, divided by the basic chemical industry input share from (ii), or for that industry with the maximum basic chemical industry dependency ratio;

(iv) divide the results from (ii) for each industry by the basic chemical sector industry; and

(v) sum the results of (iv) across all the chemical industries to give the basic chemical industry multiplier, with a multiplier of unity for the basic chemical industry itself.

Table 4.1 gives the results of the calculation for Australia in 2008-09. The highest input ratio is for the plastics industry and the maximum basic chemical dependency ratio for this industry is nominated at 60 per cent. From this flows the multiplier estimates by industry shown in the second column of the table. The total multiplier value is 1.6.

Table 4.1 The chemical industry basic chemical multiplier		
	Input from basic chemicals – ratio of output	**Basic chemical sector – output multiplier**
Basic chemicals	0.12	1.00
Paints	0.05	0.02
Pharmaceutical products	0.01	0.04
Soap and detergents	0.06	0.01
Cosmetics	0.06	0.01
Other chemicals	0.07	0.07
Rubber products	0.02	0.01
Plastic products	0.13	0.44
Total	**–**	**1.60**

4.1.1 The importance of the local supply chain

It may be asserted that Australia's non-basic chemical enterprises would be best served by securing basic chemical inputs from anywhere in the world so long as they are at lowest cost and that a local basic chemicals industry is therefore not important. This view is wrong. The benefits of the local supply chain come from:

(i) just-in-time manufacturing capability;

(ii) manufacture of product that is required by the particular production technologies and product types produced by the local industry (these are not fully available elsewhere in the world);

(iii) security of supply; and

(iv) mutual dependency placing upper limits on price settings.

In this context, the multiplier value of Table 4.1 could be considered as being too low.

4.1.2 The non-ferrous metals industry

The non-ferrous metals industry consists of the alumina, aluminium and other processing industries, such as zinc, nickel, etc. Most certainly the alumina industry would not exist without the availability of natural gas, and almost certainly part of the aluminium industry would not exist without the availability of a strong local supply chain extending from bauxite to alumina and finally to aluminium.

Accordingly, the assumption adopted here is that half the Australian non-ferrous basic metals industry would not exist without the availability of plentiful natural gas supplies at reasonable prices.

4.1.3 Natural gas dependent industries: The direct value estimates

Given the above methodology, Table 4.2 profiles the direct benefit Australia receives from the supply of natural gas to the local gas-dependent industries. The estimates are in terms of $m of output per petajoule (PJ) of natural gas input.

Table 4.2	The direct benefit to Australia per PJ of natural gas – natural gas dependent industries (2008-09)
	$m
Non-ferrous metals	
Output per PJ	476
Adjusted output per PJ	238
Chemical sector ($m per PJ)	
Basic chemicals	168
Paints	3.9
Pharmaceuticals	4.0
Soaps and detergents	6.4
Cosmetics	2.2
Other chemical products	11.6
Rubber products	1.6
Plastic products	73.9
Total	**271.6**
LNG exports	**11.5**

The total value of a PJ of natural gas into the basic chemical industry, given the spillover benefits from the other industries, comes to $271 million per PJ. This is in accordance with the 1.6 multiplier developed above for the chemical sector.

The PJ value for LNG exports over the fiscal years from 2009 to 2011 has averaged $11.5 million. It is extremely important to recognise that this exported gas was sourced without affecting supply to domestic industrial users. The trade-off ratio means that if 1 PJ is instead shifted from local use by gas-dependent industries to export, the result is a direct loss of gross output of (averaging the basic metals and chemical sector estimates) of $255 million, compared to a $12 million gain from export revenues. The direct net loss in Australian value added is $243 million, or a loss/benefit ratio of 21 to 1.

This by itself would justify a national interest evaluation methodology which investigates whether local industry has an adequate supply of gas for the next two to four decades and approves LNG plants only when they can be supplied without affecting supply and price to domestic users. The fact that this evaluation is so compelling suggests that no such evaluation has been applied in national interest assessment to date. However, to be secure in this conclusion a further analysis needs to be undertaken, placing the direct estimates in the context of an input-output framework for the total national economy, incorporating into the analysis parameters reflecting differentials in the depreciation rates, tax rates and foreign ownership rates between industries, and assessing the net impact on the indicators selected as appropriate for national interest evaluations.

4.2 The input-output modelling framework

To evaluate the issue further, it is necessary to adopt a mixed demand-supply constrained input-output framework. This is because the existence of gas dependent industries means that these industries' activity levels are determined not simply by demand, but by whether or not there is an adequate supply of natural gas at reasonable prices to support domestic supply expansion where this is required to accommodate an increase in demand.

Let x_i represent (gross) output of industry i.

The economy consists of n industries, of which m industries are supply constrained by the availability of natural gas. By supply constrained is meant that they cannot automatically respond to demand changes unless the natural gas industry decides to provide the required inputs of (in this case) natural gas without major price increases.

The input-output relationship for the case where no industry is constrained is:

$$
\begin{pmatrix} x_1 \\ \vdots \\ x_m \\ \cdots\cdots \\ x_{m+1} \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ x_n \end{pmatrix}
=
\begin{pmatrix} a_1 & \cdots & a_{1,m} \\ \vdots & & \vdots \\ a_{m,1} & \cdots & a_{m,n} \\ \cdots & \cdots & \cdots \\ a_{m+1,1} & \cdots & a_{m+1,n} \\ \vdots & & \vdots \\ \vdots & & \vdots \\ \vdots & & \vdots \\ \vdots & & \vdots \\ a_{n,1} & \cdots & a_{m,n} \end{pmatrix}
\begin{pmatrix} x_1 \\ \vdots \\ x_m \\ \\ x_{m+1} \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ x_n \end{pmatrix}
$$

$$
+
\begin{pmatrix} c_1 & \cdots & c_{1,n} \\ \vdots & & \vdots \\ \vdots & & \vdots \\ c_{m,1} & & c_{m,n} \\ c_{m+1,1} & & c_{m+1,n} \\ \vdots & & \vdots \\ \vdots & & \vdots \\ \vdots & & \vdots \\ \vdots & & \vdots \\ c_{n,1} & \cdots & c_{m,n} \end{pmatrix}
\begin{pmatrix} x_1 \\ \vdots \\ \vdots \\ x_m \\ x_{m+1} \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ x_n \end{pmatrix}
$$

$$
+
\begin{pmatrix} f_1 \\ \vdots \\ \vdots \\ f_m \\ f_{m+1} \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ f_n \end{pmatrix}
$$

Given that x_1 to x_m are constrained, the (4.1) can be rewritten as:

$$
\begin{pmatrix} x_{m+1} \\ \vdots \\ \vdots \\ \vdots \\ x_n \end{pmatrix}
=
\begin{pmatrix} a_{m+1,1} & \cdots & a_{m+1,m} \\ \vdots & & \vdots \\ \vdots & & \vdots \\ \vdots & & \vdots \\ a_{n,1} & \cdots & a_{n,m} \end{pmatrix}
\begin{pmatrix} x_1 \\ \vdots \\ \vdots \\ \vdots \\ x_m \end{pmatrix}
$$

$$
+
\begin{pmatrix} a_{n+1,m+1} & \cdots & a_{m+1,m} \\ \vdots & & \vdots \\ \vdots & & \vdots \\ \vdots & & \vdots \\ a_{n,m+1} & \cdots & a_{n,n} \end{pmatrix}
\begin{pmatrix} x_{m+1} \\ \vdots \\ \vdots \\ \vdots \\ x_m \end{pmatrix}
$$

$$
+
\begin{pmatrix} c_{m+1,1} & \cdots & c_{m+1,m} \\ \vdots & & \vdots \\ \vdots & & \vdots \\ \vdots & & \vdots \\ c_{m,1} & \cdots & c_{n,m} \end{pmatrix}
\begin{pmatrix} x_1 \\ \vdots \\ \vdots \\ \vdots \\ x_m \end{pmatrix}
$$

$$
+
\begin{pmatrix} c_{m+1,m+1} & \cdots & c_{m+1,n} \\ \vdots & & \vdots \\ \vdots & & \vdots \\ \vdots & & \vdots \\ c_{n,m+1} & \cdots & c_{n,n} \end{pmatrix}
\begin{pmatrix} x_1 \\ \vdots \\ \vdots \\ \vdots \\ x_m \end{pmatrix}
$$

$$
+
\begin{pmatrix} f_{m+1} \\ \vdots \\ \vdots \\ \vdots \\ f_n \end{pmatrix}
$$

Or in matrix form:

$$\boldsymbol{x}^u = \boldsymbol{A}^c\boldsymbol{x}^c + \boldsymbol{C}^c\boldsymbol{x}^c + \boldsymbol{A}^u\boldsymbol{x}^u + \boldsymbol{C}^u\boldsymbol{x}^u + \boldsymbol{f}^u$$

Where:

$$
\boldsymbol{x}^u = \begin{pmatrix} x_{m+1} \\ \vdots \\ \vdots \\ \vdots \\ x_n \end{pmatrix}
$$

$$
\boldsymbol{x}^c = \begin{pmatrix} x_1 \\ \vdots \\ \vdots \\ \vdots \\ x_m \end{pmatrix}
$$

$$
\boldsymbol{f}^u = \begin{pmatrix} f_{m+1} \\ \vdots \\ \vdots \\ \vdots \\ f_n \end{pmatrix}
$$

A^c = $(n - m) * m$ matrix of coefficient of inter-industry input-output coefficients.

A^u = $(n - m) * (n - m)$ coefficients of inter-industry input-output coefficients.

C^c = $(n - m) * m$ matrix of consumption output coefficients for constrained industries.

C^u = $(n - m) * (n - m)$ matrix of consumption output coefficients for unconstrained industries.

Unconstrained industry output is, therefore, given by:

$$\boldsymbol{x^u} = \boldsymbol{[I - A^u - C^u]^{-1} [A^c + C^c] + [I - A^u - C^u]^{-1} f^u}$$

Other indicators

Other indicators are given by the general form:

$$i_{o,j} = va_j \,.\, i^c_o \, x_j$$

Where:

$i_{o,j}$ = other indicator value (net national product, wage, salaries and mixed income, etc.) for industry j.

va_j = share of value added at factor cost to total gross output for industry j.

i^c_o = ratio of indicator o to value added (or gross surplus) for industry j.

x_j = total gross output for industry j.

The aggregate value across industries is given by:

$$i^t = \sum_{j-1}^{n} i_j$$

The key coefficients, i^c_o, are presented in Appendix B.

4.3 The input-output tables

The direct allocation of imports input-output table used for this study for 2008-09 is given in Appendix B. Other associated tables used are:

(i) the flow table with indirect allocation of imports;

(ii) the indirect tax flow table;

(iii) the import flow table as the difference between the Appendix B table and the indirect import table described in (i).

The key coefficients, tax, income, etc. by industry are also given in the table in Appendix B.

Adjustments are made to the coefficients given in Appendix B to better reflect the East Coast LNG industry as distinct from the offshore Western Australian industry, which is the only LNG industry reflected in the 2008-09 input-output tables. The main adjustment is to employment. The East Coast LNG industry is likely to be more labour intensive in operation due, in part, to its reliance on a land-based, dispersed natural gas collection and distribution system. As a result, the employment to output ratio is set at 0.19 or 60 per cent greater than the Western Australian average. Appropriate adjustments are made to other related parameters.

The foreign ownership ratio is also likely to be lower than for Western Australian projects. The average foreign ownership ratio for Queensland projects is set at 30 per cent.

The other issue is the tax rate. Once the Resource Rent Tax (RRT) becomes operational the ratio of direct tax to gross surplus will approach 50 per cent. However, this will not occur until towards 2030. In the early years, the tax rate will be negligible, rising to around 15 to 20 per cent once company tax rates become applicable. One way to account for this is to adjust the tax rates year by year, requiring all results to be presented in cumulative discounted terms only rather than as yearly average impacts. Accordingly, the tax rate is set at its average project level of around 35 cents in the dollar of gross surplus, which gives a significant upward bias to the benefits of LNG in the first half of a project's life.

4.4 The impact on the economy of LNG exports – a 50 PJ expansion

The model framework developed above will be used to assess the impact on the economy of a 50 PJ (approximately one million tonnes) LNG export expansion supplied at the expense of supply to domestic gas-dependent industries. The construction impacts are not considered.

In 2008-09 dollars, the additional gross output of LNG (and exports) comes to $620 million. Table A.1 indicates that GDP at market prices increases by $729 million, implying a standard multiplier of 1.2. However, the increase in net national product is half the increase in GDP. The increase in the benefit indicator is $401 million annually.

4.5 A 50 PJ contraction in natural gas supply to natural gas dependent industries

The second column in Table A.2 assumes that the 50 PJ expansion allocated to the LNG project is diverted from natural gas dependent industries. The reduction in gross output for the constrained industries given in Table A.2 runs to $12.8 billion in 2009 prices. This follows directly from the calculations given above on the assumption that 25 PJ is withdrawn from the non-ferrous metal industry and 25 PJ from the basic chemicals industry.

In this case the annual average loss in GDP at market prices is $11.0 billion, while total employment falls by 203,000 from what otherwise would have been the case. From column three of Table A.2 the gross negative from the natural gas withdrawal from natural gas dependent industries so overwhelms the positive impacts of LNG expansion that the net change between the two cases is close to the negative impacts of the gas withdrawal case for gas dependant industries.

The net (LNG plus gas dependant industry) cumulative discounted benefit indicator outcome is -$100 billion. The cost benefit ratio for gas withdrawal increases to 24.2 to 1, which may be compared with the preliminary estimate of 21 to 1 calculated in Section 4.1.3 above. Far from reducing the burden, placing the two cases in the broader context of the national economy increases the net cost of shifting gas from gas-dependent industries compared to LNG export expansion.

4.6 Conclusion

When natural gas is reallocated to exports from domestic use in gas-dependent industries, for every $1 of benefit gained from exports $24 of benefits is lost in contraction of the gas-dependent industries. This can be stated in discounted terms. In 2009 140 PJ of natural gas was allocated to Australian gas-dependent industries. It would have taken 3,400 PJ of LNG exports to deliver this benefit. If, at full development, the Australian east coast LNG industry is supplied at the expense of domestic gas-dependent industry, it will deliver less than a third of the benefit required to offset the loss of domestic industry.

On the other hand, the domestic gas using industrial sector does not put a significant claim on the supply options for Australian LNG and thus the growth options for LNG are not significantly constrained by domestic needs at present. However, this will change if large demands are made on gas as a transitional fuel to renewables.

The core issue is whether the large scale export of gas will constrain the ability of the domestic industry to expand or even maintain existing production levels. This will be considered in Chapter 6. In Chapter 5 we generalise the calculations of the present chapter.

5. The net benefits: LNG exports versus domestic gas use – the case of the general economy

One way to assess the impact of switching natural gas from domestic to export sales on the general economy, that is the non-resource sector of the economy, would be to use a large scale multi-sector model of the economy with detailed industry energy demand equations. Energy prices in general and natural gas prices in particular could then be adjusted until domestic natural gas use was reduced to required levels and the impact on the macroeconomic indicators assessed.

NIEIR has such a model and has used it for similar exercises many times. However, the model results are highly sensitive to model closure conditions. The final outcomes depend on which sector bears the cost adjustment for whatever the changed energy capacity arrangements have to be put in place to maintain overall demand/supply balance. From experience, the quantitative impact of the optimum strategy is approximated by a simple approach, which is adopted here.

The approach requires the direct estimation of a production function for the non-resource economy with capital, labour, gas and electricity as factor inputs. The estimated production function coefficients are then used to calculate the elasticity of substitution between gas and electricity. These two fuels are sufficient to specify the production function since, after the adjustment from the oil price shocks of the 1970s and early 1980s, the substitutability between natural gas and oil has been reduced to low levels. Effectively, gas now mainly competes with electricity.

A quantitative estimate of the elasticity of substitution between gas and electricity will enable the calculation of the quantity of electricity that must be supplied to leave economic activity unchanged after the withdrawal of domestic gas.

However, the economic adjustment does not end there. If the additional electricity supply can only be secured at significant additional cost, the additional costs on the economy will have to be taken into account. If these costs are allowed to flow into the industry structure of the economy there will be a whole range of flow-on effects, including loss of exports, increased imports and reduced real incomes. The least cost option (in terms of the fall in economic activity) is to channel the costs into the household sector with the major burden of adjustment being via real household incomes rather than by reduction in investment, exports, employment, and so on.

An alternative strategy would assume that there is no attempt to compensate for the loss of gas supply and non-resource gross product falls in line with the production function coefficient implications. This channel will also be evaluated in this chapter.

There is a third possible approach. This involves suppressing natural gas supply into the electricity sector which would force electricity production to exploit alternative and higher cost sources of supply. This lies outside the production function approach since natural gas input into electricity is included in the electricity input into the general economy.

These three alternative approaches are evaluated in turn.

5.1 The Australian production function

The task is to estimate a production function to determine directly the role of gas and electricity in driving Australia's economic activity. By definition it takes a supply side approach to economic activity.

A general production function can be written in the form:

$$Y = ae^{rt} (K, L, E, G) \quad (5.1)$$

Where:

Y = output, which may be defined as gross product of the economy, gross product of the private sector, or gross product of a combination of industries.

L = labour employed.

t = transport or total general government capital stock.

r = rate of exogenous technological change.

If a Cobb-Douglas production function is specified, then (4.1) becomes:

$$ln\ Y = ln\ a + rt + \alpha_1\ ln\ K + \alpha_2\ ln\ L + \alpha_3\ ln\ TE + \alpha_4\ ln\ G \quad (5.2)$$

where ln denotes natural logarithms.

The key estimate is for the a coefficient, or the elasticity of output with respect to gas input.

However, the Cobb-Douglas production function is restrictive in terms of the implied returns to scale for individual factors and the elasticity of substitution between factors. The latter is important for this study because of the requirement to use the elasticity of substitution between gas and electricity to obtain estimates of the costs of gas demand suppression.

To circumvent this, a flexible, that is, unrestricted, transcendental production function is estimated. This takes the form:

$$Y = Ae^{rt}\ ln^{\alpha 1}\ e^{b,L} \cdot K^{\alpha 2}\ e^{b2K} \cdot E^{\alpha 3}\ e^{b3E} \cdot G^{\alpha 4}\ e^{b4G} \quad (5.3)$$

The two estimated coefficients which are of particular interest to this study are α_4 and b^4.

5.1.1 The data

Pooled time series cross section data are used to estimate the coefficients. The data is for the five mainland states. The period of estimation is from 1980 to 2011.

The output variable is state gross non-resource product (total state gross product at factor cost less gross product of agriculture and mining and ownership of dwellings. The annual data over recent years is from the Australian Bureau of Statistics (ABS) "*Australian National Accounts*", Cat. no. 5202.0. These estimates are spliced back to 1980 using estimates by NIEIR.

The labour input variable is total hours of work of the non-resource sector by state obtained from ABS "*Labour Force Australia*", Cat. no. 6203.0.

The methodology of estimating capital stock input by state for business capital stock and transport infrastructure capital stock is outlined in NIEIR's "*Transport Infrastructure Investment: An Instrument for Sustainable Debt Financed Fiscal Policy*", April 2012.

The energy data is taken from the Bureau of Resources and Energy "*Economics – data base for energy consumption by state and industry*". The electricity sector energy input is excluded from the non-resource sector totals for electricity and natural gas.

To remove cyclical effects a five year moving average is passed through the data.

5.1.2 The production function: Coefficient estimates and implications

The estimated coefficients are given in Table 5.1. Ignoring the constraints, non-zero coefficients are of the correct sign and, bar one, strongly significant.

A sensitivity analysis was used to calculate the elasticity of substitution between gas and electricity input and the elasticity of non-resource gross product for the four Eastern Australian mainland states. The elasticity of substitution, as at 2011, was calculated as -0.67. This means that if one PJ of natural gas is withdrawn from Eastern Australian markets, it will require an increase in supply of 0.67 PJ of electricity to maintain a constant level of non-resource gross product.

The elasticity of non-resource gross product at factor cost, with respect to natural gas input for the four Eastern Australian mainland states, was found to be 0.082.

Table 5.1 Estimated coefficients of the transcendental production function

Parameters	Coefficient	t-value
α_1	0.455	9.9
b_1	0.00000015	1.4
α_2	0.483	10.6
b_2	-0.0000067	10.1
α_3	0.011	0.6
b_3	0.103	3.2
α_4	0.0	–
b_4	0.00088	7.6
NSW constant	-0.428	0.8
VIC constant	-0.609	1.1
QLD constant	-0.653	1.2
SA constant	-0.615	1.2
WA constant	-0.803	1.6
$R^2 = 0.985$		

5.2 General economy adjustment to domestic suppression of 50 PJ of natural gas – the electricity substitution case

The three self-contained cases for the adjustment of the general economy to the suppression of 50 PJ of natural gas will be examined in terms of their impact on the economy using the framework applied in the previous chapter.

The elasticity of substitution between natural gas and electricity estimated above suggests that if 50 PJ of natural gas are withdrawn from the domestic market, 34 PJ of electricity will be required to maintain production capacity. The substitution would be partially focussed on space and water heating and process heat involving drying and melting.

Table 5.2 indicates that a considerable cost differential currently exists between electricity and gas, depending on the market and the carbon price. This means that total direct costs of adjustment will depend on the carbon price and a scenario analysis is therefore needed. This will be undertaken in Chapter 7 below. To illustrate the impact on the economy, in terms of the analysis of the previous section, a $50 price of carbon will be assumed. The data in Table 5.2 includes all transmission and distribution costs. The analysis here is for ex-plant costs.

Table 5.2 Current electricity and gas prices in Australia: The impact of carbon prices

	Electricity price	Gas price
No carbon pricing		
Industrial	$100/MWh = $28/GJ	$10/GJ
Residential/commercial	$250/MWh = $69/GJ	$16/GJ
Carbon pricing – $25/t CO_2e		
Industrial	$125/MWh = $35/GJ	$11.8/GJ
Residential/commercial	$275/MWh = $76/GJ	$17.8/GJ
Carbon pricing – $50/t CO_2e		
Industrial	$145/MWh = $40/GJ	$13.3/GJ
Residential/commercial	$295/MWh = $82/GJ	$19.3/GJ

5.2.1 The net cost of electricity substitution

It is critical that the same model framework be used for all evolutions of the possible adjustment paths for gas suppression. The framework developed in the previous section is ideal in terms of transparency and assessing the plausible impact of the contraction in gas dependent industries. For the more general adjustment paths of this chapter, other evaluation approaches are possible, but these would result in unacceptably different methodologies for quantifying impacts. Accordingly, the methodology used for calculating impacts in the electricity substitution case has been designed so that the modelling framework of the previous chapter can be employed. This framework also allows the straightforward introduction of probability analysis. The result is that the shock which is imposed on the model structure becomes a direct adjustment to real household disposable income.

It should be noted that no allowance has been made for the impact on distribution margins. It is assumed that the same total margins have to be recouped to support the distribution infrastructure installed, irrespective of throughput. In any case, the reduction in gas distribution margin would be offset to some extent by the increase in electricity margins.

These preliminaries out of the way, we proceed to model the full electricity substitution case. In the absence of the East Coast LNG plants, the industrial gas price will be taken to be $6/GJ. For each $10 of carbon price the cost of natural gas increases by $0.72/GJ, so the alternative gas price is $9.6/GJ. Therefore, the forgone cost of natural gas will be 9.6 x 50, or $480 million in 2009 prices.

Assuming that between 2012 and the 2020s there is increasing public and international anxiety about the baleful consequences if CO_2 emissions are not curbed, and therefore increasing political and economic pressure to reduce CO_2 emissions, the alternative electricity substitution cost will be taken to be an average of renewable options, for which recent cost estimates range from wind at $110 MWh to solar at over $200 MWh, with other renewables such as geothermal between the two polar cases. The average will be set at $150 MWh. This translates into $42 million additional cost per PJ, or $1.43 billion for the 34 PJ of electricity required.

The net cost is, therefore, 1.43 – 0.48 = $0.95 billion in 2009 prices annually.

To minimise the loss of employment and economic activity, the optimum cost allocation strategy would be to channel the impact into additional cost imposts on the household sector. This would hypothetically be done by:

(i) increasing direct taxes on households to pay for subsidies to shelter industry from the additional energy costs;

(ii) increasing residential electricity prices more than prices for non-household users; and

(iii) increasing the costs of electricity for those commercial sectors that service the household and Government sectors rather than trade-exposed industries.

The results of doing this for the full electricity substitution case are given in Table A.4 to Table A.6.

For the gross product indicators the impact is positive being about two thirds of the LNG overall impact. The combined total impact is a strong $1199m at factor cost. For net national product the increase is much less because of the high depreciation rate for the electricity sector. More importantly private consumption expenditure falls by $810m, or a net $646m if the LNG impact is included. The benefit indicator falls by $423m, more than cancelling out the gain from LNG exports. Full electricity substitution therefore results in no net benefit from LNG exports. The strong response for gross product is due to the fact that the drivers of this growth are dominated by factors (foreign income and depreciation allowances) which cannot be used to support domestic consumption and tax growth.

5.3 General economy adjustment to domestic suppression of 50 PJ of natural gas: The decline in economic activity case

Rather than release gas for export by switching to electricity, it would be possible to release the gas by reducing industrial activity. It is implausible to assume that all the natural gas suppression will involve reductions to industry; part will come from reductions in allocation to households. In the case here it is assumed to be 30 per cent of the total reduction impacts directly on households at a cost similar to the electricity substitution.

This still leaves 35 PJ to be suppressed from the non-resource industries. For the Eastern Australian market this will represent a 7.6 per cent reduction in supply. Using the elasticity estimated above, this will generate a 0.6 per cent reduction in gross non-resource product which translates into a $4.68 billion reduction in non-resource gross product at factor cost for the four Eastern Australian states. Using the relationship between direct reductions in household income and gross product at factor cost (see the model sensitivity results in the previous section) this indicates a direct reduction in household income of $3.58 billion. To this has to be added the reduction in real household incomes due to the transfer of 15 PJ of natural gas from the household sector to exports and its replacement with electricity. Using the full substitution case as the benchmark this will add $0.3 billion, bringing the total to $3.9 billion in 2009 prices.

Table A.4 shows the impact on the general economy for the general reduction in economic activity case. In terms of gross and net product, the decline in activity is six times the LNG benefit. The benefit indicator declines by 17 times the LNG benefit. Even if we make no particular allowance for gas-dependent industries and instead base the calculations on the non-resource sector as a whole, the outcome is decidedly unattractive.

5.4 General economy adjustment to suppression of 50 PJ of natural gas: The electricity sector gas substitution case

We now consider the case where gas is switched from the electricity sector to LNG exports. In this case, before the need for gas suppression, the 50 PJ of gas would have been used in the electricity sector to generate electricity. The scenario is that, in the absence of East Coast LNG exports, large scale gas-fired electricity plants would have been built near major CSM deposits and these exports require that the electricity sector will have to substitute other sources of electricity generation.

The two key determinants of the cost of this response are the cost of electricity generated from natural gas and the cost of the alternatives.

The cost of natural gas derived electricity will be a function of the natural gas price and the carbon price. Table 5.3 indicates a range of responses depending on the gas price and the carbon price. Assessing the effect of the carbon price involves modelling probabilities, because of the range of possibilities both for a given year and across time. This is carried out in Chapter 6 below. To illustrate the impact on the economy that is comparable to the approach taken for other adjustment paths above specific assumptions have to be made. The assumptions are:

- a price per gigajoule of $4; and
- a carbon price of $50.

From Table 5.3 this indicates an electricity price of $78 MWh.

As before, the alternative electricity price will be renewables at an average rate of $150 MWh. To complete the cost estimates it is necessary to know how much electricity can be generated from 1 PJ of natural gas. 1 PJ of electricity is 278 GWh. If a conversion factor of 0.45 is assumed, then 1 PJ of natural gas will generate 125 GWh of electricity. Hence, 50 PJ will generate 6,250 GWh or $489 million. If the alternative 6,250 GWh comes from renewables, then the cost will be 6.25 x 150, or $938 million, giving a net cost of $457 million.

Table 5.3 Natural gas based electricity – cost of supply by input costs

Combinations	Natural gas price ($/GJ)	Carbon price ($/tonne of CO_2)	Long-run marginal cost CCGT ($/MWh)
1	3	0	49
2	4	0	55
3	5	0	61
4	6	0	67
5	3	50	69
6	4	70	83
7	5	80	93
8	6	100	107
Alternative			**150**

Note: CCGT denotes combined cycle gas turbine. Assume 65 per cent capacity factor. For every $10 increase – carbon price a $/tonne of CO_2, the price will increase by $4/MWh. For every $1/GJ increase in the natural gas input price the $/MWh price increases by approximately $6 in 2009 prices.

The impact on the general economy of the gas suppression case is given in Table A.4. This is a low cost case compared to the decline in economic activity case but comes at a higher cost than the full electricity substitution case. For the gross product indicators, the decline is a little under 40 percent of the LNG benefit. However, there is a deterioration compared to the net product indicator with the loss from the gas suppression case almost cancelling out the gain from the LNG expansion. However for the benefit indicator the loss from gas suppression in electricity use is nearly 30 percent more than the LNG benefit.

It should also be noted that the suppression of gas supply to the electricity sector, or if suppression is avoided the increase in gas prices that will result from LNG netback pricing and production from higher-cost reserves, would ultimately have implications for the costs of all existing gas-fired generators. Operating costs for both peaking plants and CCGT would increase, driving higher spot and contract prices in the National Electricity Market.

The electricity sector gas suppression case is a relatively low cost option. Nevertheless the net costs are still significant.

5.5 Conclusion

Analysis which abstracts from the position of the gas-dependent industries concludes that natural gas can be switched from domestic sales to LNG export sales using a number of strategies, the best of which yields little benefit to the economy and the worst substantial net costs. In this worst case, the costs approach those calculated when concentrating on the position of the gas dependant industries. To minimise cost, the following factors would have to be put in place, namely:

(i) the natural gas dependent industries were quarantined from any impact of LNG expansion on available gas supplies and costs;

(ii) the electricity sector would have to plan to carry the full cost of adjustment including higher quantitative targets for renewable energy; and

(iii) the household sector would have to accept that it and not industry would have to directly accept the full costs of adjustment.

Historical experience, the current design of the policy for the introduction of carbon taxes and the political debate over carbon pricing give no grounds for businesses to expect that the minimum cost path would be adopted if it becomes necessary to withdraw domestic natural gas supply to meet export contracts.

How the four options may be combined to determine an overall gas suppression response is outlined in Chapter 7 below.

6. The Australian gas market: Resources, prices and risk of supply shortage by 2040

The prime objective of this chapter is to assess the risks of supply shortages in the Eastern Australian gas market by 2040. This is a critical final step to assessing the likelihood that the costs of natural gas supply withdrawal assessed in the previous two chapters will be realised. The risk of gas supply shortages emerging in turn depends on estimates of natural gas reserves remaining to be discovered.

6.1 The Australian natural gas market: Background

The Australian natural gas industry has three distinct components:

1. the domestic Eastern Australian system;
2. the domestic west/north coast systems; and
3. the LNG export industry (currently only on the west coast fed mainly from off-shore fields, with plants proposed for Eastern Australia based on coal seam methane).

As with electricity, there is no transmission connection between the east and west coasts (Tasmania is connected to the eastern gas and electricity transmission systems).

In 2012-13 total Australian gas production will be about 2,500 PJ, about 35 per cent of which will be exported as LNG. The main producing basins are: in the East, the Gippsland, Cooper-Eromanga and Otway (conventional); and the Bowen and Surat (coal seam gas); and in the West, the Carnarvon, Bonaparte and Browse.

In the domestic markets, east coast demands are about 800 PJs and west/north coast demands 650 PJs. The major domestic markets are for gas-powered electricity generation (GPG), industrial and residential consumption. The GPG market is growing most rapidly but future GPG increases depend significantly on carbon pricing policies.

The current CO_2e price of \$23/t CO_2e is not high enough to stimulate substantial growth in GPG for combined cycle gas turbine (CCGT) base load plants. Gas peaking plants are relatively unaffected by carbon pricing, being mainly responsive to growing summer peak loads where gas plants (open cycle gas turbines, OCGTs) have distinct quick response advantages. Growth in GPG base load will depend on carbon tax levels, gas prices, coal prices and any policy initiatives that directly favour gas (such as the Queensland gas generation policy).

In the industrial sector gas is used for process heat (drying, etc. such as alumina production), water heating, steam raising and for production of petrochemicals (such as ammonia). Metal products, petroleum and chemicals and non-metallic mineral products account for about 85 per cent of industrial gas consumption in Australia.

The alumina industry, a major use of gas for drying (often with cogeneration), is concentrated in south-west Western Australia (Kwinana region) and Gladstone in Queensland. In Western Australia, industrial gas prices have increased substantially (from \$4/GJ to \$8/GJ) due to domestic market supply/demand constraints and reliance (65 per cent) on the North West Shelf project (LNG predominantly) supply. In eastern Australia industrial gas prices are in the \$4 to \$6/GJ range, including network costs as well as wholesale gas costs. At higher prices (>\$10/GJ) some industrial gas users could lose competitiveness to competitors based

in gas rich regions, such as the Middle East. Fertiliser and other chemical plants would be at risk, as would alumina.

Over 2011-25 NIEIR estimates (July 2012) growth in industrial gas use will average 2.91 per cent per year, residential 1.48 per cent, commercial 2.4 per cent and electricity generation 4.48 per cent per annum.

The major industrial market is in Western Australia (alumina, direct reduced iron and ammonium nitrate), 55 per cent of national industrial market. The major residential market is in Victoria (space and water heating), 65 per cent of national residential market. GPG is strongest in Queensland and Western Australia.

6.2 Estimates of reserves

Category 1 reserves (commonly referred to as 'Proven' or 'P1' reserves) include recoverable reserves that have been declared commercially viable. **Category 2** reserves (commonly referred to as "Probable' or 'P2' reserves) comprise estimates of recoverable reserves that have not yet been declared commercially viable, although they have been geologically proved or are awaiting further appraisal. Geoscience Australia (GSA) are now **mainly** using the McKelvey classification of economic and sub-economic demonstrated resources (EDR, SDR), but do not precisely define (for example, $/G) EDR and SDR. In addition, P3 possible/potential reserve estimates are sometimes estimated. Also, inferred resources are mentioned. These arise from recent discoveries and finds that require further appraisal.

While there is always some uncertainty associated with any reserves estimates, GSA's estimates are often regarded as conservative. These estimates should perhaps be seen as a lower bound estimate of actual reserves. Due to this conservatism, NIEIR formulates its own estimates of reserve levels in the eastern basins by supplementing official data with information recently published by operators and other basin participants. Over the years (1980s on) we have observed significant increases in GSA reserves towards NIEIR estimates.

West Coast (Western Australia/Northern Territory) reserves are mainly in off-shore basins (Carnarvon, Browse, Bonaparte) and amount to about (2009 data, no recent update) 165,000 PJ in P1 and P2 reserves (not including CSM or shale gas). Source: Geoscience Australia, Oil and Gas Resources of Australia 2008.

Eastern Australian reserves, from the same source, P1 and P2 reserves were about 11,000 PJ (excluding CSM and shale reserves); and P3 at 28,000 PJ. CSM reserves (P1, P2) were estimated at 37,000 PJ (P3 at 60,000 PJ).

McKelvey classification reserve estimates are outlined below. Source: Australian Gas Resource Assessment, 2012.

Table 6.1 Australian conventional gas resource represented as McKelvey classification estimates as of 1 January 2011

Conventional gas resources	PJ	tcf
Economic demonstrated resources	113,400	111
Sub-economic demonstrated resources	59,600	53
Inferred resources	11,000	20
Total	**184,000**	**184**

Table 6.2 McKelvey classification estimates by basin as at 1 January 2011

McKelvey class.	Basin	Gas PJ	Gas tcf
EDR	Carnarvon	74,700	68
EDR	Browse	17,900	16
EDR	Bonaparte	10,100	9
EDR	Gippsland	7,000	6
EDR	Other	3,600	0
Total EDR		**113,400**	**103**
SDR	Carnarvon	26,800	24
SDR	Browse	17,900	16
SDR	Bonaparte	11,900	11
SDR	Gippsland	2,300	2
SDR	Other	1,200	1
Total SDR		**59,600**	**54**
Total (EDR + SDR)		**173,000**	**157**

CSM/G reserve estimates, not included above are presented below.

Table 6.3 CSG resources at January 2011

CSG resources	PJ	tcf
Economic demonstrated resources	35,905	33
Sub-economic demonstrated resources	65,529	60
Inferred resources	122,020	111
Total	**223,454**	**203**

Table 6.4 Total Australian gas resources

Resource category	Conventional gas		Coal seam gas		Tight gas		Shale gas		Total gas	
	PJ	tcf	PJ	tcf	PJ	tcf	PJ	tcf	PJ	tcf
EDR	113,400	103	35,905	33	–	–	–	–	149,305	136
SDR	59,600	54	65,529	60	–	–	2,200	2	127,329	116
Inferred	11,000	10	122,020	111	22,052	20	–	–	155,072	141
All identified resources	**184,000**	**167**	**223,454**	**203**	**22,052**	**20**	**2,200**	**2**	**431,706**	**392**
Potential in ground resource	Unknown	Unknown	258,888	235	Unknown	Unknown	435,600	396	694,488	631
Resources – identified, potential and undiscovered	184,000	167	258,888	235	22,052	20	435,600	396	900,540	819

Note: Conventional gas demonstrated resources as of January 2011; CSG demonstrated resources as of January 2012. Note CSG 2P reserves and 2C resources are used as proxies for EDR and SDR respectively.

Tight gas and shale gas resources

Currently Australia has no proven reserves of tight or shale gas. The in-place resources of tight gas are estimated at around 22,000 PJ (20 tcf) but together with shale gas could be considerably higher. The largest known resources of tight and shale gas are in low permeability sandstone reservoirs in the Perth, Canning, Cooper and Gippsland basins with APPEA's estimates at 440,000 PJ of total possible reserves

6.3 Total Australian reserves (identified, potential and undiscovered)

What is important for this study is not total Australian reserves, but reserves that can supply the integrated Eastern Australian market. This is the market that the East Coast LNG projects will impact. The situation would be different if the Western Australian market was integrated with the Eastern Australian market.

6.3.1 Two estimates of Eastern Australian case reserves

One recent attempt to estimate Eastern Australian reserves was carried out by **Core Energy Group** (COE): gas (Eastern Australian) resource studies, 2012. This study included a section on the distribution of gas reserves by gas production costs (COE page 24).

Core estimated a total of 143,066 PJs potential resource at 1 January 2012 at up to $6/GJ and about 161,000 PJs at up to $8/GJ.

In the report (Table 7.1) **conventional** resources were estimated to be 13,000 PJ at up to $7.37/GJ at a 10 per cent rate of return. In Table 7.2, **coal seam gas** reserves were estimated to be 96,000 PJ at up to $5.58/GJ at a 10 per cent return. In Table 7.3 estimates for total Eastern Australian **prospective** resources were given as 190,000 PJ at up to $9.27/GJ at a 10 per cent return.

The study also gave estimates of gas transmission costs as at April 2012. Indicative tariffs for **existing** pipelines are provided in this report in Table 6.4, page 12.

For **new** pipelines estimated tariffs are presented in **Figure 10.4** for a range of pipelines. For example, an estimated tariff of $0.0018/GJ/km for a 1,000 kilometre hypothetical pipeline would result in a tariff of $1.8/GJ for the full 1,000 kilometres of gas transmission. Estimated tariffs are also presented in **Figure 10.4** for a range of existing pipelines such as $0.0014/GJ/km for the Eastern Gas Pipeline. Tariff components (WACC, taxation, etc.) are also provided for several pipelines.

Another study which also estimates remaining gas reserves was by **ACIL Tasman**: draft report, December 2011, Fuel cost projections. This report was prepared for Worley Parsons to provide natural gas and coal outlooks for AEMO modelling.

ACIL Tasman estimated (page 6, Figure 3) that around 90,000 PJ of potential (reserves and resource) could be developed on the East Australian seaboard at up to A$8/GJ (of which 50,000 PJ is Queensland CSM); and 60,000 PJ (about 40,000 PJ of CSM) at up to $6/GJ. **Note** that in the same report ACIL Tasman estimated that in addition to these reserve estimates 25,000 PJ of Eastern Australian shale gas could be available at $9/GJ.

These estimates are much lower than the COE estimates outlined above. The reasons for estimate differences are difficult to discern from the two sets of reports, though COE allows for sales of liquids from gas projects, thus improving project economics.

Potential use of Eastern Australian reserves over 2012-2040 are presented below.

Table 6.5 Potential domestic use of Eastern Australian natural gas reserves

		2015 (NIEIR)	2025 (NIEIR)
Gas (2011, 1,300 PJ)	**Total**	1,400 PJ	2,300 PJ
	GPG use	416 PJ	986 PJ
	Excluding gas for power generation (GPG)	≈ 950 PJ	≈ 1,300 PJ
Electricity consumption	Total in NEM	200,000 GWhs	256,000 GWhs
	Australia	236,000 GWhs	311,000 GWhs

Potential GPG (electricity) use

A 400 MW CCGT	at 90 per cent capacity factor requires about	22 PJ/a
A 10,000 MW CCGT	at 90 per cent capacity factor requires about	550 PJ/a

Potential LNG export use

LNG	4 Mt plant requires	200 PJ/a	1 train
	20 Mt plant requires	1,000 PJ/a	5 trains

28 years (2012-2040) potential use

End use	Approximate average	1,700 PJ/a	= 47,600 PJ
10,000 MW GPG by 2040	Approximate average	300 PJ/a	= 8,400 PJ
LNG (6 trains by 2040)	Approximate average	800 PJ/a	= 22,400 PJ
			78,400 PJ

This suggests adequate availability at up to $8/GJ on the above assumptions: LNG use could be higher but GPG and end-use could be lower. Table 6.5 is the basis for the Eastern Australian market's natural gas projections for the case of no LNG plants outlined below.

6.3.2 Western Australia/Northern Territory

Domestic gas use

In 2012 Western Australia's total gas use is estimated at 617 PJ and Northern Territory at 43 PJ. Western Australia's gas use is dominated by industrial use (442 PJ) and GPG (145 PJ), growing respectively over 2012-25 at 2.65 per cent and 3.44 per cent average per year. Total use in 2025 is estimated to be 905 PJ, the increase mainly through alumina, direct reduced iron, ammonium nitrate and GPG expansion.

In the Northern Territory industrial (24 PJ) and GPG (19 PJ) dominate gas use, growing respectively over 2011-25 at an average per year of 8.4 and 7.0 per cent. Total use in 2025 is projected to be 122 PJ through increases in industrial use (Gove Alumina conversion to gas from fuel oil) and GPG.

Potential domestic use over 2012-2040

At an average annual use in the region (Western Australia/Northern Territory) at the 2025 level of 1,027 PJ, regional gas use over 2012-40 would be about 30,000 PJ. Use could be higher depending on GPG economics (carbon and gas prices) and industrial use (regional competitiveness in global markets).

Potential LNG use over 2012-40

LNG use of gas in the region (Western Australia/Northern Territory) will depend on global demands for LNG and competitiveness of regional LNG plants.

Global LNG demand is projected to increase significantly over the period depending on global climate change policies: aggressive policies could constrain global gas demands. Regional LNG competitiveness could be constrained by high regional costs for new LNG plants and global LNG competition from the Middle East, East Africa, North America and Europe. The strength of this competition will depend considerably on the success of Middle East and Russian gas export strategies and on global shale gas developments. At regional (Western Australia/Northern Territory) average LNG exports over 2012-2040 of 100 Mtpa (about 5,000 PJ per year) LNG exports would total 140,000 PJ.

Total requirements, reserves and prices: Western Australia/Northern Territory

On the basis of the above estimates, 170,000 PJ of regional gas would be consumed (domestic, LNG) over 2012-40, about the current estimates (P1, P2/EDR, SDR) of regional reserves (excluding CSM and shale, which are not yet prominent in the region).

No costs of reserve estimates for the region are available as far as we are aware. Based on net back estimates required for existing and proposed LNG projects, we consider the requirements could be met at <A$8/GJ (ex-processing plant) and <A$10/GJ delivered to customers.

6.4 Proposed LNG plants, 2012-18

Over the period to 2018, 12 LNG plants are proposed: 8 on the west coast (output 70 mtpa) and 4 on the Eastern Australian (30 mtpa). If all proposed plants proceed, gas use by the plants over the period to 2040 would be about 3,400 PJ/a and about 84,000 PJ in total on the west coast; and 1,500 PJ/a and 36,000 PJ in total on the Eastern Australian. (ABARE/BREE, 2010; 5,930 PJ **total** exports in 2029-30.)

Given the prices of gas from LNG in export markets and the cost of liquefaction, transport, regasification and transmission to pricing hubs, to be profitable we judge LNG exporters must be able to access gas at $6-8/GJ (the net back price) for existing and proposed LNG plants.

6.5 Gas prices: weighted average, 2007-08 to 2039-40 – the current view

Gas prices have not been historically transparent whether at the well-head, ex-processing plant or delivered, particularly for large users.

Preliminary estimates for weighted average gas prices (ex-processing plant) are set out below.

Table 6.6 Projection of natural gas prices

Year	Prices (2011-12 $/GJ)	
2007-08	$4	
2011-12	$5	
	Conventional view	**Alternative (optimistic) view**
2019-20	$9	$7
2029-30	$13	$10
2039-40	$15	$11

The alternative optimistic view is based on potential global trends in gas supplies and demands (climate change policies and gas technology improvements for exploration and development).

Traded gas prices, for example those used by ACIL Tasman for the AEMO scenarios, continue to be mainly based on the oil price/gas export price relationship which could be loosened resulting in lower gas prices as global gas competition increases. That is, we believe that despite its continued use in gas trade pricing, there is no longer a logical basis for this concept. Gas and oil are no longer significant substitutes in energy markets for electricity generation, space and water heating, etc. Exploration, development and marketing of the two commodities have diverged over the past 20 years.

6.6 Shale gas: A global gas revolution

The production of gas from low permeability gas rich structures has led to a transformation of the USA gas industry. Gas production from this source in the USA has risen from 4 per cent of total USA gas production in 2004 to 25 per cent in 2011, a total in 2011 of 5,650 PJ (twice Australia's 2011 production) with a reserve estimate (USA EIA) of 4.8 x 10^6 PJs. The flood of shale gas has dropped wholesale gas prices in the USA from >US$10/GJ in 2006 to >US$3/GJ in 2011-12 and stimulated investment in USA LNG export plants.

There is potential for the North American (Canada also has shale gas reserves) experience with shale gas to be repeated elsewhere, but caution is advised as conditions (geologic, development costs, environmental, infrastructure, politics) for shale gas development can vary widely.

In Australia there appears to be significant shale gas potential in the Cooper, Galilee, Perth and Canning Basins.

In North America viable/profitable wellhead prices for shale gas appear to be >US$5/GJ, so the industry is currently not profitable leading to a write-down of shale gas assets by companies (including BHPB). Of the majors, Chevron appears to be shale gas positive with Exxon-Mobil less so.

In a report on Fuel Cost Projections to provide outlooks/inputs for AEMO modelling, ACIL-Tasman in December 2011 estimated an aggregate shale gas resource of 25,000 PJs in eastern Australia at a cost of around A$9/GJ (2012-13 $'s). The report noted that this would tend to limit upward pressures on gas prices. It should be noted, however, that this upper limit, if realised, would still be twice to three times as high as previous wholesale prices.

6.7 The specification of the probability distributions

The above analysis for Eastern Australia needs to be incorporated into the analysis by the specification of probability distributions for two key parameters, namely the remaining reserves and the percentage of remaining gas reserves discovered by 2040.

Table 6.7 gives Trigen probability estimates for the two parameters. The lower bound estimate is the ACIL Tasman estimate. The upper bound estimate is the Core Energy Growth estimate plus the tight and shale gas reserves estimate. There is considerable upside in terms of shale gas availability. This is incorporated into the analysis by setting the upper bound probability relatively low at 85 per cent. This ensures that the maximum upper bound will be higher than the estimate set in the table.

The specification of the estimates of the per cent of remaining reserves at 2011 discovered by 2040 is straightforward and given in Table 6.7.

The reserve production trigger ratio requires explanation. It is one of the most important parameters in the analysis. The central assumption is that there is a minimum identified reserve to production ratio which, if attained, will render prohibitive the risks of investing in gas-intensive projects. This applies equally to new projects as it does to the investment to maintain the competitiveness of existing facilities. This trigger's value will vary from project to project and industry to industry. It is unlikely to be much lower than 15. Below 15 means that the risks are high that there will not be enough gas to feed the gas-using capacity currently installed. For large scale gas-using projects, the realised reserves to production ratio would have to be significantly above 15 given a three year construction period and a 20 to 30 plant life. Hence, the upper boundary is set at a reserve to production ratio of 25 in Table 6.7.

Table 6.7 The specification of the Trigen probability distribution parameters

		Unit	Lower bound	Mode	Upper bound	Lower bound probability	Upper bound probability
1	Reserves remaining as at 2011	PJ	90,000	163,000	237,000	0	85
2	Per cent of reserves remaining as at 2011 discovered by 2040	Per cent	55	70	80	0	95
3	Reserves – production ratio trigger for suppressing gas demand	No.	15	20	25	0	100

In the model, if Eastern Australia's gas reserve to production ratio falls below the trigger level, the new growth in demand ceases and normal replacement investments are not made, meaning that underlying demand will fall by 2 per cent per annum. The level of demand falls to regain the benchmark reserve to production ratio. If more gas suppression is required gas is suppressed in the electricity sector and finally, in the case of severe restrictions, there will be plant closures.

6.8 The outcomes for the Trigen distribution

Probability estimates from the Trigen distribution parameters specified in Table 6.7 are presented in Table 6.8. The table indicates that the maximum estimate for discovered and undiscovered reserves, as at 2012, is 263,400 PJ. There is a 75 per cent probability that 147,000 PJ will be discovered and a 25 per cent probability that at least 200,000 PJs will be discovered.

The extraction ratio by 2040 of discovered reserves rises from a 5 percentile rate of 60 per cent through a mean of 70 per cent to a 95 percentile level of 80 per cent.

Table 6.8 Reserves and extraction probabilities		
	Ultimately recoverable reserves (PJs)	**Per cent of reserves discovered by 2040 (%)**
Aggregate indicators		
Minimum	91288.86	55.35
Maximum	263437.80	84.62
Mean	173481.80	69.89
Std Deviation	36426.91	6.06
Distribution		
5% Percentile	115200.30	59.67
10% Percentile	125942.10	61.64
15% Percentile	134066.20	63.15
20% Percentile	140810.00	64.43
25% Percentile	146886.90	65.53
30% Percentile	152278.00	66.55
35% Percentile	157293.80	67.46
40% Percentile	161965.70	68.33
45% Percentile	166397.90	69.14
50% Percentile	171161.40	69.90
55% Percentile	176066.50	70.66
60% Percentile	181323.10	71.46
65% Percentile	186829.00	72.32
70% Percentile	192840.70	73.23
75% Percentile	199367.60	74.23
80% Percentile	206442.70	75.32
85% Percentile	214675.40	76.58
90% Percentile	224387.30	78.05
95% Percentile	236890.60	79.99

6.9 The cost of natural gas ex-plant

A price constraint is also inserted into the model. If prices exceed a benchmark level new growth in demand (including replacement demand) will cease. The price formula in the model is given by:

$$Pg = 5 + 0.15 \,.\, RD$$

Where:

Pg = price of gas ex-processing plant.

RD = per cent of reserves extracted as a per cent of remaining reserves, as at 2012.

The schedule has an upper limit of $15/GJ as the extraction ratio of estimated 2012 remaining reserves approaches its upper limit.

6.10 The base case: No Eastern Australian LNG plants

Given the model developed above, the base case will be the case of no Eastern Australian LNG plants to 2040. This will indicate the risk of suppressed demand for gas in the absence of the LNG projects proceeding. The results are given in Table A.7.

If there were no East Coast LNG plants, there is no chance of suppressed demand by 2020.

In the absence of the LNG exports from Queensland, there is only a very small chance, at the 95 percentile level, of the need for gas suppression in the 2020s.

In the 2030s there is a mean risk of the need for natural gas suppression but it is small, at 25 PJ per annum. This is on the basis that between 2025 and 2040 the Eastern Australian domestic natural gas demand grows at 2 per cent per annum for non-electricity sector gas use. The electricity sector case stays constant at the 2025 level to 2040.

6.11 The case of LNG exports

The alternative case is of the impact of 24 million tonnes of East Coast LNG exports on the Eastern Australian demand-supply balance. For the 2012-2020 period there is a mean expected outcome that the Eastern Australian domestic demand will be suppressed by an average of 40 PJ a year. For the 2020s the mean expectation is for a suppression of 600 PJs, with the 25 to 75 per cent probability range being between 165 and 952 PJs. By the 2040s the expectation (that is, the mean) is that there will be a suppression of natural gas equal to 40 per cent of the unconstrained demand case. The 25 to 75 per cent probability range is for a 2040 natural gas suppression rate of between 24 and 58 per cent.

Overall the mean expectation is that a cumulative 15,000 PJs of natural gas demand will be suppressed.

Table A.9 gives the net impact of the East Coast LNG exports on the domestic demand supply balance. As the results in Table A.8 demonstrate, there is little difference between the results in the two tables.

The tables enable readers to apply their own judgement. If one wanted to be optimistic, then the 30 per cent percentile case could be made equal to the expected case. In this case there is still a cumulative shortfall by 2040 of suppressed domestic natural gas demand of 7,640 PJs, with severe supply shortages appearing in the 2020s and the expectation that by 2040 the suppressed demand as a per cent of base case demand is 27 per cent.

6.12 Conclusion

The results are very significant. The results indicate that either the national interest evaluation of the LNG plants was deficient or that confidential knowledge of the gas resources available confirmed that these resources are considerably greater than what is in the public domain. Even if the latter is the case, impacts will not be avoided. There may well be adequate reserves but businesses make decisions on what they know and what they know would indicate that gas is likely to be transferred from domestic to LNG export sales. In this case the net economic cost of the East Coast LNG plants having preferred access to supply will involve very large costs on the economy.

The exact costs will be quantified in the next chapter.

7. The net benefit of East Coast LNG expansion in the context of Eastern Australian demand/supply balance

This chapter takes the results of the last three chapters and assesses the net national benefits and costs of the East Coast LNG expansion. In the event of limited supply to domestic users, the burden of adjustment will be divided between:

- gas dependent industries;
- general economy adjustment – decline in activity;
- general economy adjustment – full electricity substitution; and
- electricity sector gas suppression.

The key task in preparing input to the analysis is to specify the distribution of the burden of adjustment.

7.1 Domestic industrial gas demand suppression in the allocation of the burden of adjustment

The allocation of the share each adjustment path will play is critical in driving the overall net benefits or costs. The reason for this, as Chapter 6 indicated, is that there is a wide range in the net costs of adjustment per channel with the highest being for gas dependent industries and the lowest for the full electricity substitution case.

One approach would simply be to assume the lowest cost outcome. The full electricity substitution case may be appropriate for an efficiently planned state like China which would incorporate the strategy into its five year planning guidelines and more often than not achieve the desired result. In Australia, the mechanism for adjustment is via price changes which, in this case, will have a negative impact on economic activity and real incomes, and increase inflationary pressures via loss of competitiveness.

The fact of the matter is that adopting the full electricity substitution strategy would require a large scale investment in the electricity sector where prices would need to rise to finance it. Given the current reaction to price movements driven by large investments in electricity distribution it would appear that further rises to substitute electricity for gas would be very difficult to achieve.

The second-best course of action, the suppression of gas usage in electricity production, would also be difficult to achieve as it would require increases in the share of renewable production. As the reliance on renewables increases, the stability of the electricity system will decline in that variations in climatic conditions (perhaps aggravated by climate change) will result in greater volatility in supply. The need to have gas fired generating capacity as a back-up supply source can only increase. The reality is that by the 2020s and certainly by the 2030s, there may well be severe constraints on the ability to suppress gas usage in electricity production.

While the costs of a choice to suppress supply to gas-dependent industries are extremely high, this scenario should not be ignored without study. The reality is that it is already happening. Major domestic natural gas users in Queensland (Rio Tinto and Incitec Pivot) are already forecasting natural gas shortages by 2015. This must affect their incentive to expand in Australia and even to maintain their Australian assets at a level that would prevent medium-term closure.

The only way to ensure that gas-dependent industries do not atrophy is to ensure that they have new and guaranteed supply sources for the next three to four decades at prices that can be projected with a degree of confidence. To guarantee supplies to gas-dependent industry will require substantial interventions in the existing regime. However, the need for intervention should be put in perspective: the gas-dependent industries' entire consumption (4 million tonnes a year) is less than the allocation of gas required to keep one LNG train supplied.

Because of the uncertainty surrounding the adjustment paths, a probability approach is adopted. Table 7.1 gives the Trigen probability distribution parameter settings. The burden of the adjustment of the gas-dependent industries is biased downwards compared to their share of overall gas demand. However, the setting of the upper bound probability at 0.85 allows for cases where the burden of adjustment may well be greater.

The resulting distribution of the adjustment share of gas-dependent industries is given in Table 7.2. The mean is a 10 per cent adjustment burden with the 25th percentile at 8 per cent and the 75th percentile at 12 per cent.

For the other channels of adjustment the means are:

- suppression of gas usage in electricity production – 22 per cent; and
- a general fall in economic activity – 16 per cent.

The remaining share would be borne by the residential sector and, at the mean, would be 100 less 22 less 16 less 10, or 52 per cent. This allocation imposes a conservative bias on the analysis, as the above discussion implies that the decline in economic activity should perhaps have a greater weight than it has been accorded.

Table 7.1 Trigen probability distribution parameters – domestic natural gas suppression of the adjustment burden by sector

		Maximum lower bound	Mode	Maximum upper bound	Lower bound probability	Upper bound probability
1	Gas dependent industries – share in gas suppression	0.05	0.09	0.13	0	0.85
2	Electricity gas usage – share in gas suppression	0.15	0.20	0.25	0	1.00
3	General economy – actual decline of electricity substitution – residual given the above three outcomes	0.08	0.15	0.25	0	1.00
4	Carbon price 2040 ($/tonne)	60	100	200	0	0.9
5	Alternative natural gas input price into electricity production ($/GJ)	3	4	5	0	0.9

Table 7.2 Reserves and extraction probabilities		
	Carbon price (2009 $/tonne)	Share of natural gas dependent industries in total gas suppression (%)
Aggregate indicators		
Minimum	15.18	5.35
Maximum	219.78	16.35
Mean	119.98	10.22
Std Deviation	44.41	2.42
Distribution		
5% Percentile	45.67	6.54
10% Percentile	59.50	7.13
15% Percentile	71.17	7.65
20% Percentile	79.88	8.05
25% Percentile	88.31	8.42
30% Percentile	95.00	8.74
35% Percentile	102.51	9.03
40% Percentile	108.53	9.33
45% Percentile	114.59	9.65
50% Percentile	119.88	9.96
55% Percentile	125.38	10.33
60% Percentile	131.42	10.65
65% Percentile	137.94	11.08
70% Percentile	144.24	11.48
75% Percentile	151.91	11.93
80% Percentile	159.74	12.39
85% Percentile	168.84	12.99
90% Percentile	179.75	13.66
95% Percentile	194.48	14.57

7.2 The distribution of CO_2 price outcomes

A probability approach was taken for the determination of the CO_2 price with the probability distribution parameters given in Table 7.1. The resulting distribution for the CO_2 price is also given in Table 7.1. The mean over the project period is $120 and the 25 to 75 per cent probability benchmarks are $88 to $152 a tonne.

The operating cost of natural gas for electricity in the absence of East Coast LNG also is determined by a probability distribution with the parameters given in Table 7.1.

7.3 The impact of East Coast LNG exports on the national economy: The expected outcome

Expected outcomes from the mean settings of the various inputs are determined by the probability distributions. This applies whether the input variable is carbon prices or estimates of natural gas reserves to be discovered. The expected results are given in Tables A.11 to A.13.

From Table A.8 there is some risk of gas shortages by 2020, though the risk is not large. What is significant is the inability to secure long-term contracts for gas at competitive rates as gas producers see the opportunity of LNG exports as a windfall, particularly since some LNG plants have yet to secure all their needs. This is the real driver of the crowding out of domestic supply which will have a very significant negative impact on downstream production, jobs and overall economic benefit.

The GDP increase at market prices is initially greater than the direct impact of the LNG exports. Employment increases by 82,000 compared to what would have otherwise been the case. From Table A.8, however, over the 2020s, the expectation is that domestic gas demand will be suppressed by 592 PJ on an average annual basis. This means that by 2020 the positive stimulus from the LNG exports is fully offset by the negative stimulus of the crowding out by gas suppression. All the production series are negative with the greatest decline being for NNP.

The decline continues but at a slower rate in the outcomes for the 2020-2025 period. By 2040 the decline is $22 billion for gross domestic product at market prices, while the net national product is $34 billion lower in 2040 compared to what otherwise would have been the case. The decline by 2040 is 775,000 in employment, while the benefit indicator declines by $46 billion, compared to the disallowance of East Coast LNG exports. This represents about 1.6 to 1.8 per cent below what national baseline GDP would be expected to be by 2040.

The employment loss may appear implausibly large. However, it is likely that the main response to a decline in employment will be via reduction in immigration. The employment loss over 30 years implies a net average annual reduction in immigration of some 35,000. The response to this may be that there is no national loss if the cost is borne by residents who will not be in Australia. The risk is, however, that the decline in employment may be so great that the required level of immigration will fall below the “bedrock” 170,000 to 200,000 level. In this case there will be increases in the effective unemployment rate. There is a limit to the size of a negative shock which can be imposed on the economy without considerable eventual economic pain.

The cumulative decline of the net benefit indicator is $160 billion. If the probability distribution for the expected reserves is near reality, the only strategy to minimise costs is to reduce LNG exports by the amount of the expected supply shortage. By 2040 the expected supply shortage equals the LNG requirement. This is, of course, when the plants are near the end of their expected life. The critical time is in the mid-2020s when the supply shortage is half the LNG demand.

In this context a prudent strategy would have been to perhaps approve one project and delay the approval of other projects until:

(i) the local industry was protected by identified reserves which are allocated to domestic use with a minimum headline reserve to production rate of 20 to 1 by 2040 given expected demand growth; and

(ii) identified available reserves support any new projects over there complete life.

7.4 The range of possible outcomes

Table A.10 shows the distribution of expected outcomes around the mean outcomes for 2020 and 2040. High negative outcomes would result if the ACIL Tasman estimates of remaining natural gas reserves are anywhere near the mark. The low negative and marginally positive outcomes would occur if the alternative estimates of reserves by COE are near the mark, at least in terms of reserves that can be extracted at $10/GJ.

The point about the results is that even if the reserves remaining are at the upper end of the range, the benefit of the East Coast LNG projects are marginal in that costs and benefits are in balance. This is clearly shown in Table A.10 where, if eventually recoverable reserves are near 240,000 PJ, the value of the net benefit indicator in 2040 is $2.4 billion.

7.5 Conclusion

The most important point of all is that even if ultimately recoverable reserves are in fact near the upper range currently assessed, or indeed in excess of the upper range, if these reserves are not identified and they cannot be quickly extracted to meet shortfalls at reasonable costs, the negative consequences in the table are likely to be realised. This is because:

(i) the natural gas dependent industries will not expand and would most likely go into decline;

(ii) gas using electricity plants will not be built; and

(iii) unnecessary costs will be imposed on the economy because businesses and Governments in the main will base demand on realised outcomes with an allowance for future supply security.

To illustrate the issue, assume that the ultimate recoverable reserves are 300,000 PJ. If gas producers continue their practice of allocating resources to export the reserves will not be identified and extracted for domestic use unless Governments force them to do so. The negative results of this analysis would remain, albeit reduced by the additional benefits of another LNG train or two. The only certain way to prevent the negative outcomes of this chapter is the identification and allocation of sufficient reserves for domestic use to cater for their needs for the next 30 to 40 years. In this context the estimates of overall remaining reserves are irrelevant. In any case, given the conservative allocation of weights in this study (that is, biased to low cost options), the benefits of additional potential reserves are likely to be neutralised by increasing the weight towards the higher cost adjustment options.

A related issue is the ownership structure of the enterprises which control the identification of reserves. If their interests are in “just-in-time” identification of reserves, a significant proportion of the negative consequences identified above will still be realised, even if the actual level of eventually recoverable reserves is much greater. Unfortunately, on the estimates presented here, future reserve estimates will affect domestic investment decisions even if they turn out to be too low.

Under the current reserves management practice and with the pipeline infrastructure limitations, Australia does not seem to have enough available reserves of gas to be able to avoid the negative effects of large increases in demand or of falls in the headline reserve/production ratio on business decision making.

8. East Coast LNG expansion: Additional downside risks

Three additional areas could add to the net cost over and above those identified in the previous chapters. These include:

(i) lower prices for LNG than expected;

(ii) higher alternative benefits from the use of the gas domestically; and

(iii) balance of payments adjustment costs to a rapid decline in the terms of trade.

8.1 East Coast LNG expansion: The impact of lower LNG prices

On the world stage, identified recoverable shale gas reserves, together with the extraction of the resource, are now growing strongly, particularly in the United States. United States reserves are large, estimated currently at 865 Tcf with relative low cost investment and production costs at around $4 to $6 per GJ. As a result, shale gas currently constitutes one quarter of United States total gas production and this is expected to increase to 50 per cent by 2035.

Once the United States authorities are satisfied that there is sufficient gas to satisfy domestic requirements for the foreseeable future, large scale LNG exports may be encouraged. Initially this will be done at low cost, converting LNG import infrastructure (currently unused because of the rapid expansion of shale gas production) to LNG export plants.

Given the analysis of the previous section, where the extraction costs are expected to rise to the $7 to $10 per GJ range because of resource depletion, the export of lower cost gas from the United States could force a $2 to $4 reduction in the export LNG price from the East Coast which would be a reduction of between 14 and 28 per cent. Even if LNG prices for East Coast Australia are linked, in part, to the price of oil, downward price pressure will not be avoided. The United States will not allow large scale export of gas until the gas has been fully utilised domestically to maximise the reduction in its dependence on oil imports. Other countries with substantial shale gas resources will also apply the same policies which, combined, will put significant downward pressure on oil prices and hence LNG prices.

If it is assumed that world-wide expansion of shale gas extraction reduces LNG prices by, in real terms, 20 per cent by the latter part of this decade, the effect of the decrease per PJ of output is:

- contribution to gross domestic product reduced by 25 per cent;
- tax receipts down by 66 per cent;
- domestic distributed income reduced by 28 per cent; and
- net national product reduced by 34 per cent.

These are average declines over the first 20 years of the project. The decline in tax revenue occurs because the collection of PRRT revenue is delayed until towards the end of the life of the project.

Table 8.1 shows the economy-wide impact given the above assumed price changes. The base case price is the 2011 level. The alternative case is a 20 per cent reduction in this level.

From the table, the reduction in net benefits is proportional to the reduction in the input parameters. The reduction in the net benefit indicator is $171 million for 50 PJ of exports, or a 43 per cent reduction to $229 million from the base case of $401 million.

This result provides the rule of thumb that:

- **for every 1 per cent reduction in the LNG price the economy-wide benefits from LNG exports will be reduced by approximately 2 percentage points. This stems mainly from the fact that tax receipts and domestic profits will be disproportionately impacted. Interest owed overseas will still have to be paid and debt repaid.**

Table 8.1 The impact of lower LNG prices

		Case study: 50 PJ of natural gas allocated to LNG exports – base case prices	Case study: 50 PJ of natural gas allocated to LNG exports – 20% reduction in base case prices	Net benefit of 50 PJ of LNG exports with 20% reduction in base case prices
Macroeconomic aggregates				
Gross domestic product at factor cost	$2009m	729.56	-186.22	543.34
Gross domestic product at market prices	$2009m	767.76	-198.23	569.53
Gross national product at market prices	$2009m	538.64	-187.21	351.43
Net national product at market prices	$2009m	355.40	-132.73	222.67
Total imports of goods and services	$2009m	75.85	-21.53	54.33
Total employment	**ths.**	**4.28**	**-1.25**	**3.03**
Household activity				
Wages and mixed income	$2009m	170.21	-48.13	122.08
Property income	$2009m	128.49	-54.30	74.20
Direct taxes paid	$2009m	67.21	-23.05	44.16
Household consumption	$2009m	184.68	-63.33	121.36
Government revenue				
Direct taxes on households	$2009m	67.21	-23.05	44.16
Direct taxes on business	$2009m	156.55	-112.19	44.36
Indirect taxes	$2009m	38.21	-12.01	26.19
Total tax revenue	$2009m	261.96	-147.24	114.72
Other indicators				
Income paid overseas	$2009m	229.12	-11.03	218.10
Benefit indicator	$2009m	401.02	-171.65	229.37

8.2 Foregone growth benefits from expansion of the chemicals sector

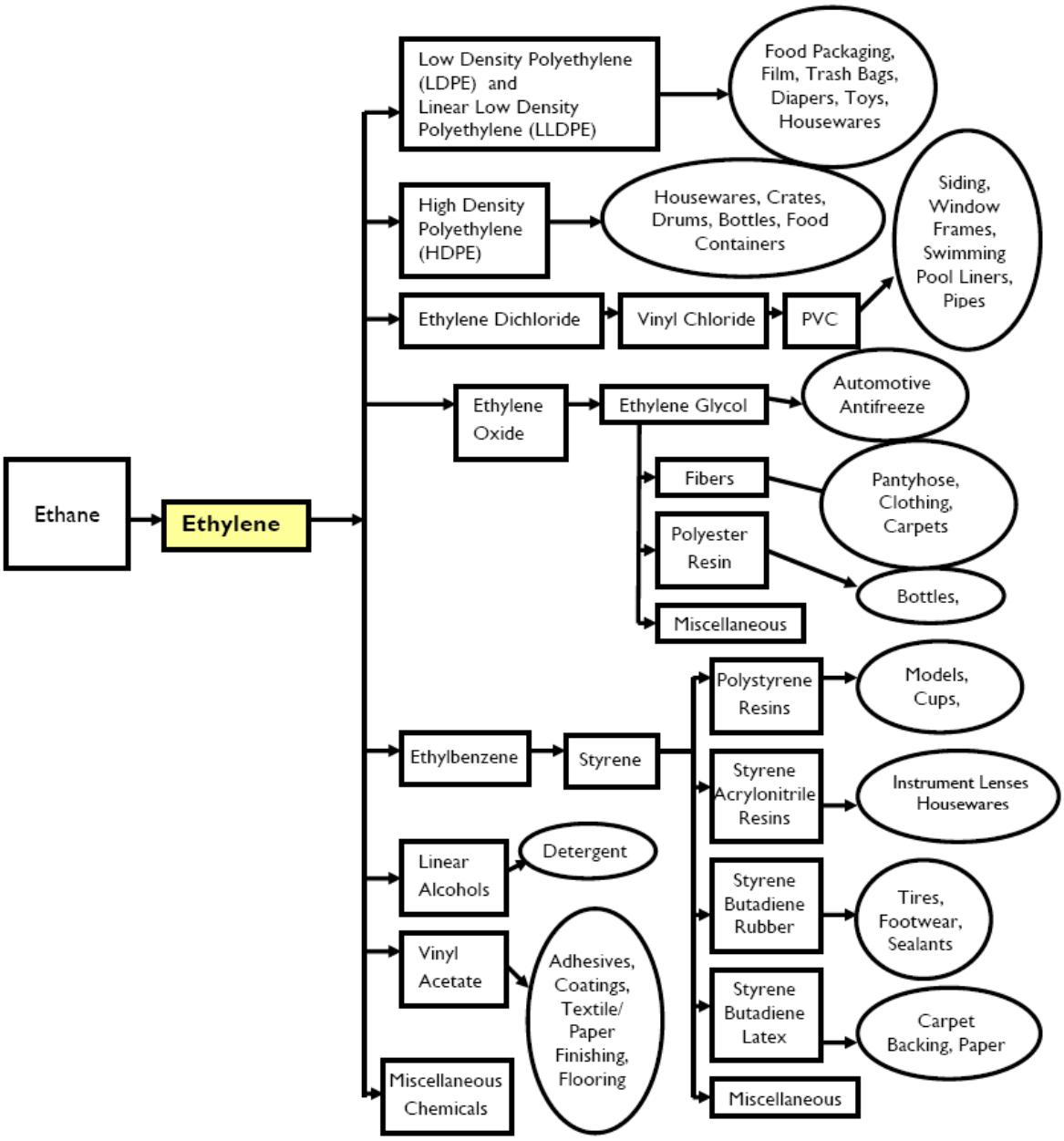
The analysis of Chapters 4 to 7 above were in the context of the existing chemicals sector being crowded out by natural gas shortages. This analysis provided minimum estimates which made no allowance for the foregone ability to grow the chemicals sector as a strategic industry – not only the gas-intensive chemicals industry (fertilizers, explosives) but also that part of the chemicals industry which uses natural gas liquids in general, and ethane in particular. Ethane is the next largest component of natural gas after methane. Its concentration varies from negligible levels to up to 6 per cent of a natural gas deposit. As Figure 8.1 shows, ethane is used to produce ethylene, which is an essential input into a wide range of chemical products.

A 2011 study by the American Chemistry Council (ACC) examined the benefits to the United States of an expansion in the chemicals industry enabled by expanded supply of natural gas. The American study had an indirect (that is inter-industry) effect of $US36 billion from a hypothetical but plausible 25 per cent increase in ethane supply. The ACC study used a completely unconstrained input output framework whereas for this study the chemical sector is treated as a constrained set of industries because of the methodology assuming it is constrained by gas supply. Therefore for this study it was necessary to estimate the indirect inter-industry effect on the rest of the chemical sector by the methodology outlined in developing the data in Table 4.2 which underlies the multiplier of 1.6 for the chemical sector as a whole. The induced multiplier for this study in the context of the Australian economy is of the order of 1.4. This represents the employment income, household consumption expenditure induced plus the non-chemical inter-industry effects which are identical to the Chemical Council study in methodology and concept. Thus if the Australian basic chemical value of $168 million per PJ is multiplied by 1.60 and 1.4 the result is $376 million per PJ which is less than the $415 million per PJ for the American study. The American total multiplier would be expected to be bigger because of the lower import content of the American economy and the greater complexity of the inter-industry supply chains.

Once this adjustment is taken into account the two studies are extremely similar in their quantitative conclusions.

If the investment effects are taken into account an interesting conclusion emerges. While the investment to output ratio for LNG is between 4.0 and 4.5 times the annual value of output, the equivalent ratio for the chemical sector is 0.5 because of the greater value extracted from the chemical sector use of natural gas. The value of output per PJ of natural gas used by the chemicals sector is 2.7 times that for the LNG sector. There is no validity in the argument that LNG should be promoted simply because of its investment intensity.

Figure 8.1: Ethane/Ethylene and the chemical industry flow chart



Source: American Chemistry Council, "*Shale Gas and New Petrochemicals Investment: Benefits for the Economy, Jobs and US Manufacturing*", March 2011.

8.3 The costs of adjustment when the mining boom ends

When the mining boom ends, the terms of trade will decline, the exchange rate will fall and the current account deficit will expand rapidly to double digit levels as a percentage of GDP. The current account deficit circa 2016 to 2020 at least will be around 5 to 6 per cent of GDP with terms of trade near current levels, and given Australia's existing high net international debt any fall in the terms of trade will increase the measured debt and require that the current account deficit be closed rapidly back to the 5 per cent of GDP mark.

Normally the exchange rate decline would be expected to carry some of the burden by facilitating an export expansion/import replacement response to cushion the impact on economic activity. However Australia is destroying capacity in its non-resource trade-exposed industries from a combination of natural gas suppression and the investment-discouraging effects of the loss of competitiveness due to the high exchange rate which has accompanied the boom in mining investment. (Admittedly the iron ore export industry bears major responsibility for the high exchange rate, but LNG exports have played a role.) The high prices for iron ore, coal and other mineral exports are bound to subside, if only because of current investment in expanding capacity in Australia, Africa and elsewhere, and when the high prices fall the Australian dollar exchange rate is likely to fall with them. At this point the loss of capacity in manufacturing, tourism and other trade-exposed industries will have two unpleasant consequences:

(i) the current account deficit will be considerably worse than what would have been the case; and

(ii) most of the adjustment required to bring the current account deficit back to sustainable levels will have to come from demand suppression via contractionary monetary and fiscal policies.

To illustrate, from Table A.11, the expected benefit from East Coast LNG exports would lead to a $6 billion increase in imports. At an average 20 per cent share of imports in GDP to neutralise the impact of the import increase of the balance of payments will require a loss in GDP of $30 billion. However, normal income elasticity effects will reduce this to around $15 billion. This is because imports are highly elastic with respect to GDP change. Even so, it is two to four times the expected GDP loss from Table A.11 from East Coast LNG exports in the 2020s.

Hence, the following rule of thumb.

- **For every $1m of lost GDP from the absence of effective policies to neutralise the impact of domestic gas suppression costs on the economy, at least an additional $2 million will be lost from the current damage being done to the Australian non-resource tradeable industries from the general effects of the currently high exchange rate and potentially from domestic gas suppression.**

This analysis has only been done in terms of the marginal case of Table A.11. The risks for the national economy in the period 2016-2020 appear to require careful analysis. The inference from the above calculations is that a sharp end to the mining boom and a return of the terms of trade to near pre 2005 levels would risk severe economic instability.

9. A review of current policy is urgent

It is not the task of this study to outline the appropriate policy regime. This study goes no further than demonstrating that, unless an appropriate policy regime is put in place, the cost of East Coast LNG exports from Australia is likely to be a net negative for the national economy.

In order to avoid the likelihood of net negative consequences to the economy, a policy review is urgent that considers the impacts and risks discussed in this report and develops policies which gave continuity to existing and potential large scale uses of natural gas in regard to:

(i) adequate supply availability over a 40 year horizon;

(ii) benchmarks for the determination of costs of supply; and

(iii) institutional arrangements which would ensure that domestic customers' long-term interests are protected.

In relation to (iii), the CME study, "*The Impact of Liquefied Natural Gas on Queensland Gas Markets and Gas Users*", March 2010, points to a number of factors which will contribute to negative outcomes from the East Coast LNG exports.

Firstly, as noted in Chapter 1, the interest of gas producers in LNG plants is giving foreign customers first preference in the supply of gas in part because sales on foreign markets are expected to be more profitable than sales to domestic customers. However, as the CME report notes, even if domestic gas sales had higher margins once the LNG plant came into production the domestic sales would become small compared to foreign sales. Higher margins on domestic sales will, therefore, make a small contribution to overall profits.

The drive to secure large scale supply for export markets has driven consolidation in the gas supply industry in Queensland and greatly reduced competition. Second, the control of gas producers over pipelines and, therefore, access is also contributing to a decline in competition. This discourages smaller scale producers from expanding or commencing production. The volume of gas going through pipelines to service export markets will make it easier for pipeline owners to apply for exemptions from pipeline access on the grounds of capacity constraints.

There will indeed be producers who will be willing to supply the local market. However, as the larger producers become increasingly export focussed, these producers are likely to be small scale and, therefore, inefficient and under-capitalised, which will not assist in increasing the confidence of local gas users in long-run prospects.

In this environment the required policy regime to optimise the national interest and to avoid the costs quantified in Chapter 7 is self-evident.

Appendix A: Tables related to chapters of this report

Table A.1 Natural gas dependent industries response to 50 PJ suppression of domestic natural gas demand – macroeconomic implications of different adjustment paths

		Case study: 50 PJ of natural gas allocated to LNG exports	Case study: 50 PJ of natural gas withdrawn from natural gas dependent industries	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export
Macroeconomic aggregates				
Gross domestic product at factor cost	$2009m	729.56	-11004.69	-10275.13
Gross domestic product at market Prices	$2009m	767.76	-12289.23	-11521.46
Gross national product at market prices	$2009m	538.64	-10994.01	-10455.37
Net national product at market prices	$2009m	355.40	-9112.42	-8757.02
Total imports of goods and services	$2009m	75.85	5680.81	5756.67
Total employment	**ths.**	**4.28**	**-203.34**	**-199.06**
Household activity				
Wages and mixed income	$2009m	170.21	-6441.65	-6271.45
Property income	$2009m	128.49	-2169.01	-2040.51
Direct taxes paid	$2009m	67.21	-1937.40	-1870.19
Household consumption	$2009m	184.68	-5323.87	-5139.19
Government revenue				
Direct taxes on households	$2009m	67.21	-1937.40	-1870.19
Direct taxes on business	$2009m	156.55	-706.87	-550.32
Indirect taxes	$2009m	38.21	-1284.54	-1246.33
Total tax revenue	**$2009m**	**261.96**	**-3928.81**	**-3666.85**
Other indicators				
Income paid overseas	$2009m	229.12	-1295.22	-1066.09
Benefit indicator	$2009m	401.02	-9182.55	-8781.53
Cumulative discounted (at 5%) benefit indicator 2016-2040	$2009m	4629.63	-104509.34	-99879.72

Table A.2 Gross output formation by industry ($2009m)

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: 50 PJ of natural gas withdrawn from natural gas dependent industries	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export
Constrained industries			
Basic chemicals	0.00	-4202.24	-4202.24
Paints	0.00	-98.17	-98.17
Medicinal and pharmaceutical products, pesticides	0.00	-98.77	-98.77
Soap and detergents	0.00	-159.09	-159.09
Cosmetics and toiletry preparations	0.00	-55.37	-55.37
Other chemical products	0.00	-288.82	-288.82
Rubber products	0.00	-40.00	-40.00
Plastic products	0.00	-1847.01	-1847.01
Basic non-ferrous metal and products	0.00	-5951.61	-5951.61
LNG	620.73	0.00	620.73
Unconstrained industries			
Sheep	0.70	-28.13	-27.43
Grains	1.06	-47.17	-46.11
Beef cattle	1.94	-87.10	-85.15
Dairy cattle	1.08	-33.71	-32.62
Pigs	0.27	-10.67	-10.40
Poultry	0.60	-22.74	-22.14
Other agriculture	3.94	-135.46	-131.52
Services to agriculture, hunting and trapping	0.92	-39.85	-38.94
Forestry and logging	0.50	-23.60	-23.11
Commercial fishing	0.63	-18.96	-18.34
Coal	1.79	-80.86	-79.07
Gas	5.80	-83.10	-77.30
Oil	1.47	-65.27	-63.81
Iron ores	0.20	-5.91	-5.71
Non-ferrous metal ores	0.31	-2448.79	-2448.48
Other mining	0.45	-69.09	-68.64
Services to mining	15.45	-281.93	-266.48
Meat and meat products	4.60	-191.72	-187.12
Dairy products	3.54	-110.34	-106.80
Fruit and vegetable products	1.12	-33.81	-32.69
Oils and fats	0.44	-19.27	-18.83
Flour mill products and cereal foods	1.83	-72.38	-70.55
Bakery products	1.51	-45.15	-43.64
Confectionery	1.15	-35.13	-33.98
Other food products	2.69	-100.96	-98.27

Table A.2 Gross output formation by industry ($2009m) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: 50 PJ of natural gas withdrawn from natural gas dependent industries	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export
Soft drinks, cordials and syrups	1.48	-46.55	-45.07
Beer and malt	1.26	-37.46	-36.20
Wine, spirits and tobacco products (a)	1.44	-45.56	-44.12
Textile fibres, yarns and woven fabrics	0.12	-6.26	-6.14
Textile products	0.37	-11.76	-11.38
Knitting mill products	0.26	-8.45	-8.19
Clothing	0.57	-18.84	-18.27
Footwear	0.12	-3.97	-3.85
Leather and leather products	0.09	-3.46	-3.36
Sawmill products	0.54	-16.20	-15.65
Other wood products	1.09	-38.72	-37.63
Pulp, paper and paperboard	0.30	-13.32	-13.01
Paper containers and products	0.90	-47.09	-46.20
Printing and services to printing	2.88	-101.92	-99.04
Publishing, recorded media, etc.	3.29	-122.30	-119.01
Petroleum and coal products	6.35	-282.82	-276.47
Glass and glass products	0.67	-27.41	-26.74
Ceramic products	0.12	-4.41	-4.30
Cement, lime and concrete slurry	0.83	-29.53	-28.70
Plaster and other concrete products	0.43	-15.83	-15.40
Other non-metallic mineral products	0.23	-7.38	-7.16
Iron and steel	4.24	-122.60	-118.36
Structural metal products	2.92	-73.11	-70.19
Sheet metal products	0.91	-37.26	-36.35
Fabricated metal products	2.23	-73.55	-71.32
Motor vehicles and parts, other transport equipment	4.75	-137.15	-132.41
Ships and boats	0.40	-13.72	-13.31
Railway equipment	1.21	-13.28	-12.06
Aircraft	1.39	-21.41	-20.02
Photographic and scientific equipment	0.91	-27.53	-26.62
Electronic equipment	0.83	-24.03	-23.20
Household appliances	1.37	-38.35	-36.98
Other electrical equipment	1.34	-41.45	-40.12
Agricultural, mining, etc. machinery	1.79	-36.27	-34.49
Other machinery and equipment	1.60	-44.46	-42.87
Prefabricated buildings	0.85	-8.07	-7.22
Furniture	1.26	-36.77	-35.51
Other manufacturing	1.07	-57.35	-56.28

Table A.2 Gross output formation by industry ($2009m) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: 50 PJ of natural gas withdrawn from natural gas dependent industries	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export
Electricity supply	10.97	-460.21	-449.24
Gas supply	1.10	-65.39	-64.29
Water supply, sewerage and drainage services	4.06	-157.67	-153.62
Residential building	1.94	-47.42	-45.48
Other construction	3.52	-78.84	-75.32
Construction trade services	19.47	-418.47	-399.00
Wholesale trade	25.88	-1231.10	-1205.22
Wholesale mechanical repairs	2.89	-22.17	-19.28
Other wholesale repairs	5.51	-111.48	-105.97
Retail trade	32.74	-984.54	-951.80
Retail mechanical repairs	7.63	-229.35	-221.72
Other retail repairs	0.44	-13.03	-12.59
Accommodation, cafes and restaurants	16.97	-515.86	-498.90
Road transport	9.58	-489.81	-480.23
Rail, pipeline and other transport	10.02	-111.10	-101.09
Water transport	1.13	-54.45	-53.32
Air and space transport	4.99	-155.51	-150.52
Services to transport, storage	13.62	-496.68	-483.06
Communication services	15.22	-500.67	-485.44
Finance	47.38	-1319.57	-1272.19
Ownership of dwellings	4.72	-135.99	-131.27
Other property services	31.27	-739.24	-707.97
Scientific research, technical and computer services	11.85	-445.16	-433.31
Legal, accounting, marketing and business management services	18.85	-766.52	-747.67
Other business services	11.10	-478.61	-467.51
Government administration	2.21	-99.62	-97.42
Defence	0.03	-1.39	-1.36
Education	9.51	-282.15	-272.63
Health services	9.29	-271.61	-262.32
Community services	1.16	-33.37	-32.21
Motion picture, radio and television services	4.08	-139.92	-135.84
Libraries, museums and the arts	1.11	-36.41	-35.30
Sport, gambling and recreational services	7.78	-192.15	-184.37
Personal services	3.71	-108.00	-104.28
Other services	3.99	-119.36	-115.37
Total	**1082.81**	**-29840.57**	**-28757.76**

Table A.3 Total employment formation (ths)

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: 50 PJ of natural gas withdrawn from natural gas dependent industries	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export
Constrained industries			
Basic chemicals	0.00	-11.20	-11.20
Paints	0.00	-1.00	-1.00
Medicinal and pharmaceutical products, pesticides	0.00	-0.80	-0.80
Soap and detergents	0.00	-0.92	-0.92
Cosmetics and toiletry preparations	0.00	-0.37	-0.37
Other chemical products	0.00	-2.81	-2.81
Rubber products	0.00	-0.35	-0.35
Plastic products	0.00	-16.88	-16.88
Basic non-ferrous metal and products	0.00	-32.47	-32.47
LNG	0.12	0.00	0.12
Unconstrained industries			
Sheep	0.01	-0.47	-0.46
Grains	0.01	-0.41	-0.40
Beef cattle	0.03	-1.24	-1.21
Dairy cattle	0.01	-0.45	-0.43
Pigs	0.01	-0.26	-0.25
Poultry	0.01	-0.20	-0.20
Other agriculture	0.04	-1.28	-1.24
Services to agriculture, hunting and trapping	0.01	-0.29	-0.28
Forestry and logging	0.00	-0.17	-0.16
Commercial fishing	0.00	-0.12	-0.12
Coal	0.00	-0.10	-0.10
Gas	0.00	-0.07	-0.06
Oil	0.00	-0.03	-0.03
Iron ores	0.00	-0.01	-0.01
Non-ferrous metal ores	0.00	-5.15	-5.15
Other mining	0.00	-0.26	-0.25
Services to mining	0.10	-1.88	-1.78
Meat and meat products	0.07	-2.82	-2.75
Dairy products	0.04	-1.17	-1.13
Fruit and vegetable products	0.01	-0.20	-0.19
Oils and fats	0.00	-0.08	-0.08
Flour mill products and cereal foods	0.01	-0.51	-0.50
Bakery products	0.03	-0.97	-0.94
Confectionery	0.01	-0.24	-0.23
Other food products	0.02	-0.63	-0.61

Table A.3 Total employment formation (ths) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: 50 PJ of natural gas withdrawn from natural gas dependent industries	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export
Soft drinks, cordials and syrups	0.01	-0.19	-0.18
Beer and malt	0.00	-0.12	-0.11
Wine, spirits and tobacco products (a)	0.01	-0.17	-0.16
Textile fibres, yarns and woven fabrics	0.00	-0.04	-0.04
Textile products	0.01	-0.16	-0.16
Knitting mill products	0.00	-0.07	-0.07
Clothing	0.01	-0.33	-0.32
Footwear	0.00	-0.04	-0.04
Leather and leather products	0.00	-0.02	-0.02
Sawmill products	0.00	-0.12	-0.12
Other wood products	0.02	-0.58	-0.56
Pulp, paper and paperboard	0.00	-0.05	-0.05
Paper containers and products	0.01	-0.35	-0.34
Printing and services to printing	0.03	-1.01	-0.98
Publishing, recorded media, etc.	0.03	-0.94	-0.92
Petroleum and coal products	0.01	-0.64	-0.63
Glass and glass products	0.01	-0.26	-0.25
Ceramic products	0.00	-0.04	-0.03
Cement, lime and concrete slurry	0.00	-0.12	-0.11
Plaster and other concrete products	0.00	-0.08	-0.08
Other non-metallic mineral products	0.00	-0.09	-0.09
Iron and steel	0.04	-1.10	-1.07
Structural metal products	0.02	-0.45	-0.43
Sheet metal products	0.00	-0.17	-0.16
Fabricated metal products	0.02	-0.78	-0.76
Motor vehicles and parts, other transport equipment	0.05	-1.53	-1.48
Ships and boats	0.00	-0.05	-0.05
Railway equipment	0.00	-0.05	-0.05
Aircraft	0.01	-0.09	-0.08
Photographic and scientific equipment	0.01	-0.29	-0.28
Electronic equipment	0.01	-0.26	-0.25
Household appliances	0.01	-0.33	-0.32
Other electrical equipment	0.01	-0.41	-0.40
Agricultural, mining, etc. machinery	0.02	-0.40	-0.38
Other machinery and equipment	0.02	-0.49	-0.47
Prefabricated buildings	0.01	-0.06	-0.05
Furniture	0.03	-0.89	-0.86
Other manufacturing	0.01	-0.71	-0.70

Table A.3 Total employment formation (ths) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: 50 PJ of natural gas withdrawn from natural gas dependent industries	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export
Electricity supply	0.03	-1.38	-1.35
Gas supply	0.01	-0.55	-0.54
Water supply, sewerage and drainage services	0.02	-0.68	-0.67
Residential building	0.01	-0.23	-0.22
Other construction	0.02	-0.56	-0.53
Construction trade services	0.29	-6.23	-5.94
Wholesale trade	0.19	-9.03	-8.84
Wholesale mechanical repairs	0.02	-0.15	-0.13
Other wholesale repairs	0.05	-0.94	-0.90
Retail trade	0.56	-16.80	-16.24
Retail mechanical repairs	0.20	-6.06	-5.86
Other retail repairs	0.01	-0.28	-0.27
Accommodation, cafes and restaurants	0.25	-7.51	-7.26
Road transport	0.10	-4.86	-4.77
Rail, pipeline and other transport	0.08	-0.89	-0.81
Water transport	0.01	-0.28	-0.28
Air and space transport	0.04	-1.10	-1.07
Services to transport, storage	0.07	-2.57	-2.50
Communication services	0.09	-3.10	-3.01
Finance	0.19	-5.40	-5.20
Ownership of dwellings	0.00	0.00	0.00
Other property services	0.11	-2.51	-2.41
Scientific research, technical and computer services	0.13	-4.86	-4.73
Legal, accounting, marketing and business management services	0.17	-6.95	-6.78
Other business services	0.08	-3.64	-3.55
Government administration	0.03	-1.18	-1.16
Defence	0.00	-0.01	-0.01
Education	0.12	-3.66	-3.54
Health services	0.11	-3.31	-3.20
Community services	0.02	-0.50	-0.48
Motion picture, radio and television services	0.03	-1.08	-1.05
Libraries, museums and the arts	0.02	-0.77	-0.74
Sport, gambling and recreational services	0.11	-2.77	-2.66
Personal services	0.10	-2.77	-2.68
Other services	0.05	-1.43	-1.38
Total	**4.28**	**-203.34**	**-199.06**

Table A.4 General economy responses to 50 PJ suppression of domestic natural gas demand – macroeconomic implications of different adjustment paths

		Case study: 50 PJ of natural gas allocated to LNG exports	Case study: impact of withdrawing 50 PJ of natural gas – general economy impact full electricity substitution	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – full substitution effect	Case study: impact of withdrawing 50 PJ of natural gas – decline in economic activity	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – decline in economic activity	Case study: impact of withdrawing 50 PJ of natural gas – gas substitution in electricity production	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – gas substitution in electricity production
Macroeconomic aggregates								
Gross domestic product at factor cost	$2009m	729.56	469.54	1199.10	-4658.41	-3928.85	-206.25	523.31
Gross domestic product at market Prices	$2009m	767.76	402.91	1170.67	-5697.53	-4929.77	-282.58	485.18
Gross national product at market prices	$2009m	538.64	211.60	750.23	-5492.32	-4953.68	-296.18	242.45
Net national product at market prices	$2009m	355.40	-3.10	352.30	-4966.96	-4611.56	-307.24	48.16
Total imports of goods and services	$2009m	75.85	-64.14	11.72	-1521.38	-1445.52	-113.45	-37.60
Total employment	**Ths**	**4.28**	**-0.50**	**3.78**	**-92.67**	**-88.39**	**-5.72**	**-1.44**
Household activity								
Wages and mixed income	$2009m	170.21	-1.13	169.07	-3130.00	-2959.80	-209.59	-39.39
Property income	$2009m	128.49	264.86	393.36	-922.44	-793.95	16.41	144.90
Direct taxes paid	$2009m	67.21	59.34	126.55	-911.80	-844.59	-43.47	23.74
Household consumption	$2009m	184.68	-831.59	-646.91	-6410.88	-6226.20	-576.70	-392.02

Table A.4 General economy responses to 50 PJ suppression of domestic natural gas demand – macroeconomic implications of different adjustment paths (continued)

		Case study: 50 PJ of natural gas allocated to LNG exports	Case study: impact of withdrawing 50 PJ of natural gas – general economy impact full electricity substitution	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – full substitution effect	Case study: impact of withdrawing 50 PJ of natural gas – decline in economic activity	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – decline in economic activity	Case study: impact of withdrawing 50 PJ of natural gas – gas substitution in electricity production	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – gas substitution in electricity production
Government revenue								
Direct taxes on households	$2009m	67.21	59.34	126.55	-911.80	-844.59	-43.47	23.74
Direct taxes on business	$2009m	156.55	-4.20	152.34	-248.23	-91.68	-26.12	130.42
Indirect taxes	$2009m	38.21	-66.63	-28.43	-1039.13	-1000.92	-76.33	-38.13
Total tax revenue	**$2009m**	**261.96**	**-11.50**	**250.46**	**-2199.15**	**-1937.19**	**-145.92**	**116.04**
Other indicators								
Income paid overseas	$2009m	229.12	191.31	420.44	-205.21	23.91	13.60	242.73
Benefit indicator	$2009m	401.02	-423.10	-22.07	-6788.50	-6387.47	-514.93	-113.91
Cumulative discounted (at 5%) benefit indicator 2016-2040	$2009m	4629.63	-6154.42	-1524.79	-90767.69	-86138.06	-6995.04	-2365.42

Table A.5 Gross output formation by industry ($2009m)

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: impact of withdrawing 50 PJ of natural gas – general economy impact full electricity substitution	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – full substitution effect	Case study: impact of withdrawing 50 PJ of natural gas – decline in economic activity	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – decline in economic activity	Case study: impact of withdrawing 50 PJ of natural gas – gas substitution in electricity production	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – gas substitution in electricity production
Constrained industries							
Basic chemicals	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paints	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Medicinal and pharmaceutical products, pesticides	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soap and detergents	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cosmetics and toiletry preparations	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other chemical products	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rubber products	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plastic products	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Basic non-ferrous metal and products	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LNG	620.73	0.00	620.73	0.00	620.73	0.00	620.73
Unconstrained industries							
Sheep	0.70	-2.63	-1.93	-22.11	-21.41	-1.95	-1.25
Grains	1.06	-4.28	-3.22	-34.66	-33.60	-3.08	-2.03
Beef cattle	1.94	-7.93	-5.98	-64.11	-62.17	-5.70	-3.76
Dairy cattle	1.08	-4.48	-3.40	-36.09	-35.01	-3.21	-2.13
Pigs	0.27	-1.06	-0.79	-8.69	-8.43	-0.77	-0.50
Poultry	0.60	-2.48	-1.88	-19.94	-19.34	-1.77	-1.17
Other agriculture	3.94	-16.22	-12.27	-130.01	-126.06	-11.61	-7.66
Services to agriculture, hunting and trapping	0.92	-3.57	-2.65	-29.49	-28.58	-2.61	-1.70
Forestry and logging	0.50	-0.11	0.39	-5.70	-5.20	-0.50	0.00

Table A.5 Gross output formation by industry ($2009m) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: impact of withdrawing 50 PJ of natural gas – general economy impact full electricity substitution	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – full substitution effect	Case study: impact of withdrawing 50 PJ of natural gas – decline in economic activity	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – decline in economic activity	Case study: impact of withdrawing 50 PJ of natural gas – gas substitution in electricity production	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – gas substitution in electricity production
Commercial fishing	0.63	-2.68	-2.06	-21.17	-20.54	-1.89	-1.27
Coal	1.79	127.25	129.04	15.40	17.19	38.71	40.50
Gas	5.80	-129.56	-123.77	-201.86	-196.06	-181.74	-175.94
Oil	1.47	0.52	1.98	-32.29	-30.82	-1.75	-0.28
Iron ores	0.20	0.17	0.37	-1.74	-1.54	-0.12	0.08
Non-ferrous metal ores	0.31	0.32	0.64	-3.73	-3.42	-0.20	0.11
Other mining	0.45	1.11	1.57	-4.96	-4.51	-0.08	0.38
Services to mining	15.45	-0.63	14.82	-13.67	1.78	-9.15	6.30
Meat and meat products	4.60	-18.91	-14.32	-152.31	-147.71	-13.56	-8.96
Dairy products	3.54	-14.68	-11.13	-118.18	-114.63	-10.51	-6.96
Fruit and vegetable products	1.12	-4.74	-3.62	-37.59	-36.47	-3.36	-2.24
Oils and fats	0.44	-1.80	-1.36	-14.62	-14.18	-1.30	-0.85
Flour mill products and cereal foods	1.83	-7.51	-5.68	-60.59	-58.75	-5.39	-3.56
Bakery products	1.51	-6.14	-4.63	-49.72	-48.21	-4.42	-2.91
Confectionery	1.15	-4.77	-3.62	-38.27	-37.12	-3.41	-2.26
Other food products	2.69	-10.64	-7.95	-86.71	-84.02	-7.72	-5.03
Soft drinks, cordials and syrups	1.48	-6.47	-4.99	-50.51	-49.04	-4.53	-3.05
Beer and malt	1.26	-5.01	-3.75	-40.88	-39.62	-3.63	-2.37
Wine, spirits and tobacco products (a)	1.44	-5.69	-4.25	-45.81	-44.37	-4.11	-2.67
Textile fibres, yarns and woven fabrics	0.12	-0.31	-0.19	-3.21	-3.09	-0.27	-0.15
Textile products	0.37	-1.33	-0.96	-11.30	-10.93	-1.00	-0.63
Knitting mill products	0.26	-0.99	-0.73	-8.17	-7.91	-0.73	-0.47
Clothing	0.57	-1.75	-1.18	-16.00	-15.43	-1.40	-0.83
Footwear	0.12	-0.31	-0.19	-3.63	-3.50	-0.29	-0.17

Table A.5 Gross output formation by industry ($2009m) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: impact of withdrawing 50 PJ of natural gas – general economy impact full electricity substitution	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – full substitution effect	Case study: impact of withdrawing 50 PJ of natural gas – decline in economic activity	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – decline in economic activity	Case study: impact of withdrawing 50 PJ of natural gas – gas substitution in electricity production	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – gas substitution in electricity production
Leather and leather products	0.09	-0.19	-0.09	-2.23	-2.13	-0.19	-0.09
Sawmill products	0.54	0.69	1.23	-8.10	-7.56	-0.36	0.18
Other wood products	1.09	0.98	2.07	-15.03	-13.94	-0.81	0.28
Pulp, paper and paperboard	0.30	-0.54	-0.23	-7.04	-6.73	-0.57	-0.27
Paper containers and products	0.90	-2.32	-1.42	-25.71	-24.82	-2.09	-1.19
Printing and services to printing	2.88	-4.72	-1.84	-67.72	-64.84	-5.35	-2.47
Publishing, recorded media, etc.	3.29	-10.22	-6.93	-95.69	-92.40	-8.23	-4.94
Petroleum and coal products	6.35	2.25	8.60	-139.89	-133.54	-7.58	-1.23
Glass and glass products	0.67	-1.21	-0.54	-15.11	-14.43	-1.26	-0.59
Ceramic products	0.12	0.45	0.57	-1.83	-1.71	0.01	0.13
Cement, lime and concrete slurry	0.83	5.82	6.65	-6.45	-5.62	1.11	1.94
Plaster and other concrete products	0.43	5.95	6.38	-2.71	-2.28	1.50	1.93
Other non-metallic mineral products	0.23	0.52	0.75	-1.92	-1.69	-0.03	0.20
Iron and steel	4.24	3.06	7.29	-35.80	-31.57	-2.61	1.62
Structural metal products	2.92	4.69	7.60	-17.79	-14.87	-0.77	2.15
Sheet metal products	0.91	-0.80	0.11	-15.64	-14.73	-1.28	-0.37
Fabricated metal products	2.23	2.09	4.31	-19.85	-17.62	-1.26	0.97
Motor vehicles and parts, other transport equipment	4.75	-13.68	-8.93	-127.96	-123.21	-11.19	-6.45
Ships and boats	0.40	-0.91	-0.51	-9.75	-9.34	-0.84	-0.43
Railway equipment	1.21	0.70	1.91	-6.24	-5.03	-0.67	0.55
Aircraft	1.39	-1.44	-0.04	-15.97	-14.57	-1.75	-0.36
Photographic and scientific equipment	0.91	-2.04	-1.13	-23.19	-22.28	-1.92	-1.01
Electronic equipment	0.83	-0.42	0.41	-16.44	-15.61	-1.15	-0.32

Table A.5 Gross output formation by industry ($2009m) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: impact of withdrawing 50 PJ of natural gas – general economy impact full electricity substitution	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – full substitution effect	Case study: impact of withdrawing 50 PJ of natural gas – decline in economic activity	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – decline in economic activity	Case study: impact of withdrawing 50 PJ of natural gas – gas substitution in electricity production	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – gas substitution in electricity production
Household appliances	1.37	-4.11	-2.74	-38.44	-37.07	-3.33	-1.96
Other electrical equipment	1.34	16.53	17.87	-17.25	-15.92	3.76	5.10
Agricultural, mining, etc. machinery	1.79	0.47	2.26	-10.42	-8.64	-1.19	0.59
Other machinery and equipment	1.60	0.55	2.15	-14.76	-13.16	-1.21	0.39
Prefabricated buildings	0.85	-0.05	0.80	-1.29	-0.44	-0.53	0.32
Furniture	1.26	-4.00	-2.74	-36.28	-35.03	-3.16	-1.91
Other manufacturing	1.07	-0.92	0.14	-21.80	-20.73	-1.62	-0.55
Electricity supply	10.97	1617.38	1628.35	245.05	256.02	500.12	511.09
Gas supply	1.10	22.25	23.35	-21.68	-20.58	5.50	6.60
Water supply, sewerage and drainage services	4.06	-6.94	-2.89	-106.27	-102.21	-8.00	-3.94
Residential building	1.94	9.08	11.02	-18.08	-16.15	1.11	3.05
Other construction	3.52	12.53	16.05	-30.01	-26.49	0.90	4.42
Construction trade services	19.47	134.00	153.47	-124.52	-105.05	26.28	45.75
Wholesale trade	25.88	-26.98	-1.10	-528.97	-503.09	-40.62	-14.74
Wholesale mechanical repairs	2.89	1.57	4.47	-9.40	-6.51	-1.43	1.47
Other wholesale repairs	5.51	3.25	8.76	-44.94	-39.43	-3.57	1.94
Retail trade	32.74	-133.41	-100.67	-1078.70	-1045.95	-95.95	-63.20
Retail mechanical repairs	7.63	-5.42	2.21	-149.57	-141.94	-10.97	-3.35
Other retail repairs	0.44	-1.49	-1.06	-13.13	-12.69	-1.15	-0.71
Accommodation, cafes and restaurants	16.97	-61.52	-44.56	-533.81	-516.84	-46.52	-29.55
Road transport	9.58	-16.59	-7.00	-228.91	-219.32	-18.20	-8.62
Rail, pipeline and other transport	10.02	6.02	16.03	-52.46	-42.45	-5.45	4.57
Water transport	1.13	0.88	2.01	-13.55	-12.41	-0.82	0.32

Table A.5 Gross output formation by industry ($2009m) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: impact of withdrawing 50 PJ of natural gas – general economy impact full electricity substitution	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – full substitution effect	Case study: impact of withdrawing 50 PJ of natural gas – decline in economic activity	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – decline in economic activity	Case study: impact of withdrawing 50 PJ of natural gas – gas substitution in electricity production	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – gas substitution in electricity production
Air and space transport	4.99	-13.85	-8.86	-140.33	-135.34	-11.81	-6.81
Services to transport, storage	13.62	-8.85	4.77	-172.10	-158.48	-16.09	-2.47
Communication services	15.22	-24.74	-9.52	-384.41	-369.19	-29.13	-13.90
Finance	47.38	-42.08	5.30	-1081.89	-1034.51	-75.99	-28.61
Ownership of dwellings	4.72	-21.24	-16.52	-163.75	-159.04	-14.73	-10.01
Other property services	31.27	0.18	31.44	-386.50	-355.23	-30.34	0.92
Scientific research, technical and computer services	11.85	7.43	19.28	-139.34	-127.49	-8.99	2.86
Legal, accounting, marketing and business management services	18.85	-4.21	14.63	-349.65	-330.81	-23.61	-4.76
Other business services	11.10	-1.27	9.83	-207.63	-196.53	-13.59	-2.49
Government administration	2.21	-2.87	-0.66	-41.08	-38.87	-3.50	-1.29
Defence	0.03	-0.03	0.00	-0.51	-0.48	-0.04	-0.01
Education	9.51	-30.06	-20.55	-297.24	-287.73	-24.65	-15.13
Health services	9.29	-41.36	-32.08	-320.54	-311.25	-28.80	-19.51
Community services	1.16	-5.21	-4.05	-40.18	-39.02	-3.61	-2.46
Motion picture, radio and television services	4.08	-8.30	-4.21	-101.00	-96.91	-8.25	-4.17
Libraries, museums and the arts	1.11	-1.05	0.06	-29.01	-27.90	-1.92	-0.82
Sport, gambling and recreational services	7.78	-27.59	-19.80	-216.58	-208.80	-20.18	-12.39
Personal services	3.71	-16.27	-12.56	-127.06	-123.35	-11.39	-7.68
Other services	3.99	-16.76	-12.78	-135.57	-131.58	-11.99	-8.00
Total	**1082.81**	**1156.34**	**2239.14**	**-9213.92**	**-8131.11**	**-344.93**	**737.88**

Table A.6 Total employment formation (ths)

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: impact of withdrawing 50 PJ of natural gas – general economy impact full electricity substitution	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – full substitution effect	Case study: impact of withdrawing 50 PJ of natural gas – decline in economic activity	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – decline in economic activity	Case study: impact of withdrawing 50 PJ of natural gas – gas substitution in electricity production	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – gas substitution in electricity production
Constrained industries							
Basic chemicals	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paints	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Medicinal and pharmaceutical products, pesticides	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Soap and detergents	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cosmetics and toiletry preparations	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other chemical products	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rubber products	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plastic products	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Basic non-ferrous metal and products	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LNG	0.12	0.00	0.12	0.00	0.12	0.00	0.12
Unconstrained industries							
Sheep	0.01	-0.04	-0.03	-0.37	-0.36	-0.03	-0.02
Grains	0.01	-0.04	-0.03	-0.30	-0.29	-0.03	-0.02
Beef cattle	0.03	-0.11	-0.09	-0.91	-0.89	-0.08	-0.05
Dairy cattle	0.01	-0.06	-0.05	-0.48	-0.46	-0.04	-0.03
Pigs	0.01	-0.03	-0.02	-0.21	-0.20	-0.02	-0.01
Poultry	0.01	-0.02	-0.02	-0.18	-0.17	-0.02	-0.01
Other agriculture	0.04	-0.15	-0.12	-1.23	-1.19	-0.11	-0.07
Services to agriculture, hunting and trapping	0.01	-0.03	-0.02	-0.21	-0.21	-0.02	-0.01
Forestry and logging	0.00	0.00	0.00	-0.04	-0.04	0.00	0.00

Table A.6 Total employment formation (ths) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: impact of withdrawing 50 PJ of natural gas – general economy impact full electricity substitution	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – full substitution effect	Case study: impact of withdrawing 50 PJ of natural gas – decline in economic activity	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – decline in economic activity	Case study: impact of withdrawing 50 PJ of natural gas – gas substitution in electricity production	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – gas substitution in electricity production
Commercial fishing	0.00	-0.02	-0.01	-0.14	-0.14	-0.01	-0.01
Coal	0.00	0.16	0.17	0.02	0.02	0.05	0.05
Gas	0.00	-0.11	-0.10	-0.16	-0.16	-0.15	-0.14
Oil	0.00	0.00	0.00	-0.02	-0.01	0.00	0.00
Iron ores	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-ferrous metal ores	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00
Other mining	0.00	0.00	0.01	-0.02	-0.02	0.00	0.00
Services to mining	0.10	0.00	0.10	-0.09	0.01	-0.06	0.04
Meat and meat products	0.07	-0.28	-0.21	-2.24	-2.17	-0.20	-0.13
Dairy products	0.04	-0.16	-0.12	-1.25	-1.21	-0.11	-0.07
Fruit and vegetable products	0.01	-0.03	-0.02	-0.22	-0.21	-0.02	-0.01
Oils and fats	0.00	-0.01	-0.01	-0.06	-0.06	-0.01	0.00
Flour mill products and cereal foods	0.01	-0.05	-0.04	-0.43	-0.42	-0.04	-0.03
Bakery products	0.03	-0.13	-0.10	-1.07	-1.03	-0.09	-0.06
Confectionery	0.01	-0.03	-0.02	-0.26	-0.25	-0.02	-0.02
Other food products	0.02	-0.07	-0.05	-0.54	-0.53	-0.05	-0.03
Soft drinks, cordials and syrups	0.01	-0.03	-0.02	-0.20	-0.20	-0.02	-0.01
Beer and malt	0.00	-0.02	-0.01	-0.13	-0.12	-0.01	-0.01
Wine, spirits and tobacco products (a)	0.01	-0.02	-0.02	-0.17	-0.16	-0.02	-0.01
Textile fibres, yarns and woven fabrics	0.00	0.00	0.00	-0.02	-0.02	0.00	0.00
Textile products	0.01	-0.02	-0.01	-0.15	-0.15	-0.01	-0.01
Knitting mill products	0.00	-0.01	-0.01	-0.07	-0.07	-0.01	0.00
Clothing	0.01	-0.03	-0.02	-0.28	-0.27	-0.02	-0.01
Footwear	0.00	0.00	0.00	-0.04	-0.04	0.00	0.00

Table A.6 Total employment formation (ths) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: impact of withdrawing 50 PJ of natural gas – general economy impact full electricity substitution	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – full substitution effect	Case study: impact of withdrawing 50 PJ of natural gas – decline in economic activity	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – decline in economic activity	Case study: impact of withdrawing 50 PJ of natural gas – gas substitution in electricity production	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – gas substitution in electricity production
Leather and leather products	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00
Sawmill products	0.00	0.01	0.01	-0.06	-0.06	0.00	0.00
Other wood products	0.02	0.01	0.03	-0.22	-0.21	-0.01	0.00
Pulp, paper and paperboard	0.00	0.00	0.00	-0.02	-0.02	0.00	0.00
Paper containers and products	0.01	-0.02	-0.01	-0.19	-0.18	-0.02	-0.01
Printing and services to printing	0.03	-0.05	-0.02	-0.67	-0.64	-0.05	-0.02
Publishing, recorded media, etc.	0.03	-0.08	-0.05	-0.74	-0.71	-0.06	-0.04
Petroleum and coal products	0.01	0.01	0.02	-0.32	-0.30	-0.02	0.00
Glass and glass products	0.01	-0.01	-0.01	-0.14	-0.14	-0.01	-0.01
Ceramic products	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00
Cement, lime and concrete slurry	0.00	0.02	0.03	-0.03	-0.02	0.00	0.01
Plaster and other concrete products	0.00	0.03	0.03	-0.01	-0.01	0.01	0.01
Other non-metallic mineral products	0.00	0.01	0.01	-0.02	-0.02	0.00	0.00
Iron and steel	0.04	0.03	0.07	-0.32	-0.28	-0.02	0.01
Structural metal products	0.02	0.03	0.05	-0.11	-0.09	0.00	0.01
Sheet metal products	0.00	0.00	0.00	-0.07	-0.07	-0.01	0.00
Fabricated metal products	0.02	0.02	0.05	-0.21	-0.19	-0.01	0.01
Motor vehicles and parts, other transport equipment	0.05	-0.15	-0.10	-1.43	-1.38	-0.12	-0.07
Ships and boats	0.00	0.00	0.00	-0.04	-0.03	0.00	0.00
Railway equipment	0.00	0.00	0.01	-0.03	-0.02	0.00	0.00
Aircraft	0.01	-0.01	0.00	-0.07	-0.06	-0.01	0.00
Photographic and scientific equipment	0.01	-0.02	-0.01	-0.25	-0.24	-0.02	-0.01
Electronic equipment	0.01	0.00	0.00	-0.18	-0.17	-0.01	0.00

Table A.6 Total employment formation (ths) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: impact of withdrawing 50 PJ of natural gas – general economy impact full electricity substitution	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – full substitution effect	Case study: impact of withdrawing 50 PJ of natural gas – decline in economic activity	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – decline in economic activity	Case study: impact of withdrawing 50 PJ of natural gas – gas substitution in electricity production	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – gas substitution in electricity production
Household appliances	0.01	-0.04	-0.02	-0.33	-0.32	-0.03	-0.02
Other electrical equipment	0.01	0.16	0.18	-0.17	-0.16	0.04	0.05
Agricultural, mining, etc. machinery	0.02	0.01	0.02	-0.11	-0.09	-0.01	0.01
Other machinery and equipment	0.02	0.01	0.02	-0.16	-0.14	-0.01	0.00
Prefabricated buildings	0.01	0.00	0.01	-0.01	0.00	0.00	0.00
Furniture	0.03	-0.10	-0.07	-0.88	-0.85	-0.08	-0.05
Other manufacturing	0.01	-0.01	0.00	-0.27	-0.26	-0.02	-0.01
Electricity supply	0.03	4.84	4.88	0.73	0.77	1.50	1.53
Gas supply	0.01	0.19	0.20	-0.18	-0.17	0.05	0.06
Water supply, sewerage and drainage services	0.02	-0.03	-0.01	-0.46	-0.44	-0.03	-0.02
Residential building	0.01	0.04	0.05	-0.09	-0.08	0.01	0.02
Other construction	0.02	0.09	0.11	-0.21	-0.19	0.01	0.03
Construction trade services	0.29	1.99	2.28	-1.85	-1.56	0.39	0.68
Wholesale trade	0.19	-0.20	-0.01	-3.88	-3.69	-0.30	-0.11
Wholesale mechanical repairs	0.02	0.01	0.03	-0.06	-0.04	-0.01	0.01
Other wholesale repairs	0.05	0.03	0.07	-0.38	-0.33	-0.03	0.02
Retail trade	0.56	-2.28	-1.72	-18.40	-17.84	-1.64	-1.08
Retail mechanical repairs	0.20	-0.14	0.06	-3.95	-3.75	-0.29	-0.09
Other retail repairs	0.01	-0.03	-0.02	-0.28	-0.27	-0.02	-0.02
Accommodation, cafes and restaurants	0.25	-0.90	-0.65	-7.77	-7.52	-0.68	-0.43
Road transport	0.10	-0.16	-0.07	-2.27	-2.18	-0.18	-0.09
Rail, pipeline and other transport	0.08	0.05	0.13	-0.42	-0.34	-0.04	0.04
Water transport	0.01	0.00	0.01	-0.07	-0.06	0.00	0.00

Table A.6 Total employment formation (ths) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports	Case study: impact of withdrawing 50 PJ of natural gas – general economy impact full electricity substitution	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – full substitution effect	Case study: impact of withdrawing 50 PJ of natural gas – decline in economic activity	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – decline in economic activity	Case study: impact of withdrawing 50 PJ of natural gas – gas substitution in electricity production	Net benefit of reallocating 50 PJ of natural gas from natural gas dependent industries to export – general economy effect – gas substitution in electricity production
Air and space transport	0.04	-0.10	-0.06	-0.99	-0.96	-0.08	-0.05
Services to transport, storage	0.07	-0.05	0.02	-0.89	-0.82	-0.08	-0.01
Communication services	0.09	-0.15	-0.06	-2.38	-2.29	-0.18	-0.09
Finance	0.19	-0.17	0.02	-4.43	-4.23	-0.31	-0.12
Ownership of dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other property services	0.11	0.00	0.11	-1.31	-1.21	-0.10	0.00
Scientific research, technical and computer services	0.13	0.08	0.21	-1.52	-1.39	-0.10	0.03
Legal, accounting, marketing and business management services	0.17	-0.04	0.13	-3.17	-3.00	-0.21	-0.04
Other business services	0.08	-0.01	0.07	-1.58	-1.49	-0.10	-0.02
Government administration	0.03	-0.03	-0.01	-0.49	-0.46	-0.04	-0.02
Defence	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Education	0.12	-0.39	-0.27	-3.86	-3.73	-0.32	-0.20
Health services	0.11	-0.50	-0.39	-3.91	-3.79	-0.35	-0.24
Community services	0.02	-0.08	-0.06	-0.60	-0.58	-0.05	-0.04
Motion picture, radio and television services	0.03	-0.06	-0.03	-0.78	-0.75	-0.06	-0.03
Libraries, museums and the arts	0.02	-0.02	0.00	-0.61	-0.59	-0.04	-0.02
Sport, gambling and recreational services	0.11	-0.40	-0.29	-3.12	-3.01	-0.29	-0.18
Personal services	0.10	-0.42	-0.32	-3.26	-3.16	-0.29	-0.20
Other services	0.05	-0.20	-0.15	-1.62	-1.57	-0.14	-0.10
Total	**4.28**	**-0.50**	**3.78**	**-92.67**	**-88.39**	**-5.72**	**-1.44**

Table A.7 Eastern Australian estimates of suppressed gas demand – No East Coast LNG

	Cumulative suppressed gas demand 2011-2040 – petajoules (PJ)	Average annual suppressed gas demand 2011-2020 – petajoules (PJ)	Average annual suppressed gas demand 2021-2030 – petajoules (PJ)	Average annual suppressed gas demand 2031-2040 – petajoules (PJ)	Average annual ex-plant gas cost $2011 per gigajoule 2011-2020 – petajoules ($/GJ)	Average annual ex-plant gas cost $2011 per gigajoule 2021-2030 – petajoules ($/GJ)	Average annual ex-plant gas cost $2011 per gigajoule 2031-2040 – petajoules ($/GJ)	Suppressed demand as per cent of base case domestic Eastern Australian demand (%)
Aggregate indicators								
Minimum	0	0.0	0.0	0.0	5.4	6.4	7.7	0.0
Maximum	16894	0.0	522.3	1167.1	6.0	8.4	11.4	51.6
Mean	1193	0.0	11.6	107.7	5.6	7.0	9.1	9.5
Std Deviation	2269	0.0	49.1	184.0	0.1	0.4	0.8	9.3
Distribution								
5% Percentile	0	0.0	0.0	0.0	5.4	6.5	8.0	0.0
10% Percentile	0	0.0	0.0	0.0	5.4	6.6	8.1	0.0
15% Percentile	0	0.0	0.0	0.0	5.5	6.6	8.2	0.0
20% Percentile	0	0.0	0.0	0.0	5.5	6.7	8.4	0.0
25% Percentile	0	0.0	0.0	0.0	5.5	6.7	8.4	0.0
30% Percentile	86	0.0	0.0	8.6	5.5	6.8	8.5	3.2
35% Percentile	86	0.0	0.0	8.6	5.5	6.8	8.6	3.2
40% Percentile	254	0.0	0.0	25.4	5.5	6.9	8.7	6.3
45% Percentile	254	0.0	0.0	25.4	5.5	6.9	8.8	6.3
50% Percentile	259	0.0	0.0	25.9	5.6	6.9	8.9	6.3
55% Percentile	499	0.0	0.0	49.9	5.6	7.1	9.1	9.3
60% Percentile	499	0.0	0.0	49.9	5.6	7.1	9.2	9.3
65% Percentile	817	0.0	0.0	81.7	5.6	7.2	9.4	12.2
70% Percentile	817	0.0	0.0	81.7	5.7	7.3	9.5	12.2
75% Percentile	1206	0.0	0.0	120.6	5.7	7.3	9.6	15.0
80% Percentile	1432	0.0	0.0	143.2	5.7	7.4	9.8	15.0
85% Percentile	1661	0.0	0.0	166.1	5.7	7.5	9.9	17.7
90% Percentile	3067	0.0	0.0	304.2	5.8	7.7	10.3	21.2
95% Percentile	6403	0.0	77.6	578.6	5.8	7.8	10.5	28.4

Table A.8 Eastern Australian estimates of suppressed gas demand – East Coast LNG

	Cumulative suppressed gas demand 2011-2040 – petajoules (PJ)	Average annual suppressed gas demand 2011-2020 – petajoules (PJ)	Average annual suppressed gas demand 2021-2030 – petajoules (PJ)	Average annual suppressed gas demand 2031-2040 – petajoules (PJ)	Average annual ex-plant gas cost $2011 per gigajoule 2011-2020 – petajoules ($/GJ)	Average annual ex-plant gas cost $2011 per gigajoule 2021-2030 – petajoules ($/GJ)	Average annual ex-plant gas cost $2011 per gigajoule 2031-2040 – petajoules ($/GJ)	Suppressed demand as per cent of base case domestic Eastern Australian demand (%)
Aggregate indicators								
Minimum	68.9	0.0	0.0	6.9	5.4	6.9	8.9	2.6
Maximum	43585.1	319.9	1752.8	2317.8	6.2	9.2	12.2	94.3
Mean	15170.8	40.2	597.5	883.4	5.7	7.7	10.1	40.8
Std Deviation	10525.2	59.9	450.0	562.1	0.1	0.4	0.6	19.5
Distribution								
5% Percentile	929.1	0.0	0.0	64.1	5.5	7.0	9.2	11.9
10% Percentile	1556.5	0.0	0.0	155.6	5.5	7.2	9.4	15.7
15% Percentile	2148.3	0.0	0.0	187.4	5.5	7.2	9.5	19.3
20% Percentile	2824.3	0.0	52.4	255.5	5.5	7.3	9.6	22.8
25% Percentile	5071.4	0.0	165.3	345.5	5.6	7.4	9.7	24.3
30% Percentile	7641.6	0.0	252.8	494.9	5.6	7.5	9.8	27.0
35% Percentile	9767.5	0.0	361.8	612.4	5.6	7.5	9.9	31.0
40% Percentile	11838.2	0.0	455.0	727.0	5.6	7.6	10.0	33.8
45% Percentile	13520.0	0.0	529.8	811.2	5.6	7.6	10.1	37.2
50% Percentile	15089.4	0.0	609.6	885.4	5.6	7.7	10.1	39.7
55% Percentile	16447.8	8.9	669.9	979.8	5.7	7.7	10.2	42.4
60% Percentile	17998.8	24.6	744.7	1030.2	5.7	7.8	10.3	44.6
65% Percentile	19676.0	38.2	824.7	1112.7	5.7	7.8	10.4	47.6
70% Percentile	21718.6	50.2	888.4	1209.7	5.7	7.9	10.4	51.2
75% Percentile	23340.6	63.7	952.3	1324.2	5.8	8.0	10.5	55.1
80% Percentile	25130.9	82.2	1031.1	1413.9	5.8	8.0	10.6	58.5
85% Percentile	27283.7	110.0	1113.1	1540.5	5.8	8.2	10.7	63.7
90% Percentile	29833.6	136.4	1222.5	1659.1	5.9	8.3	10.9	68.3
95% Percentile	33126.2	169.5	1339.2	1826.5	6.0	8.5	11.2	75.1

Table A.9 Eastern Australian estimates of suppressed gas demand – Impact of East Coast LNG

	Cumulative suppressed gas demand 2011-2040 – petajoules (PJ)	Average annual suppressed gas demand 2011-2020 – petajoules (PJ)	Average annual suppressed gas demand 2021-2030 – petajoules (PJ)	Average annual suppressed gas demand 2031-2040 – petajoules (PJ)	Average annual ex-plant gas cost $2011 per gigajoule 2011-2020 – petajoules ($/GJ)	Average annual ex-plant gas cost $2011 per gigajoule 2021-2030 – petajoules ($/GJ)	Average annual ex-plant gas cost $2011 per gigajoule 2031-2040 – petajoules ($/GJ)	Suppressed demand as per cent of base case domestic Eastern Australian demand (%)
Aggregate indicators								
Minimum	68.9	0.0	0.0	6.9	0.0	0.5	1.1	2.6
Maximum	26691.3	319.9	1230.5	1150.7	0.2	0.8	0.8	42.7
Mean	13977.5	40.2	585.9	775.7	0.1	0.7	1.1	31.3
Std Deviation	8255.9	59.9	400.9	378.1	0.0	0.0	-0.2	10.2
Distribution								
5% Percentile	929.1	0.0	0.0	64.1	0.0	0.5	1.2	11.9
10% Percentile	1556.5	0.0	0.0	155.6	0.1	0.6	1.3	15.7
15% Percentile	2148.3	0.0	0.0	187.4	0.1	0.6	1.3	19.3
20% Percentile	2824.3	0.0	52.4	255.5	0.1	0.6	1.3	22.8
25% Percentile	5071.4	0.0	165.3	345.5	0.1	0.7	1.3	24.3
30% Percentile	7555.6	0.0	252.8	486.3	0.1	0.7	1.3	23.8
35% Percentile	9681.5	0.0	361.8	603.8	0.1	0.7	1.3	27.8
40% Percentile	11584.7	0.0	455.0	701.7	0.1	0.7	1.3	27.4
45% Percentile	13266.5	0.0	529.8	785.8	0.1	0.7	1.3	30.9
50% Percentile	14830.2	0.0	609.6	859.5	0.1	0.7	1.2	33.4
55% Percentile	15949.2	8.9	669.9	930.0	0.1	0.7	1.1	33.0
60% Percentile	17500.2	24.6	744.7	980.4	0.1	0.7	1.1	35.3
65% Percentile	18858.7	38.2	824.7	1031.0	0.1	0.6	1.0	35.4
70% Percentile	20901.2	50.2	888.4	1128.0	0.1	0.6	0.9	39.0
75% Percentile	22134.6	63.7	952.3	1203.6	0.1	0.6	0.9	40.1
80% Percentile	23698.6	82.2	1031.1	1270.6	0.1	0.6	0.8	43.5
85% Percentile	25622.9	110.0	1113.1	1374.5	0.1	0.7	0.8	46.0
90% Percentile	26767.1	136.4	1222.5	1354.9	0.1	0.6	0.6	47.1
95% Percentile	26723.0	169.5	1261.6	1247.8	0.1	0.7	0.7	46.7

Table A.10 Eastern Australian estimates of suppressed gas demand – No East Coast LNG

	Gross domestic product at market prices (2009 $m) – 2020	Gross domestic product at market prices (2009 $m) – 2040	Total employment (ths) – 2020	Total employment (ths) – 2020	Benefit indicator (2009 $m) – 2020	Benefit indicator (2009 $m) – 2040	Cumulative discounted net benefit indicator (5% rate) (2009 $m) 2012 – 2040	Ultimately recoverable reserves (2009 $m)	Estimates of eventually recoverable reserves as at 2012 (PJ)
Aggregate indicators									
Minimum	-26636	-109626	-672	-2161	-40493	-127105	-797201	94208	91288.9
Maximum	15118	18445	82	103	7744	9647	101184	265838	263437.8
Mean	8339	-33424	-47	-837	-319	-49917	-196062	173479	173481.8
Std Deviation	9292	28332	174	505	10880	31851	212661	36543	36426.9
Distribution									
5% Percentile	-10823	-79109	-391	-1647	-21041	-98005	-561368	115734	115200.3
10% Percentile	-3839	-69326	-279	-1477	-16162	-89901	-492412	125386	125942.1
15% Percentile	-1816	-65155	-243	-1409	-12573	-84793	-433361	133987	134066.2
20% Percentile	-75	-56463	-213	-1263	-10853	-78436	-382385	140845	140810.0
25% Percentile	1720	-52830	-179	-1208	-8621	-73908	-342773	147117	146886.9
30% Percentile	3493	-49945	-131	-1131	-5658	-69629	-313076	151931	152278.0
35% Percentile	5639	-44308	-94	-1038	-3384	-66274	-292924	157163	157293.8
40% Percentile	10072	-41612	-20	-1002	1577	-61076	-263167	161852	161965.7
45% Percentile	13688	-40193	54	-940	5990	-55411	-227867	166430	166397.9
50% Percentile	15118	-35602	82	-869	7744	-52388	-197998	170863	171161.4
55% Percentile	15118	-32403	82	-824	7744	-47911	-168263	176278	176066.5
60% Percentile	15118	-28204	82	-758	7744	-44830	-130813	181130	181323.1
65% Percentile	15118	-21513	82	-637	7744	-37388	-92761	186871	186829.0
70% Percentile	15118	-15515	82	-518	7744	-30791	-39563	192865	192840.7
75% Percentile	15118	-10561	82	-428	7744	-23149	-14712	199282	199367.6
80% Percentile	15118	-5415	82	-331	7744	-18460	25583	206500	206442.7
85% Percentile	15118	593	82	-221	7744	-10114	85246	214882	214675.4
90% Percentile	15118	6777	82	-108	7744	-3718	94371	223848	224387.3
95% Percentile	15118	12600	82	-13	7744	2518	98438	237320	236890.6

Table A.11 Queensland natural gas expansion – the expected net benefit on the national economy (with year benchmarks)

		2015	2020	2025	2030	2035	2040
Macroeconomic aggregates							
Gross domestic product at factor cost	$2009m	0.0	14395.9	-3791.9	-6697.9	-8918.8	-22009.2
Gross domestic product at market prices	$2009m	0.0	15117.7	-7326.3	-10834.4	-13496.1	-29253.7
Gross national product at market prices	$2009m	0.0	10544.6	-12045.5	-15406.3	-17962.4	-33181.2
Net national product at market prices	$2009m	0.0	6903.3	-14433.9	-17458.7	-19785.0	-33728.5
Total imports of goods and services	$2009m	0.0	1455.2	6083.9	5781.5	6262.0	9284.3
Total employment	**ths.**	**0.0**	**81.8**	**-375.2**	**-434.3**	**-482.8**	**-774.6**
Household activity							
Wages and mixed income	$2009m	0.0	3275.8	-11437.0	-13396.2	-14975.8	-24450.8
Property income	$2009m	0.0	2528.8	352.4	-179.0	-480.5	-2156.4
Direct taxes paid	$2009m	0.0	1306.0	-2494.0	-3054.4	-3477.7	-5986.6
Household consumption	$2009m	0.0	3436.6	-22827.7	-26451.1	-29099.2	-45299.7
Government revenue							
Direct taxes on households	$2009m	0.0	1306.0	-2494.0	-3054.4	-3477.7	-5986.6
Direct taxes on business	$2009m	0.0	3121.2	2176.4	2004.9	1841.8	860.5
Indirect taxes	$2009m	0.0	721.8	-3534.3	-4136.5	-4577.3	-7244.5
Total tax revenue	**$2009m**	**0.0**	**5149.0**	**-3851.9**	**-5186.0**	**-6213.2**	**-12370.6**
Other indicators							
Income paid overseas	$2009m	0.0	4573.1	4719.2	4571.9	4466.3	3927.6
Benefit indicator	$2009m	0.0	7744.4	-20556.8	-24547.9	-27548.7	-45699.4
Cumulative discounted (at 5%) benefit indicator 2016-2040	$2009m	0.0	0.0	0.0	0.0	0.0	-160043.6

Table A.12 The impact of East Coast LNG exports on the national economy: Gross output formation by industry ($2009m)

	2015	2020	2025	2030	2035	2040
Constrained industries						
Basic chemicals	0.0	0.0	-5867.8	-6185.3	-6801.4	-10581.1
Paints	0.0	0.0	-137.1	-144.5	-158.9	-247.2
Medicinal and pharmaceutical products, pesticides	0.0	0.0	-137.9	-145.4	-159.9	-248.7
Soap and detergents	0.0	0.0	-222.1	-234.2	-257.5	-400.6
Cosmetics and toiletry preparations	0.0	0.0	-77.3	-81.5	-89.6	-139.4
Other chemical products	0.0	0.0	-403.3	-425.1	-467.5	-727.2
Rubber products	0.0	0.0	-55.9	-58.9	-64.7	-100.7
Plastic products	0.0	0.0	-2579.1	-2718.6	-2989.4	-4650.7
Basic non-ferrous metal and products	0.0	0.0	-8310.6	-8760.2	-9632.7	-14985.9
LNG	0.0	12414.5	14897.5	14897.5	14897.5	14897.5
Unconstrained industries						
Sheep	0.0	13.0	-89.1	-102.3	-112.7	-176.2
Grains	0.0	19.7	-146.0	-167.0	-183.8	-286.9
Beef cattle	0.0	36.3	-270.2	-308.9	-340.1	-530.7
Dairy cattle	0.0	20.2	-131.1	-151.8	-167.1	-260.7
Pigs	0.0	5.0	-34.8	-40.0	-44.0	-68.8
Poultry	0.0	11.2	-78.2	-89.9	-98.9	-154.4
Other agriculture	0.0	73.7	-491.7	-567.1	-624.4	-974.7
Services to agriculture, hunting and trapping	0.0	17.1	-122.9	-140.7	-154.9	-242.1
Forestry and logging	0.0	9.7	-34.2	-38.7	-43.5	-72.3
Commercial fishing	0.0	11.7	-76.5	-88.5	-97.4	-151.9
Coal	0.0	34.9	1028.6	1061.6	1150.7	1749.2
Gas	0.0	115.1	-2135.4	-2272.8	-2519.9	-4005.1
Oil	0.0	28.0	-117.6	-137.5	-153.1	-246.0
Iron ores	0.0	4.0	-5.8	-7.0	-8.2	-14.9
Non-ferrous metal ores	0.0	6.1	-3417.2	-3603.8	-3963.4	-6168.9
Other mining	0.0	8.8	-87.0	-94.3	-104.6	-167.1

Table A.12 The impact of East Coast LNG exports on the national economy: Gross output formation by industry ($2009m) – continued

	2015	2020	2025	2030	2035	2040
Services to mining	0.0	308.8	-97.0	-125.1	-175.6	-479.9
Meat and meat products	0.0	85.8	-621.9	-712.7	-784.6	-1224.3
Dairy products	0.0	66.1	-429.4	-496.9	-547.1	-853.6
Fruit and vegetable products	0.0	20.9	-135.5	-156.9	-172.7	-269.4
Oils and fats	0.0	8.2	-60.8	-69.5	-76.6	-119.5
Flour mill products and cereal foods	0.0	34.2	-241.8	-277.6	-305.6	-476.9
Bakery products	0.0	28.2	-178.2	-206.5	-227.4	-355.1
Confectionery	0.0	21.5	-138.3	-160.1	-176.3	-275.1
Other food products	0.0	50.3	-340.0	-391.0	-430.7	-673.1
Soft drinks, cordials and syrups	0.0	27.6	-185.1	-214.0	-235.5	-366.9
Beer and malt	0.0	23.5	-146.3	-169.6	-186.8	-291.9
Wine, spirits and tobacco products (a)	0.0	27.0	-168.9	-195.3	-215.2	-336.7
Textile fibres, yarns and woven fabrics	0.0	2.3	-14.9	-17.0	-18.8	-29.6
Textile products	0.0	7.0	-41.4	-47.9	-52.9	-82.9
Knitting mill products	0.0	4.8	-30.3	-35.0	-38.6	-60.4
Clothing	0.0	10.7	-59.7	-69.1	-76.3	-120.3
Footwear	0.0	2.3	-12.6	-14.6	-16.2	-25.4
Leather and leather products	0.0	1.8	-8.7	-10.0	-11.1	-17.8
Sawmill products	0.0	10.6	-20.8	-25.6	-29.1	-49.8
Other wood products	0.0	21.1	-51.5	-61.3	-69.3	-117.1
Pulp, paper and paperboard	0.0	5.8	-30.2	-34.6	-38.4	-61.2
Paper containers and products	0.0	16.9	-115.6	-131.9	-145.5	-228.7
Printing and services to printing	0.0	54.8	-250.9	-291.6	-323.5	-516.7
Publishing, recorded media, etc.	0.0	62.0	-370.7	-427.5	-471.8	-741.9
Petroleum and coal products	0.0	121.2	-509.4	-596.0	-663.2	-1066.0
Glass and glass products	0.0	12.8	-63.2	-72.7	-80.6	-128.8
Ceramic products	0.0	2.2	-3.4	-4.4	-5.1	-8.9
Cement, lime and concrete slurry	0.0	16.3	13.1	9.3	8.0	3.1
Plaster and other concrete products	0.0	8.4	32.1	31.1	32.7	45.6

Table A.12 The impact of East Coast LNG exports on the national economy: Gross output formation by industry ($2009m) – continued

	2015	2020	2025	2030	2035	2040
Other non-metallic mineral products	0.0	4.4	-4.8	-6.1	-7.2	-13.7
Iron and steel	0.0	83.3	-124.1	-149.5	-173.2	-314.2
Structural metal products	0.0	57.6	-34.7	-47.5	-58.9	-125.3
Sheet metal products	0.0	17.6	-69.4	-79.8	-89.0	-145.0
Fabricated metal products	0.0	43.7	-75.9	-90.2	-103.8	-184.8
Motor vehicles and parts, other transport equipment	0.0	89.8	-451.6	-525.6	-581.1	-919.4
Ships and boats	0.0	7.7	-37.0	-42.8	-47.4	-75.6
Railway equipment	0.0	24.0	1.2	-2.6	-5.6	-23.1
Aircraft	0.0	27.3	-43.0	-52.5	-60.2	-106.6
Photographic and scientific equipment	0.0	17.3	-80.8	-94.3	-104.4	-166.0
Electronic equipment	0.0	15.9	-51.0	-60.7	-67.8	-110.6
Household appliances	0.0	25.9	-132.9	-154.9	-171.1	-270.0
Other electrical equipment	0.0	25.8	76.9	69.8	73.0	100.4
Agricultural, mining, etc. machinery	0.0	35.3	-28.7	-36.2	-43.8	-88.7
Other machinery and equipment	0.0	31.4	-51.8	-62.0	-71.3	-127.3
Prefabricated buildings	0.0	17.0	3.9	2.7	0.9	-9.9
Furniture	0.0	23.7	-128.0	-148.8	-164.3	-258.8
Other manufacturing	0.0	20.5	-107.0	-121.8	-135.3	-216.7
Electricity supply	0.0	209.5	13710.6	14196.4	15426.2	23620.7
Gas supply	0.0	20.8	78.2	68.7	72.1	103.4
Water supply, sewerage and drainage services	0.0	76.8	-396.4	-460.1	-509.2	-806.9
Residential building	0.0	37.9	16.9	7.0	3.1	-15.5
Other construction	0.0	69.1	12.9	-4.1	-12.7	-57.7
Construction trade services	0.0	382.9	721.2	664.5	677.3	822.6
Wholesale trade	0.0	496.1	-2411.8	-2760.3	-3066.7	-4922.9
Wholesale mechanical repairs	0.0	57.5	25.7	20.0	15.1	-12.7
Other wholesale repairs	0.0	108.4	-97.4	-126.2	-150.3	-292.6
Retail trade	0.0	611.5	-3874.5	-4489.3	-4943.5	-7719.1
Retail mechanical repairs	0.0	146.5	-490.9	-579.9	-647.6	-1054.8

Table A.12 The impact of East Coast LNG exports on the national economy: Gross output formation by industry ($2009m) – continued

	2015	2020	2025	2030	2035	2040
Other retail repairs	0.0	8.2	-46.7	-54.2	-59.8	-94.0
Accommodation, cafes and restaurants	0.0	317.8	-1903.2	-2208.5	-2434.2	-3811.9
Road transport	0.0	182.4	-1059.5	-1208.2	-1337.7	-2124.3
Rail, pipeline and other transport	0.0	198.3	7.8	-23.9	-48.9	-194.1
Water transport	0.0	22.1	-70.6	-80.9	-91.0	-152.1
Air and space transport	0.0	94.2	-497.3	-578.4	-639.1	-1008.3
Services to transport, storage	0.0	265.5	-809.1	-929.8	-1045.8	-1747.7
Communication services	0.0	288.8	-1322.0	-1546.7	-1714.2	-2727.7
Finance	0.0	903.3	-3266.8	-3885.7	-4324.4	-6963.1
Ownership of dwellings	0.0	87.8	-583.1	-675.6	-743.3	-1157.1
Other property services	0.0	609.7	-1108.0	-1345.8	-1535.6	-2671.3
Scientific research, technical and computer services	0.0	231.3	-574.5	-671.9	-761.0	-1294.2
Legal, accounting, marketing and business management services	0.0	362.6	-1376.3	-1599.8	-1785.5	-2903.2
Other business services	0.0	213.5	-841.6	-975.7	-1088.4	-1766.6
Government administration	0.0	42.5	-195.3	-222.8	-247.9	-400.1
Defence	0.0	0.5	-2.6	-2.9	-3.2	-5.2
Education	0.0	178.2	-1015.8	-1184.4	-1306.1	-2047.0
Health services	0.0	172.9	-1146.0	-1327.5	-1460.6	-2274.4
Community services	0.0	21.5	-143.1	-165.8	-182.4	-283.9
Motion picture, radio and television services	0.0	77.6	-372.4	-432.5	-479.2	-762.5
Libraries, museums and the arts	0.0	20.9	-91.8	-108.4	-120.2	-191.1
Sport, gambling and recreational services	0.0	147.0	-751.3	-874.5	-966.0	-1525.0
Personal services	0.0	69.1	-453.0	-524.9	-577.6	-899.9
Other services	0.0	74.3	-483.5	-560.5	-616.8	-961.4
Total	**0.000**	**21268**	**-25534**	**-31834**	**-37239**	**-69242**

Table A.13 The impact of East Coast LNG exports on the national economy: Total employment formation (ths)

	2015	2020	2025	2030	2035	2040
Constrained industries						
Basic chemicals	0.000	0.000	-15.639	-16.485	-18.127	-28.201
Paints	0.000	0.000	-1.390	-1.465	-1.611	-2.506
Medicinal and pharmaceutical products, pesticides	0.000	0.000	-1.115	-1.175	-1.292	-2.010
Soap and detergents	0.000	0.000	-1.288	-1.358	-1.493	-2.322
Cosmetics and toiletry preparations	0.000	0.000	-0.523	-0.551	-0.606	-0.943
Other chemical products	0.000	0.000	-3.920	-4.133	-4.544	-7.069
Rubber products	0.000	0.000	-0.485	-0.512	-0.563	-0.875
Plastic products	0.000	0.000	-23.566	-24.841	-27.315	-42.495
Basic non-ferrous metal and products	0.000	0.000	-45.336	-47.789	-52.549	-81.751
LNG	0.000	2.359	2.831	2.831	2.831	2.831
Unconstrained industries						
Sheep	0.000	0.217	-1.483	-1.702	-1.875	-2.933
Grains	0.000	0.170	-1.260	-1.441	-1.587	-2.477
Beef cattle	0.000	0.517	-3.850	-4.401	-4.845	-7.561
Dairy cattle	0.000	0.268	-1.740	-2.014	-2.217	-3.460
Pigs	0.000	0.120	-0.834	-0.958	-1.055	-1.648
Poultry	0.000	0.101	-0.704	-0.810	-0.892	-1.391
Other agriculture	0.000	0.697	-4.652	-5.365	-5.907	-9.222
Services to agriculture, hunting and trapping	0.000	0.124	-0.891	-1.019	-1.123	-1.754
Forestry and logging	0.000	0.069	-0.244	-0.276	-0.310	-0.515
Commercial fishing	0.000	0.077	-0.503	-0.582	-0.641	-0.999
Coal	0.000	0.045	1.330	1.373	1.488	2.262
Gas	0.000	0.094	-1.743	-1.855	-2.057	-3.269
Oil	0.000	0.013	-0.055	-0.064	-0.072	-0.115
Iron ores	0.000	0.004	-0.006	-0.007	-0.008	-0.014
Non-ferrous metal ores	0.000	0.013	-7.191	-7.584	-8.340	-12.981
Other mining	0.000	0.033	-0.323	-0.350	-0.388	-0.620

Table A.13 The impact of East Coast LNG exports on the national economy: Total employment formation (ths) – continued

	2015	2020	2025	2030	2035	2040
Services to mining	0.000	2.059	-0.647	-0.834	-1.171	-3.200
Meat and meat products	0.000	1.262	-9.148	-10.484	-11.542	-18.009
Dairy products	0.000	0.701	-4.549	-5.264	-5.796	-9.043
Fruit and vegetable products	0.000	0.120	-0.782	-0.905	-0.996	-1.554
Oils and fats	0.000	0.036	-0.267	-0.306	-0.337	-0.526
Flour mill products and cereal foods	0.000	0.242	-1.712	-1.965	-2.164	-3.377
Bakery products	0.000	0.605	-3.822	-4.429	-4.877	-7.616
Confectionery	0.000	0.146	-0.940	-1.088	-1.198	-1.870
Other food products	0.000	0.315	-2.127	-2.447	-2.695	-4.212
Soft drinks, cordials and syrups	0.000	0.112	-0.750	-0.867	-0.954	-1.486
Beer and malt	0.000	0.074	-0.459	-0.532	-0.586	-0.915
Wine, spirits and tobacco products (a)	0.000	0.100	-0.626	-0.724	-0.798	-1.248
Textile fibres, yarns and woven fabrics	0.000	0.014	-0.089	-0.102	-0.113	-0.178
Textile products	0.000	0.096	-0.565	-0.654	-0.722	-1.133
Knitting mill products	0.000	0.041	-0.256	-0.295	-0.326	-0.510
Clothing	0.000	0.186	-1.036	-1.199	-1.324	-2.087
Footwear	0.000	0.024	-0.130	-0.152	-0.168	-0.264
Leather and leather products	0.000	0.011	-0.051	-0.059	-0.065	-0.104
Sawmill products	0.000	0.081	-0.159	-0.197	-0.224	-0.382
Other wood products	0.000	0.315	-0.766	-0.911	-1.031	-1.742
Pulp, paper and paperboard	0.000	0.020	-0.105	-0.120	-0.133	-0.212
Paper containers and products	0.000	0.126	-0.861	-0.982	-1.084	-1.703
Printing and services to printing	0.000	0.542	-2.480	-2.883	-3.198	-5.107
Publishing, recorded media, etc.	0.000	0.478	-2.861	-3.299	-3.641	-5.726
Petroleum and coal products	0.000	0.275	-1.155	-1.352	-1.504	-2.418
Glass and glass products	0.000	0.121	-0.598	-0.688	-0.763	-1.219
Ceramic products	0.000	0.018	-0.027	-0.036	-0.042	-0.072
Cement, lime and concrete slurry	0.000	0.064	0.052	0.037	0.032	0.012
Plaster and other concrete products	0.000	0.042	0.159	0.155	0.163	0.227

Table A.13 The impact of East Coast LNG exports on the national economy: Total employment formation (ths) – continued

	2015	2020	2025	2030	2035	2040
Other non-metallic mineral products	0.000	0.055	-0.060	-0.076	-0.090	-0.170
Iron and steel	0.000	0.749	-1.117	-1.345	-1.559	-2.828
Structural metal products	0.000	0.357	-0.215	-0.294	-0.365	-0.776
Sheet metal products	0.000	0.079	-0.312	-0.359	-0.400	-0.652
Fabricated metal products	0.000	0.463	-0.803	-0.955	-1.099	-1.956
Motor vehicles and parts, other transport equipment	0.000	1.002	-5.043	-5.868	-6.488	-10.266
Ships and boats	0.000	0.028	-0.136	-0.157	-0.174	-0.277
Railway equipment	0.000	0.097	0.005	-0.011	-0.023	-0.093
Aircraft	0.000	0.113	-0.179	-0.219	-0.250	-0.444
Photographic and scientific equipment	0.000	0.186	-0.864	-1.009	-1.117	-1.776
Electronic equipment	0.000	0.174	-0.560	-0.665	-0.744	-1.212
Household appliances	0.000	0.223	-1.146	-1.335	-1.475	-2.329
Other electrical equipment	0.000	0.255	0.761	0.690	0.722	0.992
Agricultural, mining, etc. machinery	0.000	0.387	-0.315	-0.398	-0.480	-0.973
Other machinery and equipment	0.000	0.343	-0.566	-0.678	-0.780	-1.393
Prefabricated buildings	0.000	0.129	0.030	0.020	0.007	-0.075
Furniture	0.000	0.575	-3.104	-3.609	-3.985	-6.276
Other manufacturing	0.000	0.255	-1.333	-1.517	-1.685	-2.700
Electricity supply	0.000	0.627	41.056	42.510	46.193	70.731
Gas supply	0.000	0.175	0.659	0.578	0.607	0.871
Water supply, sewerage and drainage services	0.000	0.333	-1.717	-1.992	-2.205	-3.494
Residential building	0.000	0.187	0.083	0.035	0.016	-0.077
Other construction	0.000	0.489	0.091	-0.029	-0.090	-0.409
Construction trade services	0.000	5.699	10.736	9.891	10.081	12.245
Wholesale trade	0.000	3.638	-17.687	-20.242	-22.490	-36.102
Wholesale mechanical repairs	0.000	0.393	0.176	0.137	0.103	-0.087
Other wholesale repairs	0.000	0.917	-0.824	-1.068	-1.272	-2.476
Retail trade	0.000	10.433	-66.102	-76.590	-84.339	-131.692
Retail mechanical repairs	0.000	3.870	-12.971	-15.323	-17.111	-27.872

Table A.13 The impact of East Coast LNG exports on the national economy: Total employment formation (ths) – continued

	2015	2020	2025	2030	2035	2040
Other retail repairs	0.000	0.178	-1.011	-1.174	-1.295	-2.034
Accommodation, cafes and restaurants	0.000	4.627	-27.705	-32.149	-35.435	-55.489
Road transport	0.000	1.811	-10.521	-11.998	-13.284	-21.095
Rail, pipeline and other transport	0.000	1.595	0.062	-0.192	-0.393	-1.562
Water transport	0.000	0.115	-0.367	-0.420	-0.473	-0.790
Air and space transport	0.000	0.667	-3.522	-4.097	-4.527	-7.142
Services to transport, storage	0.000	1.374	-4.185	-4.810	-5.410	-9.041
Communication services	0.000	1.790	-8.192	-9.585	-10.622	-16.902
Finance	0.000	3.695	-13.364	-15.896	-17.690	-28.485
Ownership of dwellings	0.000	0.000	0.000	0.000	0.000	0.000
Other property services	0.000	2.074	-3.768	-4.577	-5.223	-9.085
Scientific research, technical and computer services	0.000	2.527	-6.278	-7.342	-8.316	-14.143
Legal, accounting, marketing and business management services	0.000	3.290	-12.487	-14.514	-16.199	-26.339
Other business services	0.000	1.622	-6.394	-7.413	-8.270	-13.423
Government administration	0.000	0.504	-2.316	-2.643	-2.941	-4.746
Defence	0.000	0.004	-0.020	-0.022	-0.025	-0.040
Education	0.000	2.312	-13.176	-15.362	-16.941	-26.552
Health services	0.000	2.107	-13.971	-16.184	-17.807	-27.729
Community services	0.000	0.322	-2.138	-2.478	-2.726	-4.243
Motion picture, radio and television services	0.000	0.599	-2.876	-3.341	-3.701	-5.890
Libraries, museums and the arts	0.000	0.441	-1.935	-2.286	-2.534	-4.029
Sport, gambling and recreational services	0.000	2.120	-10.832	-12.609	-13.928	-21.989
Personal services	0.000	1.774	-11.621	-13.467	-14.819	-23.087
Other services	0.000	0.889	-5.786	-6.707	-7.381	-11.505
Total	**0.000**	**81.816**	**-375.199**	**-434.261**	**-482.785**	**-774.619**

Table A.14 East Coast LNG expansion: Gross output formation by industry ($2009m)

	Case study: 50 PJ of natural gas allocated to LNG exports – base case prices	Case study: 50 PJ of natural gas allocated to LNG exports – 20% reduction in base case prices	Net benefit of 50 PJ of LNG exports with 20% reduction in base case prices
Constrained industries			
Basic chemicals	0.00	0.00	0.00
Paints	0.00	0.00	0.00
Medicinal and pharmaceutical products, pesticides	0.00	0.00	0.00
Soap and detergents	0.00	0.00	0.00
Cosmetics and toiletry preparations	0.00	0.00	0.00
Other chemical products	0.00	0.00	0.00
Rubber products	0.00	0.00	0.00
Plastic products	0.00	0.00	0.00
Basic non-ferrous metal and products	0.00	0.00	0.00
LNG	620.73	-124.15	496.58
Unconstrained industries			
Sheep	0.70	-0.23	0.47
Grains	1.06	-0.35	0.70
Beef cattle	1.94	-0.65	1.29
Dairy cattle	1.08	-0.37	0.72
Pigs	0.27	-0.09	0.18
Poultry	0.60	-0.20	0.40
Other agriculture	3.94	-1.32	2.62
Services to agriculture, hunting and trapping	0.92	-0.30	0.61
Forestry and logging	0.50	-0.12	0.37
Commercial fishing	0.63	-0.21	0.41
Coal	1.79	-0.45	1.34
Gas	5.80	-1.24	4.55
Oil	1.47	-0.43	1.03
Iron ores	0.20	-0.05	0.16
Non-ferrous metal ores	0.31	-0.08	0.24
Other mining	0.45	-0.11	0.34
Services to mining	15.45	-3.11	12.34
Meat and meat products	4.60	-1.55	3.05
Dairy products	3.54	-1.20	2.35
Fruit and vegetable products	1.12	-0.38	0.74
Oils and fats	0.44	-0.15	0.29
Flour mill products and cereal foods	1.83	-0.62	1.22
Bakery products	1.51	-0.51	1.00
Confectionery	1.15	-0.39	0.76
Other food products	2.69	-0.90	1.79
Soft drinks, cordials and syrups	1.48	-0.50	0.98
Beer and malt	1.26	-0.42	0.84
Wine, spirits and tobacco products (a)	1.44	-0.48	0.96
Textile fibres, yarns and woven fabrics	0.12	-0.04	0.08
Textile products	0.37	-0.12	0.25
Knitting mill products	0.26	-0.09	0.17

Table A.14 East Coast LNG expansion: Gross output formation by industry ($2009m) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports – base case prices	Case study: 50 PJ of natural gas allocated to LNG exports – 20% reduction in base case prices	Net benefit of 50 PJ of LNG exports with 20% reduction in base case prices
Clothing	0.57	-0.18	0.39
Footwear	0.12	-0.04	0.08
Leather and leather products	0.09	-0.03	0.07
Sawmill products	0.54	-0.14	0.40
Other wood products	1.09	-0.28	0.81
Pulp, paper and paperboard	0.30	-0.09	0.21
Paper containers and products	0.90	-0.29	0.61
Printing and services to printing	2.88	-0.86	2.02
Publishing, recorded media, etc.	3.29	-1.05	2.24
Petroleum and coal products	6.35	-1.87	4.48
Glass and glass products	0.67	-0.20	0.47
Ceramic products	0.12	-0.03	0.08
Cement, lime and concrete slurry	0.83	-0.20	0.63
Plaster and other concrete products	0.43	-0.10	0.33
Other non-metallic mineral products	0.23	-0.05	0.17
Iron and steel	4.24	-1.00	3.24
Structural metal products	2.92	-0.66	2.26
Sheet metal products	0.91	-0.25	0.66
Fabricated metal products	2.23	-0.53	1.70
Motor vehicles and parts, other transport equipment	4.75	-1.48	3.27
Ships and boats	0.40	-0.12	0.28
Railway equipment	1.21	-0.27	0.95
Aircraft	1.39	-0.34	1.05
Photographic and scientific equipment	0.91	-0.28	0.64
Electronic equipment	0.83	-0.23	0.59
Household appliances	1.37	-0.43	0.94
Other electrical equipment	1.34	-0.36	0.98
Agricultural, mining, etc. machinery	1.79	-0.40	1.39
Other machinery and equipment	1.60	-0.38	1.22
Prefabricated buildings	0.85	-0.17	0.68
Furniture	1.26	-0.40	0.86
Other manufacturing	1.07	-0.30	0.76
Electricity supply	10.97	-3.21	7.76
Gas supply	1.10	-0.34	0.76
Water supply, sewerage and drainage services	4.06	-1.26	2.80
Residential building	1.94	-0.47	1.46
Other construction	3.52	-0.84	2.68
Construction trade services	19.47	-4.56	14.91
Wholesale trade	25.88	-7.38	18.50
Wholesale mechanical repairs	2.89	-0.61	2.28
Other wholesale repairs	5.51	-1.29	4.22
Retail trade	32.74	-10.99	21.75

Table A.14 East Coast LNG expansion: Gross output formation by industry ($2009m) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports – base case prices	Case study: 50 PJ of natural gas allocated to LNG exports – 20% reduction in base case prices	Net benefit of 50 PJ of LNG exports with 20% reduction in base case prices
Retail mechanical repairs	7.63	-2.15	5.48
Other retail repairs	0.44	-0.14	0.30
Accommodation, cafes and restaurants	16.97	-5.60	11.37
Road transport	9.58	-2.87	6.72
Rail, pipeline and other transport	10.02	-2.21	7.80
Water transport	1.13	-0.28	0.85
Air and space transport	4.99	-1.58	3.41
Services to transport, storage	13.62	-3.43	10.19
Communication services	15.22	-4.65	10.57
Finance	47.38	-14.02	33.36
Ownership of dwellings	4.72	-1.62	3.10
Other property services	31.27	-7.86	23.41
Scientific research, technical and computer services	11.85	-2.96	8.89
Legal, accounting, marketing and business management services	18.85	-5.24	13.61
Other business services	11.10	-3.10	8.01
Government administration	2.21	-0.61	1.60
Defence	0.03	-0.01	0.02
Education	9.51	-3.13	6.38
Health services	9.29	-3.18	6.11
Community services	1.16	-0.40	0.76
Motion picture, radio and television services	4.08	-1.24	2.85
Libraries, museums and the arts	1.11	-0.34	0.76
Sport, gambling and recreational services	7.78	-2.45	5.34
Personal services	3.71	-1.27	2.45
Other services	3.99	-1.36	2.63
Total	**1082.81**	**-256.45**	**-28757.76**

Table A.15 East Coast LNG expansion: Total employment formation (ths)

	Case study: 50 PJ of natural gas allocated to LNG exports – base case prices	Case study: 50 PJ of natural gas allocated to LNG exports – 20% reduction in base case prices	Net benefit of 50 PJ of LNG exports with 20% reduction in base case prices
Constrained industries			
Basic chemicals	0.00	0.00	0.00
Paints	0.00	0.00	0.00
Medicinal and pharmaceutical products, pesticides	0.00	0.00	0.00
Soap and detergents	0.00	0.00	0.00
Cosmetics and toiletry preparations	0.00	0.00	0.00
Other chemical products	0.00	0.00	0.00
Rubber products	0.00	0.00	0.00
Plastic products	0.00	0.00	0.00
Basic non-ferrous metal and products	0.00	0.00	0.00
LNG	0.12	-0.02	0.09
Unconstrained industries			
Sheep	0.01	0.00	0.01
Grains	0.01	0.00	0.01
Beef cattle	0.03	-0.01	0.02
Dairy cattle	0.01	0.00	0.01
Pigs	0.01	0.00	0.00
Poultry	0.01	0.00	0.00
Other agriculture	0.04	-0.01	0.02
Services to agriculture, hunting and trapping	0.01	0.00	0.00
Forestry and logging	0.00	0.00	0.00
Commercial fishing	0.00	0.00	0.00
Coal	0.00	0.00	0.00
Gas	0.00	0.00	0.00
Oil	0.00	0.00	0.00
Iron ores	0.00	0.00	0.00
Non-ferrous metal ores	0.00	0.00	0.00
Other mining	0.00	0.00	0.00
Services to mining	0.10	-0.02	0.08
Meat and meat products	0.07	-0.02	0.04
Dairy products	0.04	-0.01	0.02
Fruit and vegetable products	0.01	0.00	0.00
Oils and fats	0.00	0.00	0.00
Flour mill products and cereal foods	0.01	0.00	0.01
Bakery products	0.03	-0.01	0.02
Confectionery	0.01	0.00	0.01
Other food products	0.02	-0.01	0.01
Soft drinks, cordials and syrups	0.01	0.00	0.00
Beer and malt	0.00	0.00	0.00
Wine, spirits and tobacco products (a)	0.01	0.00	0.00
Textile fibres, yarns and woven fabrics	0.00	0.00	0.00
Textile products	0.01	0.00	0.00
Knitting mill products	0.00	0.00	0.00

Table A.15 East Coast LNG expansion: Total employment formation (ths) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports – base case prices	Case study: 50 PJ of natural gas allocated to LNG exports – 20% reduction in base case prices	Net benefit of 50 PJ of LNG exports with 20% reduction in base case prices
Clothing	0.01	0.00	0.01
Footwear	0.00	0.00	0.00
Leather and leather products	0.00	0.00	0.00
Sawmill products	0.00	0.00	0.00
Other wood products	0.02	0.00	0.01
Pulp, paper and paperboard	0.00	0.00	0.00
Paper containers and products	0.01	0.00	0.00
Printing and services to printing	0.03	-0.01	0.02
Publishing, recorded media, etc.	0.03	-0.01	0.02
Petroleum and coal products	0.01	0.00	0.01
Glass and glass products	0.01	0.00	0.00
Ceramic products	0.00	0.00	0.00
Cement, lime and concrete slurry	0.00	0.00	0.00
Plaster and other concrete products	0.00	0.00	0.00
Other non-metallic mineral products	0.00	0.00	0.00
Iron and steel	0.04	-0.01	0.03
Structural metal products	0.02	0.00	0.01
Sheet metal products	0.00	0.00	0.00
Fabricated metal products	0.02	-0.01	0.02
Motor vehicles and parts, other transport equipment	0.05	-0.02	0.04
Ships and boats	0.00	0.00	0.00
Railway equipment	0.00	0.00	0.00
Aircraft	0.01	0.00	0.00
Photographic and scientific equipment	0.01	0.00	0.01
Electronic equipment	0.01	0.00	0.01
Household appliances	0.01	0.00	0.01
Other electrical equipment	0.01	0.00	0.01
Agricultural, mining, etc. machinery	0.02	0.00	0.02
Other machinery and equipment	0.02	0.00	0.01
Prefabricated buildings	0.01	0.00	0.01
Furniture	0.03	-0.01	0.02
Other manufacturing	0.01	0.00	0.01
Electricity supply	0.03	-0.01	0.02
Gas supply	0.01	0.00	0.01
Water supply, sewerage and drainage services	0.02	-0.01	0.01
Residential building	0.01	0.00	0.01
Other construction	0.02	-0.01	0.02
Construction trade services	0.29	-0.07	0.22
Wholesale trade	0.19	-0.05	0.14
Wholesale mechanical repairs	0.02	0.00	0.02
Other wholesale repairs	0.05	-0.01	0.04
Retail trade	0.56	-0.19	0.37

Table A.15 East Coast LNG expansion: Total employment formation (ths) – continued

	Case study: 50 PJ of natural gas allocated to LNG exports – base case prices	Case study: 50 PJ of natural gas allocated to LNG exports – 20% reduction in base case prices	Net benefit of 50 PJ of LNG exports with 20% reduction in base case prices
Retail mechanical repairs	0.20	-0.06	0.14
Other retail repairs	0.01	0.00	0.01
Accommodation, cafes and restaurants	0.25	-0.08	0.17
Road transport	0.10	-0.03	0.07
Rail, pipeline and other transport	0.08	-0.02	0.06
Water transport	0.01	0.00	0.00
Air and space transport	0.04	-0.01	0.02
Services to transport, storage	0.07	-0.02	0.05
Communication services	0.09	-0.03	0.07
Finance	0.19	-0.06	0.14
Ownership of dwellings	0.00	0.00	0.00
Other property services	0.11	-0.03	0.08
Scientific research, technical and computer services	0.13	-0.03	0.10
Legal, accounting, marketing and business management services	0.17	-0.05	0.12
Other business services	0.08	-0.02	0.06
Government administration	0.03	-0.01	0.02
Defence	0.00	0.00	0.00
Education	0.12	-0.04	0.08
Health services	0.11	-0.04	0.07
Community services	0.02	-0.01	0.01
Motion picture, radio and television services	0.03	-0.01	0.02
Libraries, museums and the arts	0.02	-0.01	0.02
Sport, gambling and recreational services	0.11	-0.04	0.08
Personal services	0.10	-0.03	0.06
Other services	0.05	-0.02	0.03
Total	**4.28**	**-1.25**	**3.03**

Appendix B: Input-output flow table with direct allocation of imports – Australia

Table B.1(a) Australia input-output flow table with direct allocation of imports – $2009m

	Sheep	Grains	Beef cattle	Dairy cattle	Pigs	Poultry	Other agriculture	Services to agriculture, hunting and trapping	Forestry and logging	Commercial fishing
Sheep	2.82	2.66	4.46	1.74	1.64	2.28	2.14	1.15	0.00	0.00
Grains	46.57	1725.26	95.11	50.94	15.51	35.12	29.84	2.74	0.03	0.02
Beef cattle	0.00	0.00	11.30	2.89	0.00	0.00	0.00	0.00	0.00	0.00
Dairy cattle	0.00	0.00	1.19	1.14	0.00	0.00	0.00	0.00	0.00	0.00
Pigs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.00	0.00	0.00	0.00	0.00	13.34	0.00	0.00	0.00	0.00
Other agriculture	161.23	0.34	527.58	122.40	23.88	0.28	359.74	1194.95	4.39	0.07
Services to agriculture, hunting and trapping	555.44	612.63	1295.55	295.68	11.84	46.84	1405.10	32.09	10.57	0.00
Forestry and logging	4.17	0.08	133.48	6.99	0.02	0.07	95.67	0.00	381.55	0.00
Commercial fishing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	0.28	0.27	1.10	0.29	0.03	0.03	0.62	0.30	0.02	0.02
Gas	2.56	2.71	4.34	2.23	0.71	6.67	4.98	2.09	1.24	0.28
LNG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron ores	0.03	0.04	0.13	0.03	0.00	0.01	0.06	0.09	0.00	0.01
Non-ferrous metal ores	1.07	0.94	4.01	1.14	0.13	0.07	2.44	0.39	0.06	0.01
Other mining	0.04	0.06	0.08	0.03	0.02	0.03	0.50	0.02	0.00	0.00
Services to mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Meat and meat products	1.22	0.78	10.83	16.71	2.77	12.27	11.05	8.39	0.14	4.55
Dairy products	5.76	1.32	47.85	64.06	34.55	25.38	14.81	1.41	0.26	8.64
Fruit and vegetable products	0.49	0.98	1.07	0.74	0.51	0.48	1.25	0.45	0.17	0.46
Oils and fats	1.67	0.35	7.66	6.88	8.39	5.10	4.16	0.31	0.12	1.86
Flour mill products and cereal foods	7.86	2.93	39.92	57.05	25.76	43.30	12.99	1.81	4.31	25.16
Bakery products	0.32	0.91	0.59	0.31	0.05	0.61	1.44	0.41	0.36	0.63
Confectionery	2.47	0.70	20.51	43.20	7.62	30.55	19.36	14.31	0.12	11.03
Other food products	26.80	3.52	199.02	379.30	65.82	275.07	108.87	67.11	0.45	98.05
Soft drinks, cordials and syrups	0.63	2.30	1.04	0.89	0.05	0.11	3.33	0.42	0.04	0.12
Beer and malt	0.40	1.16	0.61	0.51	0.07	0.07	0.51	0.30	0.09	0.17
Wine, spirits and tobacco products	3.90	1.30	34.84	4.61	0.71	0.55	15.33	3.88	2.74	5.34
Textile fibres, yarns and woven fabrics	0.20	0.64	0.45	0.21	0.06	0.09	1.00	0.28	0.13	0.34

Table B.1(a) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Sheep	Grains	Beef cattle	Dairy cattle	Pigs	Poultry	Other agriculture	Services to agriculture, hunting and trapping	Forestry and logging	Commercial fishing
Textile products	0.27	0.57	0.73	0.13	0.03	0.11	0.73	0.17	0.27	1.24
Knitting mill products	0.18	0.49	0.42	0.14	0.04	0.07	0.50	0.16	0.16	0.91
Clothing	0.88	2.27	1.66	1.91	0.13	0.32	2.66	0.81	0.94	1.72
Footwear	0.14	0.36	0.24	0.31	0.04	0.08	0.45	0.16	0.23	0.32
Leather and leather products	0.25	0.57	0.97	1.44	0.24	1.03	1.32	0.24	0.15	0.67
Sawmill products	0.95	0.71	0.94	0.73	0.18	0.12	0.82	0.36	0.22	0.42
Other wood products	1.08	1.61	1.77	0.75	0.47	0.73	1.95	1.13	3.42	9.37
Pulp, paper and paperboard	0.21	0.45	0.40	0.13	0.09	0.29	2.43	0.19	0.18	0.18
Paper containers and products	0.67	1.09	1.08	0.24	0.12	6.29	18.56	0.25	0.21	0.30
Printing and services to printing	1.17	3.55	12.87	0.71	0.34	0.17	10.47	1.24	0.69	0.93
Publishing, recorded media, etc.	2.18	6.47	5.55	1.67	0.20	0.33	6.84	0.78	0.81	0.87
Petroleum and coal products	91.55	138.70	61.52	43.43	3.65	17.52	193.32	8.72	33.48	82.31
Basic chemicals	93.73	263.20	226.97	66.85	4.32	4.86	557.99	63.41	2.47	3.19
Paints	1.15	2.24	4.33	0.66	0.33	0.67	3.91	1.15	0.75	3.30
Medicinal and pharmaceutical products, pesticides	30.50	38.54	81.04	25.36	3.29	6.01	80.92	20.16	6.45	0.52
Soap and detergents	0.59	1.31	0.67	0.14	0.06	0.10	1.57	1.78	0.54	0.28
Cosmetics and toiletry preparations	0.15	0.21	0.35	0.12	0.02	0.04	0.35	0.10	0.05	0.03
Other chemical products	1.95	7.03	12.74	1.73	0.91	0.39	3.21	0.90	2.89	0.85
Rubber products	0.59	2.90	0.85	0.26	0.05	0.10	7.98	0.17	0.16	0.87
Plastic products	2.10	3.07	2.21	2.09	0.27	5.51	26.56	1.32	1.01	10.00
Glass and glass products	0.86	1.28	0.83	0.18	0.03	0.11	1.04	0.25	0.37	0.65
Ceramic products	0.04	0.12	0.08	0.04	0.01	0.02	0.60	0.07	0.24	0.52
Cement, lime and concrete slurry	0.19	0.53	0.35	0.17	0.05	0.11	0.62	0.23	6.75	0.96
Plaster and other concrete products	0.20	0.39	0.37	0.15	0.09	0.14	0.44	0.16	4.24	0.84
Other non-metallic mineral products	0.20	0.72	0.28	0.09	0.02	0.02	2.26	0.09	2.49	1.25
Iron and steel	0.76	1.92	2.51	1.10	0.21	0.46	35.39	0.68	2.21	4.07
Basic non-ferrous metal and products	1.40	3.34	2.60	1.13	0.38	0.94	6.49	1.35	0.95	2.55
Structural metal products	1.39	3.70	4.32	1.92	0.55	2.12	36.34	1.28	6.03	13.18
Sheet metal products	0.71	2.25	1.10	1.35	0.12	0.51	8.94	0.25	0.80	3.05
Fabricated metal products	11.57	9.52	7.27	1.48	0.49	1.62	26.11	0.86	9.47	18.76
Motor vehicles and parts, other transport equipment	3.43	7.64	5.95	2.28	1.34	1.86	7.00	1.97	4.09	10.82
Ships and boats	0.21	0.37	0.40	0.16	0.08	0.14	0.32	0.68	0.35	27.97
Railway equipment	0.10	0.21	0.20	0.09	0.03	0.06	0.20	0.08	0.12	0.29

Table B.1(a) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Sheep	Grains	Beef cattle	Dairy cattle	Pigs	Poultry	Other agriculture	Services to agriculture, hunting and trapping	Forestry and logging	Commercial fishing
Aircraft	0.50	1.63	1.08	0.19	0.03	0.02	0.92	5.86	0.22	0.21
Photographic and scientific equipment	1.38	1.40	3.96	2.47	0.16	0.27	2.74	0.67	0.60	2.83
Electronic equipment	0.93	4.53	2.31	1.29	0.23	0.51	1.84	0.61	1.68	4.20
Household appliances	0.51	1.52	2.49	1.11	0.13	0.23	2.09	0.60	0.58	2.31
Other electrical equipment	1.17	2.31	4.21	1.72	0.44	0.69	4.74	1.07	4.97	9.83
Agricultural, mining, etc. machinery	5.53	44.16	14.67	3.79	0.74	2.85	12.72	1.89	9.33	13.23
Other machinery and equipment	2.04	6.54	4.21	2.07	0.42	0.79	26.54	1.35	11.87	20.01
Prefabricated buildings	0.07	0.21	0.16	0.07	0.01	0.04	0.31	0.09	0.20	0.16
Furniture	0.63	1.41	0.92	0.45	0.11	0.26	2.83	0.70	0.94	3.28
Other manufacturing	2.08	4.30	5.27	6.29	1.12	4.10	11.63	0.90	1.32	6.63
Electricity supply	10.55	21.13	49.89	28.06	4.27	13.19	36.49	3.04	1.14	4.92
Gas supply	1.89	2.12	2.43	1.37	0.65	0.83	2.76	1.46	0.07	0.24
Water supply, sewerage and drainage services	14.08	218.43	132.27	87.66	22.22	24.67	160.91	4.23	0.74	2.34
Residential building	3.14	5.66	12.95	2.90	0.98	1.80	6.26	7.46	0.92	0.78
Other construction	9.67	15.68	34.82	9.65	2.05	4.11	14.92	10.50	1.71	1.06
Construction trade services	70.44	73.77	130.75	41.79	35.60	58.35	60.89	23.77	10.08	10.21
Wholesale trade	244.23	673.79	345.56	163.55	28.07	68.28	658.64	206.46	118.43	193.82
Wholesale mechanical repairs	14.22	47.95	22.30	11.29	1.57	1.78	19.10	0.22	24.73	6.42
Other wholesale repairs	4.70	33.98	15.64	4.75	0.33	2.18	12.51	1.01	2.37	17.89
Retail trade	15.84	42.37	27.49	9.11	1.79	4.53	51.27	14.81	12.29	15.43
Retail mechanical repairs	56.64	54.78	85.84	28.03	1.99	7.60	82.55	3.38	61.81	41.48
Other retail repairs	2.24	1.15	4.09	1.34	1.22	1.87	1.67	0.71	0.00	0.00
Accommodation, cafes and restaurants	19.05	36.23	30.64	12.01	0.21	1.20	38.72	0.82	1.95	6.89
Road transport	119.31	418.02	299.53	173.54	28.86	74.05	280.38	64.63	23.19	36.93
Rail, pipeline and other transport	4.88	18.24	5.65	2.37	0.80	1.44	4.40	1.92	0.30	0.28
Water transport	0.38	0.61	0.08	0.02	0.02	0.02	0.44	0.04	0.13	6.35
Air and space transport	4.38	4.54	11.79	3.01	0.49	0.54	9.35	6.36	0.65	1.46
Services to transport, storage	28.65	233.79	52.43	12.99	2.77	43.73	38.93	0.55	2.37	12.67
Communication services	45.20	45.85	93.11	20.87	5.61	9.36	46.04	4.14	3.88	6.87
Finance	117.26	344.08	258.25	93.21	15.26	43.71	345.73	56.95	39.53	79.69
Ownership of dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other property services	41.04	100.35	104.40	21.11	4.63	10.92	61.60	96.31	3.89	4.68
Scientific research, technical and computer services	21.93	68.65	109.25	6.27	2.01	2.08	114.97	8.49	0.39	0.84

Table B.1(a) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Sheep	Grains	Beef cattle	Dairy cattle	Pigs	Poultry	Other agriculture	Services to agriculture, hunting and trapping	Forestry and logging	Commercial fishing
Legal, accounting, marketing and business management services	99.12	160.64	212.32	40.35	29.62	28.86	104.69	15.28	1.72	9.14
Other business services	4.14	10.81	41.27	0.04	0.01	0.50	5.69	0.38	1.80	2.88
Government administration	3.75	5.03	3.55	0.41	0.06	0.20	9.21	0.73	1.25	3.69
Defence	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Education	0.40	2.58	2.79	0.53	0.11	0.70	4.09	0.83	0.28	1.90
Health services	1.65	0.01	21.78	8.45	0.61	2.68	0.97	2.43	0.16	1.01
Community services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motion picture, radio and television services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.55	0.86	0.00
Libraries, museums and the arts	0.57	0.80	12.64	0.07	0.01	0.02	0.31	0.08	7.27	0.12
Sport, gambling and recreational services	14.31	0.09	14.59	7.06	0.86	0.01	0.12	0.01	0.01	0.02
Personal services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	1.97
Other services	0.06	0.36	0.35	0.02	0.00	0.05	0.12	0.01	0.00	0.00
Total intermediate usage including imports	**2342**	**5978**	**5544**	**2265**	**450**	**1040**	**6109**	**2085**	**1024**	**1250**
Wages and salaries	541	466	914	439	131	163	2168	843	657	326
Gross surplus	1968	3614	4137	1699	390	847	5741	2200	517	560
Indirect taxes on production	185	393	267	179	29	50	407	117	63	114
Total gross output	**5035**	**10451**	**10861**	**4582**	**1000**	**2101**	**14424**	**5244**	**2262**	**2250**
Value added at factor cost to output ratio	0.53	0.43	0.49	0.51	0.55	0.50	0.58	0.60	0.55	0.44
Share of wages and mixed income in value added	0.81	0.76	0.82	0.82	0.84	0.80	0.79	0.77	0.80	0.68
Employment to gross output ratio	16.64	8.63	14.25	13.27	23.95	9.01	9.46	7.25	7.13	6.58
Foreign ownership ratio	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Direct tax rate on surplus	0.01	0.01	0.01	0.01	0.08	0.09	0.02	0.06	0.06	0.06
Indirect tax rate on production	0.06	0.08	0.04	0.07	0.04	0.04	0.04	0.03	0.04	0.11
Foreign income payout ratio	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Replacement depreciation to value added ratio	0.08	0.07	0.18	0.05	0.12	0.13	0.08	0.06	0.13	0.13
Net national product ratio	0.91	0.92	0.81	0.94	0.87	0.86	0.91	0.93	0.86	0.86
Domestic income distribution ratio	0.17	0.20	0.16	0.16	0.14	0.17	0.19	0.20	0.16	0.25

Table B.1(b) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Coal	Gas	LNG	Oil	Iron ores	Non-ferrous metal ores	Other mining	Services to mining	Meat and meat products	Dairy products
Sheep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1575.79	0.00
Grains	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beef cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7479.29	0.00
Dairy cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4062.56
Pigs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	651.23	0.00
Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1165.84	0.00
Other agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	16.01
Services to agriculture, hunting and trapping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forestry and logging	41.01	7.77	2.99	7.53	0.11	60.12	1.00	0.00	0.00	0.00
Commercial fishing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	150.92	30.29	11.64	29.36	9.67	19.88	0.52	0.07	0.89	0.79
Gas	12.69	215.70	77.95	49.97	35.18	19.79	1.67	2.00	37.95	58.04
LNG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	299.82	0.00	0.00	0.00	0.00	0.00	0.00
Iron ores	1.35	0.30	0.12	0.29	804.22	0.74	0.14	0.08	0.15	0.03
Non-ferrous metal ores	16.35	3.22	1.24	3.12	55.08	1108.46	5.87	16.40	0.43	0.08
Other mining	31.61	1.99	0.77	1.93	4.23	6.85	687.19	0.03	0.07	0.01
Services to mining	3243.55	622.23	239.13	603.08	4941.65	4236.04	38.20	147.94	0.00	0.00
Meat and meat products	2.44	0.42	0.16	0.41	1.57	1.97	0.12	0.64	1320.25	13.31
Dairy products	1.81	0.30	0.11	0.29	16.44	1.46	0.10	0.59	13.06	1983.16
Fruit and vegetable products	3.05	0.46	0.18	0.45	1.77	2.79	0.18	0.97	15.34	23.80
Oils and fats	1.20	0.18	0.07	0.18	0.61	1.11	0.06	0.42	3.03	11.30
Flour mill products and cereal foods	2.67	0.43	0.16	0.42	1.66	2.32	0.14	0.73	24.60	25.99
Bakery products	11.19	0.98	0.38	0.95	9.70	7.78	0.55	9.58	17.24	69.52
Confectionery	1.91	0.31	0.12	0.30	1.09	1.67	0.10	0.49	2.43	162.09
Other food products	8.22	1.43	0.55	1.39	8.55	6.93	0.61	2.34	62.32	154.13
Soft drinks, cordials and syrups	0.81	0.17	0.07	0.16	1.46	0.62	0.07	0.14	5.16	9.04
Beer and malt	3.35	0.77	0.30	0.75	6.29	7.01	0.20	0.89	0.75	4.96
Wine, spirits and tobacco products	6.11	2.67	1.03	2.59	6.92	6.10	0.43	1.20	20.50	2.34
Textile fibres, yarns and woven fabrics	3.00	0.45	0.17	0.44	3.36	2.35	0.16	1.02	0.59	2.59
Textile products	4.23	1.05	0.40	1.02	3.09	3.38	0.09	0.74	1.10	7.38
Knitting mill products	1.94	0.40	0.15	0.39	2.73	1.50	0.14	0.29	0.37	0.97
Clothing	12.11	2.01	0.77	1.95	5.19	10.11	0.47	1.35	2.67	6.60

Table B.1(b) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Coal	Gas	LNG	Oil	Iron ores	Non-ferrous metal ores	Other mining	Services to mining	Meat and meat products	Dairy products
Footwear	1.59	0.30	0.12	0.29	1.22	1.31	0.10	0.23	0.51	1.32
Leather and leather products	1.68	0.30	0.11	0.29	1.09	1.49	0.10	0.37	3.18	1.36
Sawmill products	7.21	1.20	0.46	1.16	3.24	3.17	0.15	0.70	0.79	1.60
Other wood products	45.06	9.02	3.47	8.74	38.76	30.52	1.83	4.59	1.76	9.42
Pulp, paper and paperboard	4.62	0.84	0.32	0.82	2.14	3.26	0.13	18.01	15.65	37.75
Paper containers and products	7.43	1.75	0.67	1.70	5.51	5.01	0.31	3.10	97.82	201.03
Printing and services to printing	42.11	10.63	4.09	10.31	16.72	26.74	2.34	24.95	11.38	34.98
Publishing, recorded media, etc.	17.68	5.35	2.06	5.19	6.92	13.45	0.52	9.91	3.64	11.51
Petroleum and coal products	537.32	47.85	18.39	46.38	293.63	524.75	25.50	159.67	13.20	62.35
Basic chemicals	116.48	20.45	7.86	19.82	57.52	140.73	4.45	17.00	8.64	44.15
Paints	7.93	1.46	0.56	1.41	5.00	6.73	0.23	1.05	0.30	1.14
Medicinal and pharmaceutical products, pesticides	13.72	3.09	1.19	2.99	6.13	12.85	0.45	3.45	2.67	6.70
Soap and detergents	5.00	0.64	0.24	0.62	3.72	6.47	0.20	1.37	3.41	11.10
Cosmetics and toiletry preparations	0.59	0.16	0.06	0.15	1.13	0.39	0.05	0.10	0.16	0.45
Other chemical products	259.85	43.36	16.67	42.03	144.63	142.80	10.53	3.50	0.96	4.31
Rubber products	36.17	6.30	2.42	6.10	7.49	29.41	1.01	2.19	0.18	0.46
Plastic products	33.95	6.02	2.31	5.84	16.80	32.65	1.16	10.20	23.31	503.84
Glass and glass products	17.17	2.26	0.87	2.20	13.10	13.08	0.50	4.56	0.43	0.68
Ceramic products	2.14	0.25	0.10	0.24	1.46	4.15	0.15	1.65	0.18	1.47
Cement, lime and concrete slurry	15.39	3.13	1.20	3.04	14.24	31.92	0.80	20.99	0.56	1.62
Plaster and other concrete products	15.00	1.98	0.76	1.92	14.91	18.14	0.28	2.72	0.26	1.13
Other non-metallic mineral products	13.54	4.02	1.54	3.89	15.59	8.21	0.63	4.59	0.17	0.95
Iron and steel	289.72	47.23	18.15	45.77	182.16	156.23	5.20	257.88	1.57	5.78
Basic non-ferrous metal and products	66.79	24.27	9.33	23.53	86.94	78.09	4.24	25.55	3.11	27.85
Structural metal products	223.84	45.85	17.62	44.44	217.37	259.69	8.55	175.22	1.29	3.41
Sheet metal products	48.38	8.77	3.37	8.50	24.99	56.76	1.06	17.95	2.75	134.96
Fabricated metal products	224.89	46.10	17.72	44.68	108.22	159.01	7.40	34.13	5.09	8.81
Motor vehicles and parts, other transport equipment	75.23	16.94	6.51	16.42	47.72	57.85	5.26	18.40	3.39	9.02
Ships and boats	10.01	1.89	0.73	1.83	9.32	6.03	0.38	1.93	1.58	1.00
Railway equipment	13.92	4.83	1.85	4.68	4.55	2.23	0.26	0.26	0.20	0.39
Aircraft	147.12	27.85	10.70	26.99	15.03	8.71	2.38	16.06	0.10	0.69
Photographic and scientific equipment	26.28	5.97	2.29	5.78	14.45	18.45	0.86	3.19	1.28	7.04
Electronic equipment	11.94	5.30	2.04	5.14	16.43	10.19	0.61	8.83	1.41	7.74

Table B.1(b) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Coal	Gas	LNG	Oil	Iron ores	Non-ferrous metal ores	Other mining	Services to mining	Meat and meat products	Dairy products
Household appliances	17.61	5.55	2.13	5.38	7.82	13.58	1.12	4.44	0.81	4.37
Other electrical equipment	58.14	11.45	4.40	11.10	34.89	38.15	3.04	5.61	3.63	21.19
Agricultural, mining, etc. machinery	287.42	51.61	19.84	50.03	118.37	259.25	18.44	11.49	1.56	7.78
Other machinery and equipment	215.63	34.76	13.36	33.69	95.87	196.27	10.31	26.31	8.81	16.57
Prefabricated buildings	132.33	32.96	12.67	31.95	82.80	92.89	8.32	2.66	0.24	0.53
Furniture	21.86	4.28	1.64	4.15	16.11	18.75	0.97	4.09	1.60	5.18
Other manufacturing	38.29	8.53	3.28	8.27	39.40	39.55	1.94	11.30	9.26	29.74
Electricity supply	410.33	79.29	30.47	76.85	224.80	481.93	2.50	4.01	130.75	193.52
Gas supply	6.83	1.50	0.58	1.46	19.79	14.87	0.35	0.03	2.32	4.22
Water supply, sewerage and drainage services	70.33	8.70	3.34	8.43	275.95	179.62	13.38	1.85	28.91	32.02
Residential building	99.82	24.67	9.48	23.91	211.46	77.86	18.28	44.79	4.57	3.00
Other construction	274.01	59.39	22.82	57.56	842.41	194.27	85.23	60.64	6.18	4.05
Construction trade services	1221.53	304.97	117.20	295.59	5167.95	1003.91	192.47	326.54	15.09	49.52
Wholesale trade	1677.97	237.85	91.41	230.53	925.22	1582.16	88.21	468.73	383.49	1162.12
Wholesale mechanical repairs	176.85	95.04	36.53	92.12	138.95	67.05	9.24	246.94	9.08	6.96
Other wholesale repairs	454.67	140.62	54.04	136.29	138.12	100.77	15.69	157.33	25.01	8.61
Retail trade	171.55	30.07	11.56	29.14	107.04	107.94	9.37	45.46	212.50	128.82
Retail mechanical repairs	175.58	86.96	33.42	84.28	103.17	146.53	34.47	113.23	18.62	14.28
Other retail repairs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accommodation, cafes and restaurants	124.71	33.37	12.83	32.35	89.35	64.64	7.67	113.50	3.50	2.61
Road transport	405.57	65.09	25.02	63.09	152.81	281.41	49.11	92.31	1064.24	483.67
Rail, pipeline and other transport	1926.32	342.66	131.69	332.12	119.70	55.36	0.52	3.80	11.79	15.80
Water transport	45.69	10.00	3.84	9.69	8.07	21.98	1.75	359.92	1.05	3.44
Air and space transport	93.25	17.14	6.59	16.61	86.89	72.95	4.55	89.98	2.22	1.99
Services to transport, storage	1169.62	225.91	86.82	218.96	231.79	173.66	8.91	98.91	93.79	164.35
Communication services	191.90	49.15	18.89	47.64	74.33	367.76	13.30	127.98	44.48	101.62
Finance	1141.70	295.41	113.53	286.32	723.89	952.44	176.74	327.21	80.25	81.10
Ownership of dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other property services	1721.27	407.16	156.47	394.63	1083.64	533.21	30.22	72.19	338.34	54.20
Scientific research, technical and computer services	165.77	17.00	6.53	16.47	55.03	229.07	3.40	3668.41	39.03	69.18
Legal, accounting, marketing and business management services	1028.24	120.96	46.49	117.24	302.53	844.39	15.18	312.48	41.33	208.89
Other business services	334.76	36.58	14.06	35.45	106.82	545.69	10.51	314.49	128.55	96.96

Table B.1(b) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Coal	Gas	LNG	Oil	Iron ores	Non-ferrous metal ores	Other mining	Services to mining	Meat and meat products	Dairy products
Government administration	121.14	24.00	9.22	23.26	175.98	98.03	6.49	13.19	9.75	3.59
Defence	0.11	0.02	0.01	0.02	0.11	0.08	0.00	1.30	0.14	0.13
Education	67.21	18.04	6.93	17.48	33.97	47.21	4.40	34.85	14.91	34.45
Health services	0.03	0.00	0.00	0.00	0.03	0.02	0.00	1.51	29.60	0.11
Community services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motion picture, radio and television services	5.68	2.29	0.88	2.22	20.81	54.46	0.55	18.65	7.15	48.76
Libraries, museums and the arts	0.00	0.00	0.00	0.00	0.05	1.38	0.03	49.17	0.00	0.00
Sport, gambling and recreational services	75.46	52.34	20.11	50.73	8.84	39.30	0.03	94.28	0.00	0.00
Personal services	0.23	0.00	0.00	0.00	0.00	0.00	0.00	6.79	0.00	0.00
Other services	44.27	0.00	0.00	0.00	10.11	11.83	0.11	0.00	3.36	0.38
Total intermediate usage including imports	**23076**	**4822**	**1848**	**4815**	**20960**	**19037**	**1820**	**9326**	**15582**	**11555**
Wages and salaries	4373	1486	211	1225	967	3249	769	5376	3644	1384
Gross surplus	29574	3761	7998	8488	11711	16205	1574	511	134	108
Indirect taxes on production	9	74	28	74	513	599	37	293	451	282
Total gross output	**57032**	**10143**	**10086**	**14601**	**34152**	**39091**	**4200**	**15506**	**19811**	**13329**
Value added at factor cost to output ratio	0.60	0.52	0.82	0.67	0.39	0.51	0.57	0.40	0.21	0.13
Share of wages and mixed income in value added	0.13	0.31	0.05	0.14	0.08	0.17	0.37	0.93	0.92	0.85
Employment to gross output ratio	1.29	0.82	0.19	0.47	0.95	2.10	3.71	6.67	14.71	10.59
Foreign ownership ratio	0.50	0.80	0.70	0.80	0.55	0.60	0.30	0.40	0.45	0.55
Direct tax rate on surplus	0.18	0.21	0.30	0.21	0.25	0.23	0.26	0.22	0.58	0.16
Indirect tax rate on production	-0.01	0.00	0.00	0.00	0.02	0.02	0.01	0.03	0.07	0.09
Foreign income payout ratio	0.36	0.46	0.46	0.50	0.35	0.36	0.15	0.03	0.03	0.07
Replacement depreciation to value added ratio	0.13	0.30	0.24	0.30	0.11	0.26	0.17	0.15	0.13	0.23
Net national product ratio	0.51	0.24	0.29	0.21	0.54	0.38	0.68	0.83	0.84	0.70
Domestic income distribution ratio	0.36	0.11	0.15	0.14	0.28	0.24	0.34	0.04	0.04	0.05

Table B.1(c) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Fruit and vegetable products	Oils and fats	Flour mill products and cereal foods	Bakery products	Confectionery	Other food products	Soft drinks, cordials and syrups	Beer and malt	Wine, spirits and tobacco products	Textile fibres, yarns and woven fabrics
Sheep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	418.17
Grains	12.80	153.60	1693.59	4.85	13.04	598.87	10.87	522.89	74.14	0.00
Beef cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy cattle	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00
Pigs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.00	0.00	0.00	12.44	0.00	3.63	0.00	0.00	0.00	0.00
Other agriculture	573.50	22.99	3.66	40.84	49.84	1567.91	214.38	6.88	583.85	0.01
Services to agriculture, hunting and trapping	0.00	7.13	0.00	0.00	0.00	3.20	0.00	0.00	0.00	21.06
Forestry and logging	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commercial fishing	0.00	25.76	0.63	1.58	0.30	356.64	0.00	0.00	0.00	0.00
Coal	3.55	0.67	4.31	0.56	0.92	8.32	0.04	0.49	0.14	0.38
Gas	21.46	7.47	19.29	15.73	5.25	57.53	26.17	10.15	2.78	0.03
LNG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron ores	0.00	0.00	0.02	0.00	0.00	0.02	0.01	0.00	0.00	0.00
Non-ferrous metal ores	0.01	0.00	0.05	0.01	0.01	0.07	0.02	0.01	0.01	0.00
Other mining	0.01	0.46	0.03	0.29	0.04	169.98	0.00	0.00	0.00	0.00
Services to mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Meat and meat products	34.85	70.59	7.46	362.52	5.93	446.80	0.34	0.92	1.07	0.07
Dairy products	34.16	33.63	132.74	235.56	598.75	170.25	7.65	0.27	4.42	0.03
Fruit and vegetable products	128.50	3.73	27.11	35.38	19.77	38.17	1.51	0.78	7.84	0.04
Oils and fats	6.94	82.49	31.14	31.27	7.98	53.45	0.66	0.14	2.59	0.02
Flour mill products and cereal foods	133.22	19.05	1009.40	526.35	110.04	150.15	2.33	2.18	5.51	0.05
Bakery products	3.88	0.51	6.94	59.80	122.06	103.56	0.39	0.24	1.42	0.04
Confectionery	15.34	2.03	90.71	66.75	99.57	75.05	0.55	0.74	1.82	0.04
Other food products	90.65	71.26	166.24	178.23	183.51	570.49	53.45	13.58	26.97	0.15
Soft drinks, cordials and syrups	33.79	3.48	16.07	11.31	25.99	21.26	1.18	2.96	133.27	0.01
Beer and malt	1.82	0.19	2.86	1.78	3.93	15.37	9.99	234.75	6.81	0.01
Wine, spirits and tobacco products	3.23	1.31	4.26	1.79	79.11	6.21	1.61	1.32	244.34	0.07
Textile fibres, yarns and woven fabrics	0.28	0.52	0.63	1.20	0.36	3.79	0.21	0.15	0.45	4.32
Textile products	0.59	0.36	1.38	0.83	1.41	3.50	0.60	1.29	0.84	2.29
Knitting mill products	0.20	0.11	0.43	0.20	0.13	0.72	0.14	0.11	0.14	3.06
Clothing	1.14	0.80	2.01	1.83	1.09	5.33	0.83	0.68	0.85	0.13

Table B.1(c) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Fruit and vegetable products	Oils and fats	Flour mill products and cereal foods	Bakery products	Confectionery	Other food products	Soft drinks, cordials and syrups	Beer and malt	Wine, spirits and tobacco products	Textile fibres, yarns and woven fabrics
Footwear	0.25	0.14	0.46	0.21	0.29	0.77	0.21	0.16	0.19	0.03
Leather and leather products	0.23	0.16	0.26	0.70	0.24	1.67	0.18	0.18	0.18	0.15
Sawmill products	0.38	0.16	0.63	0.26	0.33	1.00	0.28	0.25	0.40	0.04
Other wood products	2.33	1.05	1.34	0.54	0.58	2.09	4.72	1.17	1.36	0.11
Pulp, paper and paperboard	6.84	2.90	7.94	2.35	7.38	11.63	5.87	6.60	7.99	0.04
Paper containers and products	56.92	20.46	60.93	18.29	36.17	123.75	49.01	41.07	67.57	0.04
Printing and services to printing	3.67	1.41	24.82	4.44	4.21	12.32	5.68	4.77	4.52	1.28
Publishing, recorded media, etc.	1.62	0.45	2.86	1.38	3.39	7.49	1.15	1.55	1.56	0.14
Petroleum and coal products	34.01	3.68	18.87	6.87	3.14	34.42	15.63	6.35	5.13	0.39
Basic chemicals	10.15	9.92	11.82	12.47	9.17	45.74	37.50	2.30	3.68	1.83
Paints	0.16	0.06	0.30	0.20	0.14	1.35	0.15	0.09	0.13	0.03
Medicinal and pharmaceutical products, pesticides	1.17	0.62	1.99	1.03	1.59	4.09	1.15	0.88	2.51	0.15
Soap and detergents	0.26	0.10	0.52	0.32	0.41	1.56	0.35	0.19	0.23	0.18
Cosmetics and toiletry preparations	0.21	0.19	0.16	0.21	0.15	0.51	0.31	0.03	0.03	0.01
Other chemical products	0.39	0.27	0.91	0.49	1.02	1.75	0.70	1.59	0.62	0.07
Rubber products	0.15	0.12	0.33	0.12	0.54	0.67	0.09	0.07	0.09	0.02
Plastic products	82.06	44.77	42.29	35.78	34.92	142.44	189.32	6.47	8.94	0.69
Glass and glass products	100.47	0.71	0.29	0.16	1.26	14.66	98.97	35.95	53.67	0.02
Ceramic products	0.08	0.25	0.19	0.11	0.11	0.45	0.07	0.05	0.09	0.01
Cement, lime and concrete slurry	0.41	0.31	0.70	0.33	0.57	2.36	0.28	0.23	0.27	0.05
Plaster and other concrete products	0.17	0.12	0.26	0.12	0.39	0.83	0.15	0.12	0.15	0.02
Other non-metallic mineral products	0.23	0.29	0.58	0.30	1.24	0.86	0.04	0.03	0.08	0.04
Iron and steel	2.35	0.48	1.84	1.12	0.90	7.58	3.15	3.29	0.51	0.10
Basic non-ferrous metal and products	3.74	1.40	3.34	1.91	4.67	24.99	4.23	2.40	1.17	0.55
Structural metal products	6.55	0.31	0.75	0.35	0.71	4.18	6.43	4.59	3.27	0.06
Sheet metal products	89.94	5.36	4.63	0.90	1.05	30.39	176.01	90.57	3.02	0.03
Fabricated metal products	2.46	0.67	1.86	1.14	3.22	5.69	4.11	4.58	1.63	0.11
Motor vehicles and parts, other transport equipment	1.98	1.01	3.14	1.66	3.04	5.26	4.58	1.91	1.87	0.14
Ships and boats	0.18	0.14	0.71	0.26	0.75	2.57	0.91	0.24	0.25	0.01
Railway equipment	0.09	0.03	0.13	0.06	0.28	0.28	0.08	0.05	0.08	0.01
Aircraft	0.03	0.01	0.08	0.05	0.04	0.13	0.07	0.06	0.06	0.00
Photographic and scientific equipment	0.73	0.39	1.25	0.67	0.54	3.24	0.68	0.61	0.56	0.07
Electronic equipment	0.82	0.45	1.38	0.91	1.70	7.70	20.92	1.94	1.40	0.08

Table B.1(c) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Fruit and vegetable products	Oils and fats	Flour mill products and cereal foods	Bakery products	Confectionery	Other food products	Soft drinks, cordials and syrups	Beer and malt	Wine, spirits and tobacco products	Textile fibres, yarns and woven fabrics
Household appliances	0.49	0.26	0.83	0.40	0.47	1.70	0.32	1.00	0.31	0.04
Other electrical equipment	1.11	0.58	2.81	1.67	2.07	5.12	3.02	2.70	2.23	0.11
Agricultural, mining, etc. machinery	1.13	0.44	1.28	0.63	0.61	2.96	1.04	2.24	0.57	0.08
Other machinery and equipment	5.08	1.15	3.64	4.66	3.44	15.66	14.74	2.45	1.17	0.12
Prefabricated buildings	0.11	0.04	0.17	0.07	0.08	0.32	0.07	0.09	0.10	0.01
Furniture	1.11	0.35	1.17	1.33	3.72	2.56	3.45	0.89	0.56	0.16
Other manufacturing	4.51	7.92	10.19	30.80	8.80	39.44	5.72	3.53	3.83	0.83
Electricity supply	25.55	13.35	67.09	22.19	22.46	74.60	14.75	27.84	7.75	4.56
Gas supply	17.52	6.39	16.22	13.33	3.92	44.98	21.97	8.72	1.54	0.05
Water supply, sewerage and drainage services	14.97	3.53	15.91	3.49	7.89	29.42	6.99	26.34	1.87	4.92
Residential building	1.25	0.98	2.70	1.10	2.29	5.53	1.78	0.70	2.27	0.04
Other construction	1.69	1.32	3.65	1.49	3.09	7.35	2.39	0.94	2.99	0.05
Construction trade services	14.06	13.28	28.53	13.61	33.90	32.89	14.25	11.72	13.02	0.84
Wholesale trade	256.71	87.05	352.17	188.32	181.41	663.59	168.97	148.98	180.63	25.90
Wholesale mechanical repairs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other wholesale repairs	0.52	0.84	5.56	36.21	2.09	24.87	11.47	3.89	2.64	1.20
Retail trade	28.66	7.13	74.95	223.70	161.67	269.10	11.64	9.31	53.03	1.73
Retail mechanical repairs	27.40	13.85	52.14	13.81	17.75	72.46	65.97	11.19	3.51	1.05
Other retail repairs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accommodation, cafes and restaurants	6.22	4.72	15.34	26.09	22.38	66.55	158.16	111.28	80.09	0.34
Road transport	196.62	78.00	379.00	96.47	62.86	535.91	80.28	177.23	67.85	21.73
Rail, pipeline and other transport	8.36	2.12	29.22	5.66	2.17	24.52	7.07	21.73	3.97	2.78
Water transport	1.46	1.97	2.00	0.88	2.02	33.02	1.17	0.53	2.38	0.20
Air and space transport	9.85	5.40	17.88	3.84	5.24	17.40	2.68	2.09	2.97	0.21
Services to transport, storage	15.49	43.50	122.16	42.28	46.19	411.25	133.92	113.20	51.45	1.73
Communication services	12.81	5.59	77.64	13.57	11.80	52.85	26.60	10.13	13.77	1.56
Finance	37.33	29.99	103.52	36.09	19.16	259.28	26.98	129.33	31.77	8.61
Ownership of dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other property services	6.76	4.37	18.42	22.97	5.11	37.14	24.47	3.29	6.25	0.39
Scientific research, technical and computer services	40.07	2.83	50.28	32.61	11.23	149.39	41.25	1.24	28.04	1.24
Legal, accounting, marketing and business management services	34.60	22.22	175.27	26.56	90.05	220.34	64.42	54.79	54.79	2.01
Other business services	122.36	6.77	42.08	35.94	9.25	120.98	49.70	5.45	62.61	0.75

Table B.1(c) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Fruit and vegetable products	Oils and fats	Flour mill products and cereal foods	Bakery products	Confectionery	Other food products	Soft drinks, cordials and syrups	Beer and malt	Wine, spirits and tobacco products	Textile fibres, yarns and woven fabrics
Government administration	0.78	0.89	9.81	2.34	3.87	36.77	14.61	2.84	2.40	0.03
Defence	0.21	0.02	0.29	0.15	0.03	1.13	0.37	0.00	0.13	0.00
Education	3.94	4.36	8.35	8.00	6.74	12.70	9.58	6.39	3.40	0.10
Health services	0.10	0.06	0.31	0.21	0.42	0.84	0.87	0.14	4.33	0.00
Community services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motion picture, radio and television services	9.19	0.00	10.63	5.93	18.76	55.10	24.27	5.85	5.50	0.00
Libraries, museums and the arts	0.00	0.00	0.00	0.00	1.57	0.00	0.00	0.23	0.31	0.00
Sport, gambling and recreational services	0.14	0.01	0.04	0.08	0.06	2.33	0.50	0.36	7.06	0.00
Personal services	0.22	0.14	0.33	0.61	0.27	1.35	1.21	0.13	0.12	0.01
Other services	2.20	0.19	4.75	1.01	1.36	3.26	0.68	0.33	1.17	0.00
Total intermediate usage including imports	**2832**	**1291**	**5581**	**3002**	**2710**	**9080**	**2184**	**2011**	**2229**	**558**
Wages and salaries	440	71	578	1135	948	2329	632	442	1352	405
Gross surplus	776	345	442	364	236	821	1401	1407	2827	109
Indirect taxes on production	96	55	133	124	105	292	94	74	384	144
Total gross output	**4144**	**1762**	**6734**	**4625**	**4000**	**12522**	**4312**	**3933**	**6791**	**1216**
Value added at factor cost to output ratio	0.32	0.27	0.17	0.35	0.32	0.27	0.49	0.49	0.67	0.54
Share of wages and mixed income in value added	0.35	0.17	0.54	0.78	0.78	0.73	0.31	0.24	0.31	0.62
Employment to gross output ratio	5.77	4.40	7.08	21.45	6.80	6.26	4.05	3.14	3.71	5.99
Foreign ownership ratio	0.37	0.42	0.43	0.23	0.32	0.10	0.50	0.29	0.15	0.14
Direct tax rate on surplus	0.02	0.01	0.06	0.09	0.07	0.19	0.15	0.15	0.03	0.02
Indirect tax rate on production	0.05	0.09	0.06	0.06	0.06	0.05	0.03	0.03	0.08	0.27
Foreign income payout ratio	0.22	0.31	0.18	0.05	0.06	0.02	0.28	0.18	0.09	0.04
Replacement depreciation to value added ratio	0.13	0.10	0.17	0.22	0.21	0.14	0.13	0.05	0.11	0.09
Net national product ratio	0.65	0.59	0.66	0.74	0.73	0.84	0.59	0.77	0.80	0.87
Domestic income distribution ratio	0.38	0.42	0.23	0.15	0.13	0.21	0.28	0.43	0.52	0.24

Table B.1(d) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Textile products	Knitting mill products	Clothing	Footwear	Leather and leather products	Sawmill products	Other wood products	Pulp, paper and paperboard	Paper containers and products	Printing and services to printing
Sheep	0.01	0.00	0.08	0.00	41.29	0.00	0.00	0.00	0.00	0.00
Grains	0.02	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00
Beef cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pigs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other agriculture	1.93	0.07	0.22	0.14	6.11	0.00	0.00	0.00	0.00	0.61
Services to agriculture, hunting and trapping	0.28	8.99	3.91	0.04	42.09	0.00	0.00	0.00	0.00	0.00
Forestry and logging	0.00	0.00	0.00	0.00	0.00	747.20	164.62	74.11	13.12	3.76
Commercial fishing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	9.00	0.43	0.01	0.00	0.01	0.21	1.70	2.02	1.50	0.38
Gas	7.69	1.01	0.86	0.42	0.22	12.29	21.49	34.76	39.60	14.18
LNG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron ores	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.01	0.02	0.08
Non-ferrous metal ores	0.01	0.01	0.01	0.00	0.01	1.12	0.36	0.02	0.07	0.26
Other mining	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.01	0.03
Services to mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Meat and meat products	12.93	0.11	18.95	0.02	325.32	0.27	0.47	0.09	0.21	0.70
Dairy products	0.07	0.07	0.11	0.03	0.05	0.24	0.37	0.06	0.17	0.41
Fruit and vegetable products	0.14	0.09	0.26	0.03	1.71	0.26	0.42	0.08	0.19	0.63
Oils and fats	0.08	0.04	0.06	0.01	0.02	0.13	0.16	0.06	0.07	0.30
Flour mill products and cereal foods	0.10	0.11	0.19	0.04	0.08	0.34	0.51	0.09	0.25	0.78
Bakery products	0.08	0.09	0.16	0.03	0.07	0.24	0.41	0.07	0.18	0.62
Confectionery	0.07	0.08	0.14	0.03	0.06	0.22	0.37	0.06	0.16	0.55
Other food products	0.94	0.25	0.75	0.13	4.19	1.16	2.55	0.37	0.81	2.03
Soft drinks, cordials and syrups	0.08	0.02	0.03	0.01	0.01	0.07	0.10	0.14	0.23	2.15
Beer and malt	0.07	0.06	0.03	0.01	0.01	0.32	0.24	0.04	0.12	0.49
Wine, spirits and tobacco products	0.51	0.43	0.05	0.01	0.02	1.31	1.79	0.31	0.44	4.40
Textile fibres, yarns and woven fabrics	22.20	14.29	20.17	0.65	0.34	0.23	0.71	0.06	1.06	2.29
Textile products	3.07	6.05	11.20	0.22	0.51	0.26	3.53	0.05	1.12	1.55
Knitting mill products	7.17	45.85	39.29	0.14	0.11	0.17	0.24	0.04	1.52	0.86
Clothing	1.38	3.37	37.10	3.23	3.23	0.81	1.49	0.20	0.69	6.20

Table B.1(d) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Textile products	Knitting mill products	Clothing	Footwear	Leather and leather products	Sawmill products	Other wood products	Pulp, paper and paperboard	Paper containers and products	Printing and services to printing
Footwear	0.10	0.12	3.21	11.62	2.69	0.23	0.41	0.04	0.12	0.99
Leather and leather products	2.02	0.58	5.40	8.52	77.73	0.30	0.31	0.06	0.20	0.56
Sawmill products	0.16	0.12	0.18	0.08	0.11	318.93	539.16	25.54	1.34	1.04
Other wood products	1.24	0.34	1.91	0.24	0.39	38.14	397.97	0.68	1.80	15.12
Pulp, paper and paperboard	0.51	0.35	0.61	0.21	0.06	4.88	4.98	5.40	28.76	148.32
Paper containers and products	0.73	2.52	3.16	0.91	0.28	4.85	6.75	1.81	71.55	69.79
Printing and services to printing	23.16	24.62	10.76	0.88	0.74	7.45	17.03	6.35	35.87	373.65
Publishing, recorded media, etc.	0.93	0.84	10.90	0.28	2.44	1.94	10.72	19.85	34.30	43.88
Petroleum and coal products	1.89	0.36	0.60	0.12	0.22	11.84	8.63	5.93	2.31	10.66
Basic chemicals	17.21	25.93	4.83	0.89	5.79	22.06	47.29	15.10	63.39	126.17
Paints	0.19	0.25	0.10	0.04	0.06	1.18	19.87	0.21	1.55	5.27
Medicinal and pharmaceutical products, pesticides	0.95	0.56	0.78	0.58	0.56	4.80	4.15	3.59	3.96	7.58
Soap and detergents	1.34	0.11	0.13	0.05	0.12	2.02	1.68	1.29	2.14	4.85
Cosmetics and toiletry preparations	0.03	0.01	0.02	0.01	0.01	0.13	0.09	0.04	0.09	0.08
Other chemical products	6.00	0.44	0.28	1.50	0.29	6.15	64.21	2.09	13.11	79.28
Rubber products	0.31	0.02	0.10	0.39	0.04	0.16	0.85	0.22	2.03	4.73
Plastic products	14.14	9.45	4.81	1.67	0.93	4.73	26.62	2.35	31.08	265.05
Glass and glass products	1.59	0.07	4.21	1.59	0.55	7.69	15.00	0.08	1.15	3.48
Ceramic products	0.08	0.02	0.18	0.08	0.02	0.17	0.62	0.55	0.86	0.48
Cement, lime and concrete slurry	0.15	0.17	0.18	0.08	0.08	1.74	1.88	0.42	0.98	1.00
Plaster and other concrete products	0.08	0.05	0.10	0.05	0.04	0.92	29.72	0.46	0.79	1.97
Other non-metallic mineral products	0.44	0.21	0.05	0.01	0.01	2.47	5.53	0.72	0.64	0.99
Iron and steel	1.66	0.43	0.29	0.15	0.15	3.93	41.36	2.48	2.66	6.72
Basic non-ferrous metal and products	5.84	2.62	1.34	0.77	0.77	13.21	71.81	2.40	13.28	72.79
Structural metal products	5.47	0.16	0.30	0.06	0.19	1.92	112.06	29.03	0.59	2.47
Sheet metal products	0.42	0.07	0.19	0.06	0.07	0.52	16.76	0.21	1.63	6.76
Fabricated metal products	3.10	7.68	0.51	0.26	0.25	10.98	53.45	6.47	4.73	16.28
Motor vehicles and parts, other transport equipment	0.96	0.39	0.56	0.21	0.23	1.94	9.09	0.54	2.16	8.09
Ships and boats	0.04	0.04	0.05	0.02	0.03	1.20	1.33	0.43	1.29	3.36
Railway equipment	0.02	0.03	0.03	0.01	0.02	0.10	0.17	0.02	0.11	0.25
Aircraft	0.01	0.01	0.02	0.00	0.01	0.03	0.05	0.23	0.18	0.09
Photographic and scientific equipment	0.20	0.14	0.85	0.14	0.18	10.90	12.85	0.34	1.14	12.35
Electronic equipment	0.18	0.20	0.33	0.17	0.20	10.04	11.69	0.34	0.93	8.86

Table B.1(d) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Textile products	Knitting mill products	Clothing	Footwear	Leather and leather products	Sawmill products	Other wood products	Pulp, paper and paperboard	Paper containers and products	Printing and services to printing
Household appliances	0.08	0.09	0.15	0.03	0.07	8.07	9.27	0.09	0.24	6.48
Other electrical equipment	0.43	0.24	0.39	0.09	0.16	10.95	14.51	4.89	4.24	12.69
Agricultural, mining, etc. machinery	0.16	0.17	0.67	0.06	0.14	10.35	13.11	0.16	0.46	8.63
Other machinery and equipment	0.30	0.25	1.18	0.34	0.29	11.64	16.73	4.10	1.10	10.57
Prefabricated buildings	0.14	0.05	0.12	0.04	0.02	0.25	2.36	0.02	0.13	0.30
Furniture	0.79	0.67	1.09	0.31	0.30	0.74	11.01	0.20	0.67	1.60
Other manufacturing	12.83	6.13	37.44	1.00	0.63	5.36	36.53	1.67	11.09	19.99
Electricity supply	10.21	12.10	3.22	1.44	2.02	85.97	130.66	57.67	80.66	109.78
Gas supply	6.23	0.64	0.68	0.12	0.18	6.15	11.92	25.50	31.94	11.61
Water supply, sewerage and drainage services	4.28	11.64	1.12	0.25	1.49	3.29	12.55	11.18	13.54	17.38
Residential building	0.85	0.62	0.18	0.09	0.21	4.79	5.08	0.37	2.70	8.08
Other construction	1.14	0.83	0.24	0.12	0.28	9.05	9.46	0.57	3.90	11.12
Construction trade services	3.57	4.14	2.42	1.29	1.51	63.01	54.18	4.43	14.29	28.23
Wholesale trade	50.85	53.40	98.73	20.51	40.23	226.90	323.00	45.86	117.14	375.61
Wholesale mechanical repairs	0.00	0.00	0.00	0.00	0.00	12.32	8.92	0.70	3.16	0.00
Other wholesale repairs	10.15	3.19	0.82	6.35	4.71	57.68	67.89	6.87	24.56	47.52
Retail trade	9.64	118.90	57.37	2.74	3.24	14.68	25.55	8.39	24.97	69.28
Retail mechanical repairs	15.54	11.50	0.00	8.90	5.31	25.33	14.96	4.27	37.01	147.03
Other retail repairs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accommodation, cafes and restaurants	8.95	7.55	7.30	0.13	3.10	14.68	20.64	2.06	14.21	84.91
Road transport	20.91	17.58	19.76	13.54	52.95	237.59	128.80	36.86	58.35	126.20
Rail, pipeline and other transport	2.14	16.41	0.25	0.49	0.51	8.73	3.08	6.72	5.98	4.82
Water transport	3.11	1.14	2.58	1.09	0.33	8.66	3.05	9.27	10.32	5.49
Air and space transport	2.70	4.94	7.03	0.40	1.02	2.24	9.69	0.50	5.20	79.96
Services to transport, storage	5.36	3.40	21.75	3.52	3.32	279.77	261.89	26.22	217.09	126.76
Communication services	8.58	6.94	8.93	1.96	1.96	30.36	77.84	3.43	16.84	190.35
Finance	20.83	11.03	12.49	2.42	5.80	45.67	75.02	15.47	33.21	167.58
Ownership of dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other property services	2.69	1.93	8.64	1.67	4.18	244.87	190.88	2.13	19.76	153.39
Scientific research, technical and computer services	42.99	24.21	8.26	1.44	5.98	27.55	42.09	1.71	28.75	226.54
Legal, accounting, marketing and business management services	37.53	18.85	19.13	5.26	8.00	98.48	170.73	9.10	174.78	425.72
Other business services	6.66	14.71	31.08	7.57	8.61	103.11	154.47	8.98	93.05	409.15

Table B.1(d) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Textile products	Knitting mill products	Clothing	Footwear	Leather and leather products	Sawmill products	Other wood products	Pulp, paper and paperboard	Paper containers and products	Printing and services to printing
Government administration	0.58	0.60	0.07	0.01	0.06	7.82	7.34	1.47	13.86	34.27
Defence	0.08	0.19	0.03	0.01	0.02	0.11	0.13	0.00	0.12	0.42
Education	1.91	1.35	16.06	0.28	0.79	5.13	9.23	1.56	6.27	26.60
Health services	0.02	0.06	5.31	5.53	0.01	4.79	7.61	0.18	1.73	8.84
Community services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motion picture, radio and television services	0.72	0.18	1.02	0.19	0.00	1.50	31.55	0.00	0.62	1.51
Libraries, museums and the arts	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.76	2.22
Sport, gambling and recreational services	0.03	0.02	0.02	0.00	0.01	0.04	0.06	0.01	0.04	0.25
Personal services	0.39	0.07	0.00	0.00	0.00	0.40	0.32	0.07	0.55	2.26
Other services	0.00	0.00	0.68	0.04	0.20	1.33	1.37	1.75	6.48	9.71
Total intermediate usage including imports	**725**	**740**	**999**	**245**	**728**	**3232**	**4258**	**717**	**2046**	**5934**
Wages and salaries	672	81	732	111	151	448	1626	240	1481	3227
Gross surplus	145	51	418	77	191	768	608	473	610	1743
Indirect taxes on production	51	30	83	16	24	93	120	57	125	251
Total gross output	**1594**	**902**	**2232**	**449**	**1094**	**4542**	**6612**	**1488**	**4262**	**11154**
Value added at factor cost to output ratio	0.54	0.18	0.55	0.45	0.33	0.29	0.36	0.52	0.52	0.47
Share of wages and mixed income in value added	1.01	0.65	0.79	0.64	0.50	0.39	0.87	0.32	0.69	0.69
Employment to gross output ratio	13.65	8.43	17.35	10.39	5.84	7.68	14.87	3.47	7.45	9.88
Foreign ownership ratio	0.03	0.09	0.02	0.15	0.22	0.05	0.15	0.29	0.27	0.05
Direct tax rate on surplus	0.25	0.04	0.08	0.08	0.02	0.06	0.13	0.02	0.03	0.06
Indirect tax rate on production	0.05	0.15	0.06	0.07	0.04	0.04	0.03	0.07	0.05	0.03
Foreign income payout ratio	0.00	0.03	0.00	0.05	0.11	0.02	0.02	0.16	0.08	0.01
Replacement depreciation to value added ratio	0.15	0.09	0.06	0.09	0.06	0.09	0.18	0.54	0.13	0.13
Net national product ratio	0.85	0.89	0.93	0.87	0.83	0.88	0.80	0.29	0.79	0.86
Domestic income distribution ratio	0.00	0.26	0.18	0.27	0.36	0.49	0.10	0.39	0.20	0.27

Table B.1(e) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Publishing, recorded media, etc.	Petroleum and coal products	Basic chemicals	Paints	Medicinal and pharmaceutical products, pesticides	Soap and detergents	Cosmetics and toiletry preparations	Other chemical products	Rubber products	Plastic products
Sheep	0.00	0.00	4.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grains	0.00	0.00	8.95	2.30	90.72	10.00	1.85	5.74	0.01	0.03
Beef cattle	0.00	0.00	23.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pigs	0.00	0.00	2.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.00	0.00	4.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other agriculture	1.98	0.00	0.52	0.68	0.05	0.25	0.04	0.20	3.14	55.40
Services to agriculture, hunting and trapping	0.00	0.00	7.66	3.90	0.00	8.89	5.40	2.86	0.00	0.00
Forestry and logging	0.66	0.00	17.31	0.12	10.12	0.00	1.57	9.86	0.00	0.00
Commercial fishing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	0.10	316.26	101.18	0.01	0.38	0.01	0.01	0.45	0.01	0.12
Gas	4.58	-4821.55	75.97	0.82	8.15	2.17	0.35	5.61	0.30	14.04
LNG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	5844.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron ores	0.02	0.35	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.02
Non-ferrous metal ores	0.10	10.72	118.82	1.20	0.05	0.02	0.00	0.09	0.01	0.11
Other mining	0.01	3.98	75.39	0.03	0.03	0.40	0.07	4.16	0.03	0.14
Services to mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Meat and meat products	0.20	0.47	104.51	6.50	17.95	103.67	6.38	16.42	0.05	0.77
Dairy products	0.12	0.36	9.41	0.19	5.17	2.10	0.79	1.27	0.03	0.65
Fruit and vegetable products	0.17	0.60	2.05	0.18	1.04	0.48	0.12	0.45	0.04	0.68
Oils and fats	0.07	5.05	12.35	3.36	13.17	6.68	1.07	0.92	0.06	0.35
Flour mill products and cereal foods	0.20	0.57	39.21	1.48	3.03	2.69	0.75	3.45	0.05	0.83
Bakery products	0.16	0.44	1.86	0.06	0.57	0.14	0.04	0.19	0.04	0.66
Confectionery	0.14	0.39	2.13	0.08	0.51	0.14	0.04	0.21	0.03	0.59
Other food products	0.73	2.53	39.63	8.03	23.49	15.11	5.40	15.19	0.14	2.37
Soft drinks, cordials and syrups	0.38	0.40	8.32	0.02	0.97	1.41	0.51	2.57	0.01	0.28
Beer and malt	1.69	0.47	0.47	0.04	0.16	0.07	0.02	0.07	0.02	0.27
Wine, spirits and tobacco products	9.72	2.35	10.79	0.48	2.87	0.53	0.17	0.60	0.18	1.14
Textile fibres, yarns and woven fabrics	1.94	0.67	3.77	0.07	1.81	0.11	0.33	0.58	1.03	5.44
Textile products	0.70	0.44	1.81	0.13	0.33	0.31	0.21	0.34	0.16	2.26
Knitting mill products	0.98	0.54	0.66	0.03	0.26	0.07	0.03	0.09	0.02	2.95
Clothing	3.31	1.43	4.49	0.17	1.66	0.49	0.28	0.69	0.73	5.89

Table B.1(e) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Publishing, recorded media, etc.	Petroleum and coal products	Basic chemicals	Paints	Medicinal and pharmaceutical products, pesticides	Soap and detergents	Cosmetics and toiletry preparations	Other chemical products	Rubber products	Plastic products
Footwear	0.40	0.34	0.74	0.05	0.37	0.12	0.03	0.18	0.10	0.76
Leather and leather products	0.13	0.26	0.73	0.07	0.30	0.13	0.04	0.16	0.21	0.74
Sawmill products	1.24	0.83	1.90	0.07	1.11	0.20	0.09	1.34	0.06	1.87
Other wood products	1.56	6.56	17.79	0.56	3.63	2.08	0.47	3.47	0.71	19.22
Pulp, paper and paperboard	176.63	1.64	2.90	0.15	10.87	2.32	0.45	1.27	0.40	8.86
Paper containers and products	8.72	1.20	22.54	2.66	110.93	19.01	3.94	9.79	0.37	28.04
Printing and services to printing	135.08	5.43	18.01	2.06	16.55	2.52	1.31	4.91	1.15	24.69
Publishing, recorded media, etc.	203.77	10.17	31.72	1.88	34.52	1.73	1.65	16.43	3.43	44.21
Petroleum and coal products	10.34	399.46	200.51	14.46	5.59	3.59	2.39	18.96	6.99	29.97
Basic chemicals	4.97	351.43	1388.08	58.61	58.97	94.98	33.06	172.44	23.88	1102.74
Paints	0.21	4.82	45.64	2.58	1.21	0.95	0.14	2.96	0.13	5.58
Medicinal and pharmaceutical products, pesticides	0.29	4.10	710.67	2.07	98.70	2.47	0.60	6.97	1.29	9.31
Soap and detergents	0.14	10.01	35.63	1.77	2.17	3.16	0.70	5.24	0.39	3.65
Cosmetics and toiletry preparations	0.03	0.91	2.64	0.03	0.44	0.04	0.04	0.19	0.02	0.22
Other chemical products	9.13	26.59	81.52	1.60	6.34	2.93	1.77	102.90	0.74	40.42
Rubber products	1.07	1.48	5.63	0.18	0.61	0.09	0.04	0.70	13.79	18.05
Plastic products	11.49	17.83	133.65	4.36	135.75	72.31	24.31	39.88	5.55	259.92
Glass and glass products	0.51	1.65	5.14	0.11	35.39	8.30	0.28	7.18	0.15	14.59
Ceramic products	0.52	0.63	1.12	0.08	1.95	0.22	0.08	1.25	0.02	1.30
Cement, lime and concrete slurry	0.48	5.42	7.03	0.54	1.98	1.76	0.24	2.30	0.28	2.64
Plaster and other concrete products	0.40	1.30	8.10	0.56	0.71	0.17	0.06	0.50	0.17	5.92
Other non-metallic mineral products	0.59	0.46	3.00	1.14	0.84	0.60	0.21	1.02	0.51	6.18
Iron and steel	1.46	3.13	17.51	0.71	3.82	0.90	0.34	2.84	0.72	9.35
Basic non-ferrous metal and products	4.66	55.07	131.31	6.08	12.95	16.92	1.88	12.09	2.99	185.01
Structural metal products	1.00	1.67	6.04	0.95	3.16	0.77	0.13	1.42	0.19	23.38
Sheet metal products	0.87	7.93	14.61	13.98	35.89	1.83	2.17	9.49	0.12	13.24
Fabricated metal products	16.74	3.46	52.10	2.78	24.60	4.51	1.31	14.62	7.68	29.18
Motor vehicles and parts, other transport equipment	1.30	3.18	5.11	0.37	2.85	0.87	0.33	1.35	0.78	9.03
Ships and boats	6.30	4.66	3.65	0.16	0.44	0.29	0.07	0.43	0.04	0.50
Railway equipment	0.09	0.87	0.30	0.01	0.19	0.03	0.02	0.05	0.04	0.87
Aircraft	0.08	0.34	0.10	0.00	0.05	0.01	0.00	0.01	0.00	0.26
Photographic and scientific equipment	13.22	29.51	6.80	0.11	3.31	0.32	0.11	0.51	0.10	2.45
Electronic equipment	10.98	26.58	5.73	0.12	0.98	0.30	0.09	1.26	0.23	1.97

Table B.1(e) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Publishing, recorded media, etc.	Petroleum and coal products	Basic chemicals	Paints	Medicinal and pharmaceutical products, pesticides	Soap and detergents	Cosmetics and toiletry preparations	Other chemical products	Rubber products	Plastic products
Household appliances	8.72	21.70	4.39	0.08	0.91	0.22	0.05	0.28	0.07	2.13
Other electrical equipment	12.74	28.32	9.02	0.21	2.75	0.55	0.18	0.98	4.86	9.36
Agricultural, mining, etc. machinery	11.02	27.82	9.39	0.15	1.97	0.48	0.12	0.72	0.09	1.70
Other machinery and equipment	11.16	28.36	14.38	0.75	4.46	1.37	0.37	2.85	0.37	6.50
Prefabricated buildings	0.08	0.19	0.36	0.01	0.18	0.04	0.01	0.08	0.01	0.54
Furniture	0.66	0.93	2.94	0.16	1.41	0.29	0.09	0.58	0.27	1.78
Other manufacturing	2.55	5.99	17.62	1.09	11.44	4.27	1.64	7.89	0.52	32.11
Electricity supply	21.64	84.85	164.76	2.61	40.78	6.38	3.07	20.08	7.53	154.35
Gas supply	3.68	24.68	41.45	0.59	6.46	1.60	0.23	4.01	0.10	8.72
Water supply, sewerage and drainage services	5.75	62.36	54.44	0.86	16.99	3.20	3.06	20.94	1.52	10.52
Residential building	5.46	39.76	5.17	0.44	5.70	0.76	0.25	0.91	0.90	5.33
Other construction	7.72	164.87	6.97	0.59	7.68	1.02	0.34	1.23	1.22	7.19
Construction trade services	14.56	735.40	32.56	5.16	21.22	10.55	3.16	11.44	8.01	35.76
Wholesale trade	107.35	606.03	845.70	35.16	385.31	80.88	23.92	111.75	23.11	395.23
Wholesale mechanical repairs	0.00	0.00	1.87	0.53	1.01	1.03	0.31	1.12	0.00	0.00
Other wholesale repairs	94.95	2.84	48.42	3.02	4.31	1.71	0.28	1.05	7.00	78.60
Retail trade	51.50	42.31	69.81	2.81	52.62	11.12	2.38	13.11	2.44	45.36
Retail mechanical repairs	76.80	33.13	72.66	4.04	24.56	7.79	1.82	15.81	0.46	23.16
Other retail repairs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accommodation, cafes and restaurants	89.46	131.70	63.86	3.18	76.70	7.31	5.36	20.12	0.65	19.13
Road transport	43.72	126.10	363.08	12.71	160.72	41.78	11.39	51.06	8.02	178.81
Rail, pipeline and other transport	4.66	17.14	25.23	0.42	6.58	1.48	0.37	2.49	0.21	66.14
Water transport	5.22	191.07	16.16	0.16	2.17	0.66	0.29	6.16	1.11	9.22
Air and space transport	55.06	17.51	18.53	1.61	17.28	3.68	1.19	3.17	0.65	10.11
Services to transport, storage	356.83	135.90	383.77	7.33	232.04	10.43	2.87	103.22	4.72	67.35
Communication services	170.76	135.89	50.37	8.69	41.24	7.65	2.16	18.39	3.56	65.56
Finance	295.24	77.38	116.25	5.88	101.67	15.98	4.36	16.14	10.52	79.55
Ownership of dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other property services	553.54	204.32	22.22	5.35	32.66	4.29	2.72	11.95	1.85	42.95
Scientific research, technical and computer services	157.07	23.54	126.68	6.73	340.76	24.98	5.38	14.23	18.84	126.30
Legal, accounting, marketing and business management services	442.18	780.98	317.70	15.51	335.97	10.69	4.32	28.98	21.79	294.02
Other business services	392.91	583.24	134.30	2.75	510.35	38.26	12.74	32.26	109.60	256.18

Table B.1(e) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Publishing, recorded media, etc.	Petroleum and coal products	Basic chemicals	Paints	Medicinal and pharmaceutical products, pesticides	Soap and detergents	Cosmetics and toiletry preparations	Other chemical products	Rubber products	Plastic products
Government administration	114.98	25.43	98.31	5.44	2.85	7.27	1.75	5.60	0.51	9.02
Defence	0.35	0.10	0.77	0.04	1.18	0.09	0.03	0.06	0.10	0.51
Education	8.05	51.17	19.34	2.44	14.48	0.77	1.25	4.75	1.19	14.17
Health services	38.08	1.18	4.83	1.66	76.87	0.16	0.03	0.17	0.10	0.77
Community services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motion picture, radio and television services	113.70	14.89	6.54	4.43	32.56	4.13	9.07	0.00	0.05	11.86
Libraries, museums and the arts	51.32	0.00	0.24	1.11	0.00	14.16	1.14	1.82	0.00	0.00
Sport, gambling and recreational services	9.12	0.17	1.77	0.01	0.22	0.83	0.18	0.06	1.76	1.96
Personal services	8.33	0.00	0.75	0.15	0.53	0.11	0.08	0.09	0.22	0.87
Other services	9.41	1.47	4.75	0.15	8.76	0.97	0.37	0.88	0.44	4.86
Total intermediate usage including imports	**5559**	**22850**	**8908**	**462**	**4088**	**1019**	**278**	**1488**	**432**	**5880**
Wages and salaries	3639	618	1642	532	1671	261	164	727	374	1963
Gross surplus	2523	2022	1242	82	711	259	115	145	195	776
Indirect taxes on production	369	364	235	34	173	36	21	53	44	192
Total gross output	**12090**	**25854**	**12027**	**1111**	**6644**	**1575**	**578**	**2413**	**1046**	**8810**
Value added at factor cost to output ratio	0.54	0.12	0.26	0.58	0.38	0.35	0.52	0.38	0.59	0.33
Share of wages and mixed income in value added	0.59	0.24	0.56	0.85	0.68	0.49	0.57	0.82	0.63	0.70
Employment to gross output ratio	7.72	2.27	2.67	10.14	8.08	5.80	6.76	9.72	8.69	9.14
Foreign ownership ratio	0.03	0.80	0.50	0.48	0.65	0.60	0.45	0.28	0.90	0.20
Direct tax rate on surplus	0.04	0.02	0.12	0.06	0.41	0.21	0.21	0.34	0.06	0.13
Indirect tax rate on production	0.05	0.02	0.04	0.05	0.05	0.04	0.06	0.04	0.07	0.04
Foreign income payout ratio	0.01	0.58	0.19	0.07	0.16	0.24	0.16	0.04	0.30	0.05
Replacement depreciation to value added ratio	0.01	0.23	0.24	0.14	0.15	0.13	0.15	0.37	0.09	0.20
Net national product ratio	0.98	0.19	0.58	0.79	0.69	0.63	0.70	0.59	0.61	0.75
Domestic income distribution ratio	0.37	0.15	0.19	0.08	0.09	0.16	0.19	0.11	0.03	0.21

Table B.1(f) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Glass and glass products	Ceramic products	Cement, lime and concrete slurry	Plaster and other concrete products	Other non-metallic mineral products	Iron and steel	Basic non-ferrous metal and products	Structural metal products	Sheet metal products	Fabricated metal products
Sheep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grains	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beef cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pigs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.21	0.14
Services to agriculture, hunting and trapping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forestry and logging	0.00	0.00	0.00	0.00	0.00	0.65	8.80	0.00	0.00	0.00
Commercial fishing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	0.00	0.00	9.65	0.19	0.00	263.70	8.85	0.54	0.17	3.23
Gas	102.59	97.20	550.65	7.25	22.22	162.42	212.82	8.77	5.21	12.14
LNG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron ores	0.01	0.00	0.04	0.01	0.00	837.81	1.93	30.04	0.03	16.00
Non-ferrous metal ores	0.05	0.00	0.12	72.63	14.97	24.75	25675.69	0.27	0.10	10.53
Other mining	40.68	0.00	683.28	184.78	19.97	582.95	220.53	2.72	0.07	2.67
Services to mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Meat and meat products	0.19	0.00	0.46	0.26	0.03	1.58	1.40	1.11	0.42	0.60
Dairy products	0.11	0.00	0.28	0.15	0.02	0.91	1.17	0.63	0.17	0.51
Fruit and vegetable products	0.19	0.00	0.41	0.23	0.03	1.14	1.25	0.93	0.24	0.47
Oils and fats	0.08	0.00	0.17	0.21	0.01	0.58	0.49	0.34	0.11	0.22
Flour mill products and cereal foods	0.20	0.00	0.50	0.30	0.04	1.42	1.50	1.13	0.29	0.59
Bakery products	0.16	0.00	0.40	0.22	0.02	1.23	1.25	0.92	0.23	0.47
Confectionery	0.14	0.00	0.36	0.20	0.02	1.04	1.09	0.81	0.21	0.41
Other food products	0.49	0.00	1.19	1.26	0.10	3.75	3.29	4.52	1.52	2.41
Soft drinks, cordials and syrups	0.06	0.00	0.10	0.06	0.01	0.36	0.28	0.20	0.06	0.11
Beer and malt	0.08	0.00	0.26	0.09	0.01	0.45	0.34	0.31	0.14	0.18
Wine, spirits and tobacco products	1.10	0.00	2.21	0.95	0.13	1.29	0.92	1.17	0.70	0.87
Textile fibres, yarns and woven fabrics	0.20	0.00	0.28	0.51	0.04	2.55	1.05	1.08	0.65	0.83
Textile products	0.46	0.00	0.72	1.17	0.04	2.40	1.74	7.43	0.34	4.98
Knitting mill products	0.10	0.00	0.19	1.54	0.02	0.97	0.64	0.61	1.29	0.39
Clothing	0.59	0.00	1.14	1.10	0.11	4.06	3.51	5.74	1.86	3.39

Table B.1(f) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Glass and glass products	Ceramic products	Cement, lime and concrete slurry	Plaster and other concrete products	Other non-metallic mineral products	Iron and steel	Basic non-ferrous metal and products	Structural metal products	Sheet metal products	Fabricated metal products
Footwear	0.19	0.00	0.30	0.26	0.03	0.76	0.73	0.71	0.27	0.86
Leather and leather products	1.63	0.00	0.46	0.36	0.06	0.44	0.64	1.04	0.19	4.43
Sawmill products	1.05	0.00	0.47	1.75	0.07	7.58	1.81	91.38	2.25	8.48
Other wood products	9.78	0.00	1.34	4.78	0.34	37.23	8.99	48.45	4.54	22.32
Pulp, paper and paperboard	0.85	0.00	5.03	2.30	0.10	1.96	0.79	1.86	0.44	1.56
Paper containers and products	3.83	0.00	52.97	9.97	0.84	4.12	2.47	5.31	1.24	11.82
Printing and services to printing	4.80	0.00	13.08	10.07	1.09	21.59	9.47	34.81	7.19	16.39
Publishing, recorded media, etc.	1.18	0.00	13.15	4.33	0.33	17.26	10.98	56.89	6.85	9.02
Petroleum and coal products	13.83	5.79	196.84	16.09	8.60	116.62	51.87	33.91	15.22	26.73
Basic chemicals	82.80	0.00	5.64	29.24	11.55	51.37	77.78	58.12	13.67	48.82
Paints	3.53	0.00	0.25	0.88	0.22	36.81	1.34	2.98	3.20	5.93
Medicinal and pharmaceutical products, pesticides	2.33	0.00	0.79	1.57	0.36	6.20	5.39	1.96	1.14	3.52
Soap and detergents	4.13	0.00	0.36	2.26	0.50	3.42	2.06	0.54	0.49	2.15
Cosmetics and toiletry preparations	0.38	0.00	0.05	0.08	0.01	0.32	0.21	0.25	0.04	0.09
Other chemical products	3.57	0.00	2.00	5.55	2.40	11.27	3.04	6.60	1.43	8.14
Rubber products	0.20	0.00	0.09	0.48	0.11	1.75	7.01	1.85	1.51	6.76
Plastic products	12.24	0.00	4.58	10.39	3.54	19.14	18.96	47.13	11.77	16.74
Glass and glass products	309.44	0.00	0.90	1.63	0.81	1.67	2.91	170.33	1.84	8.03
Ceramic products	0.90	0.00	74.46	33.96	1.45	6.29	2.23	7.34	0.17	5.99
Cement, lime and concrete slurry	8.55	0.00	1038.10	481.95	18.61	64.79	42.79	8.56	1.61	5.11
Plaster and other concrete products	9.49	0.00	92.16	112.04	9.88	10.25	6.57	19.57	1.24	1.99
Other non-metallic mineral products	22.40	0.00	20.86	13.75	3.54	5.17	6.06	12.31	2.06	9.35
Iron and steel	20.12	0.00	29.12	71.25	3.04	2416.38	237.64	1992.57	334.37	750.88
Basic non-ferrous metal and products	129.53	0.00	8.90	31.74	2.84	2125.18	15296.53	1395.96	1131.20	955.96
Structural metal products	22.62	0.00	8.62	115.15	14.35	65.54	74.88	1299.37	39.11	258.57
Sheet metal products	0.69	0.00	0.31	3.40	1.31	42.47	12.46	60.17	43.16	22.04
Fabricated metal products	5.86	0.00	3.47	12.61	1.71	117.47	47.28	406.52	64.17	153.78
Motor vehicles and parts, other transport equipment	20.52	0.00	4.03	4.74	1.07	21.71	11.71	18.57	8.25	13.76
Ships and boats	0.66	0.00	3.62	0.74	0.08	2.60	1.14	3.99	0.54	1.87
Railway equipment	0.06	0.00	0.12	0.38	0.02	3.32	0.71	0.41	0.22	0.45
Aircraft	0.04	0.00	0.06	0.05	0.00	0.34	0.19	0.11	0.03	0.05
Photographic and scientific equipment	0.34	0.00	0.85	1.08	0.06	6.67	5.93	2.76	0.88	1.69
Electronic equipment	0.90	0.00	1.16	0.82	0.12	5.26	3.13	18.81	1.76	3.31

Table B.1(f) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Glass and glass products	Ceramic products	Cement, lime and concrete slurry	Plaster and other concrete products	Other non-metallic mineral products	Iron and steel	Basic non-ferrous metal and products	Structural metal products	Sheet metal products	Fabricated metal products
Household appliances	2.42	0.00	0.57	0.50	0.06	2.61	1.92	2.39	0.96	1.40
Other electrical equipment	1.67	0.00	2.73	2.75	0.25	18.56	9.25	21.83	8.12	13.51
Agricultural, mining, etc. machinery	0.65	0.00	5.25	6.38	0.21	15.15	14.28	14.24	1.54	19.84
Other machinery and equipment	3.70	0.00	2.94	10.83	0.50	27.15	42.17	22.37	9.54	13.60
Prefabricated buildings	0.11	0.00	0.22	0.93	0.21	1.31	1.30	38.54	0.63	1.34
Furniture	0.86	0.00	0.93	1.44	0.51	11.75	7.69	13.57	2.58	8.53
Other manufacturing	3.79	0.00	2.53	5.40	1.48	71.17	160.88	27.82	6.45	8.91
Electricity supply	80.90	44.40	204.79	33.97	42.42	995.46	529.79	67.54	26.89	80.18
Gas supply	77.97	74.03	431.96	3.31	14.81	104.62	133.25	6.52	4.08	9.14
Water supply, sewerage and drainage services	7.92	0.00	16.50	9.61	0.80	94.92	20.66	6.46	1.71	5.88
Residential building	1.58	0.00	3.88	1.99	0.14	32.21	11.77	8.28	3.11	3.51
Other construction	2.18	0.00	6.11	2.77	0.19	43.55	15.94	11.18	4.20	4.73
Construction trade services	12.25	0.00	17.65	10.16	1.67	133.17	92.10	32.09	14.03	19.06
Wholesale trade	97.80	0.00	238.06	133.43	15.24	735.32	1176.60	551.40	164.68	290.43
Wholesale mechanical repairs	0.17	0.00	12.99	5.60	0.23	6.29	0.80	0.00	0.00	0.00
Other wholesale repairs	13.48	0.00	92.41	11.09	0.38	53.79	4.93	53.51	17.17	21.53
Retail trade	8.84	0.00	35.61	16.07	1.21	87.69	56.82	54.39	19.77	29.19
Retail mechanical repairs	3.44	0.00	24.00	7.02	0.29	15.88	5.30	15.52	6.74	5.24
Other retail repairs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accommodation, cafes and restaurants	18.38	0.00	36.90	16.33	3.02	48.15	23.82	93.37	25.15	39.18
Road transport	73.46	0.00	564.22	181.37	22.43	620.55	415.74	186.63	48.57	94.16
Rail, pipeline and other transport	27.11	0.00	180.51	4.10	2.20	244.25	307.80	13.20	3.90	9.73
Water transport	2.44	0.00	25.05	5.94	1.51	44.38	220.56	31.51	4.77	8.24
Air and space transport	2.34	0.00	11.48	3.18	0.69	22.74	10.36	20.31	6.55	9.58
Services to transport, storage	30.96	0.00	131.37	56.99	3.37	282.86	148.82	217.46	139.14	130.69
Communication services	17.40	0.00	72.26	63.93	10.18	78.62	23.53	138.63	23.62	69.10
Finance	49.33	0.00	112.88	32.56	7.39	128.52	215.90	129.79	31.38	66.35
Ownership of dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other property services	15.82	0.00	34.83	11.67	0.73	1530.66	476.80	191.93	60.43	101.44
Scientific research, technical and computer services	45.33	0.00	238.43	32.76	2.47	277.10	114.57	218.39	70.27	63.88
Legal, accounting, marketing and business management services	37.71	0.00	107.18	205.19	11.96	163.92	57.77	235.96	77.37	151.19
Other business services	37.22	0.00	210.38	126.04	2.25	247.53	81.02	312.32	76.43	182.20

Table B.1(f) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Glass and glass products	Ceramic products	Cement, lime and concrete slurry	Plaster and other concrete products	Other non-metallic mineral products	Iron and steel	Basic non-ferrous metal and products	Structural metal products	Sheet metal products	Fabricated metal products
Government administration	2.32	0.00	11.23	3.49	0.18	35.22	3.79	12.85	8.37	6.70
Defence	0.16	0.00	0.53	0.16	0.01	0.50	0.26	1.02	0.47	0.31
Education	5.68	0.00	26.22	9.97	0.46	34.30	16.51	24.02	4.27	7.23
Health services	0.19	0.00	0.78	0.31	0.02	0.70	0.38	0.99	0.22	0.30
Community services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motion picture, radio and television services	1.31	0.00	1.22	11.85	0.58	0.94	0.01	9.12	0.29	4.99
Libraries, museums and the arts	0.32	0.00	0.43	0.47	0.00	0.00	0.00	0.00	0.00	0.00
Sport, gambling and recreational services	0.06	0.00	0.11	0.05	0.01	0.14	0.08	0.28	0.07	0.11
Personal services	0.13	0.00	0.33	0.18	0.01	0.94	0.05	0.49	0.32	0.36
Other services	0.52	0.00	2.81	3.09	0.03	2.16	1.07	8.32	2.56	3.51
Total intermediate usage including imports	**2034**	**230**	**6099**	**2622**	**356**	**15381**	**58564**	**10198**	**3063**	**5178**
Wages and salaries	609	507	1330	1254	536	3079	2786	2201	1078	2703
Gross surplus	246	238	483	157	266	2064	3315	1341	464	702
Indirect taxes on production	66	-121	194	83	32	338	945	268	114	195
Total gross output	**2954**	**853**	**8106**	**4115**	**1191**	**20862**	**65611**	**14008**	**4719**	**8777**
Value added at factor cost to output ratio	0.31	0.73	0.25	0.36	0.70	0.26	0.11	0.27	0.35	0.41
Share of wages and mixed income in value added	0.72	0.75	0.71	0.88	0.88	0.61	0.47	0.64	0.74	0.84
Employment to gross output ratio	9.47	8.14	3.93	4.97	12.42	9.00	5.46	6.20	4.50	10.59
Foreign ownership ratio	0.37	0.08	0.42	0.22	0.22	0.25	0.52	0.22	0.32	0.20
Direct tax rate on surplus	0.07	0.14	0.22	0.22	0.05	0.15	0.04	0.18	0.15	0.16
Indirect tax rate on production	0.05	0.07	0.06	0.03	0.03	0.03	0.03	0.04	0.05	0.04
Foreign income payout ratio	0.09	0.02	0.09	0.02	0.03	0.08	0.25	0.07	0.08	0.03
Replacement depreciation to value added ratio	0.27	0.19	0.23	0.14	0.11	0.14	0.32	0.07	0.10	0.08
Net national product ratio	0.63	0.79	0.67	0.84	0.87	0.77	0.43	0.86	0.83	0.89
Domestic income distribution ratio	0.16	0.20	0.13	0.08	0.09	0.25	0.23	0.24	0.16	0.12

Table B.1(g) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Motor vehicles and parts, other transport equipment	Ships and boats	Railway equipment	Aircraft	Photographic and scientific equipment	Electronic equipment	Household appliances	Other electrical equipment	Agricultural, mining, etc. machinery	Other machinery and equipment
Sheep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grains	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beef cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pigs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other agriculture	0.00	0.00	0.00	0.00	0.25	0.04	0.04	0.17	0.00	0.21
Services to agriculture, hunting and trapping	0.00	0.00	0.00	0.00	0.03	1.11	0.00	6.68	0.00	0.00
Forestry and logging	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Commercial fishing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal	1.88	0.06	0.01	0.04	0.21	0.35	0.08	0.09	0.07	1.17
Gas	24.14	4.36	1.41	25.75	6.21	3.26	4.51	4.91	9.62	4.83
LNG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron ores	0.54	0.02	0.00	0.01	0.05	0.10	0.01	0.02	0.02	0.03
Non-ferrous metal ores	1.51	0.05	0.24	0.02	0.62	0.29	3.10	38.76	6.98	0.99
Other mining	0.15	0.06	0.03	0.20	0.35	0.05	0.17	1.61	0.10	0.18
Services to mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Meat and meat products	4.02	0.58	0.14	1.47	0.74	0.65	1.54	0.74	1.05	0.92
Dairy products	5.17	2.00	0.08	1.68	1.26	0.78	1.01	0.66	0.78	1.05
Fruit and vegetable products	3.65	0.88	0.28	1.68	0.55	0.59	0.76	0.58	0.69	1.58
Oils and fats	1.46	0.40	0.06	0.32	0.21	0.21	0.25	0.21	0.25	0.28
Flour mill products and cereal foods	4.18	0.66	0.16	0.89	0.68	0.72	0.84	0.71	0.84	0.92
Bakery products	3.84	0.75	0.13	0.73	0.59	0.68	0.80	0.67	0.81	1.11
Confectionery	3.65	1.05	0.12	0.82	0.48	0.52	0.60	0.51	0.60	0.66
Other food products	9.71	1.90	0.47	2.26	17.70	1.90	2.60	2.06	3.25	3.42
Soft drinks, cordials and syrups	0.71	0.10	0.03	0.17	0.13	0.11	0.12	0.11	0.12	0.14
Beer and malt	0.95	0.16	0.03	4.17	0.11	0.12	0.16	0.15	0.18	0.23
Wine, spirits and tobacco products	1.51	0.61	0.17	2.83	0.96	0.38	0.63	0.49	0.66	0.88
Textile fibres, yarns and woven fabrics	7.82	1.63	0.42	0.74	1.12	0.53	1.32	0.70	1.53	1.48
Textile products	1.76	2.37	0.41	0.73	1.45	1.47	1.44	3.16	1.57	3.13
Knitting mill products	1.78	0.47	0.07	0.35	0.34	0.27	0.34	0.27	0.32	0.35

Table B.1(g) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Motor vehicles and parts, other transport equipment	Ships and boats	Railway equipment	Aircraft	Photographic and scientific equipment	Electronic equipment	Household appliances	Other electrical equipment	Agricultural, mining, etc. machinery	Other machinery and equipment
Clothing	12.80	1.91	0.66	2.25	2.41	1.85	2.93	2.30	3.87	2.25
Footwear	1.80	0.42	0.16	0.86	0.53	0.32	0.43	0.32	0.40	0.46
Leather and leather products	3.18	0.32	0.29	0.48	1.73	0.37	0.52	0.49	0.70	0.39
Sawmill products	5.86	4.58	0.21	0.70	1.32	1.03	1.38	1.65	1.83	1.54
Other wood products	24.60	97.68	2.72	5.61	4.78	2.07	6.75	3.90	8.07	10.59
Pulp, paper and paperboard	2.41	0.81	0.28	1.08	2.13	0.74	2.16	0.76	0.55	1.67
Paper containers and products	12.95	1.51	0.50	3.04	12.77	4.21	20.71	3.78	3.86	4.82
Printing and services to printing	50.86	7.41	1.20	3.84	12.58	6.04	17.92	16.38	24.78	29.08
Publishing, recorded media, etc.	32.09	4.19	0.63	4.08	6.44	15.20	11.66	10.68	10.68	9.64
Petroleum and coal products	27.81	22.80	4.39	5.92	6.61	3.07	6.01	6.28	15.33	28.85
Basic chemicals	124.74	15.74	4.41	6.05	71.67	10.16	51.58	128.17	6.90	11.55
Paints	57.09	14.75	0.55	3.69	1.29	0.55	8.07	1.94	4.29	5.98
Medicinal and pharmaceutical products, pesticides	6.18	0.82	0.22	1.19	2.44	0.92	1.12	0.96	1.03	1.12
Soap and detergents	2.11	0.26	0.16	0.35	0.88	0.23	0.32	0.45	0.30	0.37
Cosmetics and toiletry preparations	0.40	0.08	0.02	0.11	0.06	0.05	0.10	0.06	0.07	0.08
Other chemical products	9.65	1.75	2.04	2.34	13.39	0.79	3.33	1.63	2.80	3.37
Rubber products	31.70	2.38	1.58	0.30	3.66	1.29	6.95	2.53	3.01	10.66
Plastic products	105.54	5.66	5.41	4.57	83.76	30.27	48.17	32.41	20.32	33.64
Glass and glass products	157.23	16.62	6.72	4.84	3.07	1.31	26.92	9.47	7.08	6.73
Ceramic products	2.46	0.18	0.86	0.99	0.83	0.50	1.79	1.94	2.78	1.62
Cement, lime and concrete slurry	11.86	2.05	1.18	2.50	4.50	1.26	10.13	1.39	6.24	12.87
Plaster and other concrete products	6.48	1.98	1.88	2.08	2.57	0.90	1.44	1.66	2.64	3.81
Other non-metallic mineral products	9.03	6.27	3.14	3.23	6.12	1.53	2.44	1.62	3.96	3.32
Iron and steel	948.29	292.57	84.49	14.28	158.91	35.60	586.40	158.45	731.01	881.53
Basic non-ferrous metal and products	537.71	254.17	27.41	73.46	616.39	124.15	142.68	1588.34	93.03	219.09
Structural metal products	79.40	68.70	139.13	5.66	26.86	12.54	27.47	104.41	117.13	243.02
Sheet metal products	88.41	15.79	6.97	38.12	13.27	4.83	97.24	18.68	58.35	105.25
Fabricated metal products	161.52	49.43	20.71	67.42	26.92	14.68	56.20	49.59	76.60	96.91
Motor vehicles and parts, other transport equipment	1240.96	15.20	6.98	41.18	17.34	6.47	27.51	9.68	45.91	18.04
Ships and boats	6.46	10.35	0.49	3.11	0.71	0.42	0.55	0.82	2.39	1.22
Railway equipment	13.22	0.44	322.99	0.40	0.73	0.94	3.39	2.21	1.44	3.39
Aircraft	1.59	1.70	0.03	489.32	0.05	0.05	0.06	0.07	0.39	0.06

Table B.1(g) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Motor vehicles and parts, other transport equipment	Ships and boats	Railway equipment	Aircraft	Photographic and scientific equipment	Electronic equipment	Household appliances	Other electrical equipment	Agricultural, mining, etc. machinery	Other machinery and equipment
Photographic and scientific equipment	9.98	123.04	1.22	15.01	9.09	7.43	14.52	8.85	11.72	10.24
Electronic equipment	16.57	10.64	3.46	24.05	30.63	50.23	26.67	21.99	17.50	24.86
Household appliances	28.78	9.50	1.18	2.80	3.20	2.57	95.48	5.43	8.45	6.61
Other electrical equipment	33.79	14.76	10.17	16.47	69.07	59.28	230.96	255.74	74.23	114.12
Agricultural, mining, etc. machinery	58.58	87.82	8.11	9.96	4.20	6.41	7.18	9.84	47.25	31.18
Other machinery and equipment	84.61	74.84	14.15	15.36	10.12	14.33	40.88	27.46	71.17	83.36
Prefabricated buildings	1.86	1.38	1.63	0.26	0.31	0.28	0.63	1.51	1.43	2.58
Furniture	10.42	30.87	1.22	2.29	1.61	1.94	2.58	2.89	5.19	5.37
Other manufacturing	28.78	12.29	7.04	5.85	9.58	5.36	19.14	12.26	12.24	22.09
Electricity supply	238.06	32.64	13.41	1.60	27.95	116.63	52.53	54.39	67.84	98.40
Gas supply	16.27	2.36	1.15	18.71	3.55	2.88	3.75	3.93	4.66	3.93
Water supply, sewerage and drainage services	40.68	3.17	0.92	0.00	4.26	7.85	9.31	5.34	12.15	18.66
Residential building	19.38	2.50	1.02	0.07	4.84	1.78	2.94	1.63	2.20	2.46
Other construction	26.22	3.39	1.38	0.10	6.54	2.41	3.97	2.21	2.98	3.33
Construction trade services	62.24	37.43	17.35	7.77	47.69	16.13	26.56	17.54	23.10	29.43
Wholesale trade	1976.45	321.92	77.63	422.63	335.53	352.18	407.21	392.76	411.13	448.39
Wholesale mechanical repairs	129.75	0.00	0.00	0.00	0.09	0.07	0.07	0.22	0.59	0.97
Other wholesale repairs	61.14	7.46	0.83	0.00	5.16	4.54	1.78	5.01	44.00	42.61
Retail trade	208.36	22.50	4.85	31.59	41.52	27.29	27.63	27.87	31.23	31.47
Retail mechanical repairs	13.58	3.96	0.07	0.00	1.39	1.15	1.09	3.43	9.31	15.47
Other retail repairs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accommodation, cafes and restaurants	81.73	9.50	2.63	0.00	28.36	21.44	17.06	8.30	18.18	17.31
Road transport	186.29	43.54	12.71	30.17	63.53	30.76	90.79	56.60	74.37	87.08
Rail, pipeline and other transport	18.77	1.63	0.55	4.89	4.01	1.69	4.87	2.85	13.80	28.89
Water transport	6.26	0.44	0.38	0.26	3.56	0.70	3.57	3.40	9.43	7.03
Air and space transport	33.98	6.90	0.32	0.99	13.89	10.51	18.55	14.24	30.57	25.43
Services to transport, storage	276.44	61.10	11.35	2.81	18.45	10.63	16.45	25.22	28.25	50.17
Communication services	137.83	31.82	8.41	0.00	60.22	33.99	67.30	60.93	102.34	165.98
Finance	229.53	29.86	13.91	18.11	38.92	40.23	38.08	42.80	55.57	49.08
Ownership of dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other property services	1179.65	36.93	2.08	13.01	38.31	28.13	20.76	28.56	47.95	70.37
Scientific research, technical and computer services	738.74	19.33	13.09	0.00	155.22	226.63	310.89	165.78	165.05	108.54

Table B.1(g) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Motor vehicles and parts, other transport equipment	Ships and boats	Railway equipment	Aircraft	Photographic and scientific equipment	Electronic equipment	Household appliances	Other electrical equipment	Agricultural, mining, etc. machinery	Other machinery and equipment
Legal, accounting, marketing and business management services	254.06	51.78	7.33	0.00	189.08	33.45	72.99	55.18	93.65	176.05
Other business services	740.23	43.30	1.30	0.00	121.42	87.01	204.31	93.89	197.87	139.98
Government administration	57.69	6.57	0.73	0.00	4.11	1.84	4.91	3.02	6.07	4.29
Defence	0.80	0.03	0.02	0.00	0.30	0.20	0.20	0.10	0.17	0.13
Education	43.85	5.05	1.60	0.00	13.28	12.56	15.67	9.25	17.18	16.36
Health services	29.00	0.65	0.01	0.00	0.36	0.55	0.41	0.40	0.52	0.65
Community services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motion picture, radio and television services	178.76	0.00	0.00	0.00	5.41	1.98	17.85	9.19	3.87	1.85
Libraries, museums and the arts	2.39	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sport, gambling and recreational services	0.24	0.03	0.01	0.00	0.09	0.06	0.05	0.02	0.05	0.05
Personal services	3.64	1.20	0.01	0.00	2.49	2.51	0.46	0.25	0.31	0.45
Other services	17.45	1.59	0.28	0.00	3.04	1.56	3.41	1.26	2.76	2.68
Total intermediate usage including imports	**14123**	**3107**	**1520**	**2799**	**3590**	**2244**	**4368**	**4814**	**4151**	**5181**
Wages and salaries	3199	1020	642	1196	1637	1614	642	1303	1748	2023
Gross surplus	2743	127	22	-31	60	296	441	649	477	589
Indirect taxes on production	532	94	45	119	104	138	110	159	153	147
Total gross output	**20597**	**4349**	**2229**	**4083**	**5390**	**4293**	**5562**	**6925**	**6529**	**7940**
Value added at factor cost to output ratio	0.31	0.29	0.32	0.31	0.33	0.48	0.21	0.30	0.36	0.35
Share of wages and mixed income in value added	0.54	0.96	1.06	1.09	1.03	0.82	0.59	0.67	0.80	0.80
Employment to gross output ratio	11.17	3.67	4.05	4.16	10.70	10.96	8.62	9.89	10.97	10.94
Foreign ownership ratio	0.50	0.40	0.50	0.50	0.30	0.20	0.18	0.13	0.80	0.42
Direct tax rate on surplus	0.07	0.75	0.75	-0.03	1.98	0.42	0.07	0.15	0.31	0.28
Indirect tax rate on production	0.06	0.05	0.04	0.07	0.03	0.06	0.05	0.05	0.04	0.03
Foreign income payout ratio	0.19	0.01	0.00	0.00	0.00	0.03	0.07	0.04	0.14	0.08
Replacement depreciation to value added ratio	0.24	0.07	0.05	0.27	0.12	0.08	0.09	0.07	0.07	0.08
Net national product ratio	0.57	0.91	0.95	0.73	0.88	0.89	0.85	0.89	0.80	0.85
Domestic income distribution ratio	0.19	0.02	0.00	0.00	0.00	0.12	0.31	0.25	0.03	0.11

Table B.1(h) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Pre-fabricated buildings	Furniture	Other manufacturing	Electricity supply	Gas supply	Water supply, sewerage and drainage services	Residential building	Other construction	Construction trade services	Wholesale trade
Sheep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	77.64
Grains	0.05	0.05	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beef cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63.83
Dairy cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.55
Pigs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.55
Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.20
Other agriculture	0.17	0.53	19.27	0.88	0.00	6.51	23.93	93.58	15.49	9.17
Services to agriculture, hunting and trapping	0.00	0.25	34.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forestry and logging	0.03	19.34	0.65	1.90	0.00	0.00	1.61	56.86	6.77	0.00
Commercial fishing	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.18	0.00	0.00
Coal	0.00	0.00	0.00	3017.38	5.90	0.99	2.82	8.51	2.49	10.64
Gas	2.43	7.18	9.06	1797.48	0.00	0.00	2.76	8.63	2.43	3624.98
LNG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron ores	0.00	0.00	0.01	0.93	0.27	0.04	1.22	3.57	1.07	4.06
Non-ferrous metal ores	0.00	0.21	0.03	6.07	0.73	0.60	3.41	11.35	2.98	554.21
Other mining	0.03	0.02	6.24	0.47	0.12	12.02	107.66	336.14	159.21	1.96
Services to mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Meat and meat products	0.10	0.56	7.73	0.93	0.11	2.55	7.36	23.41	8.19	222.65
Dairy products	0.26	1.36	1.43	2.33	0.10	10.10	12.03	21.75	6.20	55.82
Fruit and vegetable products	0.08	0.51	0.50	0.93	0.15	0.78	4.60	8.17	4.10	7.00
Oils and fats	0.03	0.21	0.20	0.72	0.10	1.23	2.96	5.12	2.04	5.53
Flour mill products and cereal foods	0.10	0.62	0.61	1.04	0.12	0.80	4.42	7.35	4.66	4.61
Bakery products	0.08	0.48	0.48	2.43	1.40	3.20	3.95	6.56	3.92	11.00
Confectionery	0.08	0.52	0.46	1.18	0.08	2.13	6.61	11.39	4.53	9.06
Other food products	1.15	2.37	5.46	3.61	0.85	3.47	26.15	41.32	16.31	32.21
Soft drinks, cordials and syrups	0.02	0.09	0.13	0.19	0.02	0.14	4.33	6.01	0.86	1.79
Beer and malt	0.02	0.12	0.12	0.20	0.02	0.36	2.63	3.77	1.69	9.00
Wine, spirits and tobacco products	0.24	0.47	1.32	0.45	0.13	3.92	5.44	7.99	3.92	20.32
Textile fibres, yarns and woven fabrics	0.12	10.11	1.78	0.75	0.31	0.96	10.50	19.36	12.88	11.86
Textile products	0.77	7.75	11.13	0.86	0.12	0.47	34.10	55.24	23.28	9.22
Knitting mill products	0.06	7.08	2.85	0.54	0.06	0.28	5.44	8.70	2.74	9.93
Clothing	0.50	3.32	2.82	3.71	0.42	1.70	10.06	18.05	9.97	18.81

Table B.1(h) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Pre-fabricated buildings	Furniture	Other manufacturing	Electricity supply	Gas supply	Water supply, sewerage and drainage services	Residential building	Other construction	Construction trade services	Wholesale trade
Footwear	0.13	0.41	1.44	3.01	0.13	0.51	2.66	7.36	2.98	5.19
Leather and leather products	0.13	5.63	51.53	0.55	0.99	0.42	3.46	7.31	4.71	6.00
Sawmill products	23.87	500.93	44.41	0.81	0.15	1.53	804.82	137.05	742.35	16.37
Other wood products	38.01	351.66	49.68	3.91	0.56	29.34	1664.80	423.85	1350.10	231.96
Pulp, paper and paperboard	0.47	6.60	4.24	1.81	0.09	0.30	35.44	55.15	10.19	34.50
Paper containers and products	0.84	6.38	5.18	12.81	1.32	5.73	126.54	198.98	33.05	244.40
Printing and services to printing	2.31	13.23	18.84	33.90	8.51	14.66	152.72	375.26	55.19	1021.94
Publishing, recorded media, etc.	1.74	6.49	8.76	13.30	2.81	11.55	56.53	116.62	23.66	469.77
Petroleum and coal products	2.16	7.18	8.13	390.97	3.70	188.32	186.34	398.33	360.74	512.03
Basic chemicals	2.73	30.44	55.10	35.94	15.30	96.86	241.00	635.34	404.98	86.63
Paints	1.84	23.84	18.84	8.53	0.93	15.20	112.63	121.71	155.04	11.54
Medicinal and pharmaceutical products, pesticides	0.49	1.71	3.10	6.10	3.36	41.43	10.87	45.50	30.44	44.04
Soap and detergents	0.08	0.90	2.20	3.19	0.98	6.01	2.65	10.35	6.32	23.04
Cosmetics and toiletry preparations	0.03	0.14	0.14	0.17	0.04	0.24	0.90	2.24	1.26	2.61
Other chemical products	1.39	15.09	7.13	4.12	1.07	3.93	82.64	215.26	169.33	28.68
Rubber products	0.23	5.93	10.52	10.85	1.22	1.40	16.05	37.38	16.07	15.23
Plastic products	3.17	68.41	163.38	11.69	29.03	44.59	686.62	910.51	528.20	221.76
Glass and glass products	6.74	34.95	7.38	2.46	0.47	3.09	122.26	143.77	75.18	264.14
Ceramic products	0.42	0.92	0.87	5.61	0.40	5.64	286.71	28.46	183.62	5.26
Cement, lime and concrete slurry	0.77	1.10	3.95	40.19	1.02	85.20	1442.16	2268.57	2051.67	10.39
Plaster and other concrete products	2.14	13.15	4.87	98.02	0.30	4.95	1247.73	776.93	1203.20	22.04
Other non-metallic mineral products	1.17	3.11	6.80	7.12	1.37	8.30	207.53	228.09	230.54	26.17
Iron and steel	104.17	168.01	274.12	30.05	13.26	44.24	837.47	2236.45	1161.22	147.99
Basic non-ferrous metal and products	83.51	249.01	598.38	20.57	6.98	24.57	636.73	492.96	278.11	63.46
Structural metal products	55.00	42.51	93.36	44.35	7.41	84.69	3027.96	3216.94	1450.53	77.75
Sheet metal products	5.96	15.01	22.42	3.73	21.00	7.43	275.29	433.92	189.19	135.96
Fabricated metal products	23.09	63.61	45.23	58.40	36.72	118.84	495.20	1184.73	479.64	123.63
Motor vehicles and parts, other transport equipment	2.80	13.78	55.27	14.92	1.46	11.82	122.76	214.53	155.03	159.31
Ships and boats	0.17	0.32	0.49	1.26	0.39	0.83	72.79	108.94	34.95	80.95
Railway equipment	0.02	0.91	0.87	2.98	0.08	0.22	5.84	9.57	4.07	4.02
Aircraft	0.01	0.03	0.24	0.48	0.02	0.11	14.87	23.23	7.02	121.36
Photographic and scientific equipment	0.24	1.44	3.68	14.80	0.35	4.32	16.23	88.40	20.88	39.01
Electronic equipment	1.42	1.93	4.70	22.15	1.06	9.75	45.82	271.54	137.05	23.66

Table B.1(h) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Pre-fabricated buildings	Furniture	Other manufacturing	Electricity supply	Gas supply	Water supply, sewerage and drainage services	Residential building	Other construction	Construction trade services	Wholesale trade
Household appliances	0.18	1.68	2.85	5.79	0.37	2.12	462.97	263.01	230.32	15.50
Other electrical equipment	1.73	5.10	12.07	399.50	1.61	13.97	170.77	1299.73	401.27	110.60
Agricultural, mining, etc. machinery	0.69	1.35	5.59	22.96	0.92	4.25	72.54	131.66	144.71	36.96
Other machinery and equipment	1.62	7.68	7.79	30.62	5.03	22.57	126.39	444.89	150.03	78.97
Prefabricated buildings	1.03	0.74	0.82	0.43	0.06	0.59	49.86	142.46	36.62	3.93
Furniture	7.00	21.66	3.91	2.42	0.39	14.88	279.97	214.42	231.97	41.11
Other manufacturing	4.20	18.39	35.76	19.02	7.90	10.00	201.35	413.32	364.40	143.34
Electricity supply	1.47	23.17	33.57	4827.31	5.92	282.16	104.04	510.88	83.52	629.05
Gas supply	1.92	5.55	7.33	585.29	0.00	0.99	28.27	6.10	10.87	241.42
Water supply, sewerage and drainage services	0.26	3.91	5.28	97.68	19.28	436.75	304.70	173.35	72.58	251.48
Residential building	0.18	0.68	1.24	160.25	82.17	62.56	1426.15	1976.41	2201.08	271.33
Other construction	0.25	0.91	1.67	230.25	111.09	86.27	2060.11	2681.58	2984.62	434.89
Construction trade services	2.31	6.96	13.39	2220.62	815.06	950.43	11408.93	13437.05	34415.77	1814.01
Wholesale trade	52.88	297.28	306.59	550.84	49.44	449.78	2181.57	3724.59	2502.70	2741.35
Wholesale mechanical repairs	0.09	0.42	0.18	67.54	31.76	36.10	101.58	216.97	59.17	58.03
Other wholesale repairs	4.90	30.34	19.14	147.54	163.60	52.18	130.66	178.25	65.25	579.01
Retail trade	4.94	44.43	94.23	70.91	12.16	39.88	243.68	626.68	275.68	1132.59
Retail mechanical repairs	6.25	24.39	29.37	234.72	47.87	61.64	178.14	502.70	895.85	983.25
Other retail repairs	0.00	0.00	0.00	0.00	0.00	0.00	13.53	22.77	13.07	30.94
Accommodation, cafes and restaurants	4.84	16.71	24.36	122.48	11.67	33.58	38.76	49.67	12.43	579.98
Road transport	13.32	105.45	102.28	164.16	11.44	100.55	947.47	1437.57	1065.81	1141.59
Rail, pipeline and other transport	0.78	3.03	5.29	271.92	2.07	1.07	62.45	115.20	28.30	119.07
Water transport	0.33	1.36	10.01	48.19	13.87	0.29	2.68	6.36	4.19	85.85
Air and space transport	1.47	4.65	5.44	58.93	19.46	29.85	88.59	94.80	23.54	960.80
Services to transport, storage	1.93	20.57	51.35	51.73	2.77	24.67	340.74	3216.56	388.10	9969.41
Communication services	5.48	39.23	76.67	348.59	86.62	143.56	644.46	1482.10	251.68	3116.56
Finance	9.81	43.71	38.38	1313.33	197.77	722.21	3454.88	3401.09	4318.10	3141.12
Ownership of dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other property services	1.55	18.79	39.26	391.96	312.37	5.11	2745.85	6598.09	2147.70	8405.65
Scientific research, technical and computer services	8.79	25.09	17.42	248.89	51.90	28.04	253.43	6225.46	746.88	1398.42
Legal, accounting, marketing and business management services	3.99	76.50	97.04	316.29	971.67	693.63	1794.49	5040.22	2410.66	5356.98
Other business services	13.98	101.11	74.39	223.77	369.80	101.27	954.49	2917.96	1293.09	1504.10

Table B.1(h) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Pre-fabricated buildings	Furniture	Other manufacturing	Electricity supply	Gas supply	Water supply, sewerage and drainage services	Residential building	Other construction	Construction trade services	Wholesale trade
Government administration	0.43	3.28	2.62	19.07	1.65	38.65	263.71	480.88	83.84	121.97
Defence	0.01	0.07	0.07	0.09	0.00	0.00	0.67	0.73	0.14	8.58
Education	0.48	3.35	3.31	160.64	26.71	25.69	46.29	42.02	10.32	33.03
Health services	0.08	0.27	0.59	1.17	0.00	3.61	0.21	7.13	0.05	12.91
Community services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motion picture, radio and television services	1.97	8.26	1.78	13.38	17.43	20.31	46.26	28.59	15.71	285.24
Libraries, museums and the arts	0.50	12.85	1.19	38.49	56.88	50.38	40.11	7.05	0.88	51.48
Sport, gambling and recreational services	0.01	0.05	0.07	0.37	0.03	0.09	227.26	349.43	126.74	158.71
Personal services	0.03	0.60	0.28	0.76	0.00	1.60	15.15	56.23	6.02	18.62
Other services	0.26	1.36	1.26	8.80	0.00	4.59	141.07	448.76	62.11	13.91
Total intermediate usage including imports	**698**	**3597**	**4012**	**20752**	**3980**	**6704**	**48434**	**83660**	**74435**	**62975**
Wages and salaries	194	1447	872	4350	182	3434	4084	13387	21745	30714
Gross surplus	136	485	49	12228	922	6065	7436	19748	17410	18696
Indirect taxes on production	20	125	75	1012	106	20	1053	1768	1902	4578
Total gross output	**1048**	**5654**	**5009**	**38342**	**5189**	**16223**	**61006**	**118564**	**115491**	**116963**
Value added at factor cost to output ratio	0.33	0.36	0.20	0.46	0.23	0.59	0.21	0.29	0.36	0.46
Share of wages and mixed income in value added	0.61	0.94	1.30	0.25	0.16	0.39	0.43	0.48	0.97	0.64
Employment to gross output ratio	7.58	24.25	12.46	2.99	8.42	4.33	4.93	7.08	14.89	7.33
Foreign ownership ratio	0.03	0.05	0.07	0.40	0.30	0.01	0.05	0.15	0.05	0.35
Direct tax rate on surplus	0.16	0.10	0.16	0.01	0.02	0.01	0.07	0.06	0.08	0.23
Indirect tax rate on production	0.03	0.04	0.02	0.04	0.05	-0.01	0.05	0.03	0.02	0.08
Foreign income payout ratio	0.01	0.00	0.00	0.27	0.23	0.01	0.03	0.07	0.00	0.10
Replacement depreciation to value added ratio	0.21	0.08	0.07	0.35	0.35	0.29	0.03	0.02	0.06	0.08
Net national product ratio	0.78	0.92	0.93	0.38	0.42	0.71	0.95	0.91	0.94	0.82
Domestic income distribution ratio	0.32	0.05	0.00	0.41	0.53	0.59	0.49	0.42	0.03	0.19

Table B.1(i) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Wholesale mechanical repairs	Other wholesale repairs	Retail trade	Retail mechanical repairs	Other retail repairs	Accommodation, cafes and restaurants	Road transport	Rail, pipeline and other transport	Water transport	Air and space transport
Sheep	0.00	0.00	502.50	0.00	0.00	181.44	0.00	0.00	0.00	0.00
Grains	0.00	0.00	0.04	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Beef cattle	0.00	0.00	413.05	0.00	0.00	149.45	0.00	0.00	0.00	0.00
Dairy cattle	0.00	0.00	3.59	0.00	0.00	1.31	0.00	0.00	0.00	0.00
Pigs	0.00	0.00	236.53	0.00	0.00	85.58	0.00	0.00	0.00	0.00
Poultry	0.00	0.00	310.29	0.00	0.00	134.42	0.00	0.00	0.00	0.00
Other agriculture	0.00	0.86	318.37	2.96	0.36	482.42	0.77	1.27	0.00	0.00
Services to agriculture, hunting and trapping	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forestry and logging	0.00	0.00	1.34	0.00	0.00	0.65	3.47	14.34	0.00	0.00
Commercial fishing	0.00	0.00	190.81	0.00	0.00	142.71	0.00	0.00	0.00	0.00
Coal	0.04	1.90	9.97	0.49	0.02	2.40	1.97	9.87	0.99	0.99
Gas	0.84	5.34	115.00	7.57	1.16	167.93	12.48	34.52	0.00	2.86
LNG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron ores	0.02	0.81	1.90	0.21	0.01	1.01	0.56	0.89	0.01	0.29
Non-ferrous metal ores	0.05	2.10	5.64	0.57	0.02	2.99	4.49	25.51	0.33	0.98
Other mining	0.01	0.39	0.46	0.09	0.00	3.67	0.26	0.92	0.00	0.14
Services to mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Meat and meat products	0.38	1.56	2613.99	7.05	0.21	1837.30	3.77	1.40	0.05	1.36
Dairy products	1.54	3.07	739.73	13.59	0.92	703.01	6.83	3.32	0.12	6.46
Fruit and vegetable products	0.39	1.69	213.73	3.12	0.20	215.58	3.13	0.32	0.09	1.53
Oils and fats	0.31	0.72	134.36	2.25	0.12	82.00	1.66	0.31	0.03	0.60
Flour mill products and cereal foods	0.44	1.80	719.60	3.72	0.24	383.44	3.73	0.36	0.06	1.62
Bakery products	0.37	1.53	430.33	3.09	0.20	401.24	3.68	1.25	1.50	3.98
Confectionery	0.55	1.65	175.99	4.38	0.28	225.87	3.41	0.73	0.04	1.28
Other food products	1.17	4.30	376.52	9.25	0.60	305.00	13.24	2.35	0.22	7.69
Soft drinks, cordials and syrups	0.07	0.28	423.16	0.55	0.05	99.17	0.86	0.35	0.01	0.33
Beer and malt	0.06	0.62	4.89	1.53	0.19	1550.84	2.28	0.69	0.01	1.84
Wine, spirits and tobacco products	0.10	1.40	5.17	3.09	1.14	902.16	4.61	1.52	0.04	4.36
Textile fibres, yarns and woven fabrics	0.44	1.15	19.88	7.24	0.14	6.36	4.70	0.69	0.08	0.75
Textile products	0.06	0.84	17.71	0.76	0.20	7.75	5.40	0.96	0.13	0.23
Knitting mill products	0.16	0.72	44.33	1.79	0.13	2.02	3.16	0.63	0.03	0.62
Clothing	17.02	5.17	18.56	51.44	1.16	10.84	8.55	2.27	0.20	3.78

Table B.1(i) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Wholesale mechanical repairs	Other wholesale repairs	Retail trade	Retail mechanical repairs	Other retail repairs	Accommodation, cafes and restaurants	Road transport	Rail, pipeline and other transport	Water transport	Air and space transport
Footwear	0.16	4.97	2.76	1.50	1.35	1.62	1.76	0.30	0.03	0.80
Leather and leather products	0.60	1.17	5.20	10.14	0.29	2.08	4.16	0.69	0.29	3.37
Sawmill products	0.29	1.37	28.60	2.43	0.17	2.98	12.12	2.10	0.39	1.82
Other wood products	2.62	3.03	143.12	9.63	0.50	15.76	36.78	5.08	1.17	4.82
Pulp, paper and paperboard	0.08	0.87	21.63	1.17	0.26	24.61	13.86	3.25	1.91	16.27
Paper containers and products	1.10	6.41	192.83	6.22	2.20	93.60	10.62	10.11	1.85	19.39
Printing and services to printing	4.35	6.96	1664.05	36.44	1.56	205.04	44.97	31.26	3.66	13.65
Publishing, recorded media, etc.	3.47	6.39	820.06	28.11	1.31	103.76	22.61	36.72	3.32	12.08
Petroleum and coal products	11.11	81.63	392.69	70.68	16.25	168.35	1466.79	146.92	58.79	2002.78
Basic chemicals	3.31	8.90	49.75	20.90	1.53	56.47	16.54	11.58	0.53	8.51
Paints	4.51	8.94	5.63	19.39	1.20	4.25	1.32	1.09	0.27	0.51
Medicinal and pharmaceutical products, pesticides	0.62	2.20	23.36	5.12	0.34	10.99	5.26	2.02	0.07	2.88
Soap and detergents	0.47	1.49	11.89	2.58	0.27	25.61	4.62	1.44	0.04	0.58
Cosmetics and toiletry preparations	0.06	0.14	1.27	0.37	0.03	0.85	0.31	0.29	0.01	0.13
Other chemical products	1.37	3.91	17.17	4.09	0.82	5.19	4.32	1.38	0.27	3.29
Rubber products	1.38	6.43	4.63	15.69	0.74	4.96	20.27	0.70	0.01	0.22
Plastic products	2.48	11.20	121.51	37.34	1.35	124.50	57.90	12.38	1.88	70.53
Glass and glass products	16.56	2.32	31.70	92.26	0.28	20.45	12.81	5.64	0.02	0.47
Ceramic products	0.06	0.52	5.09	0.63	0.09	1.66	1.34	0.20	0.01	0.21
Cement, lime and concrete slurry	0.34	1.35	22.66	2.14	0.36	1.85	2.43	0.63	0.08	1.05
Plaster and other concrete products	0.33	0.90	9.80	1.59	0.10	3.96	1.36	2.90	0.08	0.51
Other non-metallic mineral products	0.16	0.54	16.12	1.20	0.07	1.74	1.05	0.55	0.02	0.19
Iron and steel	4.78	13.41	75.88	44.09	2.19	9.40	16.60	84.05	0.36	1.62
Basic non-ferrous metal and products	2.97	9.16	90.75	23.58	2.15	30.98	22.03	17.62	0.41	6.80
Structural metal products	10.34	12.96	42.54	42.59	1.01	10.74	18.20	287.25	0.55	2.37
Sheet metal products	2.44	3.40	93.18	21.33	3.15	5.46	181.07	33.52	0.91	4.19
Fabricated metal products	17.19	44.45	137.20	69.57	9.33	36.40	35.98	36.89	1.43	13.74
Motor vehicles and parts, other transport equipment	66.20	18.73	167.17	1582.32	4.39	35.59	680.59	12.00	0.51	6.40
Ships and boats	4.49	1.87	3.41	3.81	0.31	3.28	2.09	1.64	203.12	0.78
Railway equipment	1.55	2.05	4.48	4.53	0.13	1.78	6.04	1156.96	0.04	0.41
Aircraft	0.11	1.49	43.00	2.58	0.35	2.88	0.97	0.55	0.04	1368.70
Photographic and scientific equipment	3.24	27.49	16.77	13.05	2.47	12.76	8.64	4.11	0.79	17.10
Electronic equipment	4.83	101.24	11.21	15.96	5.61	18.32	13.67	4.41	0.81	15.73

Table B.1(i) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Wholesale mechanical repairs	Other wholesale repairs	Retail trade	Retail mechanical repairs	Other retail repairs	Accommodation, cafes and restaurants	Road transport	Rail, pipeline and other transport	Water transport	Air and space transport
Household appliances	4.07	41.41	28.73	17.89	108.99	43.90	16.05	8.17	0.59	12.31
Other electrical equipment	8.63	87.19	57.42	47.66	12.39	27.00	110.44	6.60	0.96	17.51
Agricultural, mining, etc. machinery	54.10	50.63	17.77	162.41	4.48	22.29	11.58	18.75	0.81	16.82
Other machinery and equipment	37.03	128.97	66.75	130.15	12.25	81.40	40.18	16.04	1.72	17.94
Prefabricated buildings	0.10	0.54	3.01	1.15	0.05	1.07	1.47	4.79	0.03	0.40
Furniture	0.89	3.27	39.80	6.32	0.39	38.34	18.10	3.57	0.12	2.86
Other manufacturing	3.69	31.46	136.75	75.26	5.92	85.95	17.01	15.98	0.42	5.53
Electricity supply	38.96	137.13	1018.69	228.00	44.40	780.66	194.40	360.15	52.31	39.47
Gas supply	0.89	3.07	115.31	7.28	1.23	147.08	6.91	12.83	2.96	2.96
Water supply, sewerage and drainage services	17.05	24.71	303.83	76.85	4.96	314.12	309.03	89.19	25.10	20.71
Residential building	10.35	69.98	123.85	21.14	1.12	78.29	46.82	40.52	1.16	14.90
Other construction	14.02	94.38	168.36	28.52	1.52	233.75	72.29	131.16	2.19	21.74
Construction trade services	144.95	185.97	598.79	119.23	16.06	793.76	112.48	781.56	5.83	30.93
Wholesale trade	210.08	913.10	1680.96	1765.04	118.91	1237.11	2245.13	167.52	42.01	1195.34
Wholesale mechanical repairs	1.06	0.00	326.59	0.00	0.00	0.50	34.92	8.08	15.45	0.00
Other wholesale repairs	0.00	0.00	715.52	0.00	0.00	26.65	125.69	32.81	51.54	77.35
Retail trade	13.15	55.31	2399.89	122.04	7.97	2584.89	330.52	43.24	3.03	383.65
Retail mechanical repairs	0.00	81.23	1145.36	0.00	13.68	37.94	3448.50	47.01	58.83	43.87
Other retail repairs	0.00	0.00	56.33	0.00	0.00	19.91	51.45	28.90	21.11	14.70
Accommodation, cafes and restaurants	1.41	9.76	345.67	22.33	4.91	54.01	160.29	15.26	6.35	39.00
Road transport	6.99	63.43	614.95	43.79	19.40	455.43	1310.11	69.91	6.06	223.35
Rail, pipeline and other transport	0.29	2.97	50.96	2.18	0.55	41.98	4.38	5.76	0.05	13.13
Water transport	0.09	3.65	35.73	0.46	0.03	4.95	4.40	0.32	136.02	0.14
Air and space transport	1.50	26.49	188.04	8.40	1.23	38.43	28.04	3.43	2.09	608.78
Services to transport, storage	17.07	28.68	819.74	89.70	7.58	309.37	657.77	55.87	779.88	1687.35
Communication services	59.06	238.08	3093.64	295.78	25.91	673.89	1010.35	54.95	16.80	136.18
Finance	88.29	224.03	2444.20	452.59	35.99	806.72	608.75	268.15	23.86	201.81
Ownership of dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other property services	16.70	752.39	3732.50	209.30	3.70	1624.62	1239.53	867.32	5.98	586.77
Scientific research, technical and computer services	2.20	15.87	437.73	1.50	0.03	337.05	940.88	52.59	82.82	311.62
Legal, accounting, marketing and business management services	112.86	257.39	6658.34	694.83	54.60	1109.93	2188.96	54.30	63.35	400.34
Other business services	112.29	647.25	3867.83	82.14	1.25	582.84	263.14	83.77	10.10	148.54

Table B.1(i) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Wholesale mechanical repairs	Other wholesale repairs	Retail trade	Retail mechanical repairs	Other retail repairs	Accommodation, cafes and restaurants	Road transport	Rail, pipeline and other transport	Water transport	Air and space transport
Government administration	8.41	8.76	180.14	54.25	2.72	12.60	488.72	16.75	0.91	1.62
Defence	0.00	0.00	2.55	0.00	0.00	3.08	7.92	0.39	0.11	0.67
Education	0.95	2.43	59.27	70.61	0.69	58.23	50.30	18.41	3.38	18.39
Health services	1.02	1.74	15.74	10.36	0.75	5.72	2.52	1.25	0.75	0.21
Community services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motion picture, radio and television services	1.33	1.13	1100.24	17.21	0.00	1201.12	63.12	0.82	2.77	18.34
Libraries, museums and the arts	0.00	0.00	74.09	10.96	0.00	176.12	30.36	12.70	17.21	34.47
Sport, gambling and recreational services	0.00	0.03	112.27	9.85	0.01	20.05	3.44	0.05	0.01	3.93
Personal services	0.68	0.58	54.93	4.40	0.00	21.05	0.66	1.29	0.00	0.00
Other services	0.00	0.00	21.74	5.28	0.00	6.74	18.56	0.82	0.00	0.00
Total intermediate usage including imports	**1697**	**6686**	**48333**	**9401**	**801**	**25751**	**22235**	**6070**	**2243**	**11196**
Wages and salaries	385	1445	28804	9540	1126	13483	11377	6018	461	4271
Gross surplus	264	396	18241	334	324	8547	8061	633	1177	894
Indirect taxes on production	77	360	3340	901	102	2747	2711	288	106	1573
Total gross output	**2423**	**8887**	**98718**	**20177**	**2354**	**50528**	**44384**	**13008**	**3987**	**17934**
Value added at factor cost to output ratio	0.30	0.25	0.51	0.53	0.66	0.49	0.50	0.53	0.44	0.38
Share of wages and mixed income in value added	0.60	0.75	0.68	1.05	0.85	0.62	0.72	0.88	0.29	0.66
Employment to gross output ratio	6.83	8.46	17.06	26.42	21.65	14.56	9.93	8.05	5.19	7.08
Foreign ownership ratio	0.15	0.20	0.10	0.04	0.04	0.09	0.20	0.02	0.40	0.38
Direct tax rate on surplus	0.25	0.25	0.13	0.36	0.01	0.04	0.04	0.10	0.04	0.39
Indirect tax rate on production	0.09	0.15	0.06	0.08	0.06	0.11	0.12	0.03	0.05	0.28
Foreign income payout ratio	0.05	0.04	0.03	0.00	0.01	0.03	0.05	0.00	0.26	0.06
Replacement depreciation to value added ratio	0.30	0.32	0.10	0.02	0.01	0.11	0.20	0.43	0.19	0.44
Net national product ratio	0.65	0.64	0.87	0.98	0.99	0.86	0.76	0.57	0.55	0.49
Domestic income distribution ratio	0.26	0.15	0.25	0.00	0.13	0.29	0.18	0.11	0.38	0.10

Table B.1(j) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Services to transport, storage	Commun-ication services	Finance	Ownership of dwellings	Other property services	Scientific research, technical and computer services	Legal, accounting, marketing and business management services	Other business services	Govern-ment admin-istration	Defence
Sheep	0.00	0.00	0.00	0.00	0.00	59.65	0.00	23.61	0.00	0.00
Grains	0.00	0.00	0.00	0.00	0.05	0.02	0.02	0.01	0.04	0.00
Beef cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dairy cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pigs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other agriculture	41.78	0.83	4.47	0.00	86.43	44.41	68.76	7.67	68.08	4.92
Services to agriculture, hunting and trapping	0.00	0.00	0.00	0.00	0.00	91.51	0.00	7.89	53.64	16.02
Forestry and logging	1.57	6.24	0.00	0.00	0.00	1.41	0.58	0.64	0.00	0.00
Commercial fishing	0.00	0.00	2.27	0.00	0.00	5.57	0.09	2.60	0.00	0.00
Coal	5.92	4.03	2.26	0.01	26.00	0.95	1.42	2.73	13.81	15.06
Gas	30.22	152.28	7.56	3.62	65.42	30.98	40.38	23.63	62.70	63.74
LNG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron ores	1.71	1.72	0.95	0.00	10.45	0.39	0.60	1.16	1.50	1.11
Non-ferrous metal ores	8.00	4.93	2.66	0.01	40.41	1.23	1.71	3.33	48.55	54.88
Other mining	0.82	0.83	0.45	2.86	7.81	1.27	0.48	0.67	6.06	1.47
Services to mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Meat and meat products	3.61	20.06	9.22	1.24	18.22	41.00	34.20	18.85	3.00	10.77
Dairy products	10.03	73.75	10.59	0.38	20.61	108.77	22.56	47.58	3.26	4.28
Fruit and vegetable products	2.18	6.40	0.81	0.30	4.04	5.73	4.01	2.55	1.38	4.48
Oils and fats	1.36	5.27	0.31	0.13	2.46	7.52	4.33	2.08	1.21	1.42
Flour mill products and cereal foods	2.62	4.70	0.75	0.36	3.73	38.66	16.53	15.39	11.35	9.38
Bakery products	3.91	20.25	6.42	0.29	8.16	12.52	13.77	5.21	6.79	24.75
Confectionery	2.41	13.12	0.43	0.26	4.97	12.96	5.45	5.18	2.94	2.44
Other food products	12.08	24.25	6.05	23.29	17.05	57.84	26.92	22.19	25.12	27.46
Soft drinks, cordials and syrups	1.08	1.46	0.87	0.52	3.21	1.80	1.62	0.78	1.30	29.41
Beer and malt	3.44	2.34	3.74	0.62	3.54	3.16	1.96	1.40	5.46	3.25
Wine, spirits and tobacco products	11.14	11.12	32.94	0.80	9.49	5.58	4.03	2.70	84.13	4.39
Textile fibres, yarns and woven fabrics	2.07	12.87	0.69	1.75	4.43	4.17	1.91	1.80	4.73	5.55
Textile products	4.27	5.53	0.47	11.84	5.29	3.17	1.42	1.83	8.21	2.59
Knitting mill products	1.89	4.27	0.21	0.94	4.34	5.88	4.44	2.78	1.43	8.21

Table B.1(j) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Services to transport, storage	Commun-ication services	Finance	Ownership of dwellings	Other property services	Scientific research, technical and computer services	Legal, accounting, marketing and business management services	Other business services	Govern-ment admin-istration	Defence
Clothing	9.52	16.26	0.93	1.02	6.45	12.40	4.74	4.49	3.05	35.82
Footwear	1.51	2.64	0.19	0.30	1.64	1.37	0.87	0.66	0.63	1.94
Leather and leather products	2.03	3.48	0.46	0.57	1.35	1.85	1.90	1.50	1.03	6.63
Sawmill products	26.08	9.54	1.08	7.24	25.89	2.85	3.31	3.23	4.18	3.73
Other wood products	91.54	31.22	1.78	190.07	43.00	7.59	4.61	5.95	81.62	16.29
Pulp, paper and paperboard	3.39	93.68	26.39	1.08	9.07	13.84	37.76	8.81	122.58	4.90
Paper containers and products	7.36	33.88	3.19	0.27	9.45	16.69	10.71	5.55	57.23	6.15
Printing and services to printing	56.28	723.15	158.70	9.28	265.04	599.00	621.08	289.81	588.06	153.25
Publishing, recorded media, etc.	76.99	529.53	71.99	5.69	176.46	360.28	351.41	186.76	215.97	33.12
Petroleum and coal products	385.55	361.19	6.60	10.82	121.06	188.58	271.26	122.12	71.94	156.32
Basic chemicals	23.04	52.08	4.03	32.97	83.42	100.47	40.30	33.50	37.31	52.29
Paints	1.56	2.05	0.42	10.45	12.85	10.61	6.91	3.13	1.89	2.19
Medicinal and pharmaceutical products, pesticides	18.49	8.85	1.25	3.48	40.91	58.48	12.56	13.27	2.88	4.24
Soap and detergents	3.34	5.48	0.48	1.26	18.76	28.24	36.38	12.51	6.75	5.69
Cosmetics and toiletry preparations	0.41	0.61	0.05	0.45	1.60	0.68	0.61	0.35	0.43	0.79
Other chemical products	3.21	15.28	0.82	3.98	19.13	28.34	25.48	12.68	17.23	55.05
Rubber products	6.31	8.79	0.16	1.57	2.32	6.20	1.41	1.76	27.39	48.76
Plastic products	68.24	325.88	3.07	91.85	26.62	42.83	8.80	10.33	53.41	54.74
Glass and glass products	4.92	12.12	4.26	30.51	10.30	5.37	3.28	2.42	11.58	6.16
Ceramic products	1.49	29.17	0.24	3.14	2.52	1.66	0.76	0.82	1.18	0.78
Cement, lime and concrete slurry	2.03	9.98	1.01	56.51	8.93	12.82	2.26	6.57	4.71	3.18
Plaster and other concrete products	1.23	8.79	0.26	23.73	4.21	2.33	1.35	1.22	23.81	3.47
Other non-metallic mineral products	1.72	7.03	0.14	18.96	3.78	2.70	1.89	1.71	3.19	3.72
Iron and steel	7.91	62.75	1.73	163.75	17.20	19.18	5.76	4.50	15.89	31.22
Basic non-ferrous metal and products	20.96	80.45	7.13	141.40	62.12	24.68	20.03	15.81	41.61	41.90
Structural metal products	19.84	36.78	2.23	246.70	50.63	8.12	4.99	6.32	25.64	27.92
Sheet metal products	32.86	281.97	0.98	58.29	21.68	3.92	1.70	2.71	7.85	10.72
Fabricated metal products	19.21	86.39	5.54	67.09	56.49	56.78	17.43	15.96	50.95	117.27
Motor vehicles and parts, other transport equipment	110.92	187.51	7.04	3.82	97.83	46.03	22.23	19.25	21.43	94.20
Ships and boats	10.02	3.32	1.78	1.05	8.77	6.13	2.99	3.04	4.63	2066.14
Railway equipment	2.96	4.74	1.29	1.41	6.03	3.02	1.34	1.06	2.63	2.31
Aircraft	298.89	2.08	0.28	0.95	4.73	6.58	1.93	2.42	1.33	188.16

Table B.1(j) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Services to transport, storage	Commun-ication services	Finance	Ownership of dwellings	Other property services	Scientific research, technical and computer services	Legal, accounting, marketing and business management services	Other business services	Govern-ment admin-istration	Defence
Photographic and scientific equipment	39.36	94.93	3.29	4.12	30.34	60.23	15.50	12.36	18.83	63.41
Electronic equipment	163.18	270.11	5.80	13.46	37.22	84.53	41.60	20.35	15.25	21.59
Household appliances	17.97	20.07	1.76	33.06	19.03	10.29	5.84	4.61	3.65	20.10
Other electrical equipment	91.06	422.30	9.05	21.99	48.75	82.80	28.67	16.35	26.77	28.73
Agricultural, mining, etc. machinery	34.27	38.91	2.61	6.33	35.69	41.03	10.80	9.82	12.33	21.30
Other machinery and equipment	39.20	74.82	3.29	9.41	46.59	81.17	11.87	13.05	22.64	110.05
Prefabricated buildings	1.48	2.50	0.21	2.77	4.98	0.75	0.49	0.69	1.70	11.79
Furniture	10.25	26.68	6.43	30.05	52.66	13.63	14.06	22.13	68.50	40.41
Other manufacturing	24.93	76.65	4.11	13.35	47.34	34.47	20.52	16.07	18.07	32.94
Electricity supply	969.82	451.80	183.87	55.05	494.35	408.86	654.97	375.06	460.26	96.99
Gas supply	25.66	81.30	8.88	4.06	27.96	23.66	40.15	18.86	22.24	3.20
Water supply, sewerage and drainage services	307.59	289.88	89.89	5.36	841.35	667.32	631.30	414.66	283.62	140.94
Residential building	128.46	212.35	94.93	140.75	412.45	132.00	184.91	93.44	124.79	53.29
Other construction	269.60	293.34	127.52	261.56	606.92	181.06	271.50	127.48	273.64	185.80
Construction trade services	607.59	2469.77	68.67	1690.46	850.93	378.13	510.40	239.50	1487.62	1600.03
Wholesale trade	1057.69	2233.56	147.42	181.83	806.31	1215.16	723.43	400.91	571.25	676.30
Wholesale mechanical repairs	36.29	81.26	1.07	0.00	75.27	17.58	1.59	0.22	24.62	0.00
Other wholesale repairs	469.04	840.39	651.14	3.06	328.00	377.22	363.74	297.32	6.88	11.29
Retail trade	208.32	473.28	70.11	22.41	716.91	150.56	153.93	123.81	121.55	80.38
Retail mechanical repairs	712.44	874.32	107.38	0.00	438.44	172.40	288.21	260.05	165.44	68.79
Other retail repairs	23.48	17.85	47.78	1101.68	20.18	23.01	27.66	20.14	42.28	0.00
Accommodation, cafes and restaurants	257.45	415.68	336.40	0.00	20.04	395.60	1429.73	473.40	405.40	58.21
Road transport	467.62	543.43	98.73	53.05	164.38	250.92	294.53	100.70	389.88	144.04
Rail, pipeline and other transport	84.25	124.58	15.40	1.49	129.10	63.48	89.35	39.12	6.89	6.36
Water transport	3.64	102.98	0.15	0.16	31.88	70.46	31.49	32.87	71.57	10.57
Air and space transport	108.71	457.02	146.42	0.07	46.97	265.89	556.02	210.09	299.38	113.48
Services to transport, storage	4279.14	640.42	186.86	6.39	1440.85	546.41	1185.68	865.54	1120.62	481.32
Communication services	1584.87	1385.34	2238.48	16.59	1490.04	1651.04	2679.59	475.14	1822.75	99.93
Finance	971.83	1036.47	38388.03	6387.55	4822.26	889.67	2732.08	895.87	2538.96	287.73
Ownership of dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other property services	2848.14	3954.93	2035.85	2135.99	25342.34	333.86	4208.77	2557.51	557.73	106.63
Scientific research, technical and computer services	2460.93	691.59	1258.64	28.22	2552.66	7138.12	5398.46	1272.41	2383.55	60.81

Table B.1(j) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Services to transport, storage	Commun-ication services	Finance	Ownership of dwellings	Other property services	Scientific research, technical and computer services	Legal, accounting, marketing and business management services	Other business services	Govern-ment admin-istration	Defence
Legal, accounting, marketing and business management services	1576.41	670.55	3920.44	476.39	5066.07	4302.33	4389.78	1210.08	1815.81	289.37
Other business services	1801.82	585.32	1768.95	3.39	4121.64	2299.34	3114.86	1198.50	843.49	42.06
Government administration	455.92	306.06	82.43	5.28	99.97	425.71	471.22	105.03	1494.19	46.80
Defence	19.57	5.68	6.11	0.02	3.73	9.76	8.29	4.33	14.87	0.28
Education	214.53	48.87	584.44	0.01	209.72	457.66	547.59	295.57	195.85	42.01
Health services	85.43	78.21	20.12	0.01	10.95	13.46	11.36	10.09	43.24	58.02
Community services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Motion picture, radio and television services	26.85	104.12	344.31	0.00	1294.89	1242.15	1737.30	565.23	113.23	85.69
Libraries, museums and the arts	25.28	43.17	136.21	0.00	119.85	161.10	353.28	88.32	45.67	12.54
Sport, gambling and recreational services	10.25	26.38	102.32	0.00	130.06	178.50	35.02	88.55	65.07	107.23
Personal services	1.05	29.19	3.16	0.06	34.73	53.01	77.10	28.21	2.96	43.93
Other services	30.81	19.58	9.14	0.00	71.63	46.61	58.14	31.34	35.04	26.62
Total intermediate usage including imports	**25567**	**27613**	**54460**	**14516**	**55612**	**31211**	**37774**	**15326**	**21317**	**11306**
Wages and salaries	9376	9636	44477	0	13749	25997	25657	23608	33990	4940
Gross surplus	15355	16546	37406	98384	27291	3241	7478	8761	1185	4547
Indirect taxes on production	1996	1466	4961	10668	2553	1410	3021	934	1170	726
Total gross output	**52294**	**55260**	**141304**	**123568**	**99205**	**61859**	**73930**	**48629**	**57663**	**21519**
Value added at factor cost to output ratio	0.51	0.50	0.61	0.88	0.44	0.50	0.49	0.68	0.63	0.47
Share of wages and mixed income in value added	0.37	0.41	0.55	0.00	0.38	1.01	0.90	0.86	0.95	0.49
Employment to gross output ratio	5.17	6.20	4.09	0.00	3.40	10.93	9.07	7.60	11.86	7.68
Foreign ownership ratio	0.10	0.10	0.20	0.00	0.10	0.15	0.05	0.15	0.00	0.00
Direct tax rate on surplus	0.02	0.12	0.39	0.00	0.09	0.22	0.23	0.09	0.00	0.00
Indirect tax rate on production	0.07	0.04	0.05	0.11	0.04	0.03	0.08	0.02	0.03	0.06
Foreign income payout ratio	0.06	0.04	0.06	0.00	0.05	0.00	0.00	0.02	0.00	0.00
Replacement depreciation to value added ratio	0.23	0.20	0.08	0.00	0.15	0.11	0.07	0.04	0.13	0.13
Net national product ratio	0.72	0.76	0.86	1.00	0.80	0.89	0.93	0.94	0.87	0.87
Domestic income distribution ratio	0.51	0.38	0.24	0.00	0.48	0.00	0.08	0.11	0.00	0.00

Table B.1(k) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Education	Health services	Community services	Motion picture, radio & television services	Libraries, museums & the arts	Sport, gambling & recreational services	Personal services	Other services	Households	Current government expenditure
Sheep	0.00	0.00	9.92	0.00	0.00	0.00	0.00	108.00	7.44	0.00
Grains	0.00	0.09	0.02	0.04	0.02	0.02	0.02	0.04	0.00	0.00
Beef cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.60	0.00
Dairy cattle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pigs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.44	0.00
Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	424.46	0.00
Other agriculture	7.71	8.28	6.60	238.60	39.74	500.36	59.22	31.39	5505.94	0.00
Services to agriculture, hunting and trapping	0.00	0.00	5.14	3.01	0.75	2.79	3.37	25.29	45.25	192.25
Forestry and logging	0.00	0.00	0.00	0.63	0.17	0.60	0.10	2.38	27.07	227.93
Commercial fishing	0.00	0.04	0.47	4.39	1.92	5.21	0.06	8.24	1098.56	178.32
Coal	1.30	2.09	0.11	1.92	0.65	2.34	0.45	1.04	16.49	1.69
Gas	54.14	87.14	15.29	9.04	4.34	12.14	7.53	31.40	532.34	4.66
LNG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron ores	0.18	0.45	0.04	0.54	0.19	0.73	0.19	0.41	0.88	0.03
Non-ferrous metal ores	0.72	1.94	0.17	1.53	0.55	2.04	0.53	1.52	2.20	0.10
Other mining	0.08	0.27	0.42	21.25	4.74	24.09	0.87	5.20	2.48	0.02
Services to mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	83.87
Meat and meat products	29.90	7.05	4.59	17.28	7.31	86.51	4.62	67.44	6065.47	3.11
Dairy products	116.71	17.76	17.49	6.16	3.89	26.68	2.50	156.79	5107.57	0.01
Fruit and vegetable products	7.80	7.42	1.40	2.05	2.10	5.14	1.04	5.60	2224.83	0.00
Oils and fats	6.96	5.32	1.03	1.97	1.38	4.79	4.42	2.81	719.19	11.60
Flour mill products and cereal foods	11.65	13.66	4.09	26.39	10.80	31.98	5.79	17.95	2013.20	0.01
Bakery products	56.26	20.88	12.34	4.69	2.80	8.82	0.53	8.44	2704.53	0.01
Confectionery	7.96	3.99	1.38	23.82	10.90	126.65	5.50	11.25	1949.20	0.01
Other food products	21.93	41.55	5.37	119.65	56.32	650.60	41.63	33.69	3459.07	29.57
Soft drinks, cordials and syrups	1.52	2.79	2.10	8.34	5.79	12.76	1.09	4.91	3166.43	0.01
Beer and malt	1.94	0.87	0.13	0.45	0.33	0.80	0.15	3.03	1589.55	0.01
Wine, spirits and tobacco products	13.01	1.93	0.16	1.25	0.63	1.04	0.96	5.14	2382.18	0.01
Textile fibres, yarns and woven fabrics	6.63	3.22	0.35	1.39	0.87	1.87	1.07	4.67	128.30	0.01
Textile products	10.70	11.37	0.79	1.95	0.56	7.62	1.99	7.37	741.08	0.00
Knitting mill products	3.00	110.23	5.01	2.46	0.79	2.61	0.40	4.33	445.83	0.01
Clothing	11.88	30.90	4.67	6.43	2.85	19.04	2.82	38.44	981.29	0.01

Table B.1(k) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Education	Health services	Community services	Motion picture, radio & television services	Libraries, museums & the arts	Sport, gambling & recreational services	Personal services	Other services	Households	Current government expenditure
Footwear	1.83	6.48	0.41	1.88	0.79	7.34	0.39	1.83	230.50	0.00
Leather and leather products	1.98	1.77	0.13	3.35	1.42	72.25	0.17	0.71	29.01	0.00
Sawmill products	6.71	3.44	0.24	2.45	1.67	2.67	0.62	1.44	24.72	0.06
Other wood products	162.31	9.69	1.36	48.65	27.34	18.57	3.35	7.65	156.49	0.07
Pulp, paper and paperboard	4.02	9.56	1.04	3.67	17.92	2.57	7.44	28.04	55.88	0.00
Paper containers and products	47.16	258.65	37.46	4.26	3.88	3.53	15.16	20.99	774.17	0.00
Printing and services to printing	507.29	108.59	19.69	145.34	141.13	175.77	132.09	215.34	971.34	3.63
Publishing, recorded media, etc.	1056.02	45.82	7.98	72.59	123.35	59.50	61.94	112.42	4678.66	0.08
Petroleum and coal products	7.94	169.09	11.46	23.17	9.48	39.56	26.97	179.19	6503.08	7.76
Basic chemicals	42.07	428.06	6.93	45.71	8.71	81.11	68.55	62.63	356.94	8.39
Paints	0.87	1.43	0.32	9.53	1.88	9.13	1.25	2.41	34.49	0.01
Medicinal and pharmaceutical products, pesticides	7.74	233.39	16.51	44.78	3.71	106.84	17.68	21.40	1209.88	936.84
Soap and detergents	5.67	16.71	2.20	1.76	1.10	2.01	13.90	14.63	848.87	1.66
Cosmetics and toiletry preparations	0.33	1.18	0.07	0.38	0.07	0.65	2.60	0.37	311.89	2.06
Other chemical products	4.84	8.50	2.16	3.94	1.28	4.94	5.91	27.00	231.08	2.33
Rubber products	2.63	5.27	0.40	1.27	0.36	1.93	1.48	4.65	270.56	0.45
Plastic products	40.92	64.36	3.99	13.83	8.16	14.20	32.09	37.93	785.63	0.37
Glass and glass products	14.80	24.80	1.44	5.14	3.38	5.56	1.83	8.01	386.06	0.01
Ceramic products	4.27	0.98	0.44	1.24	0.39	1.31	0.90	0.85	64.92	0.00
Cement, lime and concrete slurry	3.29	2.92	1.78	1.57	0.63	1.38	6.22	11.25	19.11	0.02
Plaster and other concrete products	6.25	2.39	0.40	2.55	1.16	1.64	3.60	6.61	12.73	0.01
Other non-metallic mineral products	2.41	2.38	0.77	1.78	0.62	1.12	10.99	7.32	17.71	0.00
Iron and steel	34.05	9.28	1.09	8.62	5.19	7.94	5.32	12.43	52.88	1.62
Basic non-ferrous metal and products	33.69	23.78	2.97	22.28	6.91	27.74	29.48	16.44	169.38	4.74
Structural metal products	172.82	6.94	0.65	26.97	24.42	25.70	4.24	6.82	71.77	0.11
Sheet metal products	17.94	20.81	1.08	5.53	2.43	6.22	2.71	3.14	95.25	0.05
Fabricated metal products	55.74	40.89	5.33	72.91	23.16	67.12	12.35	42.52	323.56	0.09
Motor vehicles and parts, other transport equipment	64.74	15.20	2.28	20.91	8.23	18.60	5.69	28.32	7152.68	1.60
Ships and boats	1.64	1.26	0.19	3.32	0.94	2.96	0.32	4.58	563.46	1.61
Railway equipment	0.95	1.67	0.08	0.48	0.21	0.67	0.18	0.63	7.63	2.54
Aircraft	2.58	0.60	0.49	6.81	0.71	4.98	0.09	8.53	25.43	1.01
Photographic and scientific equipment	134.70	639.53	1.78	7.50	2.78	18.16	3.30	24.90	1177.30	4.37
Electronic equipment	51.50	22.98	2.08	31.43	8.05	34.32	2.76	14.57	661.28	0.06

Table B.1(k) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Education	Health services	Community services	Motion picture, radio & television services	Libraries, museums & the arts	Sport, gambling & recreational services	Personal services	Other services	Households	Current government expenditure
Household appliances	9.11	23.71	2.98	31.27	10.20	45.54	1.64	6.54	2477.13	0.04
Other electrical equipment	34.40	24.94	2.69	53.58	15.84	54.09	4.51	27.46	414.90	0.09
Agricultural, mining, etc. machinery	20.20	12.43	1.58	8.41	2.80	9.27	1.72	16.01	250.42	0.07
Other machinery and equipment	33.45	27.54	2.30	15.89	5.82	21.57	6.39	31.96	303.22	0.09
Prefabricated buildings	4.34	0.85	0.07	0.71	0.76	0.78	0.27	0.95	10.27	0.01
Furniture	209.06	7.48	1.02	16.77	21.20	10.98	3.75	9.06	2358.71	0.08
Other manufacturing	75.74	50.92	5.79	37.10	14.08	31.68	10.09	36.58	820.05	0.07
Electricity supply	1299.86	389.10	62.00	181.78	57.23	216.41	104.90	281.62	10480.47	138.55
Gas supply	50.39	64.21	13.29	6.31	2.58	7.30	6.42	13.88	1180.41	38.18
Water supply, sewerage and drainage services	98.26	131.87	21.33	39.17	16.61	41.01	63.45	170.96	5128.88	1600.23
Residential building	12.41	45.81	3.93	27.59	10.09	31.52	16.18	35.71	118.03	15.17
Other construction	20.08	66.88	6.43	37.87	13.90	43.13	21.89	51.81	242.35	4735.46
Construction trade services	59.47	77.87	12.34	18.85	11.43	20.23	14.51	37.41	333.70	17.45
Wholesale trade	1196.80	1751.80	80.23	564.08	199.19	752.74	263.89	558.54	21074.07	285.60
Wholesale mechanical repairs	3.19	0.00	0.00	1.39	0.15	2.21	0.19	2.39	0.00	0.00
Other wholesale repairs	157.38	48.90	22.32	43.25	22.79	47.28	50.38	109.74	307.28	0.00
Retail trade	444.39	260.92	28.03	197.92	81.79	239.43	50.51	158.13	73095.76	3500.41
Retail mechanical repairs	60.68	243.63	14.20	90.81	42.36	147.86	25.82	137.28	6288.31	0.00
Other retail repairs	36.77	20.55	6.62	11.34	4.04	3.20	11.00	17.48	631.97	0.00
Accommodation, cafes and restaurants	173.11	18.00	19.00	171.36	58.26	172.01	45.03	125.15	36929.27	4.17
Road transport	321.95	462.56	18.62	177.54	61.09	428.09	87.28	149.39	9914.19	1350.71
Rail, pipeline and other transport	17.03	18.90	3.59	7.59	3.78	9.21	2.53	10.22	2955.80	7.74
Water transport	11.75	1.13	6.78	32.48	5.16	180.40	6.97	64.02	441.79	0.00
Air and space transport	145.94	49.68	6.33	84.65	27.62	114.93	23.64	47.94	8426.13	0.00
Services to transport, storage	259.32	180.97	12.54	100.92	42.55	111.51	16.38	97.86	1673.46	9283.50
Communication services	1219.91	1063.92	109.79	629.65	222.77	942.51	452.73	1054.68	15865.42	101.13
Finance	1061.16	1532.18	108.37	599.73	271.89	660.91	257.07	367.98	45326.34	9.78
Ownership of dwellings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	123166.19	-128.08
Other property services	318.30	485.89	51.82	919.47	346.22	1373.38	205.58	408.56	1258.70	71.81
Scientific research, technical and computer services	304.76	209.12	36.87	87.95	151.01	77.98	74.36	611.89	107.10	1763.98
Legal, accounting, marketing and business management services	605.67	1676.57	76.80	768.78	262.84	1049.42	436.74	508.53	3125.06	353.37
Other business services	489.54	1258.27	122.38	529.72	296.62	881.17	462.28	846.64	1286.38	4443.75

Table B.1(k) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Education	Health services	Community services	Motion picture, radio & television services	Libraries, museums & the arts	Sport, gambling & recreational services	Personal services	Other services	Households	Current government expenditure
Government administration	284.70	114.37	13.89	18.88	20.03	16.52	65.08	17.71	1418.87	48922.65
Defence	1.90	0.51	0.20	0.54	0.97	0.49	0.64	4.94	0.00	21228.67
Education	756.21	76.87	15.69	34.67	94.49	21.92	49.31	282.61	20514.94	33273.19
Health services	49.77	480.58	4.55	25.36	2.13	39.81	3.50	34.02	23522.61	48432.90
Community services	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3004.38	13455.31
Motion picture, radio and television services	11.51	14.04	9.46	2681.19	210.13	401.62	69.93	82.99	1907.64	1520.61
Libraries, museums and the arts	606.48	24.18	14.11	215.34	165.80	165.23	0.95	82.08	979.51	3513.40
Sport, gambling and recreational services	189.45	149.63	43.52	523.26	42.74	545.92	15.65	66.45	14871.53	2093.68
Personal services	51.89	559.33	2.41	39.79	6.22	12.62	14.40	9.34	9092.39	175.64
Other services	30.67	62.82	5.10	4.14	1.84	8.49	12.86	16.86	9898.33	14550.98
Total intermediate usage including imports	**15872**	**17842**	**1362**	**11299**	**4110**	**12951**	**4039**	**9231**		
Wages and salaries	43195	47633	11048	2589	2429	4977	4570	13807		
Gross surplus	3582	6524	3721	2428	949	2780	1755	2053		
Indirect taxes on production	1321	1862	333	482	163	567	267	808		
Total gross output	**63970**	**73862**	**16464**	**16798**	**7652**	**21275**	**10630**	**25899**	**590654**	**220243**
Value added at factor cost to output ratio	0.75	0.76	0.92	0.33	0.46	0.39	0.62	0.64		
Share of wages and mixed income in value added	0.94	0.92	0.80	0.54	1.10	0.73	1.23	0.85		
Employment to gross output ratio	12.97	12.19	14.95	7.72	21.08	14.42	25.65	11.97		
Foreign ownership ratio	0.01	0.02	0.01	0.08	0.01	0.05	0.00	0.03		
Direct tax rate on surplus	0.03	0.06	0.01	0.08	0.04	0.18	0.04	0.03		
Indirect tax rate on production	0.02	0.03	0.02	0.07	0.03	0.05	0.03	0.04		
Foreign income payout ratio	0.00	0.00	0.00	0.03	0.00	0.01	0.00	0.00		
Replacement depreciation to value added ratio	0.09	0.06	0.06	0.37	0.06	0.22	0.12	0.08		
Net national product ratio	0.91	0.93	0.93	0.60	0.94	0.77	0.88	0.91		
Domestic income distribution ratio	0.06	0.07	0.19	0.37	0.00	0.22	0.00	0.13		

Table B.1(l) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Construction investment	Equipment investment	Inventories	Exports
Sheep	0.00	367.11	-8.63	1648
Grains	0.00	0.00	-64.03	5317
Beef cattle	0.00	2254.63	-37.56	490
Dairy cattle	0.00	459.16	0.55	52
Pigs	0.00	0.00	-14.40	0
Poultry	0.00	0.00	-19.61	8
Other agriculture	0.00	0.00	-25.27	1108
Services to agriculture, hunting and trapping	0.00	0.00	-48.42	415
Forestry and logging	0.00	0.00	-16.53	111
Commercial fishing	0.00	0.00	0.20	229
Coal	0.00	568.02	142.88	52158
Gas	0.00	3201.73	341.65	0
LNG	0.00	0.00	0.00	10086
Oil	0.00	0.00	0.00	8757
Iron ores	0.00	3.58	1.01	32652
Non-ferrous metal ores	0.00	131.56	-0.94	9501
Other mining	0.00	4.53	2.49	815
Services to mining	0.00	1354.05	0.00	6
Meat and meat products	0.00	46.94	58.23	5538
Dairy products	0.00	24.20	-5.49	2415
Fruit and vegetable products	0.00	37.87	28.69	995
Oils and fats	0.00	12.50	9.13	409
Flour mill products and cereal foods	0.00	42.06	5.52	1049
Bakery products	0.00	34.54	-2.99	383
Confectionery	0.00	29.83	16.29	555
Other food products	0.00	115.58	-18.45	3924
Soft drinks, cordials and syrups	0.00	9.59	-6.64	208
Beer and malt	0.00	10.96	-1.19	386
Wine, spirits and tobacco products	0.00	20.49	-0.94	2593
Textile fibres, yarns and woven fabrics	0.00	49.14	-5.38	342
Textile products	0.00	449.10	10.85	188
Knitting mill products	0.00	14.80	7.10	60
Clothing	0.00	87.42	-2.87	612
Footwear	0.00	18.90	-2.29	79
Leather and leather products	0.00	25.96	7.04	853

Table B.1(l) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Construction investment	Equipment investment	Inventories	Exports
Sawmill products	0.00	33.84	13.24	988
Other wood products	0.00	136.99	14.28	165
Pulp, paper and paperboard	0.00	10.03	23.00	575
Paper containers and products	0.00	18.60	1.81	317
Printing and services to printing	0.00	35.38	-7.12	195
Publishing, recorded media, etc.	0.00	664.14	19.64	337
Petroleum and coal products	0.00	4835.19	91.99	2642
Basic chemicals	0.00	171.26	16.52	2173
Paints	0.00	31.11	2.45	145
Medicinal and pharmaceutical products, pesticides	0.00	55.56	-1.65	2483
Soap and detergents	0.00	13.30	-0.16	264
Cosmetics and toiletry preparations	0.00	4.51	-0.27	277
Other chemical products	0.00	26.95	-4.89	477
Rubber products	0.00	44.93	1.00	256
Plastic products	0.00	495.63	2.16	716
Glass and glass products	0.00	25.24	4.32	285
Ceramic products	0.00	5.96	4.04	95
Cement, lime and concrete slurry	0.00	24.71	17.36	50
Plaster and other concrete products	0.00	31.73	45.95	59
Other non-metallic mineral products	0.00	8.86	16.48	118
Iron and steel	0.00	368.19	-26.72	4081
Basic non-ferrous metal and products	0.00	248.57	-90.04	34003
Structural metal products	0.00	323.32	60.62	278
Sheet metal products	0.00	966.17	11.80	235
Fabricated metal products	0.00	1213.54	14.21	816
Motor vehicles and parts, other transport equipment	0.00	4265.86	-18.35	3037
Ships and boats	0.00	675.16	-3.93	302
Railway equipment	0.00	431.41	-0.53	67
Aircraft	0.00	764.41	-4.96	529
Photographic and scientific equipment	0.00	775.40	1.48	1587
Electronic equipment	0.00	1053.21	-6.66	1075
Household appliances	0.00	776.38	29.04	260
Other electrical equipment	0.00	641.62	-16.43	777
Agricultural, mining, etc. machinery	0.00	3181.43	23.91	1013
Other machinery and equipment	0.00	2497.14	15.09	1612

Table B.1(l) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Construction investment	Equipment investment	Inventories	Exports
Prefabricated buildings	0.00	248.88	0.96	38
Furniture	0.00	1527.52	2.36	156
Other manufacturing	0.00	462.21	32.19	1137
Electricity supply	0.00	5618.74	3.14	65
Gas supply	0.00	872.11	176.07	2
Water supply, sewerage and drainage services	0.00	748.00	0.00	12
Residential building	51612.53	0.00	0.00	131
Other construction	99054.39	0.00	0.00	188
Construction trade services	25627.21	0.00	-0.69	398
Wholesale trade	0.00	20936.44	-31.07	14076
Wholesale mechanical repairs	0.00	0.00	0.00	0
Other wholesale repairs	0.00	0.00	0.00	1
Retail trade	0.00	2495.55	4.31	4076
Retail mechanical repairs	0.00	0.00	0.00	21
Other retail repairs	0.00	0.00	0.00	0
Accommodation, cafes and restaurants	0.00	1.36	0.00	5417
Road transport	0.00	2825.68	-17.96	7703
Rail, pipeline and other transport	0.00	109.78	-0.70	4429
Water transport	0.00	8.45	0.09	976
Air and space transport	0.00	58.65	0.00	4633
Services to transport, storage	0.00	85.99	-0.21	3365
Communication services	0.00	3980.24	0.00	816
Finance	0.00	142.67	0.00	1453
Ownership of dwellings	0.00	0.00	0.00	529
Other property services	0.00	8617.07	0.00	569
Scientific research, technical and computer services	0.00	12231.62	0.00	2652
Legal, accounting, marketing and business management services	0.00	955.75	0.00	2312
Other business services	0.00	0.00	0.00	970
Government administration	0.00	347.48	0.00	41
Defence	0.00	84.50	0.00	84
Education	0.00	64.59	0.00	4788
Health services	0.00	26.80	0.00	612
Community services	0.00	0.00	0.00	4
Motion picture, radio and television services	0.00	565.14	0.00	232

Table B.1(l) Australia input-output flow table with direct allocation of imports – $2009m (continued)

	Construction investment	Equipment investment	Inventories	Exports
Libraries, museums and the arts	0.00	85.63	0.00	162
Sport, gambling and recreational services	0.00	0.00	0.00	596
Personal services	0.00	0.00	0.00	163
Other services	0.00	0.00	0.00	48
Total intermediate usage including imports				
Wages and salaries				
Gross surplus				
Indirect taxes on production				
Total gross output	**176296**	**139197**	**587**	**269081**
Value added at factor cost to output ratio				
Share of wages and mixed income in value added				
Employment to gross output ratio				
Foreign ownership ratio				
Direct tax rate on surplus				
Indirect tax rate on production				
Foreign income payout ratio				
Replacement depreciation to value added ratio				
Net national product ratio				
Domestic income distribution ratio				

Large scale export of East Coast Australia natural gas: Unintended consequences

National Institute of Economic and Industry Research[1]

This note summarizes the major conclusions of the NIEIR study referenced here. Many major projects to export Liquefied Natural Gas from Eastern Australia have been approved and will start to operate over the next several years. This will significantly impact the domestic supply of natural gas. The National Institute of Economic and Industry Research (NIEIR) has done an assessment, reviewing the literature and conducting its own analysis of the sectoral and macroeconomic implications of these developments.

NIEIR has found that:

- If existing plans proceed, gas exports from eastern Australia will rise from 2 million tonnes (0.29 bcf/day) in 2015 to 20 million tonnes (2.9 bcf/day) in 2018, and possibly 24 million tonnes (3.44 bcf/day) in 2023;
- The current policy framework and market settings for the Australian gas industry favor export of LNG without a subsequent assurance of reliable, competitively priced supplies of gas for domestic industry. Such supplies have historically been a competitive advantage for Australian industry, and gas export revenue is insufficient to compensate Australia for the loss of this advantage;
- Natural gas is essential to a range of industries, particularly non-ferrous metals and basic chemicals, but also plastics, pharmaceuticals, paints and cosmetics. Secure local supply at competitive prices is a fundamental requirement for the continuation of a significant part of production and the development of new investment in these industries;
- Contracts for the long term supply of gas to domestic industry have 'evaporated' as a consequence of export commitments;
- Australia has only a few years before significant economic loss is likely to be felt from the failure to secure an affordable supply of natural gas to domestic users;
- Domestic gas users are increasingly being offered "surplus" gas volumes and prices that do not reflect domestic supply, demand or extraction costs, but are instead linked to East Asia's LNG market – the highest-priced gas in the world. This is a radical reshaping of the domestic gas market, constraining supply (in the near term at least) and driving prices to high (and for many industries uneconomic) levels;
- Current gas production and proven reserves will need to expand dramatically in order to support the LNG expansion without significant large scale suppression of gas use on the domestic economy. While the total gas resource is thought to be very large, proving up additional resources and developing them will take time and faces community opposition and other barriers. To ensure gas availability for domestic users, the management of reserves and their supply to market needs attention if domestic needs are not to be overlooked in the rush to export this valuable resource;
- There are important opportunities to expand use of gas in industrial production and electricity generation, but even so domestic consumers cannot make use of the whole gas resource. There are worthwhile benefits to pursue from exporting gas production beyond these needs. But each cubic foot of natural gas that is shifted away from industrial use towards export, whether because of tight supply or uneconomic pricing, means giving up $255 million in lost industrial output for a $12 million gain in export output. That is, for every dollar gained $21 is lost. This increases to $24 when economy-wide impacts are taken into account;
- The dramatic shift in the domestic gas market will have wider impacts well beyond the gas intensive industries:
    - Increased operating costs for gas-fired electricity generators due to high gas prices. Such generators would see cost increases three times greater than those currently resulting from the carbon tax. Wholesale electricity prices would thus rise, and the viability of new gas-fired generation would suffer. These plants already play an important role in the electricity market for both peak power and base load. That role is expected to grow to meet emissions reduction targets and provide backup for expanding renewable generation;

[1] http://www.nieir.com.au

    - Some substitution away from gas towards electricity by business and households, to reduce their exposure to rising gas prices. This would still leave their costs higher than at present, and would raise greenhouse emissions;
    - A slow-down of general economic activity resulting from impacts of the tighter gas supply and higher costs for gas and electricity;
- The expected economic response to the East Coast LNG expansion will involve a combination of the adjustments above. As a result, modeling indicates that, by 2040 the gross production benefit for East Coast LNG expansion will be $15 billion annually, in 2009 prices. However, taking into account the negative effects of adjustment on other sectors, annual GDP will be $22 billion lower than it would be with secure and affordable gas. An alternative 'benefit indicator' used for this study, which combines private consumption, tax receipts and net national product, will be reduced by $46 billion;
- Under current policy settings and market structures, the unwanted consequences of the significant boom in LNG exports will persist even if, as is likely, adequate natural gas reserves exist and are brought to market; and there are substantial further risks that would lead to even greater costs if realized. These risks include:
    - LNG prices may be lower than currently expected. While this would reduce the extent of domestic price rises, it would also reduce gross export benefits while leaving domestic supply constrained in the short-to-medium term by contracted export commitments; and
    - Industry will likely be unable to grow without secure affordable gas supplies, leading to additional damage.

The likely consequences of the current policy and industry settings on natural gas export are serious for both industry and households. LNG export is a positive for Australia as long as it proceeds without significant harm to the domestic sector and with confident assurance of domestic supply.

Reference

National Institute of Economic and Industry Research, "Large scale export of East Coast Australia natural gas: Unintended consequences." A report to the Australian Industry Group and the Plastics and Chemicals Industries Association, October 2012.

Mining the Data: Analyzing the Economic Implications of Mining for Nonmetropolitan Regions

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Extractive industries such as logging and mining are generally expected to bring significant economic benefits to rural regions, but a growing number of findings have now challenged that common expectation. Still, it is not clear whether the findings of less-than-desirable economic outcomes are isolated or representative. In this article, we assemble literally all of the relevant quantitative findings on mining that we have been able to identify in published and/or technical literature from the United States. In the interest of rigor, we limit the assessment to cases in which strictly nonmetropolitan mining regions are compared against other nonmetropolitan regions and/or against those regions' own experiences over time. Overall, 301 findings meet the criteria for inclusion. Contrary to the long-established assumptions, but consistent with more recent critiques, roughly half of all published findings indicate negative economic outcomes in mining communities, with the remaining findings being split roughly evenly between favorable and neutral/indeterminate ones. Positive findings are more likely to be associated with incomes than with poverty or (especially) unemployment rates, and they are more likely to come from the western United States, where much of the mining involves relatively large, new coal strip mines. Over half of all positive findings come from the years prior to 1982. In virtually all other categories, the plurality or majority of findings have been negative. When the patterns of findings are subjected to one-sample means tests, the only way to produce a significantly positive outcome is by combining all neutral/indeterminate findings with the positive ones, while focusing exclusively on incomes; by contrast, in the case of poverty or unemployment rates—as well as for the overall body of findings—the results are consistently and significantly negative, whether the neutral/indeterminate findings are combined with negative ones or omitted from the equations altogether. Until or unless future studies produce dramatically different findings, there appears to be no scientific basis for accepting the widespread, "obvious" assumption that mining will lead to economic improvement.

Both in academic and popular discourse, the common assumption has long been that the potential environmental threats from extractive industries such as logging and mining will be accompanied by economic benefits for the industries' host regions (see, e.g., Imrie 1992; Thompson and Blevins 1983, p. 153; cf. Humphrey et al.1993; see also Lewan 1993). Indeed, particularly for areas that are remote from urban agglomerations and industrial development, the extraction of raw materials from nature is often seen to be the only hope for economic

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development. At least in principle, it would seem reasonable to expect a rich natural resource endowment to translate into increased prosperity, because resource-dependent industries have significantly less locational flexibility than do most other industrial activities. New mines, for example, can only have a realistic opportunity to be profitable in locations where actual mineral deposits are available. In recent years, however, the common assumptions have begun to be undercut by a growing body of findings.

To date, it is not clear whether the findings of less-than-desirable socio-economic outcomes are idiosyncratic or systematic. In this article, accordingly, we seek to provide a comprehensive summary and assessment of the accumulated findings, focusing on mining-dependent communities. We begin with a qualitative review of the existing literature, including known technical reports and other "gray" literature as well as the findings published in peer-reviewed journals. We follow with a quantitative analysis of the key categories of available socioeconomic findings—those on income, unemployment, and poverty rates—that permit "apples to apples" comparisons of the experiences of nonmetropolitan mining regions against those of nonmetropolitan comparison regions and/or against their own experiences over time. The closing section considers this study's implications for future research on natural resource development in nonmetropolitan regions.

Overview of the Literature

Over the past several decades, researchers have begun to question the once-common assumption that mining would bring socioeconomic prosperity to host regions. The questioning appears to have begun outside of the United States, when authors such as Frank (1966, 1967) began to draw attention to "underdevelopment," which was argued to be due in part to unfavorable terms of trade—with raw materials being sent out from extractive regions at relatively low prices, in unequal exchange for finished products that needed to be imported at high prices. In subsequent years, other international studies (see, e.g., Barham and Coomes 1993; Bunker 1985; Repetto 1995; Schurman 1993) have indicated further reasons for concern. Indeed, careful quantitative analyses have found that—even after controlling statistically for other variables, ranging from the openness of a national economy, to the efficiency of national bureaucracy, to the degree of inequality in national income concentration—nations with high rates of natural resource exports have had abnormally low rates of subsequent economic growth (see, e.g., Sachs and Warner 1995; for a careful review of the larger literature on this "resource curse," see especially Ross 1999).

The work of Corden and Neary (1983) helped to draw increased attention to the paradoxical implications of extractive industries in industrialized countries, highlighting what the authors called "Dutch disease": Holland's massive North Sea oil revenues were actually found to be associated with declining rather than

improving economic fortunes. At least initially, however, such findings received relatively little attention in U.S. community studies. As many rural community leaders have been quick to point out, after all, jobs in logging and mining tend to pay far higher wages than do service jobs such as cleaning hotel rooms or serving fast-food hamburgers. This point is not simply a widespread belief with no empirical support; instead, the nationwide study by Mills (1995), for example, found that earnings per worker were higher in mining than in many other economic sectors—whether considering metropolitan or nonmetropolitan regions, and whether focusing on the "mining boom time" of 1980 or on the nonboom years of 1970 and 1990. In important respects, accordingly, it has long seemed "obvious" to many commentators that extractive industries should be associated with significantly increased local prosperity. In addition, while examinations of the economic characteristics of mining communities have had a long history in the social sciences (for a review, see Field and Burch 1991), few studies seriously questioned the common assumptions and expectations until the 1980s.

Moreover, in one of the first studies to look at the topic in a broad-brush fashion, Bender et al. (1985) obtained results that were reasonably consistent with the usual expectations. Drawing data largely from the 1980 Census of Population and Housing and using a definition that would later be followed by many other authors—with "mining-dependent" counties being those where 20 percent or more of total labor and proprietor income came from mining—Bender et al. found that mining-dependent counties had higher population growth rates, higher incomes, and fewer people receiving social security than the nonmetropolitan average of the times. The study did note, however, that "the variations among counties . . . were large," and that decreases in demand for fuels and minerals between 1979 and the time of their study in 1985 had "produced income and population declines" that did not show up in their study's quantitative analyses (Bender et al. 1985, p. 9).

The subsequent trends were soon to be documented more systematically. Hady and Ross (1990), both of whom were coauthors on the original Bender et al. study, conducted an update, examining the differences between counties that were mining-dependent by the same definition in 1979 (during the height of the energy crisis and mineral prices) and in 1986 (after both a recession and a drop in mineral prices). In the 7 years between 1979 and 1986, mining employment in the nonmetropolitan United States declined by 14 percent; 50 counties ceased being mining-dependent, while only 19 others became mining-dependent during that period. On average, whether focusing on the counties that were mining-dependent in 1979, 1986, or both, the follow-up study found declining personal incomes and increasing unemployment from 1979 to 1986.

Other researchers soon found evidence that less-than-favorable findings were not limited to a 7-year period. In a more comprehensive review of

natural-resource-oriented industries, for example, Weber, Castle, and Shriver (1987) found that, while counties with energy-related mining experienced growth in both employment and earnings during the generally "booming" years of 1969–1985, counties with metal mining experienced declines in both indicators, even during those years.

These kinds of results have raised questions about the degree to which the findings from Bender et al. (1985) may have been influenced by the extraordinary conditions in energy extraction that happened to be approaching their peak around the time period considered in that initial study. One of the points that has become quite clear, for example, is that the areas of the United States having the highest levels of long-term poverty, outside of those having a history of racial inequalities, tend to be found in the very places that were once the site of thriving extractive industries—most notably in Appalachia (Gaventa 1980), but to a lesser extent also in other one-time mining and logging areas such as the "cutover region" of the Upper Midwest (see, e.g., Landis 1938; Lisheron 1991; cf. Schwarzweller and Lean 1993). Perhaps more ominously, the reasons for concern are not limited simply to the implications of ultimate shutdowns or "busts." Several studies have found evidence of problems even while extraction is occurring (e.g., Cook 1995; Drielsma 1984; Elo and Beale 1985; Freudenburg and Gramling 1994; Krannich and Luloff 1991; Peluso et al. 1994; Tickamyer and Tickamyer 1988).

In subsequent years, a number of studies have compared census data from different regions and times. Perhaps the most systematic of these analyses can be found in the work of Nord and Luloff (1993), who offered three kinds of comparisons—comparing data from the 1980 and 1990 censuses, from three regions of the country (the west, the south, and the Great Lakes), and from three different sectors of the mining industry (coal, petroleum, and "other," the last of which includes metal mining and quarrying). These authors' analyses mirrored the findings of Bender et al. in showing that conditions were relatively favorable at the time of the 1980 census, but further analyses showed that the economic implications of mining in all three regions of the country, and in all sectors of the mining industry, had deteriorated since that time. Except in the western region, in fact, unemployment was found to be consistently higher in mining counties than in other nonmetropolitan counties, in each respective region of the country, both in 1980 and in 1990. By 1990, in all but the western region, mining-dependent counties had lower incomes and more persons in poverty than did the nonmining counties. In all regions of the country, including the west, mining-dependent counties experienced greater increases in poverty rates from 1980 to 1990 than did other nonmetropolitan counties. All in all, the only favorable findings associated with mining areas in the 1990 census were found in the western United States—and even there, the findings provided less reason for optimism than had appeared to be the case in 1980.

Other studies have found that local residents' widespread expectations for improved employment may be particularly problematic. In analyzing a decade's worth of data compiled by Weber et al. (1987), for example—a period that included both the "boom years" of extractive industries in the late 1970s and the "agricultural crisis" years of the early 1980s—Krannich and Luloff (1991) found that mining-dependent counties had higher levels of unemployment than did agriculture-dependent counties, in every single year, even during this period. In addition, there is at least suggestive evidence that mining communities' economic problems tend to become increasingly pronounced over time, exacerbated by the volatility of commodity prices, the potential for a cost–price squeeze, and the problem of "flickering" (i.e., the periodic shutting down of extractive operations, as prices fluctuate above and below the costs of operation in specific locations—see Hibbard and Elias 1993). This flickering can contribute to problems of unemployment and poverty, given that laid-off workers will often choose to remain in the area, sometimes for extended periods, in the hope or belief that the high-wage jobs will ultimately return (see, e.g., Freudenburg 1992; Krannich and Luloff 1991).

Perhaps in part because of findings such as the ones being summarized here, there is a potentially telling contrast in two types of studies that have gauged the reactions of local leaders. In regions that are expecting increased mining or just beginning to experience a "boom," it is common to find what Gulliford (1989) calls "euphoria." Unfortunately, in regions that have actually experienced natural resource extraction, local leaders have been found to view their economic prospects less in terms of jubilation than of desperation (e.g., Krannich and Luloff 1991; Freudenburg 1992; Gulliford 1989; Peluso et al. 1994; cf. Cottrell 1951, 1955; Gaventa 1980). Thus, while the largest of the nine working groups established by the Rural Sociological Society's Task Force on Rural Poverty was the one that focused on natural resources, the working group ultimately identified resource extraction not as an antidote to poverty, but as something more like a cause or correlate. In the authors' terminology, they found resource extraction to have a "systematic relationship" with "the impoverization of rural people"—so much so that the bulk of their review was devoted to an effort to identify "social forces at work in resource-dependent rural communities that lead to the creation of relative and/or absolute poverty" (Humphrey et al. 1993, pp. 137–8; see also the responses to this report, including Freudenburg and Gramling 1994; Peluso et al. 1994; Nord and Luloff 1993).

Quantitative Analysis of Available Findings

While even a qualitative literature review can illustrate the need for caution, there is clearly also a need for a more systematic assessment of the relevant evidence. Mining would appear to deserve particularly close attention in that, to

repeat, jobs in mining tend to be associated with some of the highest incomes in any economic sector (Mills 1995). In response, we have sought to bring together and analyze the available findings in a way that would be more systematic, and yet that could be reported in a manner that is as straightforward as possible.

As suggested by the foregoing review, there are many differences across the available studies—a fact with a number of important implications. First and most clearly, differences in the units of analysis and the operationalization of variables mean that any comparisons need to be interpreted with caution—as being indicative of overall patterns, rather than as providing definitive or clearcut answers. Second, the available findings are not independent; instead, there are multiple overlaps but also differences across studies. In terms of overlaps, for example, many authors use statistics from the Census and/or the Bureau of Labor Statistics, but at the same time, there are many differences in the time periods and specific sets of counties being considered. In terms of differences, some authors distinguish carefully between "community-level" versus "county-level" data, while others use the terms more or less interchangeably, and some authors focus on officially "rural" communities (those with fewer than 2,500 residents), while many other studies include nonmetropolitan regions more broadly.

Such overlaps and differences would make it inappropriate and potentially misleading to perform extensive statistical transformations or analyses; instead, the more responsible approach is to assess the findings in terms of simple and easy-to-understand categories. In the analyses that follow, accordingly, we have classified the results in terms of a three-way typology—as indicating, in other words, conditions that are more favorable, less favorable, or no different from the conditions prevailing in relevant nonmining areas and/or during earlier time periods. In the effort to avoid the imposition of our own views, we have deferred to the original authors' interpretations of the data whenever such interpretations are available. A "favorable" finding, for example, thus usually reflects the judgement of those who wrote the report or article in question, whether the judgement was based on statistical analyses or on simple comparisons of descriptive data.

It is also important to recognize that the available literature poses still other challenges for an effort that is intended to be both careful and conservative. In particular, while the overall body of literature addressing the economic well-being of mining-dependent areas is vast, the number of studies explicitly offering systematic, quantitative data on the impacts of mining in the rural United States is actually much smaller. In the process of selecting the findings for analysis, accordingly, we needed to proceed in two main steps. The first step was to conduct an extensive search of articles published in peer-reviewed journals, books and chapters, technical reports, and governmental documents and publications. Because of this process, we ultimately identified several hundred reports and

publications in all. In the second step, however, we found it necessary to deal with the potentially misleading variations across studies by requiring an appropriate degree of consistency in the studies that were selected for more detailed examination. This process ultimately led to the identification of four relatively stringent criteria that were necessary to permit direct and meaningful comparisons and to the elimination of all studies that were unable to meet the criteria.

The first criterion was the most straightforward. The studies needed to present enough comparative data—whether across locations, across time, or both—to permit a reasonable assessment of net economic impacts for the areas affected. Second, the studies needed to provide quantitative assessments of the impacts of mining activity in nonmetropolitan communities or regions in the United States. This criterion alone was enough to eliminate roughly half of the otherwise "available" studies (e.g., those from other nations), and even in the remaining studies, there were a number of variations in the definitions of "mining" and mining dependency. Most studies have used broad definitions, encompassing the full range of metal, coal, and oil-extraction activities, as well as quarrying, while a smaller number have focused on one type of mineral. Nearly half of the studies defined "mining dependency" according to the criterion used by Bender et al. (1985), including only those counties that received at least 20 percent of their total labor and proprietor income from mining during the period specified. The remaining studies followed one or more mining areas over time, required that a given percentage of local employment be from mining, or relied on measures involving a mixture of income and employment from mining.

The third criterion also requires additional discussion: For purposes of comparability, the data in question needed to present at least one of the three variables most commonly included in such studies—namely, incomes, unemployment rates, and poverty rates—corresponding closely to the three kinds of local economic benefits that are commonly expected to be associated with mining. Even among the studies meeting this criterion, however, there proved to be a number of variations, particularly in the definitions of "poverty" and "income." In the comparisons that follow, accordingly, the "poverty" category will include all findings regarding the percentage of persons in poverty, the percentage of children in poverty, and the percentage of families in poverty, while the "income" category includes studies that provide data on median household income, per capita income, and/or wage and salary earnings. The measures of "unemployment," by contrast, involve fewer variations, usually referring to the percentage of the workforce unemployed at the time of data collection, although a few studies use analyses of unemployment insurance payments.

The fourth and final criterion proved to be particularly conservative. Even after the application of the first three criteria, there were still 363 known, quantitative findings in the available literature. The fourth criterion, however,

required the exclusion of all areas that were merely "predominantly" rural or nonmetropolitan, although many people think of predominantly rural states, such as North Dakota, or cultural regions, such as upstate New York or Appalachia, as being "rural." The reason was straightforward: Given that metropolitan areas tend to have significantly stronger economic conditions than do nonmetropolitan areas, important biases might be created by comparing (genuinely) nonmetropolitan mining regions against "control" regions that actually included one or more metropolitan areas (e.g., by comparing the nonmetropolitan mining counties in a given location against the average for the entire region, or for the United States as a whole). The net effect of this fourth criterion was to lower by 51 the number of "adverse" findings on the economic implications of mining, while lowering "positive" findings by only 11. Still, even after the application of this fourth and final criterion, there remained 301 of the "more conservative," quantitative findings, derived from 19 separate studies.

As indicated by Figure 1A, by far the most common findings in the literature are those involving adverse economic outcomes in mining regions. The dashed-line totals indicate that adverse findings constitute an outright majority of the "known" findings (those meeting all but the fourth criterion). Even after the imposition of the fourth and most conservative criterion, just under half of the findings that remain—139 of the remaining 301 findings, in other words, or 46.1 percent of them—indicate the economic conditions in mining regions to be worse than those in the relevant comparison regions. The remaining findings are split roughly evenly between neutral and favorable outcomes, at 74 (24.6%) and 88 (29.2%), respectively. For purposes of clarity, Figure 1B includes only the "more conservative" 301 findings, and in the remainder of this article as well, we will analyze only the 301 findings that meet all four criteria for inclusion. What Figures 1A and 1B show, at least at an overall level, is that favorable or improving economic conditions need to be recognized as being considerably less common in the empirical literature to date than are unfavorable or declining conditions.

Still, to leave the matter there might be too simple. As could be expected on the basis of the preceding literature review, there are a number of variations in the relationships between mining and economic well-being. While the variations among available studies suggest that more detailed analyses should be undertaken only with caution, as noted earlier, there are three types of additional comparisons that are particularly worthy of attention. First are those that focus on the differences that emerge from examining specific indicators of socioeconomic conditions (i.e., incomes, unemployment, and/or poverty rates); second are those that deal with regional variations; and third are those that offer insights into change over time. We will discuss the three in that order. In the interest of conservatism, all of the more detailed comparisons that follow will use only the

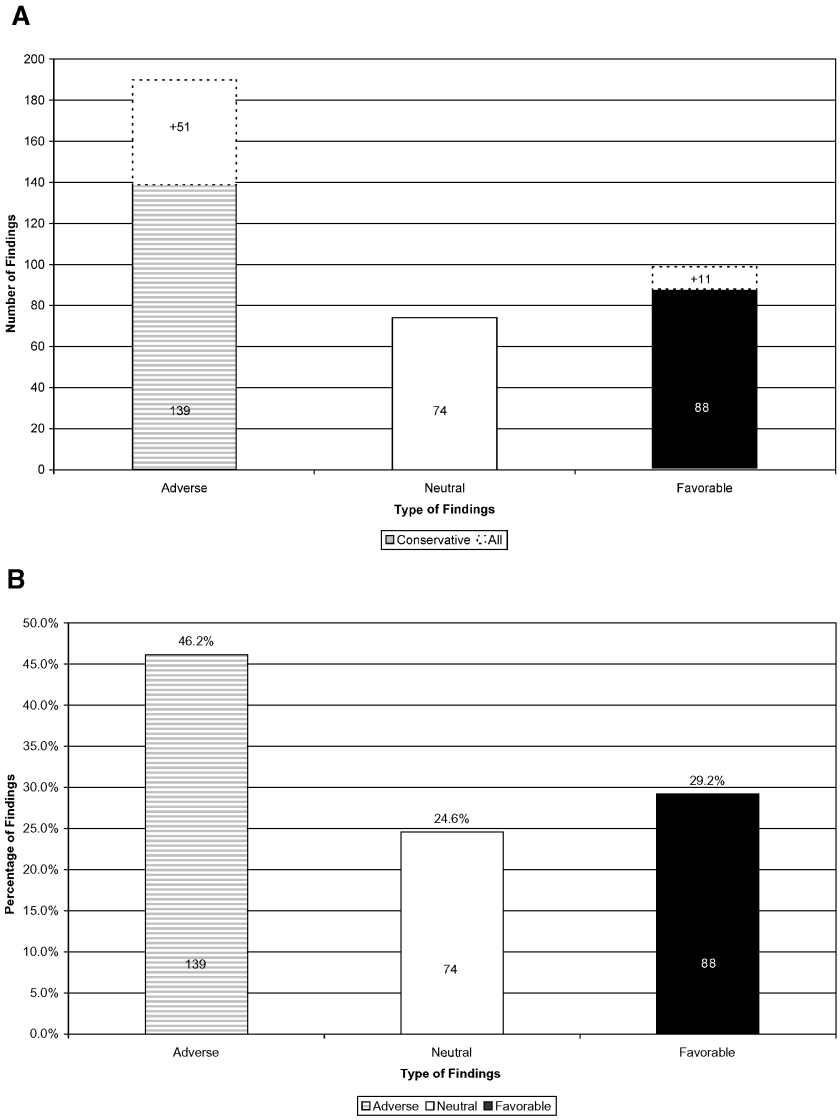

Figure 1
(A) All findings versus "conservative findings." (B) Summary of findings (used in final analysis).

301 findings that meet all four of the criteria for inclusion, and tests of statistical significance will be presented only for the overall totals and for the comparisons involving overall socioeconomic measures or indicators.

Differences across Indicators

The first set of more detailed comparisons involve differences across the three different socioeconomic indicators noted above—income, unemployment rates, and poverty rates. Of the three indicators, the most positive picture emerges from studying incomes, as illustrated in Figure 2. The available studies provide 118 quantitative findings on income differences; in 56 of these cases, or nearly half of the time, mining activity has been associated with higher incomes than in nonmining areas or in previous time periods. Incomes are lower in about one-third of the findings (40, or 33.9%) while the remaining 22 findings (18.6%) indicate a situation that is "no different." Thus, while it may not be literally accurate to describe mining as leading to improved incomes, more findings do fall into the "favorable" category than into the other two, suggesting that mining has indeed been associated with higher income levels in many cases.

A less favorable picture emerges, however, when we consider the fuller range of economic findings. Despite the fact that impoverished rural communities often expect mining to reduce their poverty rates, for example, the findings fail to

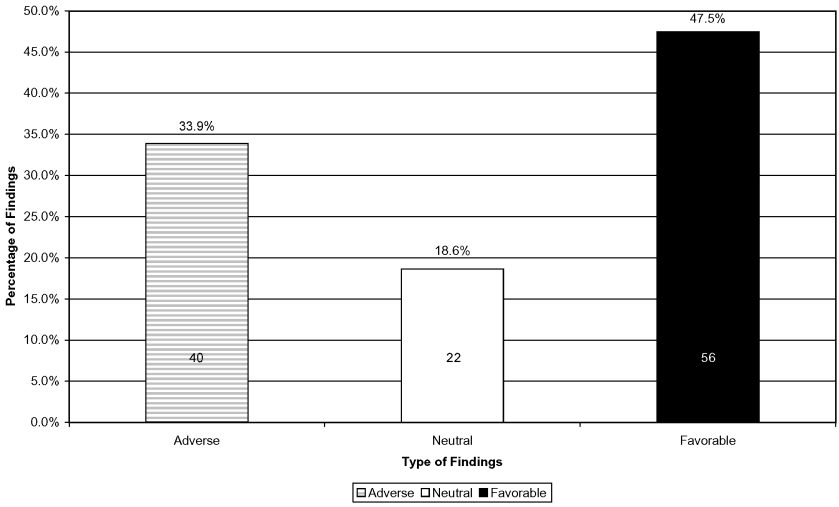

Figure 2
Summary of income findings.

support this common assumption. As can be seen from Figure 3, only about 20 percent of the 59 available findings on the topic indicate mining areas to be associated with lower poverty rates. Instead, more than twice as many findings—26 findings, or 44.1 percent—indicate higher levels of poverty in mining areas, while the remaining 21 findings (35.6%) indicate poverty levels that are neither higher nor lower than in the relevant comparison areas. Likewise, despite the usual assumption that mining will reduce the unemployment problems of rural areas, studies to date have actually tended to find higher levels of unemployment in mining areas than elsewhere. As can be seen from Figure 4, which summarizes the available findings on unemployment rates, a clear majority of the available findings (73 of the 124 findings, or 58.9%) indicate higher levels of unemployment in areas characterized by high levels of mining activity, while another 25 percent of the findings (31) point to conditions that do not differ between mining and comparison areas. Despite the widespread expectation that mining will lower local unemployment rates, actual findings of such favorable conditions prove to be relatively rare, making up the smallest category of all, with just 20 findings (16.1%) suggesting unemployment rates to be lower in mining areas than in comparison areas.

In addition to the graphic presentation of evidence in Figures 1–4, we have provided a quantitative summary and a set of significance tests in Table 1. The

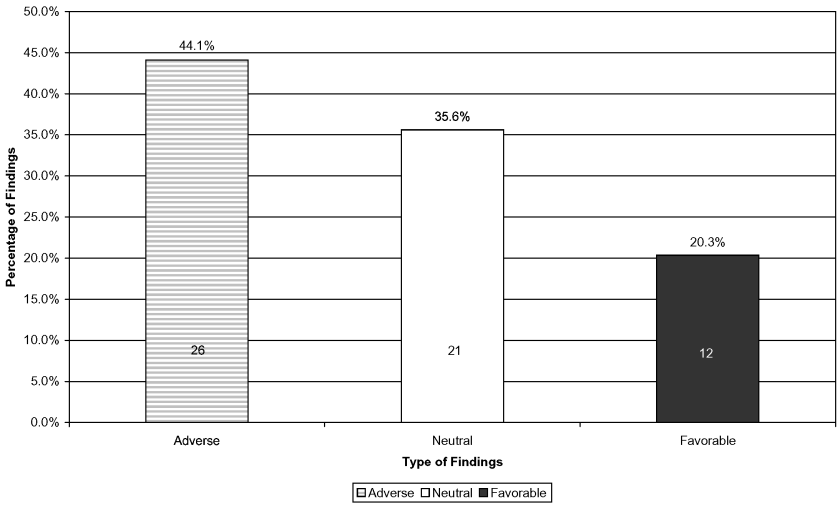

Figure 3
Summary of poverty findings.

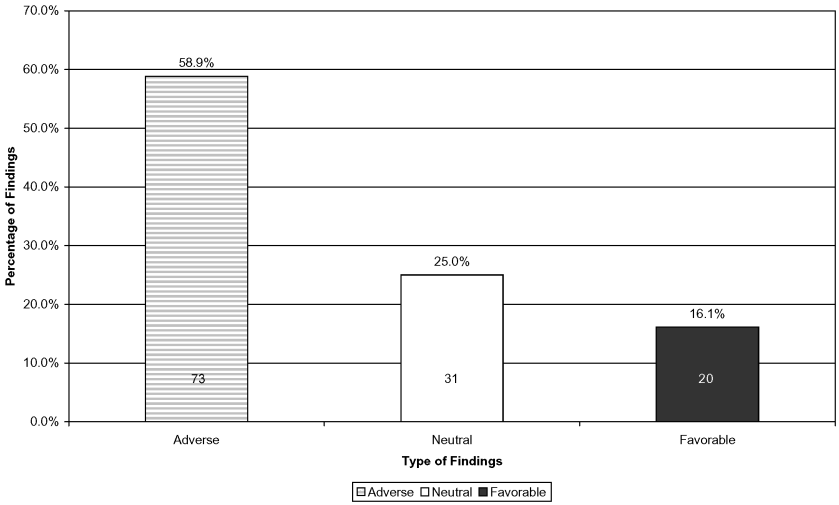

Figure 4
Summary of unemployment findings.

top three lines of the table focus on the overall findings from Figure 1; for the convenience of those who prefer a more detailed examination, the remaining lines of the table summarize the findings in more specific ways. The first column reports the raw number of findings of each type. The second column expresses this number as a percentage of the findings within a given category—that is, as a proportion of all the relevant findings on income, poverty, and unemployment rates—thus repeating the information from Figures 1–4 in tabular form. The final column of the table provides new information, expressing each subcategory of findings (e.g., adverse findings on income, or favorable findings on unemployment rates) as a percentage of the grand or overall total of 301 findings that meet all four of the criteria for inclusion in this analysis.

For each panel of the table, we also present the result of statistical significance tests. Before we turn to the tests themselves, however, four warnings are in order. First, as statistical textbooks routinely note, tests of "statistical significance" should not necessarily be taken as indicating "substantive significance." The tests, instead, are meant to assess the relative consistency of (and hence the degree of statistical confidence that can be placed in) any given pattern. Second, because we are looking at findings from the existing research literature on the three main categories of findings (i.e., incomes, poverty, and unemployment rates), the statistical tests reported here can only be generalized to the research literature addressing these comparative, quantitative results from

mining-dependent, nonmetropolitan regions of the United States. Third, given our earlier warning that outcomes reported in the existing literature are often not independent of one another, an important degree of caution is needed in drawing even these inferences; the major advantages of the significance tests have to do with clarifying and systematizing the available findings. Fourth and finally, in keeping with our earlier warning about the need for caution in interpreting the relatively small number of some of the more specific findings, we will perform the statistical tests only for the largest categories of findings, namely, those already noted—the results on incomes, poverty and unemployment rates, and overall patterns.

The simplest possible approach for testing the statistical significance of these findings is to focus on what are technically known as "binomial" outcomes—that is, those that allow for just two possible outcomes. In accordance with the need for caution, the "cost" of this simplicity is that the tests can be carried out in three different ways—with the neutral findings being combined with positive ones, with negative ones, or being omitted altogether.

In Table 1, we present information on statistical significance only for those comparisons that produced significant results. For the overall findings that are summarized in the top panel of Table 1, for example, the binomial tests show adverse findings to be significantly more common than favorable findings according to two of the three possible comparisons—those where the neutral findings are combined with the adverse findings or where they are omitted from the analysis—although not when the neutral findings are combined with positive ones. For the most favorable of the available sets of findings, by contrast—those for incomes—the only way to obtain significantly more favorable findings than negative ones, according to normal standards of statistical significance, is to treat all of the neutral or indeterminate findings as being "favorable" ones, as well. Finally, unlike the case for the income findings, there prove to be significantly more adverse findings than favorable ones in the cases of poverty and unemployment, whether the neutral findings are treated as being negative or are removed from the analysis altogether. In the case of the unemployment findings, in fact, adverse findings prove to be so much more numerous than positive ones that there are significantly more negative than positive findings even if the neutral or indeterminate findings are explicitly treated as positive ones.

In response to reviewer concerns about the extent to which this overall pattern might be shaped by methodological anomalies of one or more studies—whether through shifts in units of analysis or definition of variables, or simply by having one or two studies that contribute a significant fraction of the findings—we have conducted the additional analysis summarized in Figure 5. As can be seen from the dashed horizontal line and the bar at the far right end of this figure, the overall average, across all studies, is for negative findings to be 1.58 times as

Table 1
Percentages of Adverse/Neutral/Favorable Findings, Overall and by Measure

	No. of Findings	% of Category	% of Total
Overall			
Type of Finding			
Adverse	139	NA	46.2
Neutral	74	NA	24.6
Favorable	88	NA	29.2
Total All Findings	301	NA	
"Adverse Findings" are significantly more likely than "Favorable Findings" by two of three tests:			
$t = -7.907$, $p < .000$ when neutral findings are coded as negative.			
$t = -3.466$, $p = .001$ when neutral findings are excluded.			
By Measure			
Income Findings			
Adverse	40	33.9	13.3
Neutral	22	18.6	7.3
Favorable	56	47.5	18.6
Total Income	118	100.0	39.2
"Favorable Findings" are significantly more likely than "Adverse Findings" by one of three tests:			
$t = 3.679$, $p < .000$ when neutral findings are coded as positive.			
Poverty Findings			
Adverse	26	44.1	8.6
Neutral	21	35.6	7.0
Favorable	12	20.3	4.0
Total Poverty	59	100.0	19.6

(continued)

Table 1 *(continued)*

	No. of Findings	% of Category	% of Total
"Adverse Findings" are significantly more likely than "Favorable Findings" by two of three tests:			
$t = -5.612$, $p < .000$ when neutral findings are coded as negative.			
$t = -2.411$, $p = .021$ when neutral findings are excluded.			
Unemployment Findings			
Adverse	73	58.9	24.3
Neutral	31	25.0	10.3
Favorable	20	16.1	6.6
Total Unemployment	124	100.0	41.2
"Adverse Findings" are significantly more likely than "Favorable Findings" by all three tests:			
$t = -1.999$, $p = .048$ when neutral findings are coded as positive.			
$t = -6.652$, $p < .000$ when neutral findings are excluded.			
$t = -10.213$, $p < .000$ when neutral findings are coded as negative.			
Total across Measures	301	NA	100.0

common as positive ones. As can also be seen, however, there are very few cases in which the removal of a study or studies could be said to exert major or undue influences on the overall pattern of results.

The largest change in ratios would come from dropping the study of Mills (1995)—removing this study would increase the overall ratio of negative to positive findings from 1.58:1 to 1.82:1—yet such a change would scarcely be surprising: Mills focuses on incomes, and as noted earlier, incomes provide a consistently more favorable picture of overall socioeconomic outcomes than do

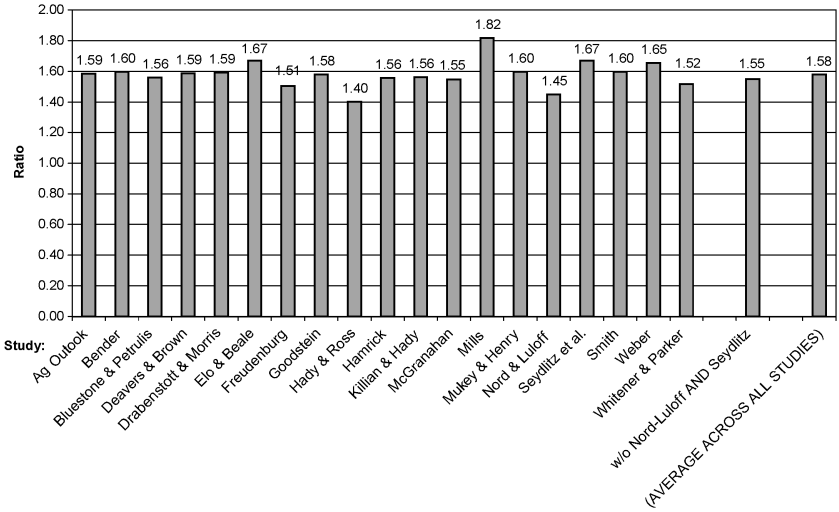

Figure 5
Ratios of adverse to favorable findings without the indicated sources.

poverty or unemployment rates, or for that matter, the overall distributions of findings. The greatest reduction in the overall ratio would come from omitting Hady and Ross (1990); as noted earlier, this study was done as an update to the original report by Bender et al. (1985), and thus it includes a strong emphasis on the years from 1980 onward, when findings have tended to be significantly more negative than in earlier years. Finally, the two studies contributing the largest number of findings are those of Nord and Luloff (1993) and of Seydlitz, Jenkins, and Hampton (1995); these two studies, in combination, provided 141 of the 301 findings just analyzed, but neither of the two studies exerts as much influence in changing the overall total as do Mills (1995) or Hady and Ross (1990), and in combination, the two studies' effects largely counterbalance one another. As can be seen from Figure 5, in other words, the effect of removing the Nord and Luloff findings would be to reduce the overall average from 1.58:1 to 1.45:1, while the effect of removing Seydlitz et al. would be to increase the overall ratio to 1.67:1. As shown by the bar near the extreme right end of the figure, the net effect of removing both studies would be a degree of shift in the overall ratio of negative to positive findings that is remarkably small—a reduction from 1.58:1 to 1.55:1.

Still, in the interest of caution, it should be noted that there would be one clear effect of removing one or both of these studies that is not reflected in Figure 5: Partly because both Nord and Luloff (1993) and Seydlitz et al. (1995) used tests of statistical significance to assess whether findings were positive,

negative, or indeterminate, these two studies reported a higher proportion of "indeterminate" outcomes than for the studies that did not use statistical significance tests. Except for these apparently minor variations, however, the simple form of sensitivity analysis presented in Figure 5 shows a considerable degree of robustness in the comparison that is likely to prove most salient to readers, involving the ratio between negative and positive findings. Indeed, there is no other study of the 19 included in the final analysis that has enough of an effect on the overall findings that the removal of that study would shift the overall ratio of negative to positive findings by as much as 0.10; instead, the overall ratio would stay within the range of 1.58 (± 0.10):1.

Variations by Region and Era

Despite the fact that the overall patterns of findings appear to be relatively robust, the existing literature suggests that more finely grained patterns may be present, as well. Given our earlier warnings about the many variations across studies, plus the exploratory nature of any further comparisons, our judgement is that further tests of statistical significance would be inappropriate for these more fine-grained assessments, but there is still a need to ask whether the findings differ systematically in other ways. In particular, given the number of findings that have come from the western "energy boomtowns" of the late 1970s and early 1980s, there is a need to consider whether the available findings differ systematically by region and/or by era.

Regional Variation. As noted by Nord and Luloff (1993), the question of regional differences is particularly relevant in light of the number of mines in the western United States that are new, that use open-pit mining techniques, and that exploit particularly rich deposits of easily accessible coal. As can be seen from Figure 6A, which summarizes the variations in findings across regions, the western mines are indeed associated with the most favorable economic findings. Only in the western United States, in other words, do the available studies provide more favorable findings than adverse ones; in the west, just over half of the 73 available findings are favorable, while 27.4 percent are adverse, and the remaining 20.5 percent are neutral. Findings from the south point to greater economic distress, with 37.2 percent of the findings indicating adverse conditions in mining regions, but only 15.4 percent indicating favorable conditions. The 31 available findings from the Great Lakes region point to even greater distress: Only two of the quantitative findings from this region (6.5%) indicate mining to be associated with favorable economic outcomes; instead, most of the available findings are split into roughly equal numbers of "neutral" and "adverse" outcomes. Finally, the results from "other" regions of the country, or from the nation as a whole, point to conditions in mining areas that are more than twice as

likely to be adverse (63.0%) than to be favorable (30.3%), while the remaining 6.7% of the findings show no differences.

Differences across Eras. Figure 6B responds to another need that was pointed out earlier—the need to assess potential changes in the relationships between mining and economic well-being over time. Although the preliminary findings from Bender et al. (1985) were relatively favorable, for example, subsequent studies indicated that those preliminary findings may have reflected the unusually prosperous or "boom" conditions that existed in many mining regions during the mid- to late-1970s.

As any number of authors have noted (see, e.g., Gulliford 1989), the era of "western energy boomtowns" came to an unexpectedly abrupt halt on a date that many residents of the Rocky Mountain region still remember as "Black Sunday"—May 2, 1982—when Exxon shut down its massive oil shale operations near Parachute, Colorado, and the mining-dependent portions of the region suddenly found themselves in a deep bust, with no "next boom" on the horizon. While many oil-extraction regions managed to avoid a serious bust for a few more years, largely because oil prices initially avoided the declines that characterized so many other commodities during the early 1980s, world oil prices ultimately dropped from $24.51 to just $9.39 per barrel in the 6 months between December 1985 and June 1986, bringing the end of the boom for oil regions as well (Freudenburg and Gramling 1998). Findings from the era that ended by the early 1980s, accordingly, might be expected to be quite different from those that have been documented in more recent years—a possibility that will be considered next.

Two main types of temporal comparisons are included in the available studies. The first involves longitudinal analyses—those that assess change over time within a given mining region or locality. The second involves cross-sectional comparisons—that is, between mining counties/communities and a matched or "control" set of counties/communities, at a given point in time. In the interest of simplicity, we use the end of 1982, after the end of "boom times" in most U.S. mining regions, as our cutoff point, comparing the findings from data collected during the years up through 1982 against those from data collected in 1983 or thereafter. Given that the overall conclusions from longitudinal analyses are inherently shaped by the conditions that prevail at the end of the study period, any longitudinal studies that straddle the 1982–1983 cutoff point are classified here with the other studies in the "1983 and thereafter" category, while the longitudinal studies that began and ended before 1982 are analyzed with the other "1982 and earlier" findings.

As shown in Figure 6B, the era of data collection does indeed appear to exert an important influence on the favorability of findings. In the years up through 1982, there were more favorable findings (52 of the 123 findings, or

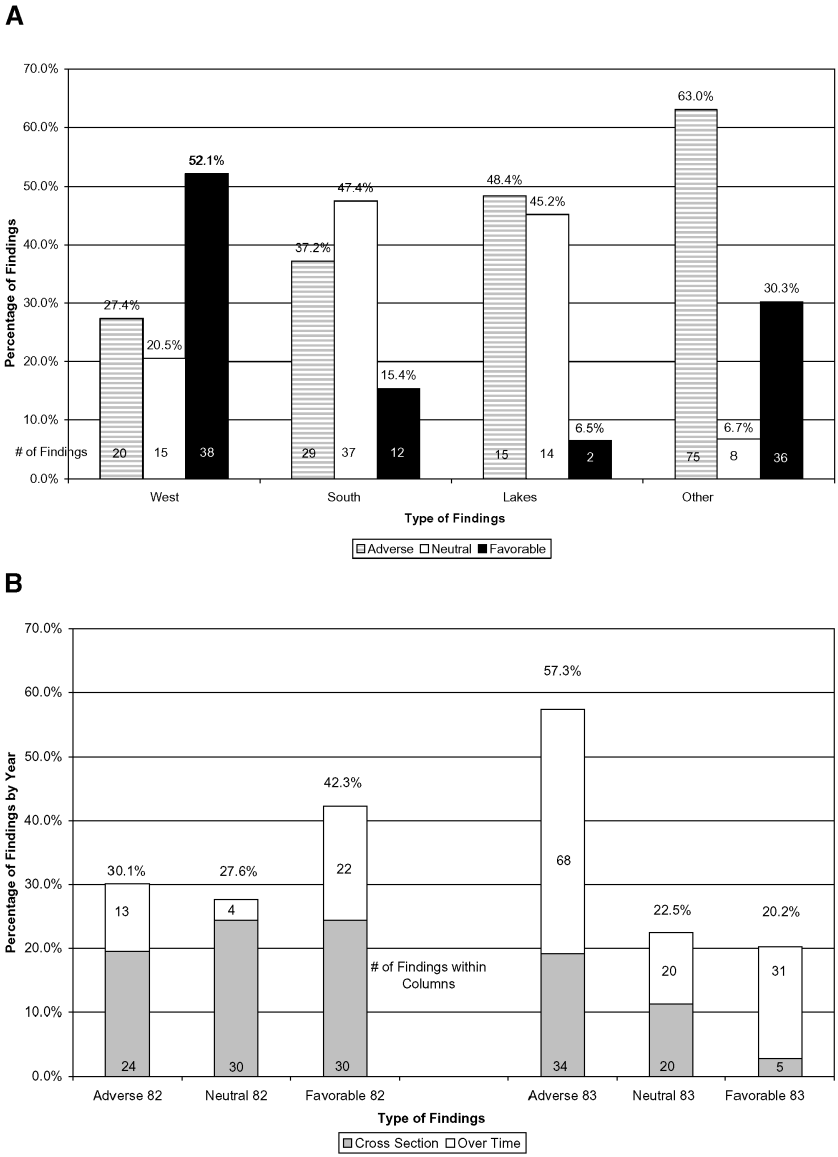

Figure 6
(A) Summary of findings by region. (B) Summary of findings by time.

42.3% of the total) than adverse or neutral ones (37 and 34 findings, or 30.1% and 27.6% of the total, respectively). In the years since then, however, the picture has been much less favorable. An outright majority of the findings since 1982 have been adverse, with 102 adverse findings constituting 57.3 percent of the 178 available findings for the era since 1982. While favorable findings were the most common category for studies that focused on the "boom" conditions that existed up until early 1982, in fact, favorable findings make up the smallest category of the findings since then—just 36 such findings, or 20.2 percent of the total—meaning that there are only about one-third as many favorable findings as adverse ones in studies using data from the years since 1982.

While the cross-sectional findings do not allow us to assess actual change over time in mining areas, a small number of studies have reported "before and after" or longitudinal findings; these findings are reported in the unshaded portions of the bars of Figure 6B, and they do indeed indicate mining to be associated with declining local economic conditions. Intriguingly, save for the fact that the longitudinal studies appear to have produced fewer neutral findings, proportionately, than have the cross-sectional studies (particularly for findings from 1982 and earlier), Figure 6B shows that the overall conclusions suggested by the two different types of methods appear broadly similar to one another, particularly with respect to the dramatic differences between findings from the "boom" era that ended in roughly 1982 and the less "euphoric" times (Gulliford 1989) that have characterized U.S. mining regions ever since. The 68 adverse findings from longitudinal studies, for example, represent 56.2 percent of the 121 longitudinal findings for the period from 1983 to present, while the 34 adverse findings using cross-sectional data represent 57.6 percent of the 59 cross-sectional findings for the same period.

Table 2 presents a summary of the comparisons that are illustrated in Figure 6, doing so in a format that mirrors that of Table 1. As can be seen from a closer examination of the findings from the two tables, most of the more favorable conclusions about economic conditions in mining areas come from a relatively small subset of the available findings—principally those focusing on incomes, in the western United States, before the end of 1982. As shown earlier by Table 1, in other words, only 88 of the 301 findings indicate favorable economic conditions in mining regions, and the clear majority of those findings (56 of the 88, or 63.6% of all favorable findings) involve incomes. Of the greater number of findings that have to do with poverty or unemployment, less than one-fifth—just 32 of the 183 (12+20 of the 59+124), or 17.5 percent—are favorable.

As shown in the top half of Table 2, similarly, it is only in the data from the western United States that favorable outcomes make up as many as one-third of the available findings; across the other regions of the United States as a whole, only 50 of the 228 remaining findings, or 21.9 percent of the total, are favorable,

while another 119 findings—52.2 percent, or an actual majority of the remaining 228 findings—point to adverse economic conditions in mining areas. As just noted, finally, the bottom half of Table 2 shows that findings of favorable economic conditions in mining regions have become relatively rare since 1982, making up only about 20 percent of the available findings that come from 1983 and thereafter, while adverse findings make up nearly three times that number, or 57.3 percent of the overall total, for the same era.

Discussion and Conclusions

These analyses strongly support the warnings of those who have expressed skepticism about the socioeconomic benefits of mines. There are clearly more positive than negative findings for incomes, but the only way for this pattern to be statistically significant is for the neutral findings to be treated explicitly as positive ones. By contrast, for the other three main categories of findings—those for poverty, unemployment, and overall—the test results are strongly significant, statistically, in the opposite direction, indicating that adverse economic outcomes are significantly more likely in the accumulated research literature to date than are positive ones. These findings for poverty, unemployment, and overall patterns remain significant when neutral findings are omitted from the analysis, and not just when the neutral findings are treated as negative ones.

Our findings also reinforce the warnings of Nord and Luloff (1993), who note the importance of analyzing the differences in findings across regions and across time; like Nord and Luloff, we find the problems to be particularly severe in the older eastern and nonfuel mining areas. In addition, our findings mirror what Elo and Beale (1985) called a "curious anomaly"—with mining-dependent counties in that study having had higher median incomes, but also higher proportions of households living in poverty. Our results, in other words, also indicate that, even when higher incomes are associated with mining, those incomes do not prove sufficient to alleviate the problems of poverty and unemployment so often associated with mining-dependent regions.

As a reviewer has noted, one partial explanation for the "anomaly" may involve the mechanization that has had particularly strong impacts on mining employment and income inequality in Appalachia. Mechanization has become associated with relatively high wages in most U.S. mining operations today, but only for the smaller number of workers still employed; many other workers once employed in mining have been displaced by the mechanization. This pattern may well be reinforced by the increasing number of "mining workers" whose jobs are professional and/or technical in nature—geologists, engineers, computer specialists, and so forth—such that the traditional blue-collar "mining jobs" are decreasing in proportion as well as in number.

Table 2
Percentages of Adverse/Neutral/Favorable Findings, by Region and Era

	No. of Findings	% of Category	% of Total
Region			
West			
Adverse	20	27.4	6.6
Neutral	15	20.5	5.0
Favorable	38	52.1	100.0
Total West	73	100.0	24.2
South			
Adverse	29	37.2	9.6
Neutral	37	47.4	12.3
Favorable	12	15.4	4.0
Total South	78	100.0	25.9
Lakes			
Adverse	15	48.4	5.0
Neutral	14	45.2	4.7
Favorable	2	6.5	0.7
Total Lakes	31	100.1	10.4
Other/Nation			
Adverse	75	63.0	24.9
Neutral	8	6.7	2.7
Favorable	36	30.3	12.0
Total Other/Nation	119	100	39.6
Total across Regions	301	NA	100.1
Era			
1982 and before			
Adverse	37	30.1	12.3
Neutral	34	27.6	11.3
Favorable	52	42.3	17.3
Total 1982 and before	123	100.0	40.9

(continued)

Table 2 *(continued)*

	No. of Findings	% of Category	% of Total
1983 and after			
Adverse	102	57.3	33.9
Neutral	40	22.5	13.3
Favorable	36	20.2	12.0
Total 1983 and after	178	100.0	59.1
Total across Eras	301	NA	100.0

Another potential factor behind the apparent anomaly may involve methodological variations: Unlike data on poverty and unemployment rates, which are almost always collected at the level of the households and hence in the communities or counties where people actually live, income data are often collected at the level of the firm—that is, where people work, rather than where they live. The potential importance of this distinction is illustrated by the recently closed White Pine Mine of Michigan's Upper Peninsula (see Wilson 2001). Income data coded by place of work show this mine's county (Ontonagon) to have had far higher incomes than those of Michigan's Upper Peninsula as a whole, but income data based on place of residence, taking cross-county commuting into account, show the same county as being at or below the average of the Upper Peninsula. As shown by recent fieldwork by one of the authors of this article, a key reason is that a significant fraction of the mine's workers lived in different counties or even a different state.

When looking toward the future, perhaps the logical starting point is to note again what this article's analyses do not support–namely, the widespread expectation that mining can be expected to increase the prosperity of isolated rural communities. Indeed, this is perhaps the central implication of our analysis, and one that will require additional examination in future research.

To date, sociologists have offered a number of attempts to explain distressed socioeconomic conditions in resource-dependent areas, drawing on theories of segmented economy, underinvestment in human capital, deindustrialization, and changes in the global economy, as well as on more resource-related or "resource contingency" approaches. Given that the findings of the present study show the experiences of mining communities to have differed significantly from the experiences of other rural regions in recent years, there appears to be a particular

need for greater attention to be paid to the last of these approaches—analyzing communities' relationships with the characteristics of natural resources themselves and with the specific technologies that are developed to exploit the resources.

As past studies have noted, most nonmetropolitan communities have little direct control over broader social, demographic, and economic trends, which can include industrial restructuring, the aging of the population, and global recessions (see, e.g., Humphrey et al. 1993; Fitchen 1995; Gaventa 1990). Still, a growing body of research indicates that certain characteristics tend to have important effects on how local economies fare within the broader changes (see, e.g., Baum 1987; Drabenstott and Smith 1995; Garkovich 1989; Malecki 1994). What has been noted in previous work on "resource contingency" (see, e.g., Freudenburg 1992; Freudenburg and Gramling 1998), in a line of logic that is reinforced by the present study's findings, is that there is a need for the range of "local characteristics" to be extended, to include the examination of characteristics of the actual natural resources and of the ways in which they are extracted. To be more specific, there appears to be a need to pay greater attention to the dynamics of resource dependency, over time, such as the potential that, as mines age, the costs of production may rise (and/or the incentive to invest in newer and more efficient technologies may drop). Such changing relationships could well contribute to what Hibbard and Elias (1993) have termed "flickering" operations (characterized by shutdowns during periods of low prices) and to what Freudenburg (1992) has termed the "extraction of concessions"—with workers, communities, and regulators being asked to make wage, tax, and/or regulatory concessions to mining operations in the interest of keeping the mines open.

While we believe our assessment is by far the most systematic appraisal ever to become available for the existing body of research, it is important that our findings be kept in perspective; other studies or methods could potentially come up with more (or less) favorable results—and in any case, it is important that the needed future research in fact be carried out. Our findings, in short, should be interpreted with caution. What is abundantly clear, however, is that caution is also in order for a set of conclusions that have rarely been treated with caution in the past—namely, the common conclusion or in some cases even the strongly asserted conviction that mining must be good for local economies. Despite the intensity with which such beliefs are often stated, the present analysis has shown that there is remarkably little evidence to support them; instead, most of the more systematic approaches to the data point instead to the opposite conclusion, often at high levels of statistical significance.

For the future, in short, it is important that more research be done; for the present, what is perhaps more important is to recognize that it can no longer be responsibly asserted that the socioeconomic impacts of mining for rural

communities will be favorable ones. Such findings have always been sporadic at best, and at least since 1982, they have become quite rare. To the extent to which past experience is to be our guide, in other words, there is surprisingly little evidence that mining will bring about economic good times, while there is a good deal of evidence for expecting just the opposite.

ENDNOTES

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A Report from the *ENERGY AND THE WEST* Series by

HEADWATERS ECONOMICS

Fossil Fuel Extraction as a County Economic Development Strategy

Are Energy-focusing Counties Benefiting?

September 2008

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Headwaters Economics, Bozeman, Montana

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ABOUT HEADWATERS ECONOMICS

Headwaters Economics is an independent, nonprofit research group. Our mission is to improve community development and land management decisions in the West.

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ABOUT THE *ENERGY AND THE WEST* SERIES

This report is the third in a series—*Energy and the West*—published by Headwaters Economics on the topic of energy development. This series is designed to assist the public and public officials in making informed choices about energy development that will benefit the region over the long term.

In forthcoming reports in the *Energy and the West* series, listed below, we cover the policy context for energy development in the West and the resulting impacts to states, counties, and communities viewed from the perspective of economic performance (i.e., jobs, personal income, wages) and fiscal health (i.e., state and county budgets, revenues and expenses). The series also includes state and local area case studies, which highlight benefits and costs in greater detail.

Titles in the *Energy and the West* series:

- Energy Development and the Changing Economy of the West
- U.S. Energy Needs and the Role of Western Public Lands
- Fossil Fuel Extraction as a County Economic Development Strategy: Are Energy-focusing Counties Benefiting?
- Energy Revenue in the Intermountain West: State and Local Taxes and Royalties from Oil, Natural Gas, and Coal
- Impacts of Energy Development in Colorado, with a Case Study of Mesa and Garfield Counties
- Impacts of Energy Development in Wyoming, with a Case Study of Sweetwater County
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INTRODUCTION

A rapid rise in the price for oil, natural gas, and coal, and a political climate that has favored energy development on public lands has made it possible for some counties in the West to use energy development as a strategy for economic development.

In this report in our *Energy and the West* series, we examine the consequences of focusing on fossil fuel extraction as an economic development strategy. Has it benefited counties in the long run?

The recent rise in fossil fuel development in the West is happening in the context of an economy that has already made a significant shift, away from a historic dependence on resource extraction, to an economy that today is driven primarily by service industries and knowledge-based occupations, and retirement and investment dollars. As a consequence, the economic role of public lands, where much of today's energy development is taking place, has also shifted.

In the past, the principal economic contribution from Bureau of Land Management (BLM), Forest Service, and state lands in the West came from the raw materials that were extracted and exported from the region. Today, there is an additional economic role for public lands. For many communities, the recreational opportunities and scenery provided by public lands are essential components of the quality of life that attracts and retains people and business, as well as retirees and investment income. The scenery, wildlife, and recreation-oriented lifestyle, in which public lands play a critical role, are now economic assets, and a key component of the West's competitive advantage.

The information provided in this report can help those entrusted with the management of the lands in the West to understand the consequences, and potential tradeoffs, of energy development.

Questions Answered in this Report:

1. Has an economic focus on energy development benefited counties of the West?
2. Is today's energy surge any different from the energy boom of the 1970s?
3. Why do energy-focusing counties underperform relative to their peers?

SUMMARY FINDINGS

Key Term: Energy-focusing

We use the term "energy-focusing," abbreviated "EF" in this report, to refer to the 26 rural counties in the West that concentrate their economic development on the extraction of fossil fuels. These counties have a relatively high proportion of total jobs (7% or more) in the county that are involved in the extraction of fossil fuels (natural gas, oil, and coal). We use the term "peers" to describe the remaining 254 western counties of similar size (57,000 people or less). For a full definition of "energy-focusing" (EF) counties and their "peers" see the Methods section on page 4.

Counties that have focused on energy development are underperforming economically compared to peer counties that have little or no energy development.

It is well documented that counties focused on energy extraction as an economic development strategy have historically gone through periods of boom and bust—that their economies are volatile. What is less well understood is how these counties fare economically in the long term.

In the long run, the economies of energy-focusing (EF) counties grow more slowly than the economies of their peers that are not pursuing energy extraction as an economic development strategy.

From 1990 to 2005, for example, the average rate of growth of real personal income in EF counties was 2.3 percent per year, compared to 2.9 percent in the peers. In terms of employment, the average annual growth of EF counties over the same time period was 1.8 percent, compared to 2.3 percent for their peers.

An energy development surge no longer guarantees strong economic performance.

In the energy boom that began in the 1970s and ended in the early 1980s, counties that were focused on energy development, with a high portion of jobs in fossil fuel development, were some of the top economic performers in the West. In today's energy surge, this is no longer the case.

As measured by average annual job growth, only one of 26 EF counties ranks among the top 30 economic performers in the West, while during the last energy boom half were top performers. In addition, more than half of EF counties are losing population in the midst of today's energy surge.

In EF counties, the share of total jobs in energy-related fields has declined, from 23 percent in 1982 (past energy boom) to 14 percent in 2005 (current energy surge). In recent years, jobs unrelated to energy extraction are growing rapidly and the western economy is much larger than in the past.

A heavy reliance on fossil fuel extraction may point to diminished future competitiveness.

As the West develops its fossil fuel energy resources, an ongoing challenge is increasing the competiveness of local economies, especially in sectors unrelated to energy development.

Compared to their peers in the West that have not pursued energy development as an economic strategy, EF counties over the long term are characterized by:

- Less economic diversity and resilience
- Lower levels of education in the workforce
- A greater gap between high and low income households
- A growing wage disparity between energy-related workers and all other workers
- Less ability to attract investment and retirement dollars

These long-term indicators suggest that relying on fossil fuel extraction may not be an effective economic development strategy for competing in today's growing and more diverse western economy.

METHODS: THE DEFINITION OF ENERGY-FOCUSING (EF) COUNTIES

We define those counties that concentrate their economic strategy on the development of fossil fuels as "energy-focusing" (EF) counties. These are counties where a relatively high proportion of total jobs in the county are involved in the extraction of fossil fuels (natural gas, oil, and coal). Fossil fuel extraction includes the following codes from the North American Industrial Classification System (NAICS): drilling and extracting oil and gas reserves, extracting coal reserves, and support activities related to these. These NAICS codes are shown in Table 1 and are defined in more detail in the Appendix.[1]

Table 1.Description of Data Used to Show Employment and Personal Income Related to Energy Development, by North American Industrial Classification System (NAICS) Code

Description	NAICS Code
Oil and Gas	
Oil and gas extraction	211
Drilling oil and gas wells	213111
Support activities for oil and gas operations (e.g., contract drilling, surveying, mapping, operating oil and gas fields on a contract basis)	213112
Coal	
Coal mining	2121
Support activities for coal mining (e.g., geophysical surveying, mapping)	213113

We define a county as energy-focusing (EF) if more than 7 percent of total private-sector employment in the county was engaged in energy development—natural gas, oil, and coal—in 2005. The 7 percent cut-off was selected for two reasons: (1) below this threshold, the percent of employment in fossil fuel energy sectors in counties across the West falls off rapidly, and (2) any less energy activity as a share of total employment does not reflect a significant concentration on this single industry.

There are 26 EF counties in the West. Table 2 shows the list of EF counties, and their relative concentration in oil and natural gas versus coal extraction. They are all counties with small populations—fewer than 57,000 people. There is one exception: San Juan County, New Mexico. We eliminated San Juan County, New Mexico from the list because it is more than twice as large as the next largest EF county, and we wanted to compare EF counties, which are overwhelmingly rural, with their rural counterparts in the West.

There are 254 "peer" counties in the West. These are western counties of similar size (57,000 people or less) that do not have significant employment devoted to the extraction of oil, natural gas, and coal (less than 7% of total private employment). EF counties (yellow), along with their non-energy "peers" (blue), are shown in Map 1 (page 6).

Of the 26 EF counties in the West, 12 had between 10 percent and 15 percent of all employment engaged in fossil fuel extraction (light green in Table 2), and another eight had more than 15

percent involved in energy development (dark green in Table 2). Four counties had more than 20 percent of all employment in energy development, and one, Campbell County, Wyoming, had a third of its workforce employed directly in energy development.[2]

We used County Business Patterns data, from the Bureau of the Census, to define EF counties. This data does not include individual proprietors (the self-employed), so the actual number of energy workers in a given county will be larger. The ratio of wage and salary workers to proprietors is fairly consistent across industries, so using wage and salary employment numbers does not significantly alter the overall employment share for each industry.[3]

Definition of Mining

When we use the term "mining" in our *Energy and the West* series, we refer primarily to jobs and income associated with the development and extraction of oil, natural gas, and coal (the fossil fuels). Because of restrictions placed on the level of detail available from the U.S. Department of Commerce and the Bureau of the Census, it is sometimes not possible to separate minerals mining from fossil fuels mining. In the energy-focusing counties analyzed in this report, the bulk (over 80%) of "mining" is in energy development.

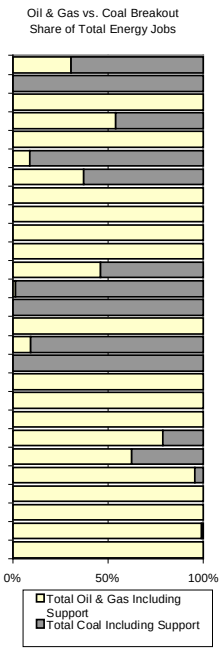
Table 2. Energy-focusing Counties in the West, 2005

				Oil and Gas Jobs:				Coal Jobs:		
	Energy Jobs in 2005	**Energy Jobs Share of Total Jobs in 2005**	Total Oil & Gas Including Support	Oil and Gas Extraction	Drilling Oil and Gas Wells	Support Activities for Oil and Gas Operations	Total Coal Including Support	Coal Mining	Support Activities for Coal Mining	Population in 2005
Campbell, Wyoming	5,436	**30.0%**	1,656	455	211	990	3,780	3,709	71	37,420
Emery, Utah	668	**24.5%**	2	-	-	2	667	660	7	10,711
Cheyenne, Colorado	99	**21.5%**	99	13	70	15	-	-	-	1,952
Rio Blanco, Colorado	343	**20.9%**	185	49	29	107	158	158	-	6,000
Uinta, Wyoming	1,163	**17.5%**	1,163	247	-	916	-	-	-	19,873
Big Horn, Montana	354	**16.7%**	32	2	-	31	322	322	-	13,076
Converse, Wyoming	610	**16.4%**	227	71	14	142	384	384	-	12,743
Hot Springs, Wyoming	233	**15.4%**	233	36	1	196	-	-	-	4,568
Fallon, Montana	124	**14.9%**	124	72	-	52	-	-	-	2,709
Blaine, Montana	133	**14.1%**	133	-	70	63	-	-	-	6,634
Sublette, Wyoming	309	**14.0%**	309	108	4	197	-	-	-	6,965
Lincoln, Wyoming	639	**13.6%**	294	37	7	250	345	345	-	15,940
Moffat, Colorado	507	**13.5%**	8	2	-	6	499	499	-	13,397
Rosebud, Montana	359	**13.4%**	-	-	-	-	359	359	-	9,279
Lea, New Mexico	2,065	**12.3%**	2,065	447	699	919	-	-	-	56,650
Carbon, Utah	807	**11.5%**	75	44	15	15	733	731	2	19,459
Gunnison, Colorado	689	**11.4%**	-	-	-	-	689	689	-	14,182
Weston, Wyoming	179	**11.2%**	179	87	14	78	-	-	-	6,642
Uintah, Utah	824	**10.9%**	824	195	60	569	-	-	-	27,129
Eddy, New Mexico	1,835	**10.5%**	1,835	798	210	827	-	-	-	51,269
San Juan, New Mexico	3,534	9.5%	2,786	671	500	1,615	748	748	-	125,820
Sweetwater, Wyoming	1,344	**9.0%**	841	217	32	592	502	502	-	38,019
Richland, Montana	317	**8.8%**	303	47	7	249	14	14	-	9,163
Yuma, Colorado	204	**8.4%**	204	17	152	35	-	-	-	9,785
Toole, Montana	124	**7.8%**	124	72	35	17	-	-	-	5,174
Big Horn, Wyoming	175	**7.3%**	174	23	-	150	1	1	-	11,325
Duchesne, Utah	293	**7.0%**	293	99	19	175	-	-	-	15,328

Energy Jobs over 15% of Total
Energy Jobs over 10% of Total

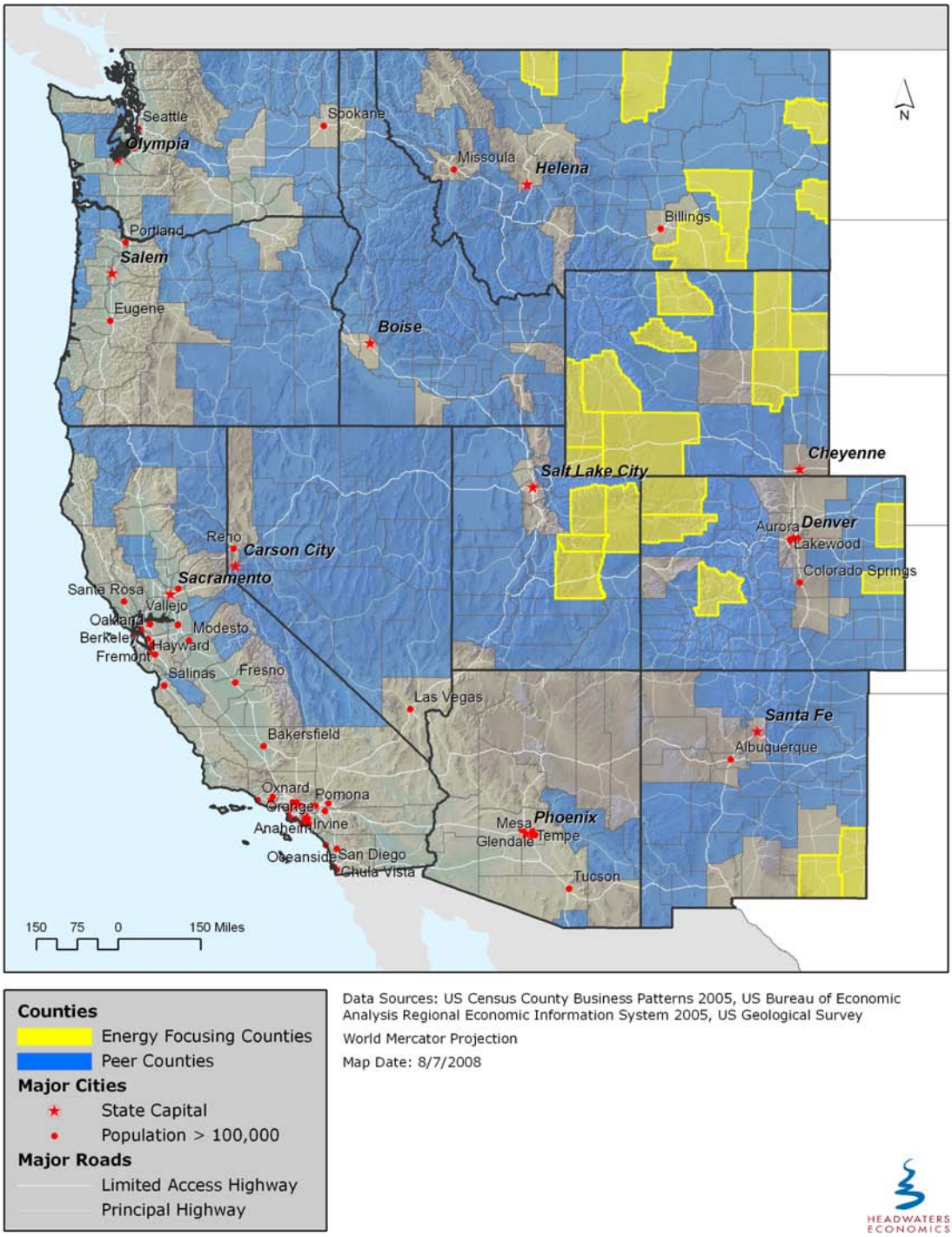
Maximum Population (excl. San Juan) 56,650

San Juan, NM was excluded because population is much larger and we want to focus on small rural communities that are heavily dependent on energy.



EF counties and their peers are shown in Map 1.

Map 1. Energy-focusing Counties and their Rural Peers



HAS AN ECONOMIC FOCUS ON ENERGY DEVELOPMENT BENEFITED COUNTIES OF THE WEST?

In order to answer this question, we compared the economic performance of energy-focusing (EF) counties, measured in a variety of ways, to their rural peers.

We use three time periods for analysis:

1970–1982 A period of economic growth, culminating in a national recession. This period also captures an energy development "boom" period in the West.

1982–1990 A period of recovery in the national economy, but decline, or energy "bust" period, for EF counties in the West.

1990–2005 The beginning of a new period of growth in the national economy, dominated by a shift to a service and knowledge-based economy, an increasingly mobile workforce, and the advent of new technology (personal computers, the Internet, telecommunications). This period also captures the most recent energy surge for parts of the West, which began approximately in 2000.

We use these periods for comparison because they frame starkly different economic stages, and highlight differences as well as emerging similarities between EF counties and their peers.

The measures of performance we used to compare EF counties to their rural peers are:

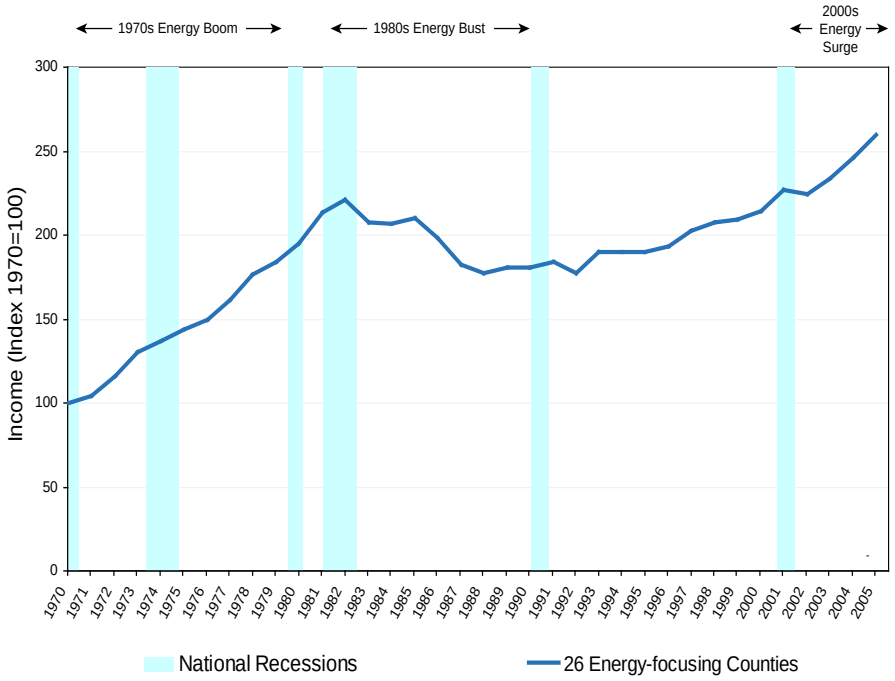
- Total personal income
- Average earnings per job
- Population
- Per capita income
- Employment

Throughout this report all dollars figures are in real terms, i.e., adjusted for inflation.

We begin by looking at the long-term economic history of EF counties. Figure 1 shows the growth and decline of real personal income from 1970 to 2005 in EF counties (in aggregate). Light blue vertical bars illustrate periods of national recession.

The economic history of EF counties is characterized by tremendous volatility. The boom in the 1970s was followed by a bust that lasted a decade in the 1980s. In the 1990s, EF counties recovered. This recovery was fueled by sectors unrelated to energy development, and represents a significant departure from the experience of the 1980s. The steady growth in the 1990s was extended and accelerated in the 2000s, when the current energy surge took root.

Figure 1. Total Personal Income in Energy-focusing (EF) Counties in the West, 1970–2005 (Indexed 1970=100)



Next we examine EF counties as compared to their peers from a historical perspective. Figure 2 shows the trends in personal income, by source (industry and non-labor income sources) from 1970 to 2000, for the aggregate of the 26 EF counties in the West. Figure 3 shows the same information for the aggregate of the 254 rural peer counties in the West.

The differences between the economic experience of EF counties and their peers are starkly evident. While EF counties went through a discernable boom/bust cycle, their peer counties saw a much steadier growth.

From 1970 to 1982, total personal income in EF counties, driven by mining, which includes energy development, grew rapidly. For the rest of the 1980s, mining and energy development contracted severely and brought the rest of the economy down with it. By the 1990s, however, with mining and energy development still declining though beginning to stabilize, the rest of the economy grew—this time independent of the fortunes of mining and energy extraction. Growth in the 1990s was driven by the rise in personal income from people employed in service and professional industries, and the even-faster increase of non-labor income (retirement, investments, government transfer payments, etc.).

For EF counties, the 1990s represented a period of economic diversification. The fact that the economies of EF counties began to diversify, even in the face of rapid declines in the mining (mostly energy development), is an important point. It underscores the economic shift that took place in the rural West between the 1980s and the 1990s, and shows that the context for today's energy surge is an economy that is both larger and more diverse that in the past.

Figure 2. Historical Trends in Personal Income by Source, Energy-focusing (EF) Counties in the West, 1970–2000 [4]

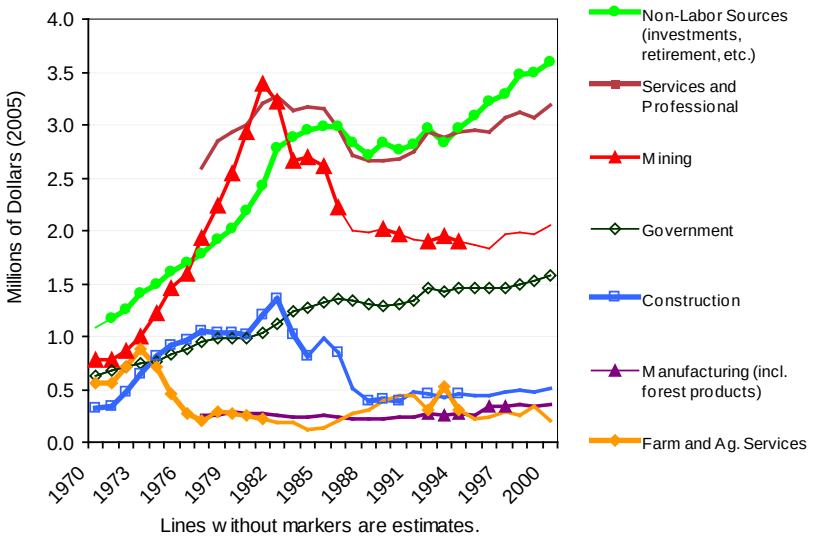
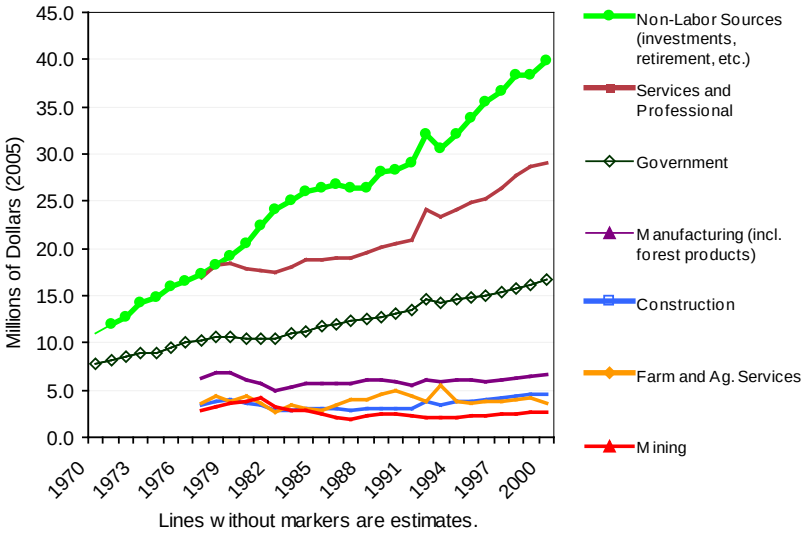


Figure 3: Historical Trends in Personal Income by Source, Peer Counties in the West, 1970– 2000 [5]

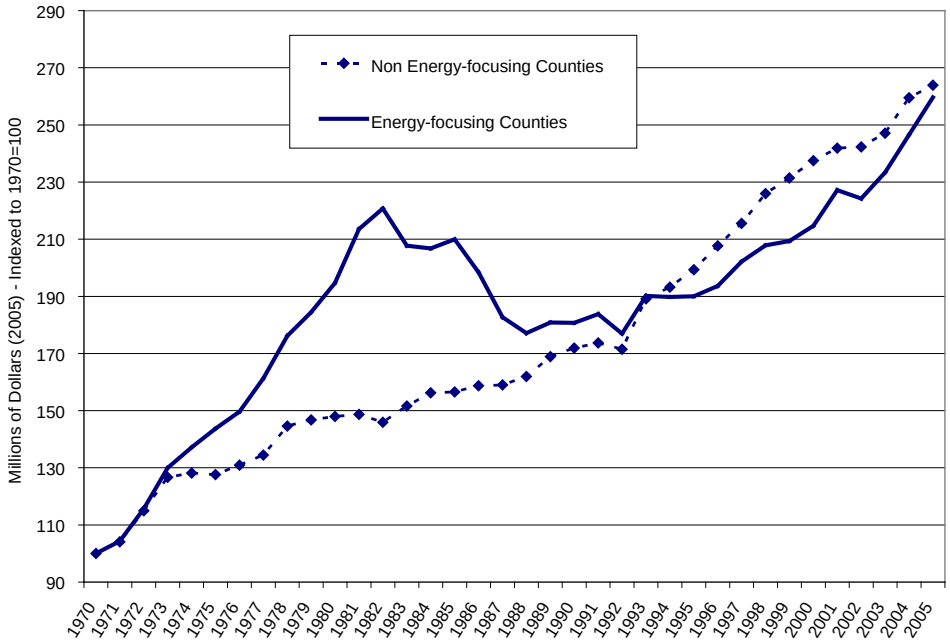


In contrast to EF counties, the non-energy peer counties saw a long and continued growth in real personal income, with no slowdown following the 1982 recession. Traditional industries, ranging from agriculture to manufacturing and construction, were all flat, while service and professional industries, non-labor income, and government enterprises accounted for the growth in personal income.

This tortoise-versus-the-hare comparison shows that it is not necessarily the case that rural counties in the West need to develop energy resources (if they have them) in order to succeed. Both sets of counties—EF counties and their peers—grew their economies at the same rate over the long term. This point is illustrated by Figure 4, which shows the long-term trend in personal income, comparing EF counties to their peer counties. The figure is indexed to 1970 in order to show relative rates of growth.

While the rate of growth in EF counties is characterized by fast acceleration and fast deceleration, the peer counties pursued a steadier expansion, with higher rates of income growth since the early 1990s. From 1990 to 2005, the average rate of real personal income growth in EF counties was 2.3 percent per year, compared to 2.9 percent in the peer counties. For the same time period, the average annual employment growth of EF counties was 1.8 percent, compared to 2.3 percent for the peer counties.[6]

Figure 4. Growth of Total Personal Income, Energy-focusing (EF) Counties versus Peer Counties in the West, Indexed, 1970–2005



These findings show that EF counties have historically gone through periods of boom and bust, outperforming their non-energy peers during the boom, and underperforming during the subsequent bust. They also show that EF counties began to grow and diversify their economies in the 1990s independent of mining and energy development. And, finally, over the last 15 years, EF counties have been falling behind in economic performance compared to their peers.

IS TODAY'S ENERGY SURGE ANY DIFFERENT FROM THE ENERGY BOOM OF THE 1970S?

Figure 5 (page 13) shows measures of economic performance (change in personal income, employment, average earnings per job, population, and per capita income), comparing EF counties to their peers. The vertical bar charts show the difference in growth rates for each measure between the two county types. In the chart, bars above 0.0% (the x-axis) indicate a period when EF counties outperformed the non-EF counties. Bar charts below 0.0% refer to episodes when EF counties underperformed compared to their peers.[7]

During the past energy boom period (1970–1982) EF counties showed fast rates of growth in personal income, employment, average earnings per job, population, and per capita income. This is consistent with Figure 4 that showed a much higher growth rate for EF counties during the 1970s. During the ensuing bust (1982–1990), the reverse occurred, and EF counties saw significant declines in all economic performance indicators relative to their peers.

The most interesting finding of Figure 5 is what occurred from 1990 to 2005, after the last energy bust and before and during the current energy surge, and how different the comparative performance is between the two sets of counties when contrasted with the earlier boom period of the 1970s. Compared to their peer counties in the West, EF counties saw a decline in personal income, employment, and population, and a rise in average earnings per job and per capita income from 1990 to 2005. This means that relative to their peers, EF counties underperformed in terms of the growth of real personal income, employment, and population, and outperformed in terms of the growth in earnings per job and per capita income. In other words, in today's economy there is no guarantee that counties that develop fossil fuel reserves have any significant advantage over those counties without those resources.

What Figure 5 also shows is that economically today's energy surge is different from those of the past. Until 1990, the pattern for EF counties was to do very well during a boom and very poorly during a bust. After 1990, this pattern changed, and it is no longer the case that an energy surge causes those counties with a higher share of economic activity devoted to energy development to outperform their rural peers. In three of the five economic indicators, the EF counties did worse than their peers. For the measures where they outperformed—average earnings per job and per capita income—there was only a modest performance difference (0.6% per year from 1990 to 2005).

The reasons for the difference in relative performance are explored in the next section. In brief, one reason is that the economy of the rural West has grown substantially in the last few decades, and as a result new energy jobs now make up a much smaller percent of total employment than in the past. Figure 6 shows that in EF counties at the peak of the last boom, in 1982, energy-related jobs were 23 percent of total employment (the green line, and right axis in the figure), whereas, in 2005, energy-related jobs in EF counties were 14 percent of total employment.[8] In other words, the relative share of energy jobs in EF counties has declined.

In addition, today's energy surge, driven in part by ready access to public lands, is occurring in a different context. Over the last three decades the economic role of public lands has changed significantly, from a repository of raw materials, to a haven for recreationists, tourists, retirees, and mobile businesses whose owners choose to locate in areas with a high quality of life. The economic transition, from a resource-based economy, to one focused on services, knowledge-based occupations, retirement, and investment dollars, has already taken place.

To put this in perspective, for the West as a whole, service-based occupations and non-labor income constitute 86 percent of the growth in the economy during the last three decades. And today, 45 percent of total personal income comes from wages earned by people employed in service-related occupations, while another 27 percent is from non-labor sources, such as retirement and investments.[9]

Of particular note, given that a new energy development surge started around the beginning of this decade, is the fact that mining, which includes oil, natural gas, and coal development, is still a relatively small component of the economy of the West, providing 1 percent of total personal income in 2005.[10]

The West is the most urbanized part of the U.S., with 90 percent of people living in metropolitan areas.[11] As a result, these trends largely represent urban phenomena. A closer look at the rest of the West—the rural West without metropolitan areas—reveals similar findings.

In the non-metropolitan West, a third of personal income in 2005 was generated by service-related industries. Non-labor income was relatively larger than in the rural West, making up more than 40 percent of total personal income.[12] Mining, including oil and natural gas, constituted less than 5 percent of total personal income and 2 percent of employment.[13]

For a thorough discussion of the economy of the West and the relative role of energy development, please consult another report in our *Energy and the West* series, *Energy Development and the Changing Economy of the West*.

Figure 5. Annual Rates of Growth of Key Economic Indicators, Shown as the Difference in Growth Rates Between Energy-focusing (EF) Counties and their Peers in the Rural West

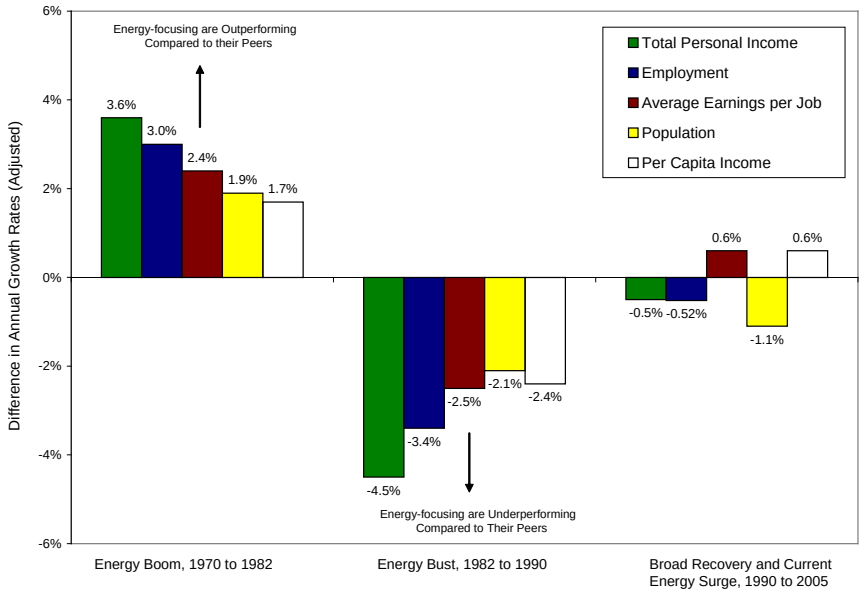
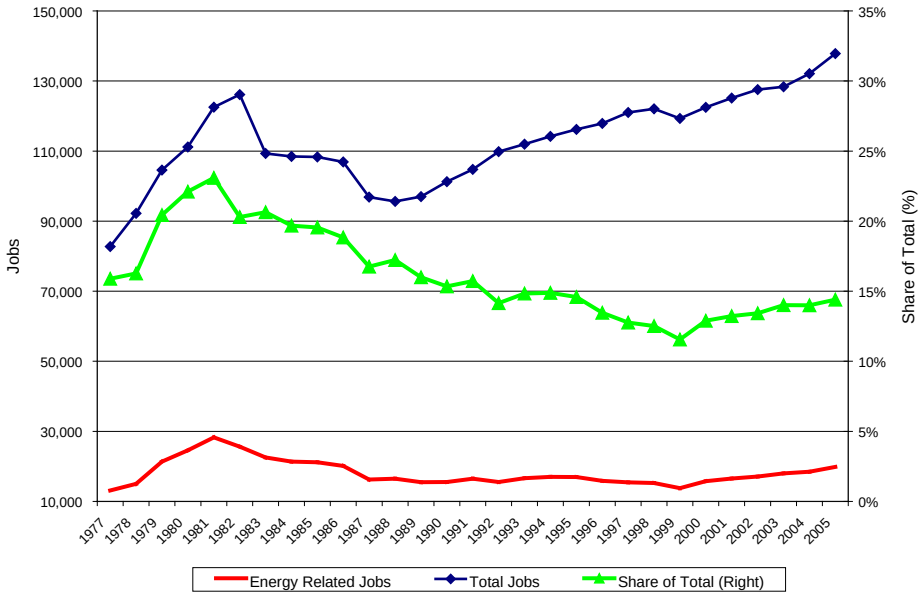


Figure 6. Energy-related Jobs in the Energy-focusing (EF) Counties in the West, as Share of Total, 1977–2005



The scale of the recent economic transition means that it is more difficult today for energy development, by itself, to turn county economies into top economic performers. This is illustrated in Table 3, which ranks EF counties among all counties in the West according to the annual growth of jobs during three time periods. In the energy boom that took place from 1970 to 1982, 10 of the 26 EF counties were in the top 30 counties in the West in terms of job growth (light green). Only one, Toole County, Montana, was among the bottom 30 counties (orange).[14]

During the ensuing bust, from 1982 to 1990, 12 of 26 EF counties ranked among the bottom 30 counties in the West in terms of job growth, and none were top performers. This is consistent with previous figures that showed significant economic decline for EF counties during this period.

The current energy surge has not created a rising tide lifting all EF boats as in the past. Only one county, Sublette County, Wyoming, ranks among the top economic performers in the West, in terms of job growth. Campbell County, Wyoming, the most energy-focusing county in the West, had the third highest rate of growth in the past energy boom, but ranks 85th in overall job growth in the current surge. Emery County, Utah ranked fifth in the past boom, and is 331st in the current surge. Even Sweetwater County, Wyoming, which is in the midst of a boom in natural gas development, ranks 254 out of 411 in terms of job growth during the current energy surge, as compared to fourth in the last boom.

Table 3. Ranking of Energy-focusing Counties Among all Counties in the West, in Terms of Average Annual Job Growth

			Rank among 411 western counties, based on average annual job growth during:		
Sorted by Energy Dependence:	Energy Jobs in 2005	Energy Share of Total (2005)	Old Boom: 1970-1982	Bust: 1982-1990	Recent Boom: 2000-2005
Campbell, Wyoming	5,436	30.0%	3	402	85
Emery, Utah	668	24.5%	5	385	331
Cheyenne, Colorado	99	21.5%	240	327	384
Rio Blanco, Colorado	343	20.9%	31	411	237
Uinta, Wyoming	1,163	17.5%	6	370	139
Big Horn, Montana	354	16.7%	296	348	202
Converse, Wyoming	610	16.4%	14	391	112
Hot Springs, Wyoming	233	15.4%	161	380	304
Fallon, Montana	124	14.9%	280	399	301
Blaine, Montana	133	14.1%	367	270	366
Sublette, Wyoming	309	14.0%	157	326	28
Lincoln, Wyoming	639	13.6%	149	353	110
Moffat, Colorado	507	13.5%	23	358	221
Rosebud, Montana	359	13.4%	7	390	375
Lea, New Mexico	2,065	12.3%	87	403	228
Carbon, Utah	807	11.5%	29	405	327
Gunnison, Colorado	689	11.4%	54	274	36
Weston, Wyoming	179	11.2%	116	382	215
Uintah, Utah	824	10.9%	28	393	88
Eddy, New Mexico	1,835	10.5%	136	351	224
Sweetwater, Wyoming	1,344	9.0%	4	386	254
Richland, Montana	317	8.8%	104	408	321
Yuma, Colorado	204	8.4%	289	131	398
Toole, Montana	124	7.8%	386	299	372
Big Horn, Wyoming	175	7.3%	205	374	278
Duchesne, Utah	293	7.0%	22	375	102

Top 30 (out of 411 Western Counties)
Bottom 30 (out of 411 Western Counties)

In spite of the recent rise in energy development activity, most EF counties are experiencing population losses. Table 4 (page 16) shows that of the 26 EF counties, 10 (38%) have seen an increase in population from 2000 to 2007 (highlighted in green). This includes some of the most heavily energy-focusing counties in Wyoming, Utah, and Colorado. Surprisingly, 16 (62%) of the energy-focusing counties lost population during the same period.[15]

Strangely, six of the counties that lost population at the same time added over 100 new jobs (not counting proprietors), from 2000 to 2005, in energy-related fields. These are: Blaine, Richland, and Rosebud counties, Montana; Eddy and Lea counties, New Mexico; and Uinta County, Wyoming.

Why are these counties losing population in the midst of an energy surge? One possible explanation may be the rising cost of living, which we discuss in more detail in the case study reports. As new jobs are created in the fields of oil, natural gas, and coal mining, workers move in, the cost of labor rises, and with a limited supply of housing, the cost of housing rises along with it. Non-energy workers, unable to compete for housing and a higher cost of living, leave. For example, rental prices in Rock Springs, Wyoming, in Sweetwater County, an EF county that is growing rapidly because of energy development, increased by 100% between 2000 and 2007.[16]

Further Reading

For more detail on the impacts of rapid energy development, see the two reports in the *Energy and the West* series listed below. They are available at: www.headwaterseconomics.org/energy.

Impacts of Energy Development in Colorado, with a Case Study of Mesa and Garfield Counties

Impacts of Energy Development in Wyoming, with a Case Study of Sweetwater County

Another possible explanation is that communities in the midst of an energy surge may displace other residents, retirees for example, who do not wish to live in what is becoming for many former rural towns a fast-paced industrial landscape. There may be other reasons for the loss of population that have nothing to do with energy development, and more to do with the plight of rural communities in general. Regardless of the reasons, there appears to be no guarantee that making a choice to focus economic activity on energy development will stem the loss of population that is so common in the rural West.

Table 4 . Net Migration per Thousand People per Year in Energy-focusing (EF) Counties, 2000–2007

	Migration 2000 to 2007 (People per 1000 per year)
Sublette, Wyoming	36.9
Campbell, Wyoming	14.8
Lincoln, Wyoming	8.0
Uintah, Utah	7.1
Converse, Wyoming	4.6
Duchesne, Utah	4.6
Weston, Wyoming	4.5
Gunnison, Colorado	2.7
Rio Blanco, Colorado	0.5
Lea, New Mexico	-1.8
Moffat, Colorado	-2.0
Sweetwater, Wyoming	-2.2
Big Horn, Wyoming	-2.9
Hot Springs, Wyoming	-4.4
Eddy, New Mexico	-4.7
Yuma, Colorado	-5.6
Uinta, Wyoming	-5.9
Richland, Montana	-6.0
Fallon, Montana	-8.2
Toole, Montana	-9.2
Carbon, Utah	-10.6
Big Horn, Montana	-10.9
Rosebud, Montana	-13.0
Emery, Utah	-15.9
Blaine, Montana	-16.5
Cheyenne, Colorado	-32.6
Unweighted Average	-2.6

These findings show that rural economies focusing on energy development today are very different than in the past. Unlike the past, EF counties are underperforming compared to their rural peers. EF counties are not the West's top economic performers they used to be. Today, only one EF county ranks among the top 30 economic performers in the West, while during the last energy boom half were top performers. Energy development also plays a smaller relative role in EF counties than in the past. The share of total jobs in energy-related fields in EF counties has declined, from a high of 23 percent in 1982 (peak of last energy boom) to 14 percent in 2005 (in the midst of today's energy surge). At the same time, 62 percent of EF counties are losing population in the midst of today's energy surge.

WHY DO ENERGY-FOCUSING COUNTIES UNDERPERFORM RELATIVE TO THEIR PEERS?

In this section, we explore answers to the question of why EF counties underperform economically.

Energy-focusing Counties are Less Economically Diverse

The more diverse the economy of a county, the better it is able to adapt to the constantly changing conditions of the global and national economy.[17]

There are indications that EF counties are diversifying. Figure 2 (page 9), for example, shows a rise in certain sectors of the economy, such as services and non-labor income, despite declines in mining, including energy development. Figure 2 shows that the relative contribution of mining is declining, in part, because the overall non-energy related portion of the economy is growing. In spite of this diversification, by 2000 (the beginning of the current surge) EF counties were still much less diverse economically than their non-EF peers.

To measure economic diversity we developed a specialization index for the aggregate economy of all 26 EF counties and compared that to one developed for the 254 peer counties in the West.[18] This index is commonly used as a measure of industrial specialization in the economy. Counties with a high specialization index are less economically diverse, more susceptible to volatility, and less innovative.[19] The most diverse score possible would be one that exactly emulated the U.S. economy, and would have a score of 0.0.[20]

Our findings show that in 2000, the specialization index for EF counties was 280, compared to a score of 106 for their peer counties. The principal ways EF counties are different from the U.S. are: a heavy reliance on mining and energy development (11.8% of total compared to 0.4% for the U.S.); under-reliance on manufacturing (4.3% compared to 14.1% for the U.S.); and under-reliance on professional scientific and technical services (2.4% compared to 5.9% for the U.S.). The main ways the peer counties in the West differ from the U.S. are: under-reliance on manufacturing (7.9%); over-reliance on agriculture, forestry and fishing (7.2% compared to 1.5% for the U.S.), and over-reliance on accommodation and food services (8.6% compared to 6.1% for the U.S.).[21]

Another way to represent economic diversity is to assess those industries that are growing, and those that are in decline. Table 5 shows the growth of jobs during the current energy surge (2000 to 2005), comparing EF counties to their peers in the West.[22]

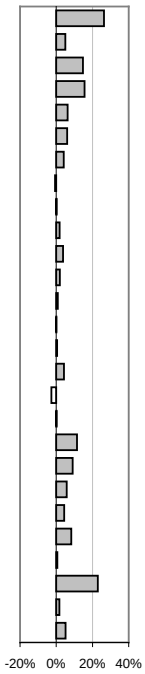
In EF counties, the principal growth (indicated in light green when over 5% of new jobs) was in direct energy-related occupations (energy, mining, support activities for oil and natural gas operations) and largely in occupations indirectly associated with energy development (manufacturing, construction, transportation, warehousing, and professional and scientific services). Other sectors, such as retail trade, health care and social assistance, and accommodation and food services also grew.

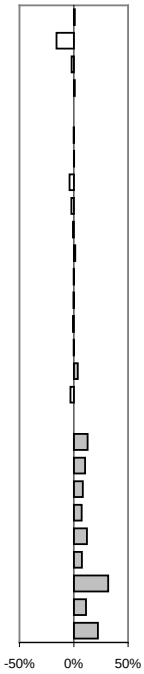
In the peer counties, the bulk of the job growth came from service-related occupations, with the largest growth in health and social assistance, and accommodation and food services. Other areas in which the peer counties grew include construction, transportation and warehousing, retail trade, real estate, and other services. In addition, other data, detailed below, show that peer counties are more successfully attracting investment and retirement dollars, and diversifying their economies with these income streams.[23]

The difference in types of growth can be seen in the column at the far right of Table 5. EF counties are specializing, adding those sectors that are necessary for the exploration, development, extraction, and transportation of fossil fuels. They do not create many new jobs that characterize the broader economic shift in the western economy over the last several decades, namely the development of a service-based and knowledge-based economy.

Table 5. New Jobs by Industrial Sector Comparing Energy-focusing Counties to Peer Counties in the West, 2000–2005

	26 Energy-Focusing Counties			254 Non Energy-Focusing Counties		
Industry	New Jobs 2000-2005 15,312	New Jobs Share of Total 100.0%	New Jobs Share of Total	New Jobs 2000-2005 62,320	New Jobs Share of Total 100.0%	New Jobs Share of Total
Energy	4,043	26.4%		643	1.0%	
Manufacturing	775	5.1%		(9,873)	-15.8%	
Mining	2,249	14.7%		(1,234)	-2.0%	
Support Activities for Oil and Gas Operations	2,387	15.6%		599	1.0%	
Management of Companies and Enterprises	969	6.3%		103	0.2%	
Drilling Oil and Gas Wells	922	6.0%		(7)	0.0%	
Oil and Gas Extraction	632	4.1%		170	0.3%	
Unclassified	(108)	-0.7%		(2,392)	-3.8%	
Forestry, Fishing, Hunting, and Agriculture Support	38	0.3%		(1,440)	-2.3%	
Information	284	1.9%		(416)	-0.7%	
Other Services (except Public Administration)	567	3.7%		830	1.3%	
Utilities	293	1.9%		(60)	-0.1%	
Educational Services	131	0.9%		(187)	-0.3%	
Wholesale Trade	12	0.1%		(523)	-0.8%	
Support Activities for Coal Mining	76	0.5%		(125)	-0.2%	
Finance and Insurance	652	4.3%		2,360	3.8%	
Auxiliaries, except Corporate, Subsidiary, and Regional M	(412)	-2.7%		(1,930)	-3.1%	
Coal Mining	25	0.2%		6	0.0%	
Construction	1,756	11.5%		7,969	12.8%	
Transportation and Warehousing	1,382	9.0%		6,466	10.4%	
Retail Trade	892	5.8%		5,187	8.3%	
Administrative and Support and Waste Management and	669	4.4%		4,533	7.3%	
Professional, Scientific, and Technical Services	1,261	8.2%		7,484	12.0%	
Real Estate and Rental and Leasing	100	0.7%		4,660	7.5%	
Health Care and Social Assistance	3,510	22.9%		19,682	31.6%	
Arts, Entertainment, and Recreation	262	1.7%		7,026	11.3%	
Accommodation and Food Services	789	5.2%		13,778	22.1%	





Green if over 5%, Brown if under -5%.

Overall Wages Have Not Increased at the Same Rate as Energy Industry Wages

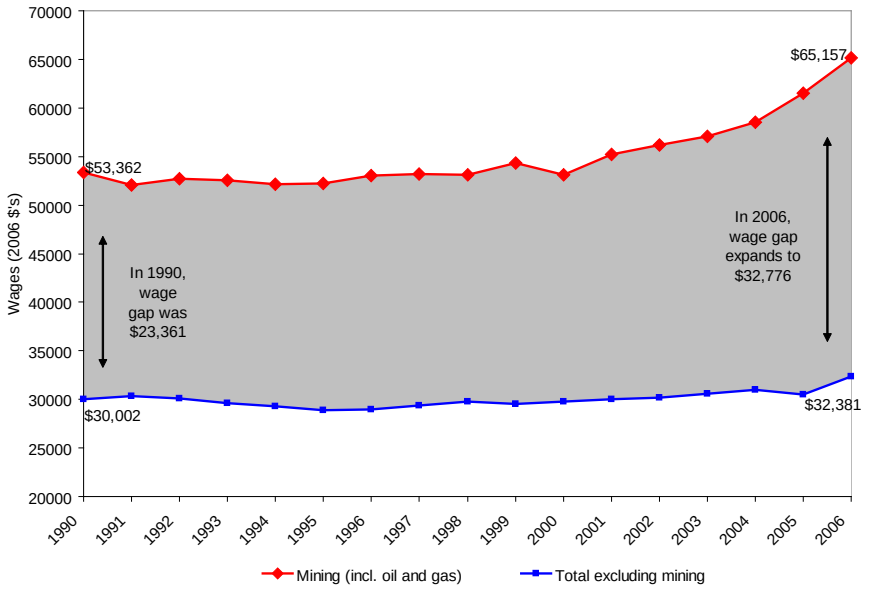
Another possible reason for the relatively lower performance of EF counties is a growing gap between what mine workers earn ("mine" includes energy-related fields in this report) compared to those working in other sectors of the economy.

Figure 7 shows average annual wages of mine workers (primarily oil and natural gas workers) in EF counties, compared to wages in the rest of the economy. In 1990, the wage gap was $23,361; mine workers earned $53,362 per year, on average, while those in other sectors earned, on average, a little over $30,000 per year. Wages in non-mining sectors have not changed much since then. From 1990 to 2006, they grew (in real terms) by 7.9 percent, to $32,381 in 2006. During that time, average annual wages for the mining sector grew by 22 percent, to over $65,000 per year in 2006. The wage gap grew to a difference of $32,776, which is $9,414 more than it was in 1990.[24]

It is possible that the 7.9 percent growth in non-mining wages would not have happened if there weren't any mining activity. From 1990 to 2006, average annual wages in the peer counties grew more slowly, by 6 percent. In 2006, average annual wages in non-mining sectors in the peer counties was $30,555, lower than that of the EF counties, at $32,381.[25]

The growing wage gap in EF counties between mine and all other workers—from $23,361 in 1990 to $32,776 in 2006—is not a healthy sign. The danger is that more people, including teachers, nurses, and farm workers, will be left behind if renewed energy development increases the general cost of living, especially the cost of housing, in a place. We explore this issue in more depth in the case study reports in the *Energy and the West* series.

Figure 7. Average Annual Wages in Mining, including Energy Development, Compared to the Rest of the Economy, in Energy-focusing Counties in the West, 1990-2006



Energy-focusing Counties Have Less Equitable Wealth Distribution

A community where everyone is doing comparatively well stands a higher chance of being able to adapt to change and grow.[26] We measured the gap between "high income" and "low income" by counting the number of households earning more than $150,000 per year ("high income") divided by the number of households earning less than $30,000 per year ("low income") .[27]

At the end of the last energy bust cycle and before EF counties started their economic recovery, in 1990, EF counties had a large gap between high income and low income households: for every household earning over $150,000 per year, there were 108 household earning less than $30,000 per year. By comparison, that same year in the peer counties, for every household earning more than $150,000 per year, there 87 households earning less than $30,000. This means that at the beginning of the recovery period that started in the 1990s, EF counties had a relatively less equitable distribution of wealth; i.e., there were many more "low income" relative to "high income."

Fortunately, by 2000 (at the beginning of the current energy surge, and at the end of the recovery that took place during the 1990s) the high income-low income ratio declined significantly for both county types.[28] In EF counties, for every high income household, there were 27 low income households (a ratio of 1:27; for the peer counties in 2000 the ratio was 1:17).

That EF counties had a larger gap between high income and low income than their peers at the end of a bust period and before embarking on economic recovery (i.e., 1990) is related to the fact that EF counties have not diversified their economies and developed a more mixed suite of service-related industries. By 2000, after a decade of more balanced economic growth, EF counties had improved their earnings distribution, but still lagged behind their peers.

In the current energy surge, EF counties are once again developing an earnings gap among residents. This is attributable to the widening gap between earnings of mine workers and the rest of the economy, a gap that is growing and was over $32,000 in 2006. If cost-of-living factors are considered, it is likely that people on fixed income or earning lower average wages are falling even further behind.

It is premature to estimate what income distribution will look like in EF counties after the current surge, but it is plausible that the gap between the high income and low income households will continue to widen for counties that focus on energy development as a rural development strategy.

Energy-focusing Counties Have Less Educated Workforces

An important condition for economic success in today's U.S. economy is an educated workforce.[29] We look at the percent of the adult population with and without a high school and college education.

At the end of the last energy bust cycle and before EF counties started their economic recovery, in 1990, EF counties had somewhat less educated workforces compared to their peers. In 1990, 24 percent of the adult population in EF counties did not have a high school diploma, which is slightly higher than their peer counties (23%). By 2000, 19 percent of the adult population in the EF counties did not have a high school diploma, an improvement from the previous decade, but still higher than their peers (17%).[30]

In terms of college education, in 1990 the percent of the adult population with a college degree was about equal among the two county types, although slightly less (14% compared to 16%) for EF counties. By 2000, at the end of the 1990s recovery, the percent of the population with a college degree increased slightly for EF counties (to 16%), but remained lower than in the non-EF peers (20%).

These statistics show that counties focused on energy development lag behind their peers in terms of workforce education levels. Even though all counties are experiencing increases in workforce education levels, the proportion of college-educated workers in EF counties at the beginning of this century had been reached by their non-energy peers a decade earlier.

Energy-focusing Counties Attract Fewer Retirement and Investment Dollars

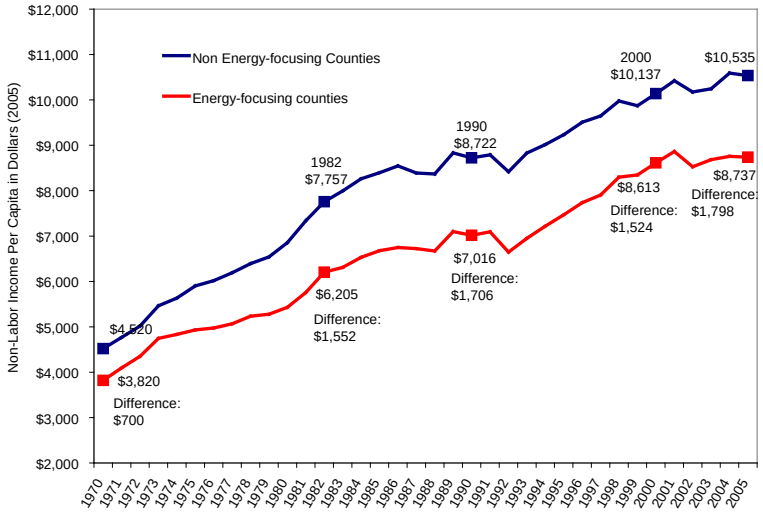
The importance of non-labor sources of income shows no signs of diminishing in the near future. As Americans generate more wealth and our population ages, more people will use their savings, investments, and programs like Social Security to sustain their livelihoods, whether they are still working or retired. By 2005, more than 40 percent of total personal income in the rural West was from non-labor sources, including transfer payments, dividends, interest, and rent.

Non-labor income, when measured on a per capita basis, is a measure of a community's ability to attract and retain this fast-growing segment of the economy.

Figure 8 shows the growth of per capita non-labor income, comparing EF counties to their peers in the West. In 1970, per capita non-labor income was similar between the two county types, with only a $700 difference. By 2005, the difference was $1,798.

These figures show that in the midst of today's energy development surge, counties focusing on energy extraction are less able to attract retirement and investment dollars than their peers.[31]

Figure 8. Growth of Per Capita Non-Labor Income, Energy-focusing Counties Compared to Peers, 1970–2005



These findings show that today's energy surge is different than in the past, and in several important ways EF counties today are less well positioned to compete economically. EF counties are less diverse economically, which makes them less resilient but also means they are less successful at competing for new jobs and income in growing service sectors where most of the West's economic growth has taken place in recent decades. EF counties are also characterized by a greater gap between high and low income households, and between the earnings of mine and energy workers and all other workers. And EF counties are less well educated and attract less investment and retirement income, both important areas for future competiveness.

CONCLUSIONS

In the West today, it is less certain that energy development will bring the prosperity it once did, and reason to be concerned that a concentration on fossil fuel extraction may impair a local economy's ability to grow and compete successfully in today's more diverse economy.

In the past, the pattern of development for counties with fossil fuel reserves was to grow quickly, reach a peak, and then decline sharply—the so-called boom and bust cycle. Beginning in the 1990s, it became clear that the economy in the West was diversifying, with especially rapid job growth occurring in service- and knowledge-based sectors, and that much of the real growth in personal income was associated with this service economy, and an aging population and the influx of retirement and investment dollars.

The implications of these changes—the growth and diversification of the western economy as a whole, including rural areas—is that energy development today does not have the same impact it had in the past. In the 1970s and early 1980s, there were few economic alternatives in rural communities. The discovery and development of oil and natural gas, or coal, created new high-wage jobs where in many cases there had been few or none. By the early 2000s, the West had, with a few exceptions, decoupled from its reliance on resource extraction, and enjoyed a wider range of economic choices than ever before.

The current surge in energy development takes place in this changed economic context. In counties that have pursued energy extraction as an economic development strategy—places we call energy-focusing (EF) in this report—the long-term indicators suggest that relying on fossil fuel extraction is not an effective economic development strategy for competing in today's growing and more diverse western economy.

When compared to their rural peer counties, EF counties suggest an analogy to the fable of the tortoise and the hare. While EF counties race forward and then falter, the non-energy peer counties grow steadily. At the finish line, counties that have focused on broader development choices are better off, with higher rates of growth, more diverse economies, better-educated populations, a smaller gap between high and low income households, and more retirement and investment income.

Economics is the study of how people make choices in a constrained environment. The findings in this report show state and rural leaders, as well as managers of public lands (where much of the energy development is taking place in the West today), that a concentration on fossil fuel development can undercut the competitive position of a regional or local economy.

Further Reading in our Energy and the West *Series*

Learn how energy development impacts:

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- National goals for energy independence.
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To access our *Energy and the West* series, visit: www.headwaterseconomics.org/energy.

APPENDIX

NORTH AMERICAN INDUSTRIAL CLASSIFICATION SYSTEM (NAICS) DEFINITIONS

The language below is copied verbatim from the U.S. Census Bureau's 2002 NAICS Manual http://www.census.gov/epcd/naics02/index.html

211 Oil and Gas Extraction

Industries in the Oil and Gas Extraction subsector operate and/or develop oil and gas field properties. Such activities may include exploration for crude petroleum and natural gas; drilling, completing, and equipping wells; operating separators, emulsion breakers, desilting equipment, and field gathering lines for crude petroleum and natural gas; and all other activities in the preparation of oil and gas up to the point of shipment from the producing property. This subsector includes the production of crude petroleum, the mining and extraction of oil from oil shale and oil sands, and the production of natural gas, sulfur recovery from natural gas, and recovery of hydrocarbon liquids.

Establishments in this subsector include those that operate oil and gas wells on their own account or for others on a contract or fee basis. Establishments primarily engaged in providing support services, on a fee or contract basis, required for the drilling or operation of oil and gas wells (except geophysical surveying and mapping, mine site preparation, and construction of oil/gas pipelines) are classified in Subsector 213, Support Activities for Mining.

213111 Drilling Oil and Gas Wells

This U.S. industry comprises establishments primarily engaged in drilling oil and gas wells for others on a contract or fee basis. This industry includes contractors that specialize in spudding in, drilling in, redrilling, and directional drilling.

213112 Support Activities for Oil and Gas Operations

This U.S. industry comprises establishments primarily engaged in performing support activities on a contract or fee basis for oil and gas operations (except site preparation and related construction activities). Services included are exploration (except geophysical surveying and mapping); excavating slush pits and cellars, well surveying; running, cutting, and pulling casings, tubes, and rods; cementing wells, shooting wells; perforating well casings; acidizing and chemically treating wells; and cleaning out, bailing, and swabbing wells.

2121 Coal Mining

This industry comprises establishments primarily engaged in one or more of the following: (1) mining bituminous coal, anthracite, and lignite by underground mining, auger mining, strip mining, culm bank mining, and other surface mining; (2) developing coal mine sites; and (3) beneficiating (i.e., preparing) coal (e.g., cleaning, washing, screening, and sizing coal).

213113 Support Activities for Coal Mining

This U.S. industry comprises establishments primarily engaged in providing support activities for coal mining (except site preparation and related construction activities) on a contract or fee basis. Exploration for coal is included in this industry. Exploration includes traditional prospecting methods, such as taking core samples and making geological observations at prospective sites.

ENDNOTES

[1] U.S. Bureau of the Census, North American Industrial Classification System (NAICS): http://www.census.gov/epcd/www/naics.html.

[2] U.S. Bureau of the Census, *County Business Patterns (CBP), 2008*. Washington, D.C.

[3] The data were derived from statistics published by the Bureau of the Census, in their publication *County Business Patterns* (CBP). We used this data sources primarily because it is devoid of disclosure restrictions. Disclosure restrictions are data gaps, where a government agency will not release information to protect the confidentiality of individual firms, and occur most frequently with data in the Regional Economic Information System (REIS) of the U.S. Department of Commerce. The disadvantage of CBP is that, unlike REIS data, it does not include the self-employed or government employment. If a relative measure is used (i.e., percent of total), as we did, the exclusion of the self-employed or proprietors does not make a significant difference. Some mining sectors employ very few single-owner proprietors, so the inclusion of proprietor's data, if it were available, would actually lower the size of mining relative to other sectors. "Coal mining" and "support activities for mining" are both examples of this, where only 8 percent of the industry is made up of proprietors. Other sectors employ more proprietors than average so the inclusion of proprietors would raise their shares. "Oil and gas extraction" is an example of this, where 12 to 14 percent of employment is in proprietors. Our definition of energy includes all three sectors. Together the differences offset each other and the resultant values for energy's share of total are not affected by the exclusion of proprietors. By using a data set that does not count government employment as part of total, our energy share of total calculations are higher than they would otherwise be, especially in some communities that have a lot of government. If we were to calculate energy shares using both proprietors and government, we expect the results would report shares that were the same or lower.

[4] U.S. Department of Commerce, *Regional Economic Information System (REIS)*, *2008*. Bureau of Economic Analysis. Washington, D.C.

[5] Ibid.

[6] CBP 2008.

[7] Data for figure derived from REIS 2008.

[8] Data for figure derived from CBP 2008.

[9] Ibid, REIS 2008. Mining personal income based on estimates. Employment based on non-disclosed data from Bureau of Labor Statistics, *Quarterly Census of Employment and Wages* (QCEW).

[10] Ibid, REIS 2008.

[11] Bureau of the Census 2008. Calculations based on dividing the total number of people living in metropolitan statistical areas (MSAs) by the total population of the West.

[12] Ibid, REIS 2008.

[13] Ibid, REIS 2008. Mining personal income based on estimates. Employment based on non-disclosed data from Bureau of Labor Statistics, QCEW.

[14] Employment data in table from REIS 2008 and CBP 2008.

[15] Figures in table derived from U.S. Bureau of the Census, 2008.

[16] Housing Data, State of WY Dept of Economic Analysis and Info. http://eadiv.state.wy.us/housing.

[17] For a useful review of the academic literature on economic diversity, see Sterling, Andrew. 1998. "On the Economics and Analysis of Diversity." Electronic Working Papers Series, University of Sussex. http://www.sussex.ac.uk/Units/spru/publications/imprint/sewps/sewp28/sewp28.pdf. More narrowly, consult Malizia, E. E. and K. Shanzai. 2006. "The Influence of Economic Diversity on Unemployment and Stability." Journal of Regional Science. 33(2): 221-235.

[18] The specialization index was calculated by summing the squares of the difference between the aggregate (i.e., 26 EF counties, 254 peer counties) and the U.S. economy:

$SPECIALit = \sum ((EMPijt/EMPit)-(EMPusjt/EMPust))\ 2$ where,
SPECIALit = specialization of economy in county i in year t
EMPijt = employment in industry j in county i in year t
EMPit = total employment in county i in year t
EMPusjt = employment in industry j in U.S. in year t
EMPust = total employment in U.S. in year t
n = number of industries

[19] For an example of the application of a similar specialization index by the Federal Reserve, see Ozcan-Kalemlt S., B.E. Sorensen and O. Yosha. 2000. "Risk-sharing and Industrial Specialization: Regional and International Evidence." RWP 00-06. Kansas City: Federal Reserve Bank of Kansas City.

[20] The data and calculations for the specialization indices can be found on page 23 of the EF and peer profiles, located on: www.headwaterseconomics/energy.

[21] Data from U.S. Bureau of the Census, 2000, File SF#, Table P48.

[22] Data for the table derived from CBP 2008.

[23] REIS 2008.

[24] Data for figure from Bureau of Labor Statistics (BLS). *Quarterly Census of Employment and Wages (QCEW), 2008.* Washington, D.C. The category "mining" consists primarily of workers involved in the development and extraction of oil, natural gas and coal.

[25] Ibid, BLS 2008.

[26] For a review of the academic literature on the relationship between income distribution and economic growth, see: http://micro5.mscc.huji.ac.il/~melchior/html/Income%20Distribution.htm. More narrowly, consult Henry, C.W. 1998. "Income Inequality, Human Capital Accumulation and Economic Performance." *The Economic Journal*. 108 (Jan): 44-59.

[27] Data from the Bureau of the Census, 1990 and 2000 Decennial Census of Population, and Housing.

[28] The improved ratios were not because there were significantly fewer low-income families in 2000. Rather, the number of high-income families, in both sets of counties, increased. In 1990, 0.9% of household in the EF counties were high-income. By 2000, 2.3% were "rich." By comparison, in 1990 1.1% of the households in the peer counties were high-income. By 2000, 5.4% were high-income.

[29] According to the Bureau of Labor Statistics, earnings are higher and the unemployment rate is lower for people who have high levels of education: http://www.bls.gov/opub/ted/2003/oct/wk3/art04.htm. See also Ray, M. and M. Tucker. 1992. *Thinking for a Living: Education and the Wealth of Nations*. Basic Books, New York, New York.

[30] Data from the Bureau of the Census, 1990 and 2000 Decennial Census of Population, and Housing.

[31] REIS 2008.

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The Economic Value of Shale Natural Gas in Ohio

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Department of Agricultural, Environmental and Development Economics

Swank Program Website: http://aede.osu.edu/programs/swank/

THE OHIO STATE UNIVERSITY
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Swank Program in Rural-Urban Policy Summary and Report
December 2011

Mark Partridge Short Biography

Dr. Mark Partridge is the Swank Chair of Rural-Urban Policy at Ohio State University. He is a Faculty Research Affiliate, City-Region Studies Centre, University of Alberta, an Affiliate of the Martin Prosperity Center at the University of Toronto, and an adjunct professor at the University of Saskatchewan. Professor Partridge is Managing Co-Editor of the *Journal of Regional Science* and is the Co-editor of new the *Springer Briefs in Regional Science* as well as serves on the editorial boards of *Annals of Regional Science, Growth and Change, Letters in Spatial and Resource Sciences, The Review of Regional Studies, and Region et Developpement*. He has published over 100 scholarly papers and coauthored the book *The Geography of American Poverty: Is there a Role for Place-Based Policy?* Dr. Partridge has consulted with OECD, Federal Reserve Bank of Chicago, Federal Reserve Bank of Cleveland, and various governments in the U.S. and Canada, and the European Commission. Professor Partridge has received funding from many sources including the Appalachian Regional Commission, Brookings Institution, European Commission, Infrastructure Canada, Lincoln Institute of Land Policy, U.S. National Science Foundation, U.S. National Oceanic and Atmospheric Administration, and Social Science and Humanities Research Council of Canada. His research includes investigating rural-urban interdependence and regional growth and policy. Dr. Partridge served as President of the Southern Regional Science Association in 2004-05 and is currently on the Executive Council of the Regional Science Association International (the international governing board).

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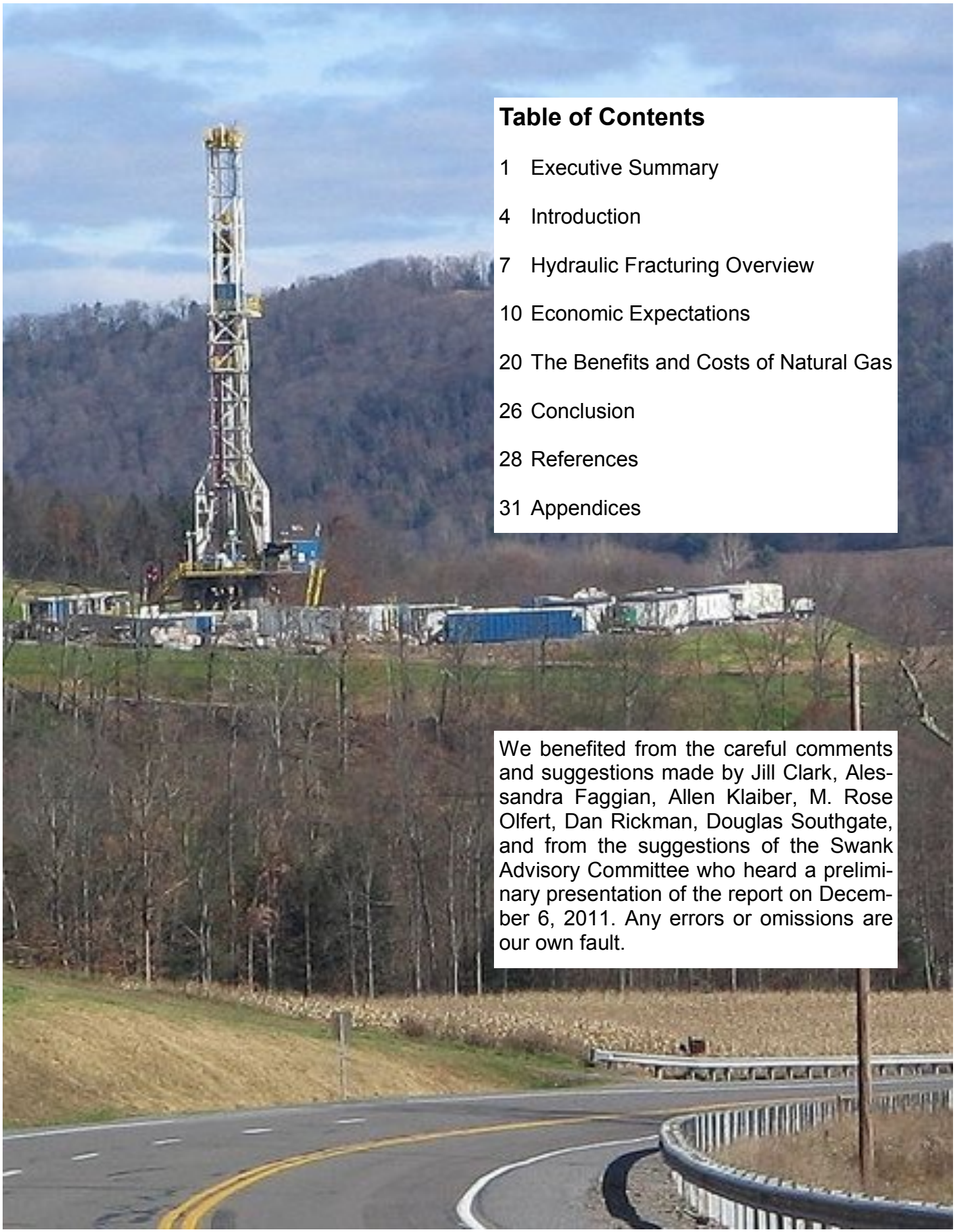
Amanda Weinstein is a PhD student in the Department of Agricultural, Environmental, and Development Economics at The Ohio State University. Her research as the C. William Swank Graduate Research Associate includes policy briefs about the employment effects of energy policies and general regional growth and policy issues. She is an OECD consultant advising on the economic impacts of alternative energy policies on rural communities. Her other research interests include women's role in economic development examining women's effect on regional productivity growth. She was awarded the Coca-Cola Critical Difference for Women Graduate Studies Grant to continue her work on gender issues in economics. She is also conducting research on the skills most valued during a recession and the impact of military service on intergenerational mobility. Before starting her PhD at OSU, she was a commissioned officer in the United States Air Force after graduating from the United States Air Force Academy. As a Scientific Analyst in the Air Force and then as a Sr. Management Analyst for BearingPoint, she advised Air Force leadership on various acquisition and logistics issues. She is currently an adjunct faculty member of Embry-Riddle University and DeVry.



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We benefited from the careful comments and suggestions made by Jill Clark, Alessandra Faggian, Allen Klaiber, M. Rose Olfert, Dan Rickman, Douglas Southgate, and from the suggestions of the Swank Advisory Committee who heard a preliminary presentation of the report on December 6, 2011. Any errors or omissions are our own fault.

Tower for drilling horizontally into the Marcellus Shale Formation for natural gas in Lycoming County, Pennsylvania.

The Economic Value of Shale Natural Gas in Ohio

The Ohio State University
Swank Program in

Executive Summary

Increased production of US natural gas in recent years has helped to meet the growing demands of American customers and has reduced natural gas imports. Natural gas is also a cleaner burning fuel when compared to its most realistic substitute, coal. This substantial increase in production has been attributed in large part due to the development of shale gas through a process called hydraulic fracturing. Hydraulic fracturing has enabled the expansion of natural gas extraction into new undeveloped areas. The Marcellus shale in Pennsylvania has experienced impressive growth in its natural gas industry and neighboring Ohio is beginning down the same path. Proponents argue that among the many purported advantages, natural gas production is associated with significant amounts of new economic activity.

Economists have 150 years of experience in examining energy booms and busts throughout the world to form their expectations of how energy development affects regional economies. Generally, economists find that energy development is associated with small or even negative long-run impacts. They refer to a "natural resources curse" phenomenon associated with the surprisingly poor performance of resource abundant economies. There appears to be more examples like Louisiana, West Virginia, Venezuela, and Nigeria of energy economies seemingly underperforming and few examples of places such as Alberta and Norway of relative over performance. This backdrop needs to be considered in forming good policy in Ohio in order to avoid being in the former group.

In supporting energy development, the natural gas industry has funded its own studies of economic performance. For example, utilizing assumptions derived from Pennsylvania economic impact studies, Kleinhenz & Associates (2011) estimate that the natural gas industry could help "create and support" over 200,000 jobs to Ohio and $14 billion in spending in the next four years. These figures are about the same size as those for Pennsylvania (in industry funded studies). As we outline in this report, impact studies such as those employed by the industry are typically flawed due to the following reasons:

1. Possible double counting economic effects from drilling activities and royalties/lease payments to landowners. Most important, these studies have multipliers well above what independent economists would normally expect.
2. Including unrealistic assumptions about the percentage of spending and hiring that will remain within the state.
3. Ignoring the costs of natural gas extraction on other sectors through higher wages, and land costs that will make them less competitive (e.g., Dutch Disease), as well as environmental damage that limits tourism and other activities. It will also displace coal mining—i.e. more natural gas jobs come at the expense of fewer jobs in coal mining.
4. Often employing out-of-date empirical methodologies that academic economists have long abandoned for better methodologies in terms of evaluation of economic effects.

Many of the same reasons why alternative energy has not been (will not be) a major job creator also applies to natural gas (Weinstein et al., 2010):

1. The energy industry and specifically the natural gas industry's employment share is small and by itself is not a major driver of job growth for an entire state the size of Ohio or Pennsylvania. During the one year span October 2010-October 2011, U.S. Bureau of Labor Statistics data reports that Ohio's unemployment rate fell from 9.7 to 9.0% or 0.7% (without shale development), while Pennsylvania's unemployment rate only fell from 8.5% to 8.1% or 0.4% (with shale development). Ohio also had faster job growth during the span (1.3% versus 1%), showing that shale development by itself is not shaping their growth.
2. It is a capital-intensive industry versus labor-intensive—or a dollar of output is associated with significantly fewer workers.

The costs of natural gas include the effects it has on other industries. Some of these effects include displacement of other forms of economic activity, the effects of pollution that drive out residents who are worried about its effects and the higher wages and land/housing costs that make other sectors less competitive. For example, the tourism industry will likely be adversely affected by fears of pollution and higher wages and costs as other sectors have to compete for workers with the higher paying natural gas sector. In Pennsylvania, for instance, the tourism industry employed approximately 400,000 in 2010 (though a much smaller number is immediately near the shale development) compared to only 26,000 in

a broad definition of the natural gas industry (Barth, 2010; BLS). Similar concerns should also apply to Ohio across various sectors of the economy.

Our broad analysis shows the expected employment effects of natural gas are modest in comparison to Ohio's 5.1 million nonfarm employee economy. We show this through (1) an assessment of impact analysis, (2) comparison of drilling counties with similarly matched non-drilling counties in Pennsylvania, (3) statistical regressions on the entire state of Pennsylvania, (4) employment comparisons with North Dakota's Bakkan shale region, and (5) an examination of the employment life cycle effects of natural gas and coal per kilowatt of electricity. Specifically, we estimate that Pennsylvania gained about 20,000 direct, indirect, and induced jobs in the natural gas industry between 2004-2010, which is a far cry fewer than the over 100,000 jobs reported in industry-funded studies (and the 200,000 expected in Ohio by 2015). Given the anticipated size of the boom, Ohio is expected to follow the Pennsylvania's experience. We believe 20,000 jobs would be a more realistic starting point for what to expect in Ohio over the next four years and is in line with what other independent assessments have suggested. However, our 20,000 job estimate does not account for displacement losses in other industries such as tourism, and we also note that local economic effects could appear larger in heavily impacted areas. Moreover, we find that mining counties had considerably faster per-capita income growth than their non-drilling peers, which likely results from royalties/lease payments and the high wages in the industry. Thus, we expect the near-term boom to be associated with frothy increases in income but more temperate job effects.

There are several reasons why the industry-funded studies produce employment results that are considerably different from our estimates. Foremost, impact studies are not viewed as best practice by academic economists and would be rarely used in peer reviewed studies by urban and regional economists. Instead, best practice usually tries to identify a counterfactual of what would have happened without the natural gas industries and compare to what did happen (we adopt two of these approaches). One advantage of identifying the counterfactual is that the estimated effects use actual employment data and are not the estimated outcome of an impact computer model. Yet, like virtually every other economic event, there are winners (e.g., landowners or high-paid rig workers) and losers (e.g., those who can no longer afford the high rents in mining communities and communities dealing with excessive demands on their infrastructure).

Moreover, the boom/bust history of the energy economy is that drilling activity usually begins with a wave of drilling and construction in the initial phases, followed by a significant slowdown in jobs as the production phase requires a much smaller number of permanent employees. Indeed Ohio has a long history of energy booms that illustrates that booms too often have few lasting effects. Ohioans need to be aware of this cycle if they are to make prudent decisions and try to gain sustainable gains after the boom has ended. The fundamental problem here is that the time distribution of jobs resulting from a new development is often ignored and it is important. For example it matters whether there are 1,000 jobs distributed as 1,000 for one year and then none, versus 100 additional jobs for 10 consecutive years, or 10 additional jobs for the next 100 years. Yet, 'impact' analysis such as that used by the energy industry typically does not differentiate among these scenarios and the whole topic is usually ignored by the media. Professional economists note that long-term regional economic development requires permanent jobs, and thus independent economists place considerably less weight on the initial construction phase associated with energy development. Policies need to be developed to ensure long-term success.

Natural gas extraction is also associated with potential environmental degradation. Pennsylvania and other areas have reported numerous incidents of water contamination; most notably in Dimock, PA, which was featured in the controversial documentary *Gasland*. Because hydraulic fracturing occurs at levels far below the aquifer level, it is most likely not to blame for contamination, but any contamination is instead likely caused by a casing/tubing failure or other part of the drilling process. Thus, the EPA exempted natural gas extraction using hydraulic fracturing from the Safe Drinking Water Act and Clean Water Act in 2005. However, recognizing increasing concerns over the impact on drinking water and ground water, in 2010 Congress directed the EPA to study the effects of hydraulic fracturing on the environment with results expected by the end of 2012. Until the federal government acts on this issue, state regulations are necessary to ensure natural gas extraction is performed in a safe manner protecting the environment and residents. Yet, coal mining is also associated with high localized environmental costs, indicating that if natural gas mining is not done, there will still be environmental problems that will need to be addressed because more coal mining will be required.

We argue that the focus on whether the industry creates jobs is misguided in assessing its true value

and is not how economists typically evaluate the effectiveness of a program or policy. Rather, the focus should be placed on the true costs and benefits of natural gas especially compared to coal (its main substitute in electricity production). *Compared to coal, natural gas is cheaper and emits less carbon and both industries have their own inherent localized environmental costs in their production.* Independent economists would note that neither industry is associated with large numbers of jobs due to their capital-intensive nature. Making a true assessment of the costs and benefits will require qualified independent analysis. Likewise, ensuring that Ohioans benefit long after the energy boom requires innovative planning that unfortunately, most locations that have experienced such booms have failed to do over the last 150 years. These findings also illustrate that Ohio will need to continue to make economic reforms if it is to prosper in the long term because no one industry—in this case energy development—will be its long-term savior.

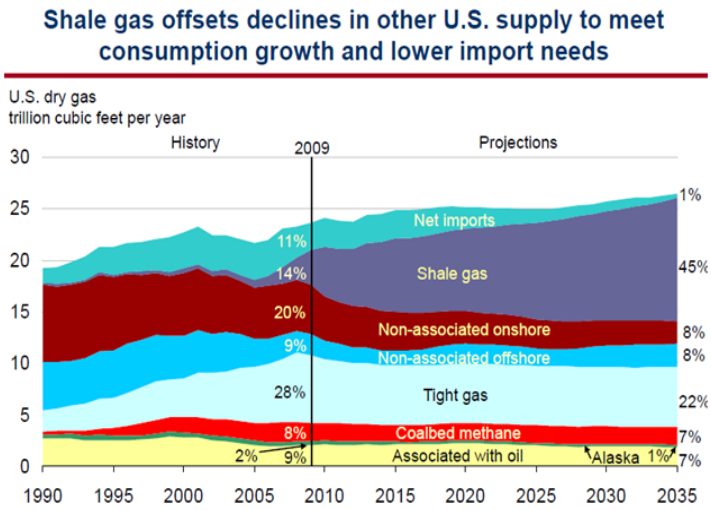
Introduction

With the US economy still struggling to recover from the Great Recession, many are looking for a quick fix to create jobs and generate income. Politicians often turn to the latest economic fad to solve unemployment problems, such as aiming to become the next Silicon Valley or, more recently, the next green energy hub. Employment effects are often overstated to justify various policies rather than having a real conversation about the true benefits and costs of a policy.[1] For example, the job creation benefits of green jobs were optimistically asserted while ignoring the high capital intensity of alternative energy and the displacement effect of jobs no longer needed in the fossil fuels industry, especially coal. In response, the fossil fuels energy industry has now put forward its own solution to unemployment and growing energy demands: natural gas from shale, which also provides its own set of environmental costs and benefits.

In their "Short-Term Energy Outlook," the US Energy Information Administration (EIA) expects that total natural gas consumption will grow by 1.8% in 2011. Despite the increase in consumption, recent increases in natural gas production have met these demands and reduced natural gas imports. Thus, shale gas proponents claim that newly accessible reserves could provide a new level of energy independence for the US. The 2010 EIA "Annual Energy Outlook" found that natural gas production reached its highest levels since 1973 at 21.9 trillion cubic feet (Tcf). This increase in production is mainly attributed to the increase in natural gas extraction from shale resources. From 2009 to 2010 shale gas production more than doubled from 63 billion cubic meters to 137.8 billion cubic meters. This trend in rising natural gas production, especially shale gas production, is likely to continue. Figure 1 below shows the increasing shale gas production the US has experienced, along with future expectations.

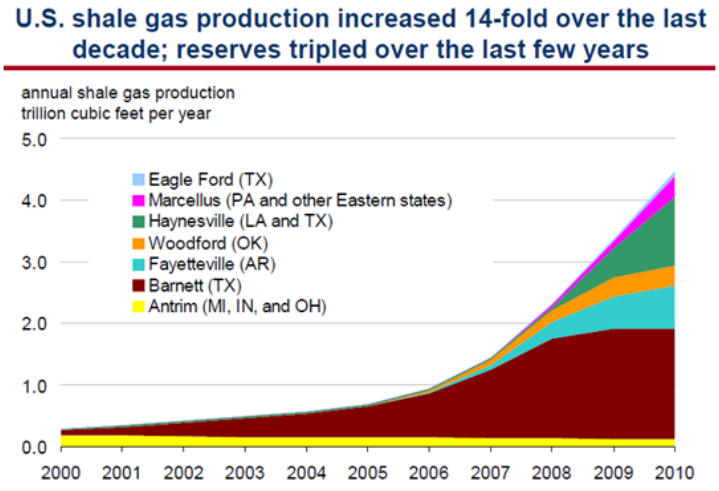
The dramatic increase in shale gas production since 2005 is shown below in Figure 2 separated by the area where shale gas has been developed. Recent technological advancements in a method called hydraulic fracturing, or "fracking", have made extracting natural gas from shale more efficient and cost effective. This has brought natural gas potential to new areas as evidenced by the increased drilling in Pennsylvania. Although still a small percentage compared to Texas, growth in shale gas production in Pennsylvania is growing rapidly and provides a roadmap for how production in Ohio will evolve.

With these innovations, shale gas potential is now growing in neighboring Ohio, which shares the same Marcellus shale with Pennsylvania. Many have already begun to speculate what this could mean in terms of the job benefits to Ohio. An industry-funded study by Kleinhenz & Associates (2011) suggests that new Ohio natural gas production could "create and support" over 200,000 jobs



Source: US EIA Annual Energy Outlook 2011

Figure 1: Shale Gas Prospects



Source: US EIA Annual Energy Outlook 2011

Figure 2: Shale Gas Areas of Production

1. Independent economists have long complained about hyped up numbers from various industry impact reports. For a tongue-in-cheek look see Leach (2011). http://www.theglobeandmail.com/report-on-business/economy/economy-lab/the-economists/who-needs-pipelines-the-oil-bucket-brigade-is-ready/article2268015/

and $14 billion injected into the state economy over the next 4 years (Gearino, 2011).[2] In this manner, Chesapeake Energy CEO Aubrey McClendon stated, "This will be the biggest thing in the state of Ohio since the plow" (Vardon, 2011). Obviously, there is considerable hype surrounding the economic effects of shale oil production

To see if these expectations are realistic, we examine the impacts that natural shale gas has had on Pennsylvania to draw comparisons to Ohio. Many industry funded studies of the economic impacts of the Marcellus shale development in Pennsylvania are consistent with the Kleinhenz & Associates (2011) predictions, which is reasonable in the sense that the early stages of Ohio's development is expected to mimic what happened in Pennsylvania.

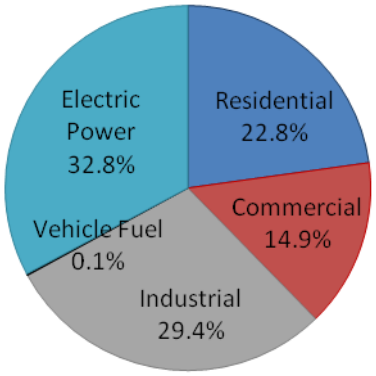
Unlike the industry funded reports, Barth (2010) doubts whether there is any net positive economic impact of drilling in Pennsylvania. She contends that previous industry-funded reports have focused on the benefits while ignoring the costs and risks associated with natural gas extraction. She claims industry funded studies haven't properly accounted for other impacts, including the costs of environmental degradation. Although replacing coal or oil with natural gas can significantly reduce carbon emissions, rising concerns have mounted, most notably in the controversial 2010 documentary *Gasland,* about the potential environmental impacts of natural gas mining on nearby water sources. This has become more of a concern as hydraulic fracturing and natural gas extraction occurs closer to both water sources and population centers in Pennsylvania and Ohio. These concerns have not yet been fully alleviated by the US EPA or the natural gas industry. In 2005, hydraulic fracturing methods were exempted from the Safe Drinking Water Act and Clean Water Act. However, recognizing increasing concerns over the impact on drinking water and ground water, in 2010 Congress directed the U.S. Environmental Protection Agency (EPA) to study the effects of hydraulic fracturing on the environment.

Barth (2010) also argues that previous industry-funded studies have not properly accounted for the impact on infrastructure, property values, and the "displacement" impact pollution can have on other industries such as tourism and fishing. In 2010, tourism employed approximately 400,000 people in Pennsylvania whereas the natural gas industry employed closer to 26,000 (Barth, 2010; BLS). If tourism suffers as a result of the natural gas industry, then a bigger industry could be put at risk from expansion of the natural gas industry, though we note that much of Pennsylvania's tourism industry is not near the mining activity.

Economists have long argued that energy development has limited overall impacts on the economy. There is a longstanding literature that refers to a "natural resources curse" that limits growth from energy development. One reason for the limited effects of energy development is Dutch Disease, which broadly refers to the higher taxes, wages, land rents, and other costs associated with energy development that make other sectors less competitive (including currency appreciation at the national level). These higher costs also reduce the likelihood new businesses will locate in the affected location. Previous research has found evidence of a natural resources curse and Dutch Disease suggesting that a natural resource boom can occur at the cost of other sectors and general long-run economic growth. For example, Papyrakis and Gerlagh (2007) found that US states with a higher degree of reliance on natural resources experience lower economic growth.[3] Kilkenny and Partridge (2009) and James and Aadland (2011) also found evidence of this resource curse at the US county level.

Figure 3 on the next page shows that most natural gas is still used to supply electricity. Thus, with rising electricity demands, increasing natural gas production will lower the need for electricity generation from coal—i.e., we will have more natural gas jobs that are offset by fewer coal jobs. Only 0.1% of natural gas is used as vehicle fuel, which is derived from oil as opposed to coal. Thus, new natural gas will not significantly decrease US reliance on foreign oil unless, as publicly suggested by T. Boone Pickens, the US considers converting more buses, trucks and other vehicles to natural gas. Thus, its effects on "energy security" are rather limited in the foreseeable future as increased electrical demand and the growing reliance on US natural gas will primarily be at the expense of US coal.[4]

2. Kleinhenz & Associates (2011) specify that over 200,000 jobs will be *created* or *supported* but they do not clearly define the difference between "created" and "supported" jobs. In terms of long-term economic development, permanent job creation would be necessary—or does natural gas development create more permanent jobs than what would have happened without the energy development? The latter counterfactual question is not addressed in that report.
3. Dutch Disease refers to natural gas development in the Netherlands in the 1960s and 1970s. The ensuing boom raised costs and appreciated the Dutch currency, rendering Dutch manufacturers less competitive on international markets. After the initial boom settled down, not only were there less employment in the natural gas industry, but Dutch manufactures found it hard to regain their market share on international markets, producing a permanent cost on their economy.
4. The recent expansion of shale development did reduce natural gas imports, but going forward, its main influence will be as a substitute for other sources of electricity, primarily coal.



Source: US EIA

Figure 3: 2010 Natural Gas Consumption by End Use

Even with a significant conversion of vehicles to natural gas, the energy sector as a whole has an employment share that is simply too small to significantly impact the high unemployment rates the US is experiencing. In 2010, the natural gas industry accounted for less than 0.4% of national employment, so even if the sector doubled in size—which is quite a stretch—overall U.S. employment would only be marginally effected (BLS).[5] This is not surprising as natural gas like much of the energy sector (including alternative energy) is quite capital intensive, which reduces the employment effects of natural gas compared to the broader economy.

The pursuit of economic fads is often justified by overpromising jobs while ignoring the displacement effects on other sectors of the economy as well as other costs on the economy. The benefits should be appropriately weighed against the costs, but this requires a better understanding of both the benefits and costs. It should not be based on the overblown hype of either side. Using previous experience from Pennsylvania, we will produce realistic estimates what Ohio should expect from shale gas development over the next four years. We find that although the employment advantages of shale gas have generally been overstated by the industry, there are clear benefits of natural gas production when compared to coal (which has its own environmental risks). The biggest advantages are that natural gas is more cost-effective than coal and can reduce carbon emissions. Coal forms the natural benchmark because in the medium term, natural gas production would displace coal production as the alternative source for electricity.

5. The calculation of total natural gas employees uses the methodology of IHS Global described in more detail in note 7 and we use U.S. Bureau of Labor Statistics Data to derive the employment figures.

Hydraulic Fracturing Overview

Innovations in hydraulic fracturing are the reasons natural gas extraction has recently been developing in the Marcellus shale regions in Pennsylvania and Ohio and now expanding to the Utica shale regions in Ohio. Before investigating the impacts of shale gas development, it is important to understand the hydraulic fracturing method that has made natural gas extraction from shale economically feasible.

Shale is a fine-grained sedimentary rock that can trap petroleum and natural gas well below the surface. Horizontal drilling and hydraulic fracturing now allow the energy industry to extract this trapped gas. Commercial hydraulic fracturing began in 1949, though it took decades of use for innovations to make shale gas extraction more cost effective. Horizontal drilling can cost 3 to 4 times more than conventional drilling, but has the potential of reaching substantially more reserves. Figure 4 from the EIA compares horizontal drilling and hydraulic fracturing to conventional methods of natural gas extraction. Figure 5, further depicts the hydraulic fracturing process.

Horizontal wells and hydraulic fracturing in conjunction with advances in micro-seismic technology aiding both exploration and the drilling process have allowed the energy industry to extract natural gas at greater depths. According to the EPA (Jun., 2010), horizontal wells are drilled to a depth between 8,000 and 10,000 feet. Hydraulic fracturing extracts natural gas from shale using a pressurized injection of fluid composed mostly of water and a small portion of sand and chemical additives that vary by site. This pressure causes the shale to fracture, requiring sand or other propping agents to keep the fissures open and allow gas to escape. Between 15 to 80% of the fluids are recovered from the well before the natural gas is collected. This water called "produced water" can be reused in other wells, but will need to be treated or disposed of at some point.

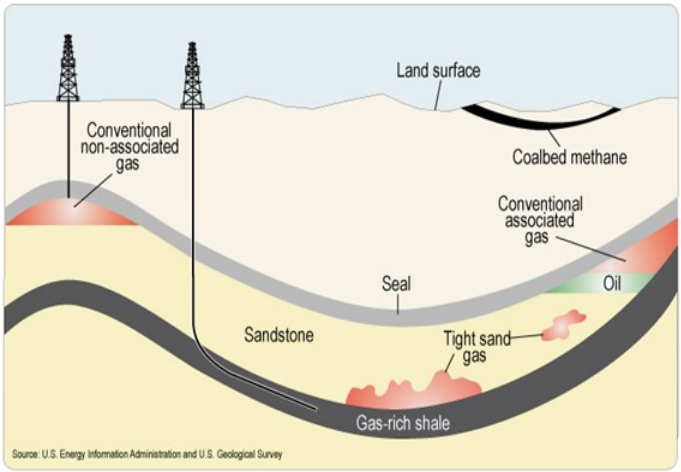
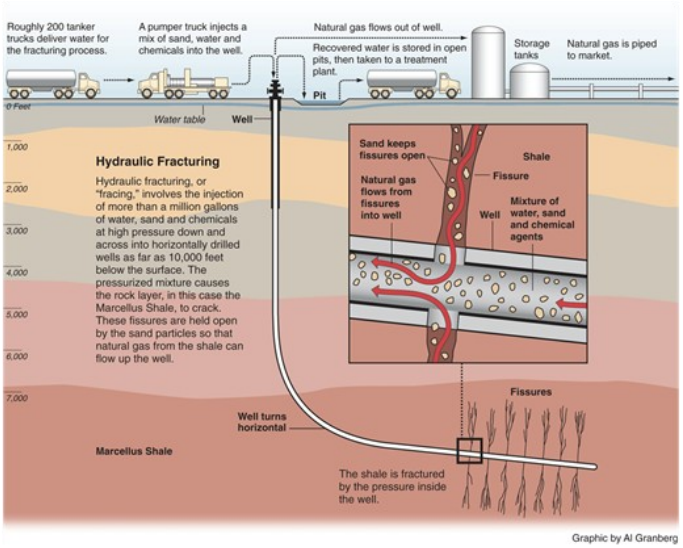


Figure 4: Natural Gas Mining Methods

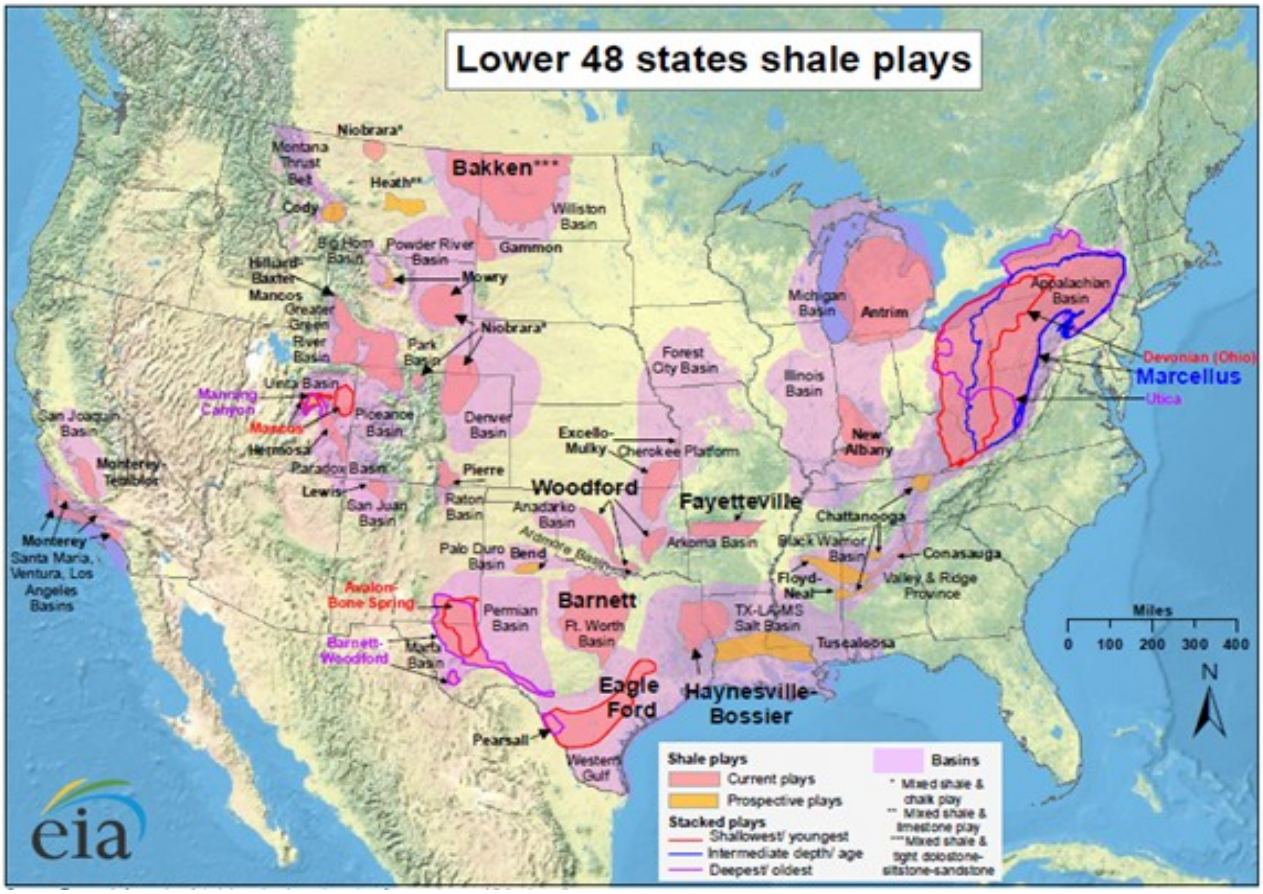


Source: ProPublica

Figure 5: Hydraulic Fracturing

Natural Gas Development in the US:

In the 1980s, the Barnett shale in Texas became the first natural gas producing shale. More than a decade of production from the Barnett shale in Texas has helped improve the hydraulic fracturing process, leading the way for it to be used in other areas such as the Marcellus shale in Pennsylvania and the Utica Shale in Ohio. The Marcellus shale is more than 60 million acres and is significantly larger than the Barnett. The EIA estimates that there are 410 Tcf of recoverable gas in the Marcellus shale alone. Figure 6 on the next page shows the location of US shale plays including the Barnett in Texas and the Marcellus and Utica in Pennsylvania and Ohio. Figure 6 clearly shows that shale natural gas is a national phenomenon that will dramatically alter natural gas availability and pricing nationally. Indeed, EIA data further documents that shale plays are a global phenomenon that will likely reduce world-wide natural gas prices.

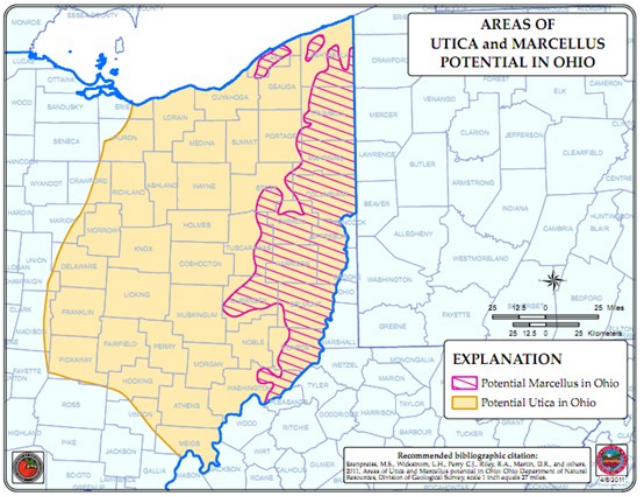


Source: US EIA

Figure 6: US Shale Resources

The large potential of the Marcellus shale, and more recently the Utica shale, has made Pennsylvania and Ohio highly attractive for mining of natural gas reserves. Figure 7 below provides a more detailed look at areas in Ohio that may be directly affected by natural gas resources. In an interview, Douglas Southgate of The Ohio State University's Subsurface Energy Resource Center states that shale resources in Ohio can provide a reliable, cheap, and local source of energy for Ohio. He explains that much of the attention has been on the Marcellus formation, though it is becoming clear that the Utica is more important. In the long term, the latter is expected to supply oil in significant quantities (Dezember and Lefebvre, 2011). It is also an important source of natural gas liquids (NGLs) such as ethane, which is converted into the ethylene used to manufacture a wide array of chemical products (American Chemistry Council, 2011). Thus, Southgate and others argue that shale deposits in and around Ohio are an important source of various hydrocarbons, not just the methane used to heat homes, generate electricity, and so forth.

Ohio shale development is just beginning. Figure 8 on the next page shows specific Marcellus and Utica well activity in Ohio from 2006 through August, 2011. It was recently reported that Chesapeake Energy has its first 4 active Utica shale wells in Ohio producing between 3 and 9.5 million cubic

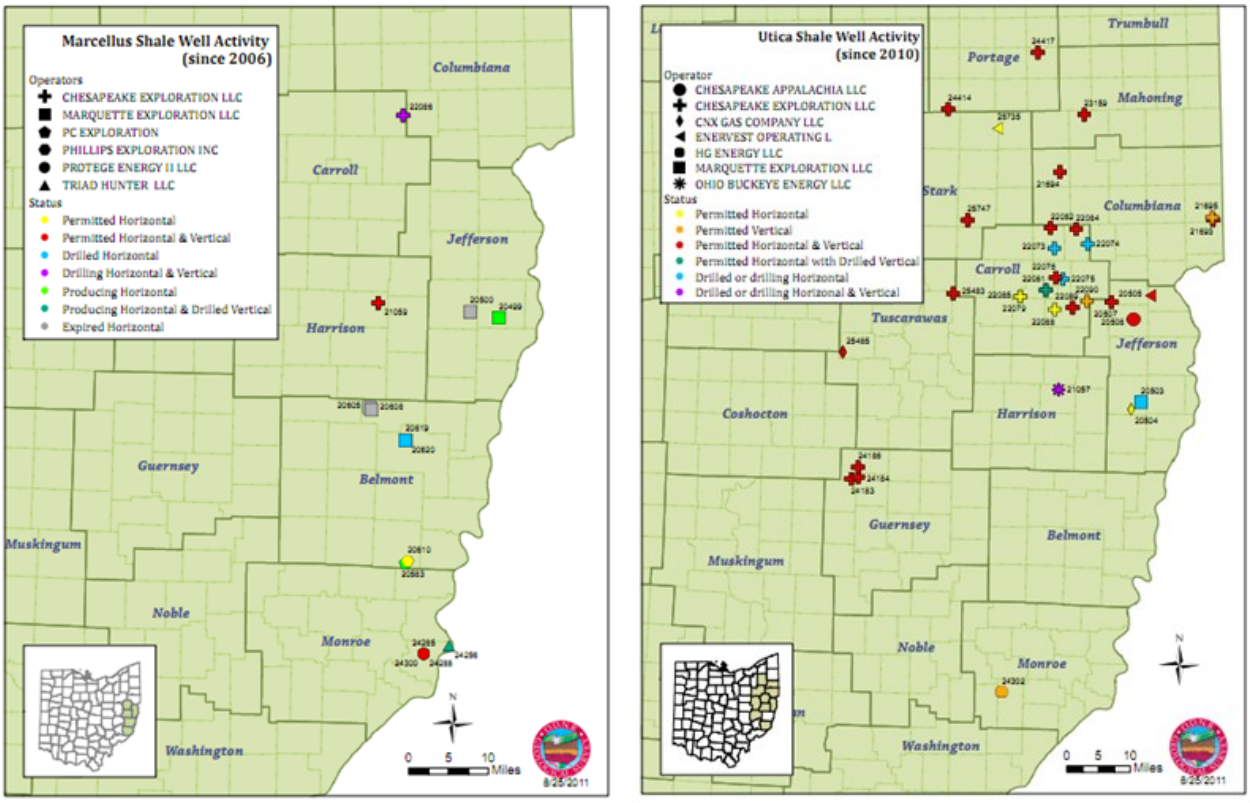


Source: ODNR

Figure 7: Ohio Shale Resources

feet of natural gas per day (Gearnino, 2011). A conventional well might produce between 100,000 and 500,000 cubic feet per day, but the Marcellus and Utica shale wells are expected to produce between 2 to 10 million cubic feet of natural gas per day. Chesapeake plans to increase the number of wells to 20 by the end of 2013.

Although shale development has already begun in Ohio, it is still nascent compared to Pennsylvania. The projected impacts on Ohio are still being debated. For example, Kleinhenz & Associates (2011) projected natural gas development in Ohio would lead to 200,000 jobs and $14 billion in spending. Much of their analysis uses assumptions derived from recent Pennsylvania impact studies such as Considine et al. (2009; 2010; 2011). Kleinhenz & Associates (2011) projected that 4,000 wells will be drilled in Ohio by 2015. Overall, they produced economic results that are similar to the industry-funded estimates for Pennsylvania.



Source: ODNR (Aug, 2011)

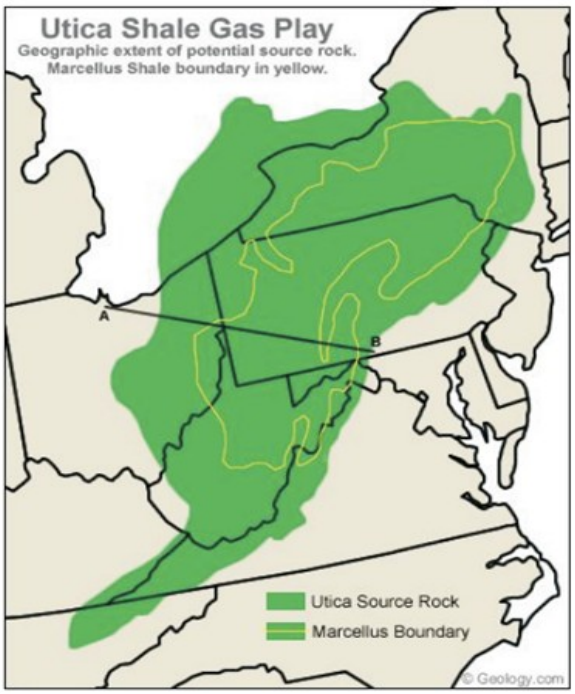
Figure 8: Marcellus and Utica Well Activity in Ohio

Economic Expectations

Pennsylvania is a particularly good gauge to predict what the impacts of shale gas will be on Ohio because they share much of the same natural resources. They are also very proximate and have similar economic structures. Figure 9 shows the Marcellus and Utica shale running through both states. Besides being neighbors, Pennsylvania and Ohio are the 6th and 7th most populous states. For both states, the shale resources are mainly located in rural areas, though there are larger population centers that are affected.

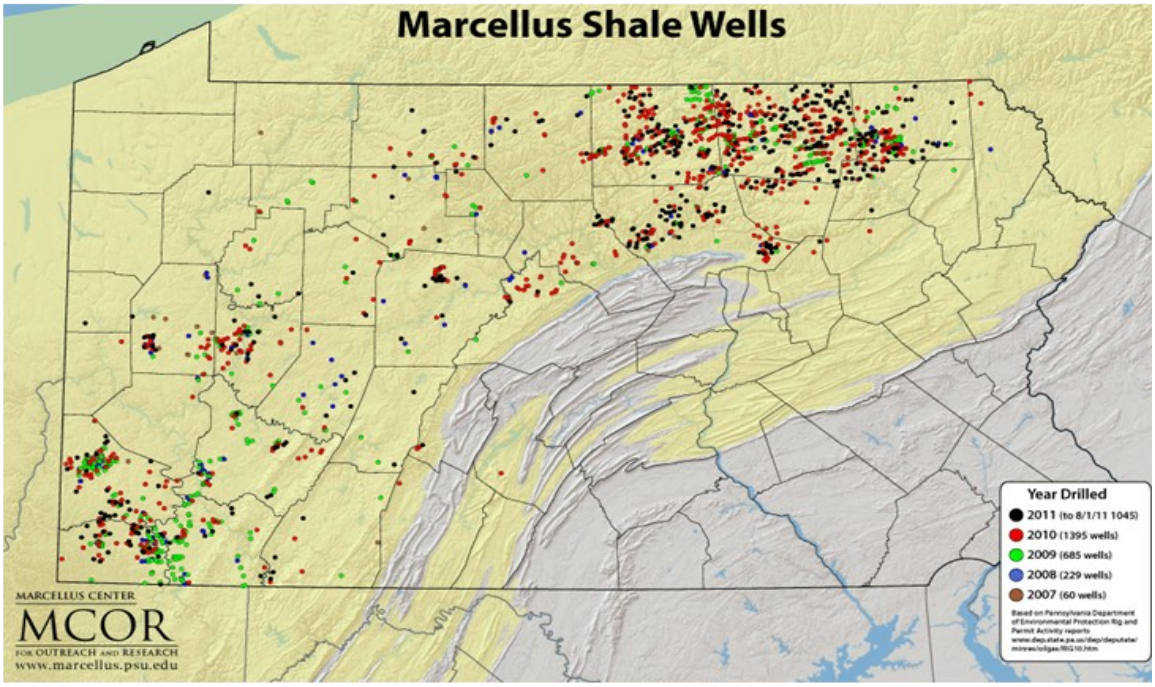
In 2005, the first well in the Marcellus shale in Pennsylvania began producing natural gas. Since then, most of the wells have been located in the northeast and southwest in Pennsylvania. Figure 10 shows the location of wells across the state by year. The number of shale wells drilled grew from 60 in 2007 to 1,395 in 2010. Considine (2010) finds that 36% of the 229 wells drilled in 2008 were horizontal and that percentage is expected to rise.

As the number of wells drilled dramatically increased, so did natural gas production in Pennsylvania, especially in the northeast region. Figure 11 on the next page shows the notable increase in production.



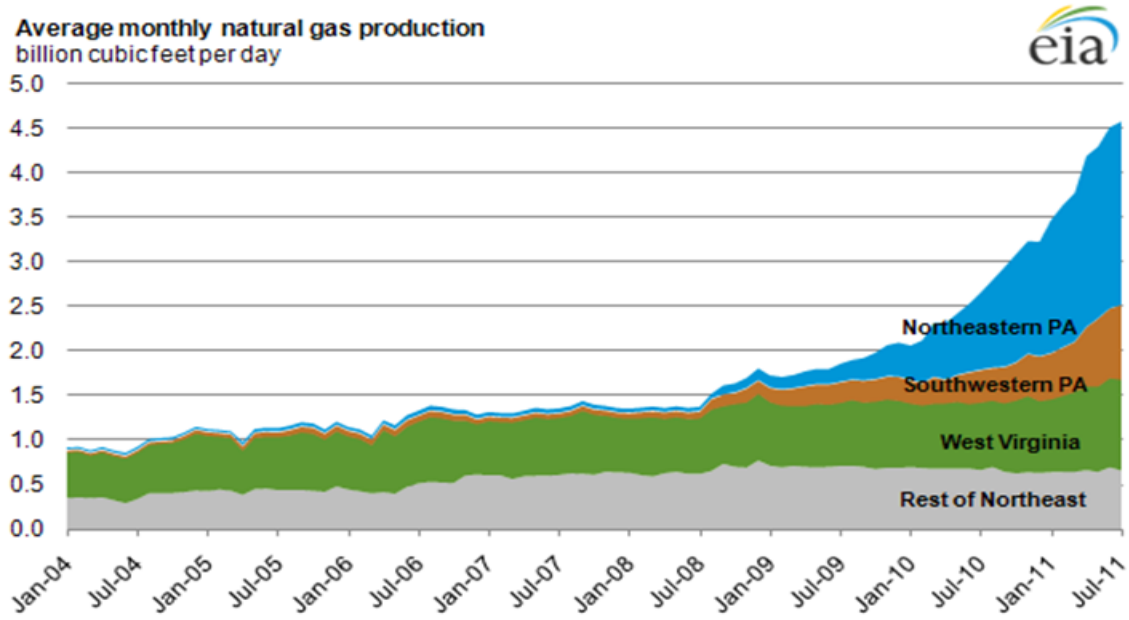
Source: Ohio EPA

Figure 9: Marcellus and Utica Shale Plays



Source: PSU

Figure 10: Marcellus Shale development 2007-2011



Source: US EIA

Figure 11: Northeast Natural Gas Production

Pennsylvania Natural Gas Employment:

Studies of natural gas's role in national and regional economies typically use impact studies (though this is not considered best practice for evaluating economic effects). Impact studies, such as the ones we describe, typically estimate three types of employment effects: (1) direct effects of the jobs directly employed in the activity (in this case natural gas mining); (2) indirect effects that would include inputs to the direct activity (such as pipeline construction); and (3) induced effects due to the added household income (e.g., workers purchasing items in the local economy) (see IMPLAN.com for more details). Summing across the three categories, if done correctly, would produce the total number of jobs "supported" by the industry (not new jobs created). As we describe below, estimating the number of new jobs created would need to assess what would have happened in the absence of natural gas mining—i.e., develop the counterfactual—which is not done in standard impact analysis.

One source of confusion is that impact studies do not produce continuous employment numbers. If an impact study says there are 200,000 jobs, this does not mean 200,000 workers are continuously employed on a permanent basis. For example, there are workers who do site preparation. Then there is another group who do the drilling followed by another group who maintains the well when it is in production. Finally, there is an entirely different group doing pipeline construction, and so on. So, while the public is likely more interested in continuous ongoing employment effects, impact studies are producing total numbers of supported jobs that occur in a more piecemeal fashion.

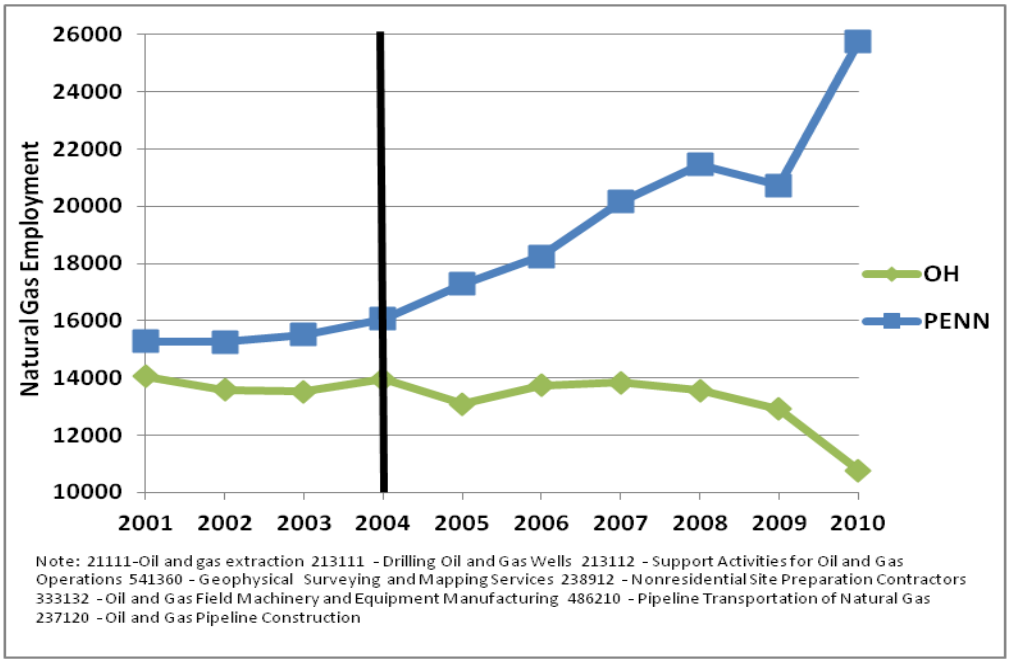
Impact analysis is usually based on an old input-output technology that is typically not used today by economists to estimate actual economic effects. Impact studies do not include various displacement effects and do not reflect the true counterfactual of comparing what would have happened without natural gas drilling. For example, oil and natural gas drilling would lead to higher local wages and land costs, which reduce employment that would have occurred elsewhere in the economy. Likewise, the environmental effects may reduce activity in the tourism sector and other residents may not want to live near such degrading activity. Finally, greater natural gas employment means that there are fewer jobs in coal that would have occurred without the increase in natural gas employment. As described below, best practice economics uses other approaches that try to adjust for displacement effects to derive more accurate estimates of actual effects (see Irwin et al. (2010) for a discussion of the weaknesses of impact studies).

Figure 12 on the next page shows the direct and much of the indirect employment in natural gas and other related sectors in Ohio and Pennsylvania.[6]

6. For the direct effect of natural gas mining, we also include some indirect suppliers that are related to natural gas drilling, which overstates the direct effects. However, not all of the indirect industries are included in Figure 12. When we use a multiplier below, because we already include some indirect effects, we would overstate the total number of supported jobs for the industry.

Since some of the sectors reported in Figure 12 include other sectors—primarily oil—we assume that all of the gain in Pennsylvania employment is due to new natural gas production. Also, we do not include "energy related" sectors in Figure 12 if they showed a large decrease in employment because we believe that would understate the importance of new natural gas production in Pennsylvania (those declines would likely be due to other factors). Thus, if anything, we believe that any measurement "errors" would work to overstate the importance of new gas production employment.[7] From Figure 12, with these assumptions, we assume that from 2004-2010, there was a gain of about 10,000 direct and indirect jobs in the natural gas industry in Pennsylvania.

The typical multiplier would take direct employment and multiply it by the multiplier to arrive at the total effects, including indirect and induced effects. Since the 10,000 number derived above includes some of indirect effects such as pipeline construction, using the standard multiplier would likely lead to an overstatement of the total employment effects of new production. Nonetheless, assuming the standard multiplier of 2 (which is on the high end), the natural gas industries would still have led to about 20,000 direct, indirect, and induced jobs from 2004 to 2010 in Pennsylvania, though this ignores employment losses in other sectors displaced by natural gas.[8] By comparison, Considine et al.'s (2011) industry funded study suggested that natural gas was associated with 140,000 Pennsylvania jobs during 2010.



Source: BLS

Figure 12: Ohio and Pennsylvania Natural Gas Employment[9]

7. IHS Global Insight (2009) notes that employment in these sectors also includes employment in the oil sector and other sectors (not just natural gas). They calculate some national estimates of natural gas's share of overall employment in each sector. For example, they estimate natural gas's employment share for the following industries as follows: (1) 2111-Oil and gas extraction, 213111 - Drilling Oil and Gas Wells, and 213112 - Support Activities for Oil and Gas was 74% in 2008; (2) 237120 - Oil and Gas Pipeline Construction was 68% in 2008; (3) 333132 - Oil and Gas Field Machinery and Equipment Manufacturing was 65% in 2008 and (4) 238912 - Nonresidential Site Preparation Contractors was 16% in 2008). We could have used IHS Global Insight's shares in our calculations, but we believe this would **understate** the increase in the size of the natural gas sector in Pennsylvania because some of the gains would be attributed to other sectors.
8. Academic economists generally use a multiplier of 2 as an upper bound multiplier. For example, Stabler and Olfert (2002) describe a range of employment multipliers in the 1.1 to 1.5 range. Hughes (2003) describes that *output* multipliers above 2.5 are likely very questionable. Likewise, Kelsey et al. (2009) found an output multiplier for natural gas in Pennsylvania to be in the 1.86 to 1.90 range, further showing that our 2.0 multiplier is reasonable. Indeed, as the economy becomes more global, fewer employment gains are on-shore or local, which would reduce employment multiplier effects. Likewise, with outsourcing and increasingly fragmented supply chains, firms are further shifting their purchases outside the firm, which further reduces the amount purchased locally. Further, keep in mind that the energy sector is highly capital intensive which would work to reduce the employment effects and increase the output effects in a multiplier. Thus, we believe our use of an employment multiplier of 2 would be viewed as "generous" by independent academic economists.
9. The direct effects would commonly include the drilling and extraction activities while indirect effects would normally include inputs such as pipeline construction and field equipment manufacturing. Hence, this is why we state that we are already including some of the key inputs as direct employment in Figure 12.

We believe that independent and academic economists in regional and urban economics would view our 20,000 employment estimate as reasonable and some may view it on the high end of actual job creation.[10] For example, Barth (2010) notes that other studies found a multiplier for oil and gas as low as 1.4. She also notes that in similar input-output studies, other industries were found to have higher multipliers than oil and gas, with agriculture having one of the highest multipliers. If shale development adversely effects employment in (say) coal mining, agriculture, and tourism, then those numbers should be subtracted from these numbers to derive the actual employment effects (including any multiplier effects in those sectors). To be sure, we only calculate an impact style estimate to give a feel of the overestimated effects produced by industry consultants (and others who produce impact studies). There are much better approaches than impact studies to calculate actual effects, which we describe below.

One other issue is that proponents of natural gas expansion in Ohio often claim that lower natural gas prices will provide a major stimulus to overall employment, especially in manufacturing. While we will not assess whether natural gas prices are a sufficient share of a typical firm's cost structure to make a tangible difference, we do note that there are reasons to be skeptical of those claims (though we hope we are wrong). Foremost, to make a difference on Ohio's relative competitive edge compared to the rest of the United States and the rest of the world, it would have to be an event that helps Ohio's businesses much more than in the rest of the world. However, as we note in the discussion surrounding Figure 6, shale natural gas is a global phenomenon, meaning that falling natural gas prices will benefit a significant share of Ohio's global competitors. Thus, there is no "edge" given to Ohio's businesses that would make them tangibly more competitive than their national and international competitors.

Economists typically subject their forecasts to "smell tests" by making comparisons to similar events. In our case, comparing energy development around North Dakota's Bakken shale formation in the far northwestern part of the state is good benchmark to assess whether our 20,000 job forecast for Ohio makes sense. Specifically, development of North Dakota's Bakken shale region has been about the same magnitude as the energy development in Pennsylvania and should produce somewhat comparable job effects on both states.[11] During the October 2007-October 2011 period (or a four year period that corresponds to Kleinhenz & Associates' Ohio study), the entire state of North Dakota added about 39,000 jobs. It is highly unlikely that this is all due to energy as high commodity prices (for example) have supported North Dakota's relatively large farm economy. Further, we would expect that the Bismarck metropolitan area (which is relatively close to the mining activity) to be more impacted by the energy boom, while the Fargo and Grand Forks metropolitan areas that are hundreds of miles away on the Minnesota border to be considerably less affected. In this comparison, Bismarck added 4,600 jobs during this four-year period, while Fargo and Grand Forks metropolitan areas respectively added 4,400 and 1,600 jobs. These figures strongly suggest that North Dakota's relative prosperity is more widespread than just an energy boom in the Bakken region. So, even if all 39,000 North Dakota jobs were due to energy (which we have already shown is highly unlikely), this would be a far cry short of the 200,000 jobs that have been forecasted for Pennsylvania and Ohio despite the comparable size of the three states' energy booms.[12] Thus, our forecast of 20,000 jobs over the next four years is further supported as a reasonable forecast based on the North Dakota experience.

Although Pennsylvania's natural gas employment gains are impressive, they still represent just a small share of total state employment. From 2004 to 2010, the employment share of oil and natural gas related sectors shown in Figure 12 increased from 0.30% to 0.48% (see Figure 13). This small employment share is simply not enough to have a significant effect on total jobs and on unemployment for the state.[13] Despite the significant increase in natural gas jobs from 2009 to 2010,

10. For example, there are many factors affecting the actual employment number. If there are workers from out of state, Ohio's employment number would be lower. Conversely, if more landowners are in state compared to Pennsylvania, that would increase the employment number. Other factors are harder to predict such as mining's effect on agriculture and timber.
11. U.S. Bureau of Labor Statistics Data (Current Employment Statistics) suggests that between October 2007 and October 2011, mining employment (which is due to the direct energy production) increased by about 12,000 in both states. The other employment numbers referred to here are from the same source.
12. U.S. Bureau of Labor Statistics Data shows that North Dakota had an October 2011 unemployment rate of 3.5%, which seems quite low compared to the 9.0% national rate. However, North Dakota always has very low unemployment rates due to long-term structural reasons (Partridge and Rickman, 1997a, 1997b). For example, it was an even lower 3.0% in October 2001, well before the energy and commodity price boom of recent years, illustrating that the energy boom is only a partial reason for North Dakota's current low unemployment rate.
13. To give a further feel for the size of the natural gas sector in Pennsylvania, Barth (2010) finds that in January 2010 there were 48,777 Walmart employees in Pennsylvania (almost double that of the natural gas industry broadly defined) and approximately 400,000 jobs in the tourism industry.

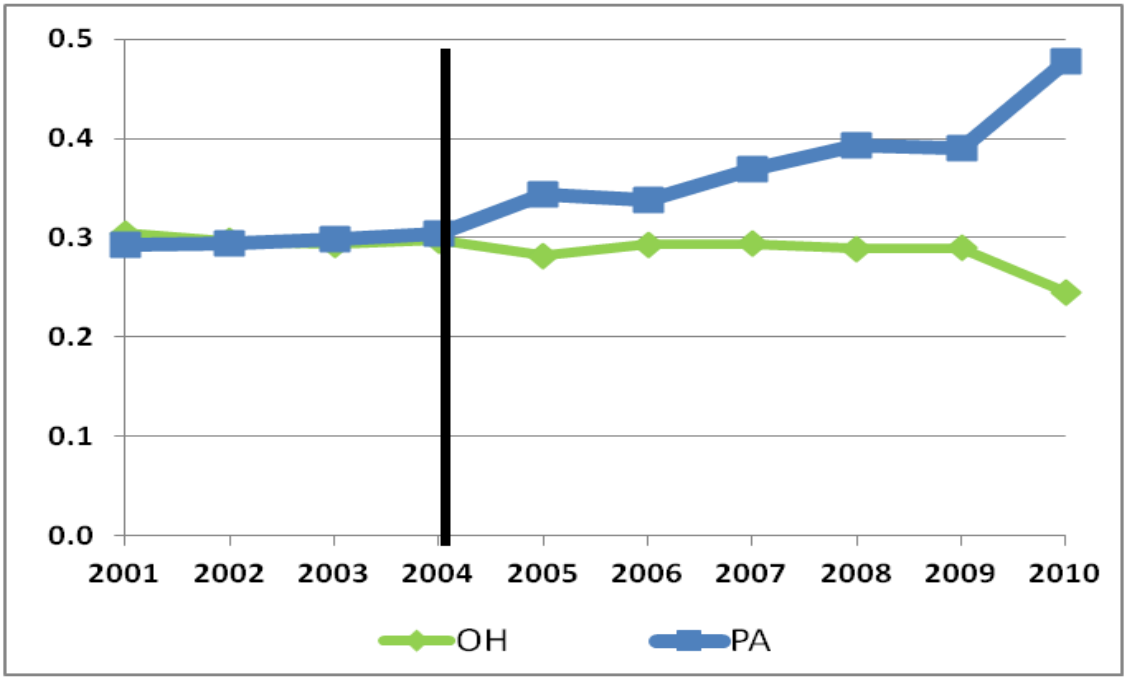
Pennsylvania's unemployment rate still increased from 8.0% to 8.7% during this time (BLS: U.S. Department of Labor, Bureau of Labor Statistics). At most, natural gas employment effects would be localized. Conversely, Ohio's unemployment rate remained unchanged at 10.1% from 2009 to 2010 (BLS) despite a loss in the energy sector jobs in Figure 12, illustrating that natural gas employment is not driving either state's economy.

Concerns with the Economic Impact Studies of Natural Gas Development:

Impact studies are typically associated with overstatements of the employment effects of new development. For example, the Considine et al. (2011) study appears to include indirect and induced jobs before applying the multiplier effect, which double-counts effects and blows up the estimated effects. Direct jobs should include those jobs directly associated with drilling the wells and extracting the natural gas. Indirect jobs include the jobs associated with various inputs required by the industry such as pipelines. Induced jobs should include those jobs and services required by the workers such as restaurants and entertainment.[14] The final two categories should be the outcome of the multiplier process.

Second, Considine et al. assumes that 95% of natural gas industry spending will occur in Pennsylvania. Kleinhenz & Associates assumes a slightly more conservative 90% of all spending will be spent in Ohio. In global economies in which state economies are integrated with national and international economies, such assumptions would not be credible for independent economists. Moreover, because the industry is relatively new and undeveloped, more of the inputs would be brought in from outside of the state, e.g., from Texas.[15]

There are other problems with impact studies because, in reality, more of the money leaks out. For example, Kelsey et al. (2011) found 37% of the Marcellus employment has gone to non-Pennsylvania residents and that landowners save or invest approximately 55% of the money they make from royalties/lease payments rather than spending it in the local economy. They use these



Source: BLS

Figure 13: Ohio and Pennsylvania Natural Gas Employment Shares of Total State Employment

14. Examples of jobs that should not be categorized as direct to natural gas mining are Finance & Insurance, Educational Services, Health, Arts & Entertainment, Hotel & Food Services, etc. By including these jobs as direct jobs, Considine et al. is essentially double counting the employment effects. While we do not have Considine et al.'s programming we believe one source of the double counting derives from how household spending from lease payments/royalties are treated. Even using the job estimates of Considine et al., it is still not a significant portion of the total employment in Pennsylvania.
15. We believe a more reasonable approach would have been to use the default state spending shares from the IMPLAN software (i.e., Considine et al. overruled IMPLAN's default numbers and incorporated 95%). In the absence of detailed and regional I-O data, other shortcuts have been used such as payroll to sales ratios (Oakland et al., 1971; Rioux and Schofield, 1990; Wilson, 1977) or Value-added to gross outlays by industry (Stabler and Olfert, 1994).

	Population 2005	Per Capita Income 2005	Employment Growth Rate 2001-2005	Employment Growth Rate 2005-2009	Income Growth Rate 2001-2005	Income Growth Rate 2005-2009
Non-Drilling Counties	255,508	$32,187	5.3%	-0.4%	12.6%	13.6%
Drilling Counties	124,928	$27,450	1.4%	-0.6%	12.8%	18.2%

Source: BEA

Table 1: Pennsylvania County Descriptive Statistics

more realistic findings to develop a better estimate of the economic impacts of shale development in Pennsylvania. Using IMPLAN, Kelsey et al. (2011) find that in 2009, Marcellus shale development economic impact was over 23,000 jobs and more than $3.1 billion. Our estimate of 20,000 jobs then closely corresponds to Kelsey et al.'s estimates (2011).

Finding Counterfactuals to Assess Growth:

The key problem with impact studies is that they do not estimate the actual number of jobs created by mining because of all of the displacement effects. They are not the true counterfactual and economists have not viewed them as best practice for decades (Irwin et al., 2010). Economists have developed other more credible approaches in developing a counterfactual, such as difference in difference approaches. One of these approaches is to match drilling counties to non-drilling counties that otherwise would have had similar employment patterns if there was no drilling. Thus, the goal is to find counties that would have looked similar to the drilling counties in the absence of drilling. We describe this approach below.

Although natural gas employment does not seem to have had a significant impact on the state as a whole, it may still have a sizeable impact on the specific counties, many of them rural. Table 1 presents data for Pennsylvania counties before and after drilling. Table 1 shows that before 2005, drilling counties are notably struggling more than non-drilling counties. Drilling counties on average are less populated, more rural, have lower per capita income and less employment growth. Natural gas leases also provide an additional source of income for landowners. Landowners that choose to lease their land to natural gas companies generally receive an upfront payment per acre and royalties on the gas produced from the well. Although the payout varies, it can be quite sizeable. From Table 2, it seems natural gas development is positively related to per capita income growth rates for drilling counties.

Table 1 highlights the fact that drilling counties on average look very different than most non-drilling counties. Thus, we look specifically at 3 significant high-drilling counties in the northeast (Tioga, Bradford, and Susquehanna) and 3 in the southwest (Washington, Greene, and Fayette).[16] We then match each of these two sets of mining counties to similar non-mining counties (as of 2009) based on population and similar employment and income dynamics *before* 2005 and the advent of shale drilling.[17] Figure 14 shows the mining and non-mining counties that were chosen. Figure 14 shows that the matches are divided into the Northeast quadrant of the state and the southern part of the state. The appendix provides additional graphs directly comparing each drilling county with its matched

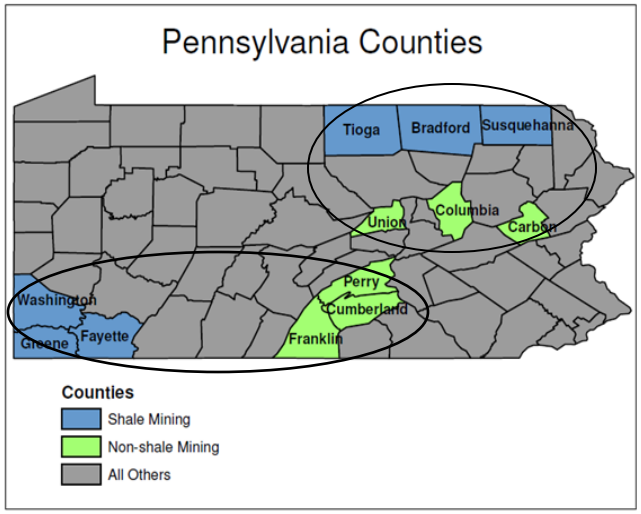


Figure 14: 2009 Matched Drilling and Non-drilling Counties

16. Drilling counties were matched to non-drilling counties on the basis of population and general urbanization as well as region (either north or south).
17. Matching studies can employ other mathematical approaches to finding matches. As will be apparent, our choice of non-drilling counties will appear to be good matches.

non-drilling county.

Using BEA employment and income data, the shale mining counties are compared to the non-mining counties with 2004 marking the point immediately before drilling activities began. One of the key features of the employment and income data is that both mining and non-mining counties are on similar growth paths prior to drilling, suggesting there they are good comparisons (see Figures 15-18 in the next pages). Figure 15 suggests that mining counties may have had faster job growth in the Southern region, but Figure 16 shows that the opposite applies in the Northeastern region. Overall, there are no clear employment effects for heavily drilled counties. We are not saying there are no drilling employment effects, but that they are not large enough to be detected in this commonly used matching approach. One reason may be that many of the new jobs may go to people outside the state who have previous experience in natural gas extraction.[18] Conversely, the positive impacts on incomes are more clear. Figures 17 and 18 show the per capita income impact of natural gas drilling appears to be positive in both Southern and Northeastern regions. While the effects may differ in longer-run periods, our four year window conforms to Kleinhenz & Associates' four year forecast for Ohio.

To be sure, there are many things happening in these county economies, but such efforts to form the true counterfactual are more in line with best economic practice than the impact studies that are often used by economic consultants. In particular, one especially appealing feature is that our approach is based on actual employment and income data and not based on the assumptions of computer software.

For further comprehensive analysis to appraise whether our previous matched results are correct, we now perform a statistical analysis on all counties within Pennsylvania. To control for county-specific effects, we use a difference-in-difference approach to find the impact of drilling on the change in employment after drilling compared to the change in employment before drilling. Details of the difference-in-difference methodology are provided in the appendix, but essentially we are examining whether having more natural gas wells is associated with more job and income growth, but this time we are considering all Pennsylvania counties. This approach accounts for the fact that drilling and non-drilling counties may have systematic differences (fixed effects) for a variety of reasons - and we are adjusting for these differences. Table 2 shows that the number of wells drilled since 2005 has no statistically significant effect on employment.[19] Overall, we believe that there have been modest employment effects in drilling counties, but they are not large enough to statistically ascertain (most likely due to some of the offsetting factors we just described). The upshot is decision makers who are interested in the actual job creation effects of natural gas need to take much more seriously the displacement effects throughout the economy.

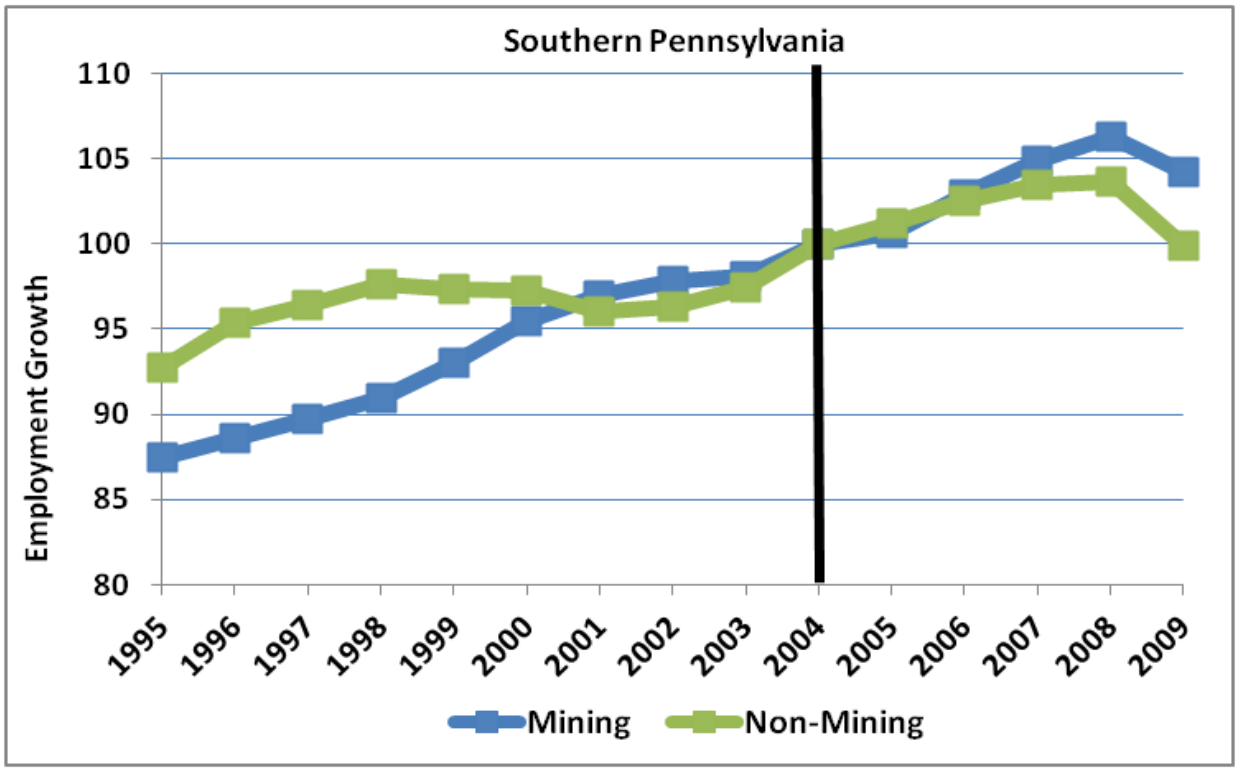
There are many important reasons why we would expect natural gas' impact on employment to be small or insignificant, which explains the findings in Figures 15 and 16 and in Table 2. Besides displacement, one reason is the production technology of natural gas. Like other fossil fuel energy industries, natural gas is rather capital intensive.

	Change in Percent Employment Growth 2005-2009 Compared to 2001-2005	
	Parameter Estimate	t-value
Total Wells 05-09	**1.769E-05**	**1.14**
2001 Log Population	0.023	2.64
2001 Log Per Capita Income	-0.096	-1.55
N	67	
R2	0.118	
Adjusted-R2	0.076	

Source: BEA and Pennsylvania DEP Data. See the appendix for more details.

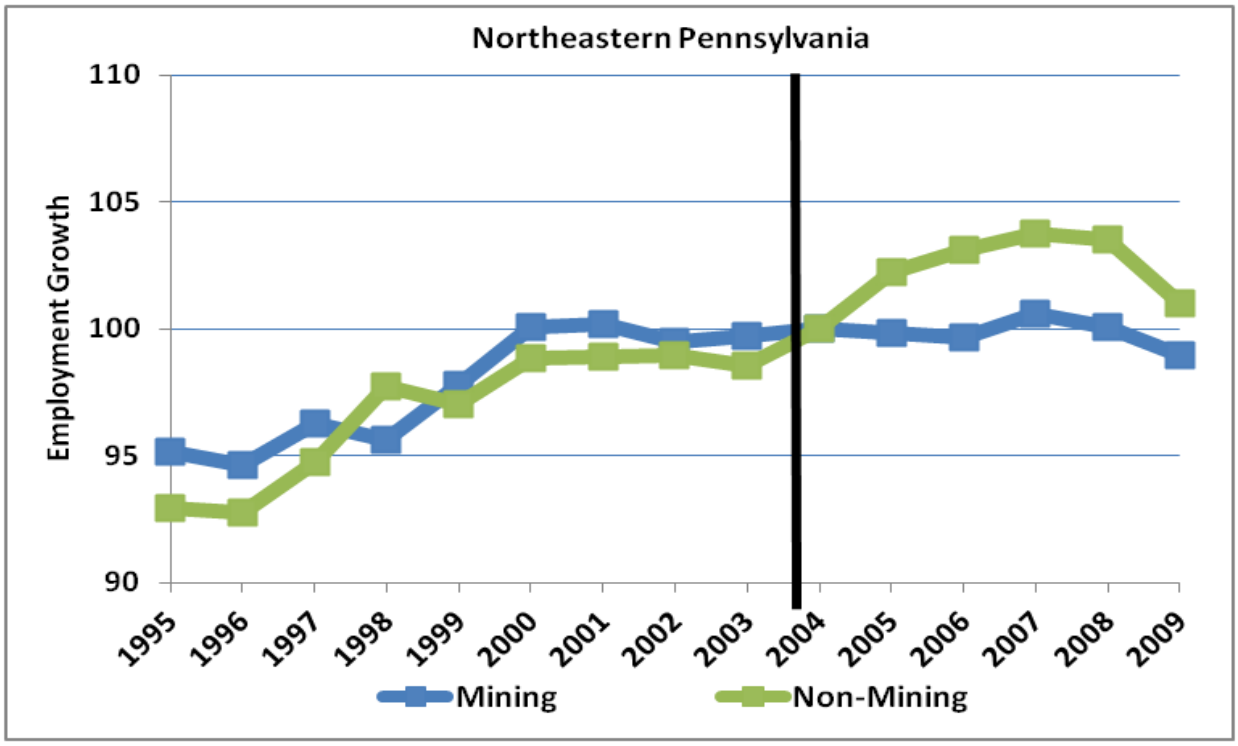
Table 2: Employment Effects of Drilling

18. Pennsylvania and Ohio residents may not have the skills and experience needed to meet the demands of the natural gas industry and royalty/lease monies may not be spent locally. Similarly with natural gas spending, Pennsylvania may not have the services and supply chain the energy industry requires initially. Along with other displacement effects, this may explain the lack of employment response.
19. We also considered that possibility that there are threshold effects (or other nonlinearities) in which drilling does not affect economic growth until a certain number of wells are drilled. We did this by adding a number of wells drilled squared term to the model. This variable's coefficient was negative and statistically insignificant in both the income and employment growth models, suggesting that there are no nonlinear effects. Additionally, these numbers don't account for people switching from part time to full time employment.



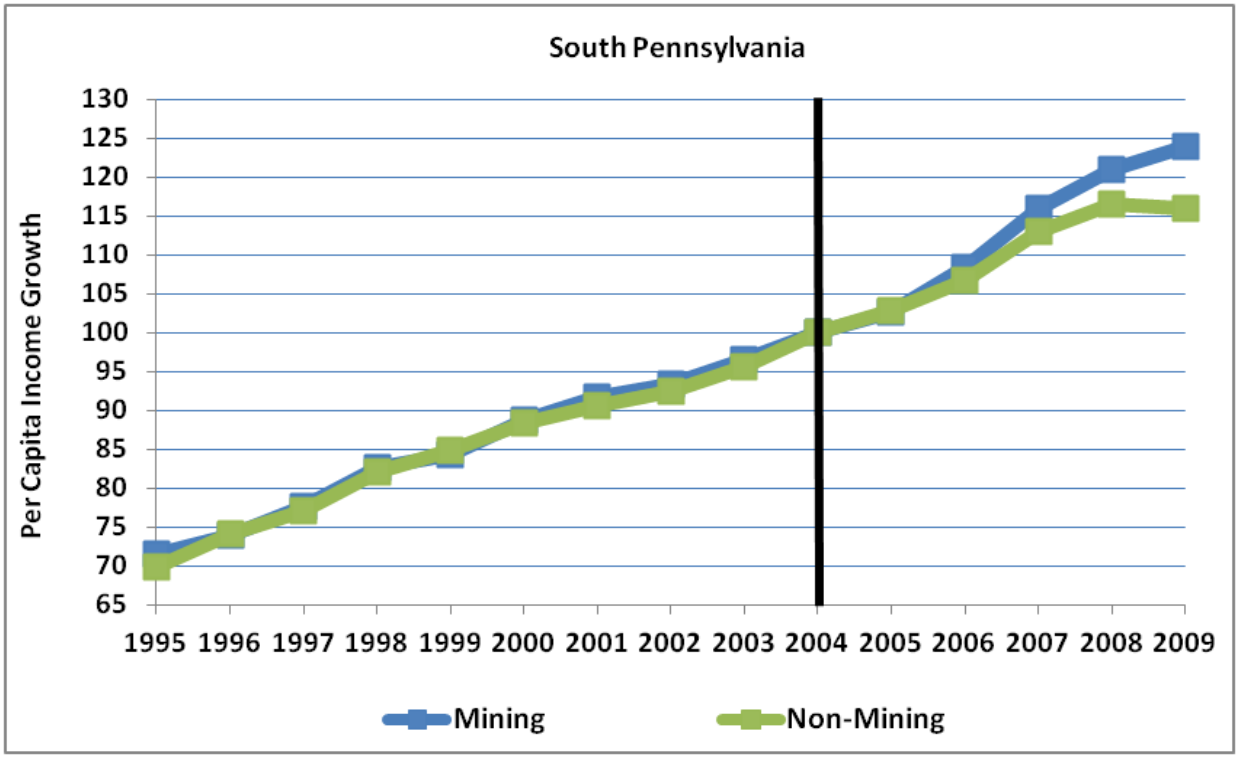
Source: BEA Mining counties (Washington, Greene, and Fayette) Non-mining counties (Perry, Franklin, Cumberland)

Figure 15: Drilling and Non-drilling Employment Comparison (2004=100)



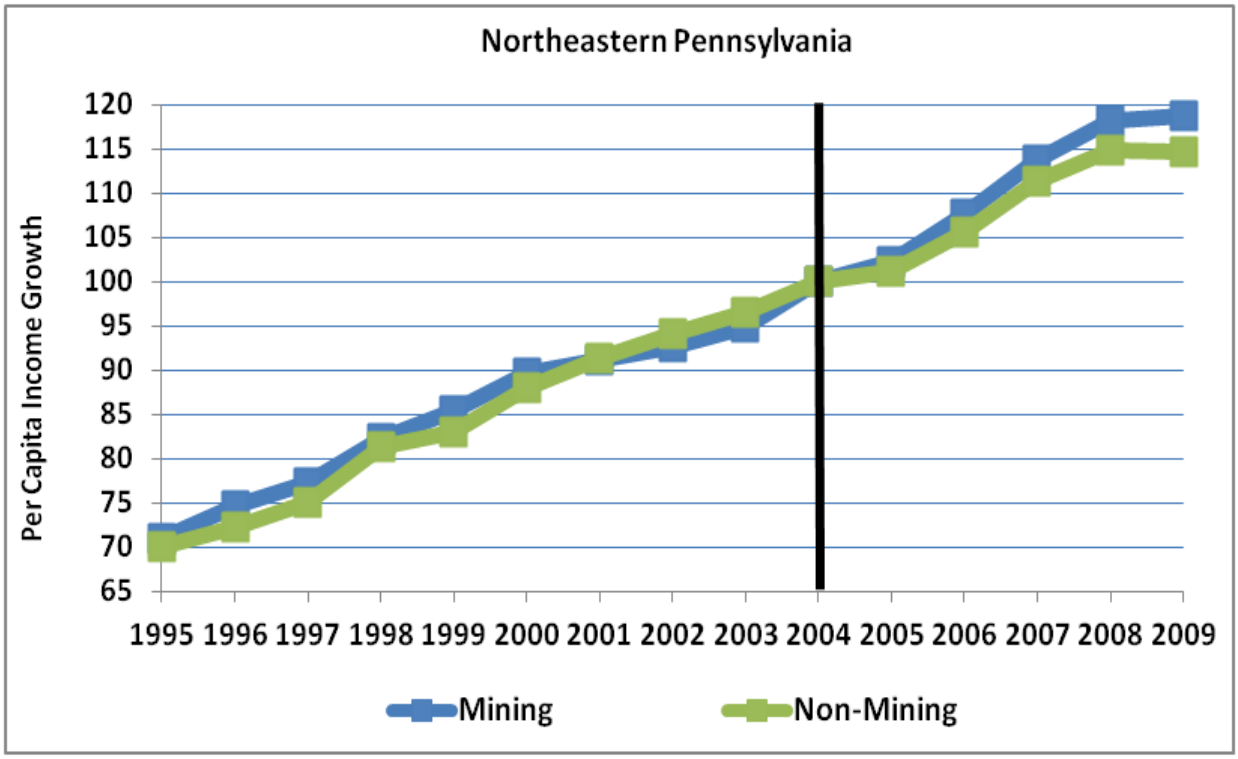
Source: BEA. Mining counties (Tioga, Bradford, and Susquehanna) Non-mining counties (Union, Columbia, Carbon)

Figure 16: Drilling and Non-drilling Employment Comparison (2004=100)



Source: BEA. Mining counties (Washington, Greene, and Fayette) Non-mining counties (Perry, Franklin, Cumberland)

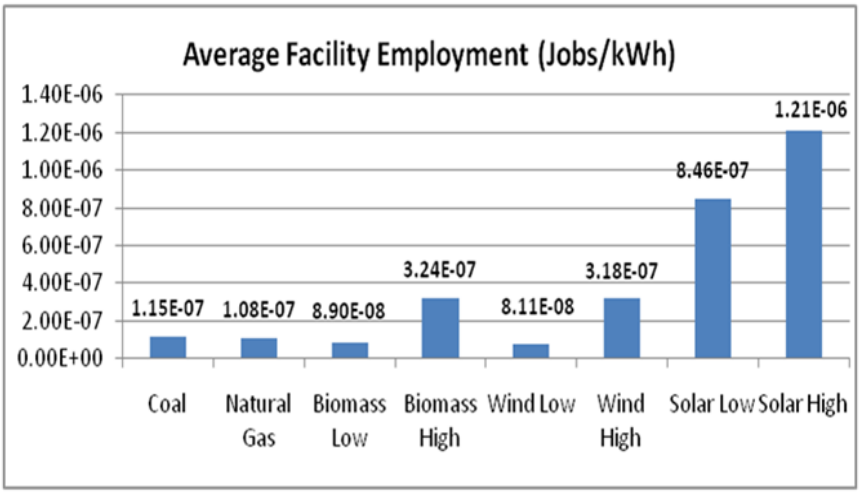
Figure 17: Drilling and Non-drilling Per Capita Income Comparison (2004=100)



Source: BEA. Mining counties (Tioga, Bradford, and Susquehanna) Non-mining counties (Union, Columbia, Carbon)

Figure 18: Drilling and Non-drilling Per Capita Income Comparison (2004=100)

Figure 19 shows the estimated number of jobs required to produce a kWh of electricity. Natural gas actually requires fewer jobs to produce a given amount of electricity than coal. The job requirements for natural gas electricity production are low because it is efficient at producing a kWh. In this case, fewer jobs created is actually a good thing for the overall competitiveness of the economy because that implies low-cost electricity, but it means that natural gas drilling has smaller employment impacts.



Source: Weinstein et al. (2010) chart using data from Kammen et al. (2004)

Figure 19: Jobs Requirements to Produce a kWh by Energy Source

As figure 3 shows, most natural gas resources (32.8%) are used for electricity. When switching from coal to natural gas, there will be significant displacement effects in addition to the effects of natural gas being more productive than coal in producing a kWh. Using the same technique shown in Weinstein et al. (2010), Table 3 shows the approximate employment effects of even large shifts (25% of the kWh produced from coal to kWh generated from natural gas) are rather small. In both cases, there are small employment losses with Ohio having more employment losses due to a higher percentage of electricity being generated from coal.

	Total kWh from Coal 2009	Change in Jobs	Change in Energy Costs (millions)	Change in Emissions (lbs)
Ohio	113,711,997,000	-195	-$491,804	-23,822,663,372
Pennsylvania	105,474,534,000	-181	-$456,177	-22,096,914,873

Source: EIA and Weinstein et al. (2010)

Table 3: Effects of Displacing Coal with Natural Gas

Table 4 shows the regression results for a difference-in-difference for county per-capita income. In this case, the income injected into the economy by the natural gas industry through leases and wages appears to have a significant positive effect on per capita income. These results, along with the employment regression results, verify our previous analysis using matched drilling and non-drilling counties. Drilling seems to have a positive and significant effect on income in drilling counties - but not on employment.

	Change in Percent income Growth	
	Parameter Estimate	t-value
Total Wells 05-09	**2.515E-05**	**2.11**
2001 Log Population	0.084	2.53
2001 Log Employment	-0.086	-2.76
N	67	
R2	0.205	
Adjusted-R2	0.167	

Source: BEA and Pennsylvania DEP Data

Table 4: Income Effects of Drilling

The Benefits and Costs of Natural Gas

Once the realistic expectations of the employment and income effects of shale natural gas development are properly assessed, these impacts can be included when weighing the benefits and costs of shale gas.

The Benefits of Natural Gas:

Other than the income effects and modest employment impacts, additional benefits to natural gas include lower energy prices, natural gas imports, and carbon emissions (especially compared to coal). First, Figure 20 below shows the average levelized cost to produce a kWh. As shown in Table 3, natural gas decreases electricity costs for end users. However, if natural gas prices are too low it will be less economical to pursue shale gas.[20]

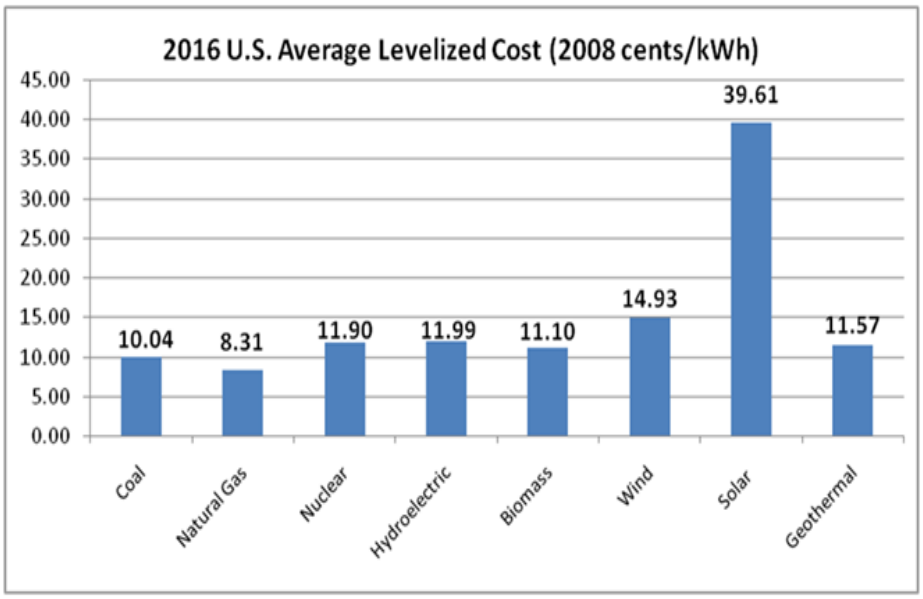
Pennsylvania and Ohio are also good locations to produce natural gas as there is significant natural gas infrastructure in the area and large population and industry centers that require natural gas as shown in Figure 21 on the next page. This proximity further decreases energy costs by reducing transportation costs.

Increasing domestic sources of natural resources are reducing the demand for foreign gas. The EIA reports that 87% of the natural gas consumed in 2009 was produced domestically. Figure 22 on the next page shows that since 2007, natural gas imports have been declining. However, as already noted, future increases in natural gas production will have very little effect on "energy security" as our largest problem relates to oil imports.

The potential benefits of natural gas have been touted by both the industry and the US EIA. However, the ability to supply the country's energy's needs may have been overstated. In the 2011 Annual Energy Outlook, the EIA estimates that 2,543 Tcf of potential natural gas resources could supply the U.S. for approximately 100 years at the 2010 level of annual consumption. However, this does not account for the increasing trends in consumption. Accounting for the trend in consumption from 1974 to 2010, this estimate falls to 65 years. Using a more recent trend from 1986 to 2010, the estimate falls to 52 years. Despite the significant reserves, natural gas energy strategies still suffer from typical fossil fuels problems such as nonrenewability.

The Environmental Benefits and Costs:

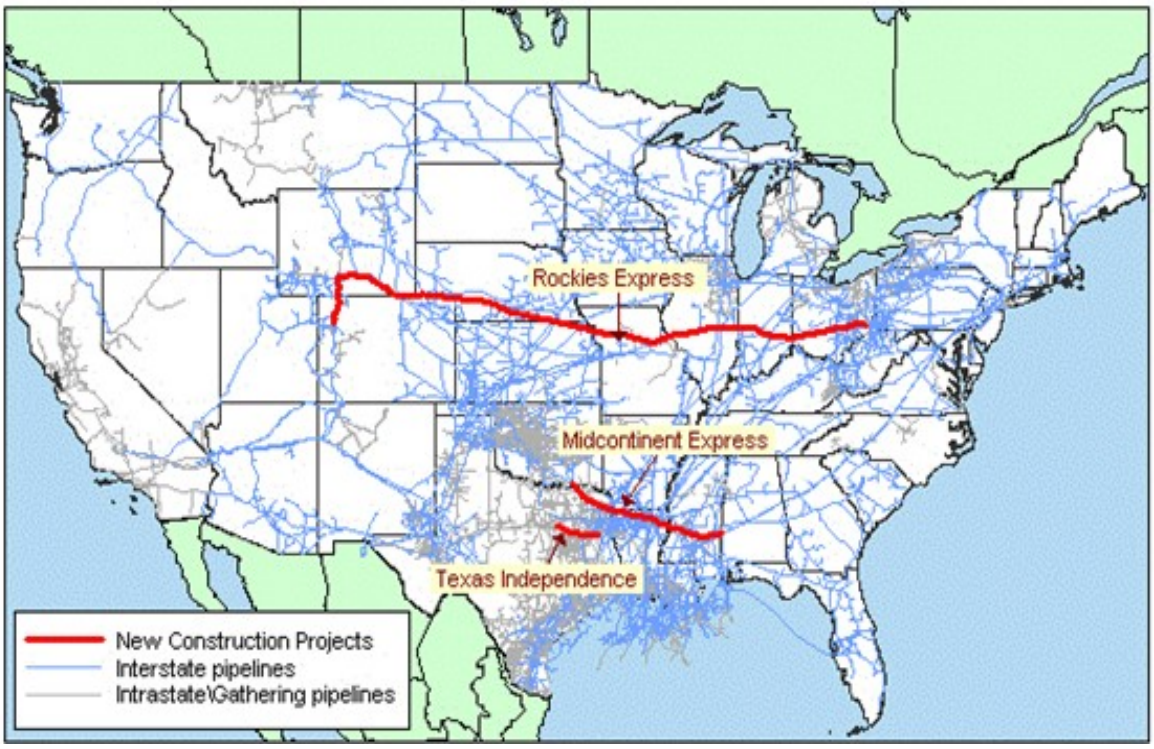
Natural gas is often viewed as a bridge between a reliance on carbon emitting fossil fuels and an energy industry comprised of some mix of alternative energy sources with far less reliance on foreign energy and carbon emitting energy sources. Figure 23 on page 22 shows the life cycle emissions rates for various sources of electricity generation. Although natural gas emits significantly more carbon than nuclear and alternative energy sources, it does emit far less than coal. Thus, as table 3 showed, switching from coal to natural gas will not only save money on energy costs it will also reduce carbon emissions. Natural gas combustion emits lower levels of carbon dioxide, nitrogen oxide, and sulfur dioxide than both coal and oil. Yet,



Source: Weinstein et al. (2010) using data from the EIA

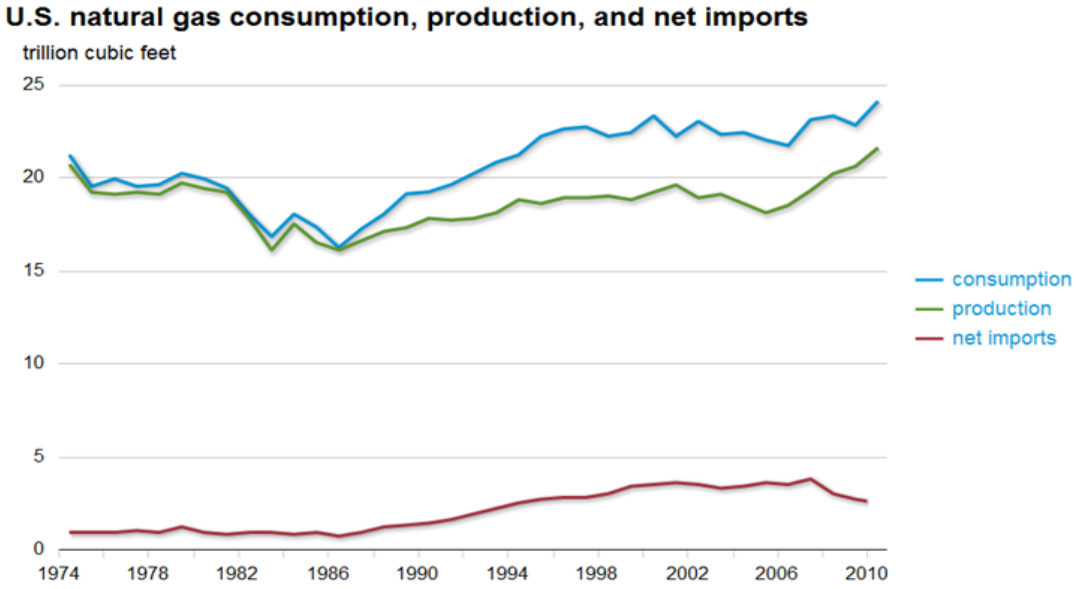
Figure 20: Energy production costs by energy source[21]

20. It should also be noted that a decoupling of natural gas prices from oil prices has realigned markets (Southgate and Daniels, 2011).
21. The average levelized cost is the present value of all costs including building and operating the plants.



Source: EIA, GasTran Natural Gas Transportation Information System.

Figure 21: Natural Gas Infrastructure



Source: EIA

Figure 22: Increasing Production Reduces Imports

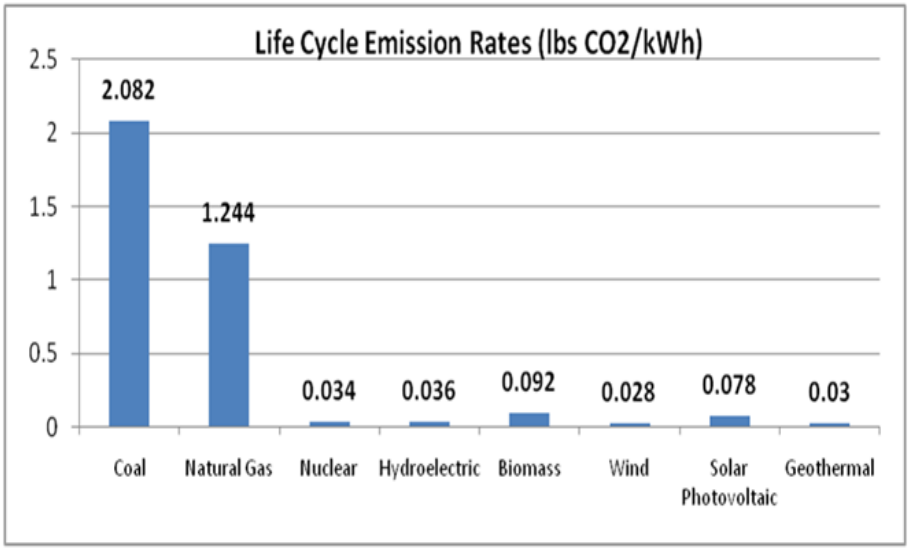
Howarth et al. (2011) find that the carbon emission benefits of natural gas are less when it extracted using hydraulic fracturing compared to conventional methods because of the water and wastewater transportation.

Despite the potential emissions advantages of natural gas, significant concerns have been raised about the environmental impact of natural gas extraction with a Duke University study finding elevated levels of methane in water near drilling sites (Osborn et al., 2011) and the EPA's recent announcement that hydraulic fracturing chemicals polluted water sources in Wyoming (The Associated Press).

The environmental concerns with natural gas have been focused on the hydraulic fracturing process and its impact on water sources. The importance of understanding the hydraulic fracturing process is essential in understanding its potential environmental effects. If cracks aren't able to be controlled or predicted during hydraulic fracturing or somehow disturb the ground, then natural gas or fracturing fluid containing toxic chemicals may shift or migrate to aquifers affecting drinking water. However, hydraulic fracturing typically occurs at depths well below the level of aquifers and drinking water. At thousands of feet below water sources, it is unlikely that hydraulic fracturing would contaminate water sources in Ohio. A 2004 EPA report found that, although fluids migrated unpredictably, hydraulic fracturing did not affect underground drinking water and posed no health risk. Representatives of the natural gas industry have made similar claims that hydraulic fracturing has never contaminated drinking water sources. These claims were used to exempt the natural gas industry from the Clean Water Act and the Safe Drinking Water Act when Congress enacted the 2005 Energy Policy Act.

Although the hydraulic fracturing method of injecting fluids deep below the aquifer level may not be a source of contamination, this level and aquifers themselves must be drilled through. Casing failures in the drilling process may cause fracturing fluids or natural gas to escape and pollute aquifers and local water sources. There are also concerns over spills that can occur during transport or impoundment failures. Thus, whether hydraulic fracturing has contaminated water sources becomes an issue of semantics as to whether the cause is the actual hydraulic fracturing or the drilling, extracting, and spills. Because of the potential impacts on water sources, it is important to be aware of the location of water sources compared to the location of shale resources. Figures 24 and 25 on the next page show the water resources of the US (aquifers are differentiated by various colors). US water resources and shale resources are clearly geographically overlapping though they are at different depths (including in Ohio and Pennsylvania).

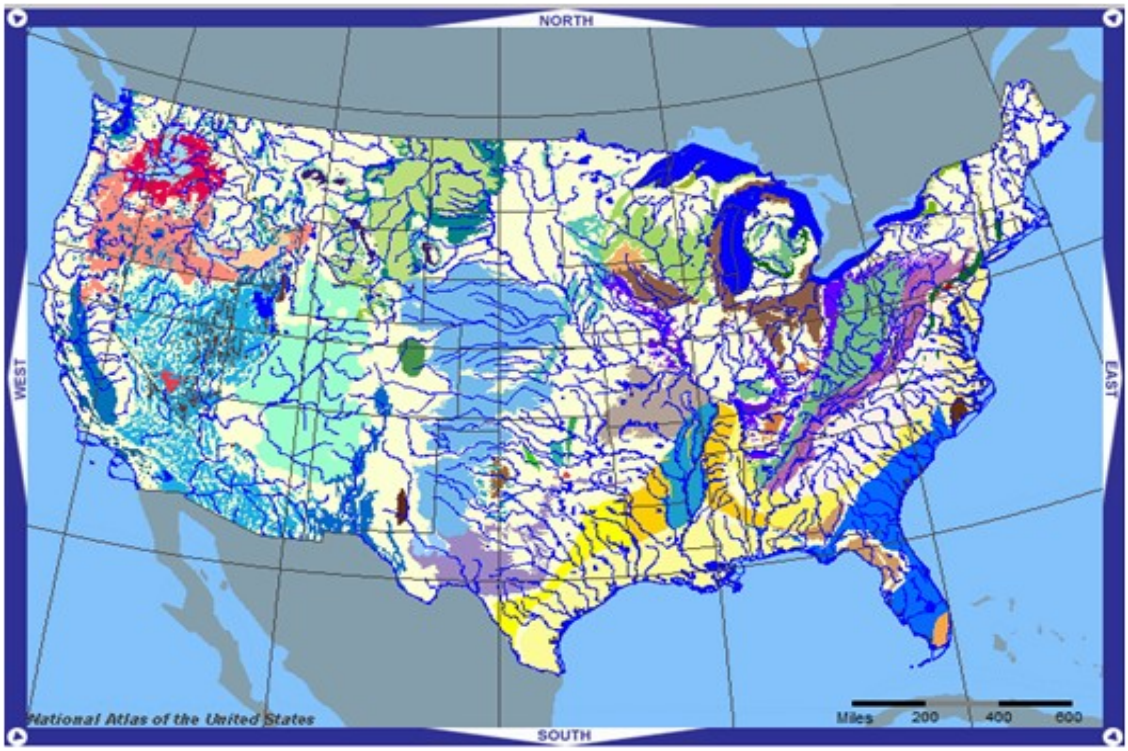
In addition to accidental contamination in the drilling and extraction process, water use and disposal are also concerns. The hydraulic fracturing method requires at least a million gallons of water per well that is combined with chemicals and sand. Sapien (2009) notes that approximately 9 million gallons of wastewater per day were produced from Pennsylvania wells in 2009, and this amount is expected to increase. This water byproduct contains elements and chemicals such as cadmium and benzene that are known to cause cancer. There may be other toxic chemicals in the hydraulic fracturing fluid mix though energy companies have continually refused to disclose these chemicals for proprietary reasons. Water byproducts also contain Total Dissolved Solids (TDS) that can make the water five times as salty as



Source: Weinstein et al. (2010) using data from Meier (2002)

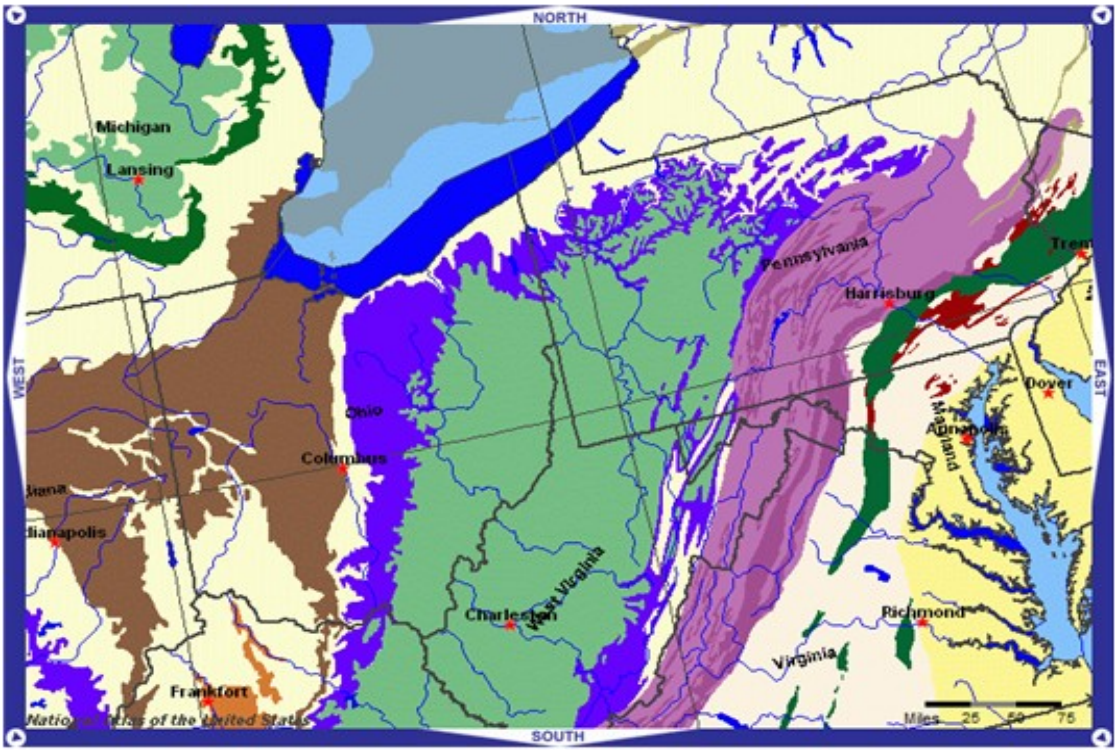
Figure 23: Carbon Emissions by Electricity Source[22]

22. Life cycle emissions rates include the total aggregated carbon emissions over the life cycle of the fuel, including extraction, production, distribution, and use.



Source: NationalAtlas.Gov

Figure 24: US Aquifer, Stream, and Waterbed Resources



Source: NationalAtlas.Gov

Figure 25: Ohio and Pennsylvania Aquifer, Stream, and Waterbed Resources

seawater. Although some of this water is left behind and some can be reused, there is still a significant amount that must be treated and disposed. Water byproducts must be stored in either open wells, closed containment wells, or injected back into the ground. Open wastewater wells can lead to air pollution as it evaporates and water contamination if the lining fails, but this method is less expensive than other methods. There are additional air pollution concerns with the increased traffic resulting from water transportation, flaring, etc.

There are also environmental costs in the form of noise pollution. Ohio residents may simply not want to look at or hear natural gas rigs in their backyard or heavy equipment driving through the countryside. Hydraulic fracturing does limit the number of rigs used compared to conventional methods.

The potential environmental impact of hydraulic fracturing on water in Ohio needs to be accounted for when estimating the economic costs of natural gas. Just as the employment and income effects for Ohio were estimated using Pennsylvania as a case study, the potential environmental impacts of hydraulic fracturing and natural gas drilling on Ohio can be approximated by examining incidents in Pennsylvania. Whether the source of contamination is from the migration of fluids and gas underground, drilling or extraction accidents, or improper disposal of water byproducts, it is important to understand what Pennsylvania residents have experienced. After gaining a better understanding of the environmental impacts, then it is important to determine the source of the contamination, how it can be prevented, and whether new regulations are needed to protect the Ohio environment and its drinking water.

Pennsylvania Environmental Concerns:

In 2008, Lustgarten noted that more than 1,000 cases of suspected contamination have been documented in Colorado, New Mexico, Alabama, Ohio, and Pennsylvania. Incidents of contamination have been most publicized in Dimock, PA. Dimock is located in Susquehanna County in northeastern Pennsylvania where natural gas development is most pronounced. Dimock is a struggling rural area with approximately 1,300 residents and nearly 1 in 7 is unemployed. Residents hoped the natural gas industry would turn their economy around. Instead, the controversial documentary *Gasland* contends it environmentally turned it upside down.[23] The documentary begins and ends in Dimock and includes footage of residents lighting their tap water on fire. After natural gas drilling began in Dimock, Lustgarten notes that several of the residents' wells have exploded. Affected residents now buy water from outside sources. The Pennsylvania Department of Environmental Protection (DEP) believes a casing failure is to blame for the drinking water contamination and is holding Cabot Oil responsible. Cabot Oil has agreed to supply clean water to some of the affected residents and has been required to pay compensation to many residents. In September of 2009, Cabot Oil spilled nearly 8,000 gallons of fracturing fluids that seeped into a nearby creek.

Evidence of fracturing fluid has now been found in drinking water sources including the Monongahela River. In response to these cases and others, the natural gas industry has been quick to label these events as unfortunate but highly unlikely implying that these cases are the result of just a few "bad apples." In some cases they claim methane has always existed in these water sources, but simply went unnoticed until now. Without conducting baseline water testing before drilling, the burden of proof required by the courts in many cases cannot be met to prove otherwise.

The *New York Times* publicized recent peer-reviewed research by Duke University showing an association between drinking water contamination and natural gas extraction. The study by Osborn et al. (2011) conducted research at 68 private water wells in Pennsylvania and New York finding that methane concentrations were 17 times higher for wells near active drilling, with some wells having methane levels requiring "immediate action." However, the study found no evidence of fracturing fluid contamination in these wells. The prevalence and commonality of these incidents, coupled with the devastating impacts, seem to suggest the need for caution. Some chemicals, particularly in the produced water, may be harder for residents to detect than methane, especially when the industry refuses to disclose all of the components of the fracturing fluid mixture. Regardless, it is clear that more information on the environmental impacts of natural gas is needed in deciding any need for further regulations.

Recent EPA Action:

Recognizing the need to further understand the true impacts of natural gas extraction, specifically hydraulic fracturing, Congress directed the EPA to

23. It should be noted that *Gasland* did not undergo the scientific scrutiny of a peer-reviewed journal article and because no baseline testing was conducted in *Gasland* or any research thus far, it is difficult to discern the source of contamination and whether it came from gas industry activity. Hopefully, US EPA research will answer these questions in 2012.

study the impact hydraulic fracturing has on drinking water and groundwater. The EPA (2011) identified seven case studies, three of which are in Pennsylvania, to examine the lifecycle of a well and whether hydraulic fracturing affects drinking water. The EPA will also collect information from computer modeling, laboratories, and other data from the industry, states, and communities. Initial results of this study are expected in late 2012. Hence, it is unlikely that there will be any national regulations in the near future, while Ohio hydraulic fracturing in the Marcellus and Utica has already begun. Until Congress or the EPA acts, the regulation of hydraulic fracturing is left to the states.[24]

Ohio Environmental Protection:

Because the EPA and Congress have essentially relegated any regulatory authority to the states, this increases the importance of the Ohio EPA and the Ohio Division of Mineral Resources Management (ODNR) for environmental regulations. The Ohio EPA (2011) states that ODNR has primary regulatory authority over natural gas drilling, including the treatment and disposal of wastewater in the hydraulic fracturing process. The Ohio EPA also has water quality certification requirements to help preserve wetlands, streams, rivers, and other water sources. The appendix includes a list of the regulatory authority between ODNR and the Ohio EPA.

The Ohio Farm Bureau's Dale Arnold contends that Ohio has better regulatory authority over the oil and gas industry compared to Pennsylvania. Although the Cuyahoga River fire in 1969 in Cleveland, OH was not associated with fracturing, Scott (2009) notes it was a catalyst not only for Ohio environmental regulations, but also the national Clean Water Act in 1972 and the creation of the US EPA (and Ohio EPA). Dale Arnold reckons that even before the Cuyahoga fire, Ohioans had built a "collective consciousness," learning from past oil and gas industry experiences, preparing themselves for future waves.

Ohio's collected experiences and advanced environmental regulations have certainly left the state better prepared to handle the wastewater produced from hydraulic fracturing than Pennsylvania. Much of the wastewater from Pennsylvania comes to Ohio injection wells. Hunt (2011) notes that in June of 2010, Ohio quadrupled out-of-state fees to limit brine coming in from Pennsylvania and other states while anticipating the increased disposal needs of Ohio's own burgeoning natural gas industry. Despite the increased prices, nearly half of the brine in Ohio injection wells came from Pennsylvania after its officials banned 27 treatment plants from dumping brine into streams. This highlights the importance of Ohio properly addressing the issue of wastewater.

Ohio has made strides in environmental regulations through the drilling permitting process. Permits or "frac tickets" are required for gas companies planning on using hydraulic fracturing to extract natural gas. A frac ticket requires that companies disclose the chemicals used in the fracturing fluid. If a spill or casing failure should occur, Ohio will know many of the possible contaminants for testing. Ohio's permitting also allows residents to more easily prove their water has been contaminated with fracturing fluid.

Because many of the residents that will be most affected by shale gas development are farmers, the Ohio Farm Bureau is advising farmers and residents on the leasing process and is recommending that residents establish independent baseline water and soil quality measures that have been so notably missing from Pennsylvania and elsewhere. In addition, it is now standard practice in Ohio for gas companies to do their own baseline testing on all residents' water within 3,000 yards of the drilling site.

Even with better regulations, accidents may happen. Lustgarten (2009) recounts a 2007 incident of a house explosion in Bainbridge, OH. In a later report, ODNR found that a faulty concrete casing failure from a nearby natural gas well caused methane to be pushed into an aquifer during hydraulic fracturing, which then found its way into the plumbing, building up in the basement of the house.

The Cuyahoga fire itself and other serious environmental incidents have a more profound impact than just on the environment. Congressmen Louis Stokes said in regards to the Cuyahoga fire, "It portrayed a totally different image of Cleveland than the image of a productive, progressive city that was making news of a progressive nature" (as quoted in Scott, 2009). The lessons of the Cuyahoga fire resonate for natural gas development. The negative impacts on the environment can affect communities in lasting ways that cannot be exactly quantified but still require consideration.

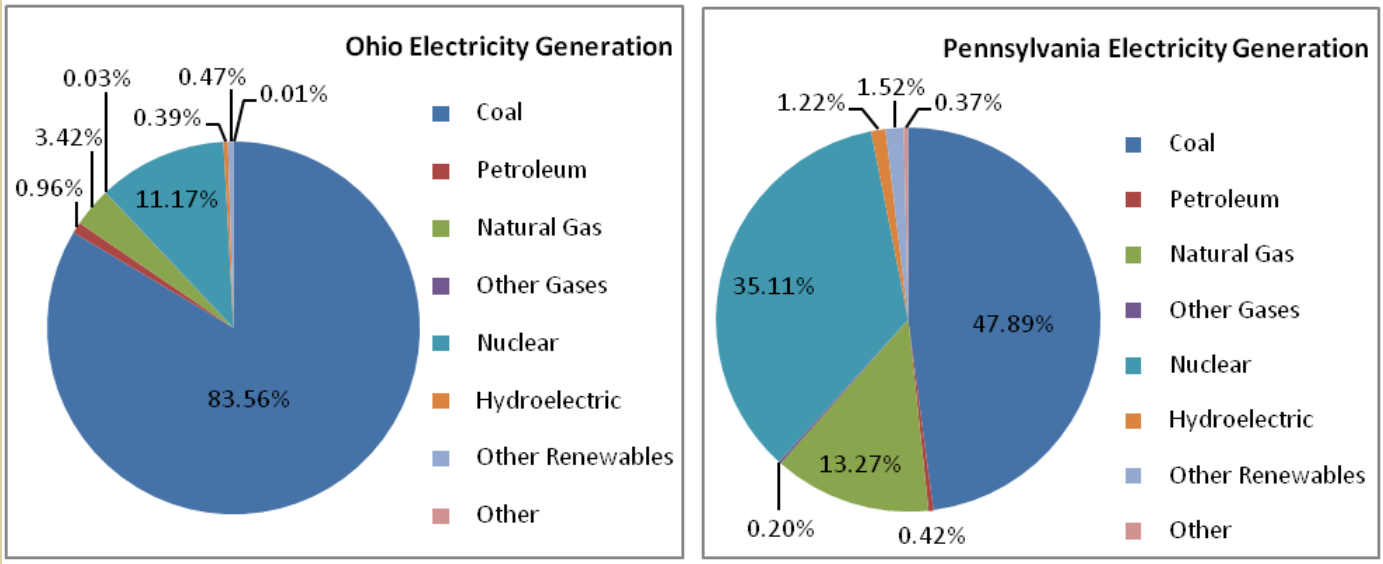
24. In 2009, members of Congress introduced the Fracturing Responsibility and Awareness of Chemicals Act, also called the "Frac Act," to undo the natural gas industry's exemption from the Safe Drinking Water Act and require the industry to disclose the chemicals used in the fracturing process. Though reintroduced in March of 2011, it is not expected to pass.

Conclusion

Hydraulic fracturing has made natural gas extraction possible and more productive in shale resources that were previously deemed uneconomical. This has brought a new wave of natural gas extraction to Ohio and other areas. However, recent experiences with hydraulic fracturing have also opened a new debate about the costs and benefits of natural gas extraction. Gary Walzer, Principle Engineer at EMTEC, states that natural gas has the potential to be a substantial source of domestic energy that is cleaner than coal with lower emissions. This has the potential to decrease US reliance on coal. Compared to Pennsylvania, Ohio clearly has a less diversified energy portfolio that relies heavily on carbon emitting coal. Based on electricity generation alone, Ohio is emitting significantly more carbon than Pennsylvania. Natural gas could be a significant first step for Ohio to diversify its energy portfolio and reduce carbon emissions.

Compared to coal, natural gas is not only cleaner but also less expensive to produce electricity. Producing energy in close proximity to where it is needed further lowers energy prices for consumers and industry. Unlike alternative energy, there are market forces pushing for the production of natural gas without the use of inefficient subsidies, though all of the social costs of natural gas (and coal) are not sufficiently priced. Low natural gas prices provide evidence that it is highly efficient for producing electricity. This efficiency is one reason why natural gas is associated with fewer jobs than coal—but the lower costs make the rest of the economy more competitive.

Does all of this also mean that natural gas will create significant numbers of job for Ohioans? Previous studies on the economic impacts of natural gas appear to have widely overstated the economic impacts. This is not surprising, as these studies are typically industry-funded and industry-funded studies are usually not the best sources of information for economic effects (regardless of the industry). One reason for the overstatement is the energy industry is generally very capital intensive. Alan Krueger, Chief Economist and Assistant Secretary for Economic Policy at the US Department of Treasury stated in 2009, "The oil and gas industry is about 10 times more capital intensive than the US economy as a whole… suggesting these tax subsidies are not effective means for domestic job creation" (US Department of Treasury). The energy industry as a whole also does not account for a significant share of employment. Even if the natural gas industry experiences significant job growth, its employment share is too small to have any significant effect on unemployment rates and on the economy (with the exception of remote rural areas such as in rural Western North Dakota). Previous studies on the economic impacts also fail to account for the displacement effects that the natural gas industry will have on other industries. Finally, from a national perspective greater natural gas production will displace other fossil fuels and their workers as they are no longer needed, in



Source: US EIA

Figure 26: 2009 Electricity Generation Profiles

particular coal.

We use Pennsylvania as a case study to estimate the employment effects of drilling that Ohio can realistically expect. Our analysis shows the employment effects of natural gas are modest given the size of the Ohio and Pennsylvania economy. We show this through (1) an assessment of impact analysis, (2) by comparing drilling counties with similarly matched non-drilling counties in Pennsylvania, (3) statistical regressions on the entire state of Pennsylvania, (4) employment comparisons with North Dakota's Bakkan shale region, and (5) an examination of the employment life cycle effects of natural gas and coal per kilowatt of electricity. Our results are not unexpected as the economic literature has long pointed to the adverse effects of natural resource development through phenomenon such as the "natural resources curse" and Dutch Disease. Likewise, a recent Cornell University study found similar overstatements by the oil industry in terms of job forecasts for the Keystone XL pipeline (Cornell University ILR School Global Labor Institute, 2011). On the other hand, our approaches suggest that natural gas activity will increase per-capita income. We expect this is primarily among landholders receiving royalties/lease payments and through higher wages in the industry. Thus, we expect a short-term infusion of income in affected economies.

As Christopherson and Rightor (2011) point out, it is important to realize these are fairly short-term estimates and may still not account for the cycle of the natural resource boom. The initial boom causes competition for labor in the short-term, bidding up wages. This makes the area less competitive and "crowds out" other sectors, especially those that rely on low cost labor such as agriculture and tourism. As housing prices are bid up, this will also further displace low-income workers. In the long-run, the business climate may suffer as there are fewer businesses that are unrelated to the oil and gas industry, which makes the local economy less diverse and more vulnerable to economic shocks. Our advice to counties experiencing drilling activity is to ensure they properly pay for infrastructure needs upfront, place monies in reserves for after the boom, and build up local assets such as schools in order to produce lasting benefits from energy development.

Finally, the environmental costs of natural gas need to be realistically addressed by the industry and regulators. Although natural gas can reduce carbon emissions compared to coal and other fossil fuels, there are concerns about its effect on drinking water. Because Ohio has been able to learn from Pennsylvania's experiences with the oil and gas industry, Ohio seems better prepared to deal with the environmental risks. Nevertheless, a realistic assessment of the environmental costs of natural gas should also include the environmental opportunity cost of natural gas. Natural gas mainly displaces coal, which emits even more carbon and also has additional environmental and safety concerns. A Clean Air Task Force report unequivocally states that "coal irreparably damages the environment." Coal poses significant health risks to both miners and nearby residents. Despite the number of years the US has been extracting coal, there are still significant issues with its waste products. Most recently on Oct. 31, 2011 a bluff collapse caused coal ash to be spilled into Lake Michigan (Jones and Behm, 2011). In 2008, the *New York Times* reported that experts called the Tennessee ash flood that dumped over 1.1 billion gallons of coal ash waste "one of the largest environmental disasters of its kind" (Dewan, 2008). We are not understating the environmental costs of natural gas, but rather putting it into perspective in relation to the environmental costs of coal, which is natural gas's main competitor.

Although we should not expect natural gas to be a big job creator, there are significant benefits to producing natural gas that are getting lost in the hype of job creation. Raising expectations that natural gas will not be able to meet is setting Ohio residents up to be disappointed. The true benefits of natural gas need to be highlighted while putting the costs into perspective. Likewise, Ohio needs to plan today about how to make some of the gains from the energy boom permanent. Among many things, this will require innovative policies and funding models to ensure that infrastructure is paid for today and there is adequate funding to maintain that infrastructure in the future.

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Appendix 1: County Comparison Mining (blue) vs. Non-Mining (green)

See notes to figures 15-18 for more details. Southern drilling counties include Washington, Greene, and Fayette. Southern non-drilling counties include Franklin, Perry, and Cumberland. Northeastern drilling counties include Tioga, Bradford, and Susquehanna. Northeastern non-drilling counties include Union, Columbia, and Carbon.

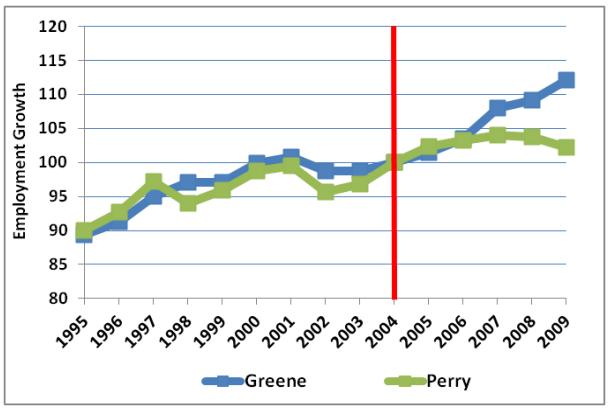

Figure 27: Employment Growth Comparison Greene vs. Perry

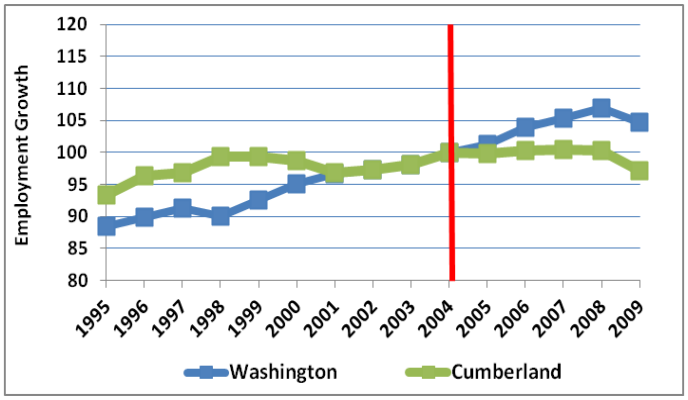

Figure 28: Employment Growth Comparison Washington vs. Cumberland

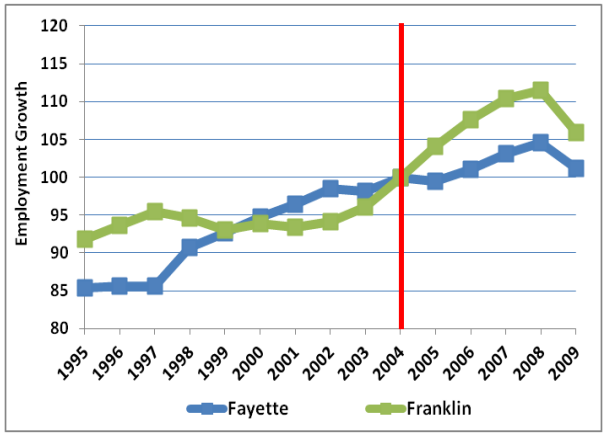

Figure 29: Employment Growth Comparison Fayette vs. Franklin

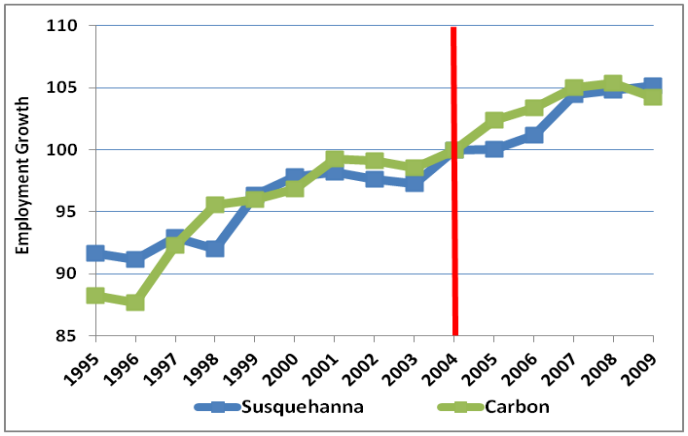

Figure 30: Employment Growth Comparison Susquehanna vs. Carbon

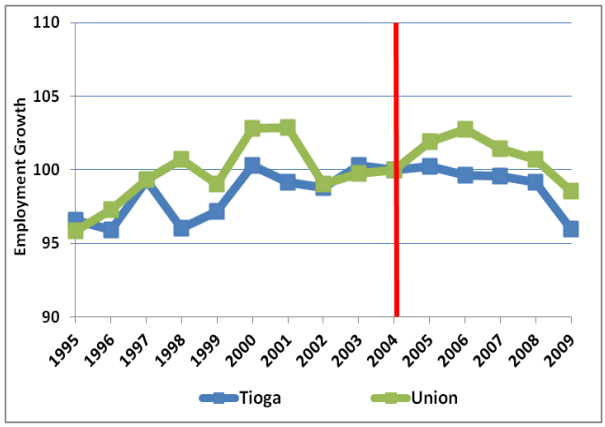

Figure 31: Employment Growth Comparison Tioga vs. Union

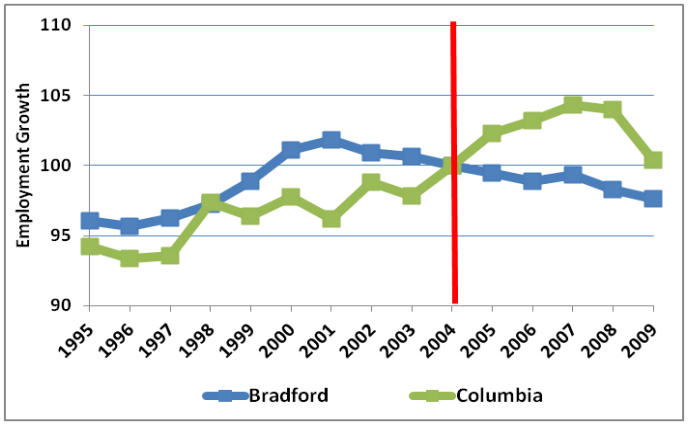

Figure 32: Employment Growth Comparison Bradford vs. Columbia

Appendix 1: County Comparison Mining (blue) vs. Non-Mining (green)

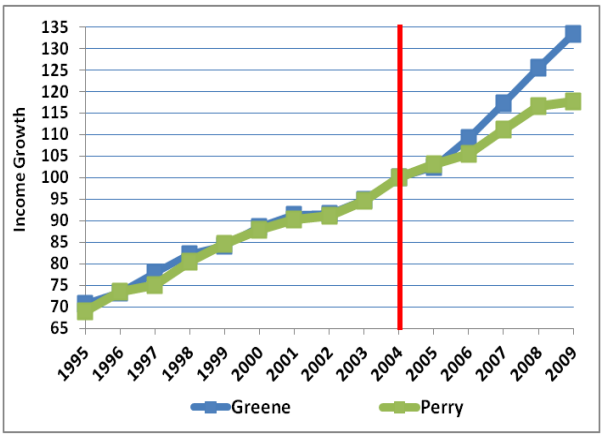

Figure 33: Per Capita Income Growth Comparison Greene vs. Perry

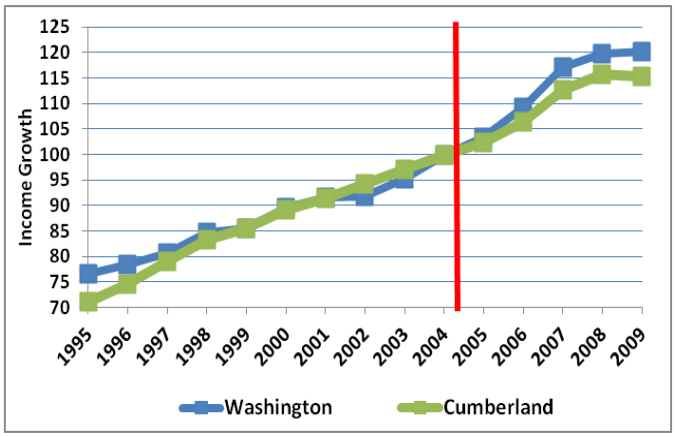

Figure 34: Per Capita Income Growth Comparison Washington vs. Cumberland

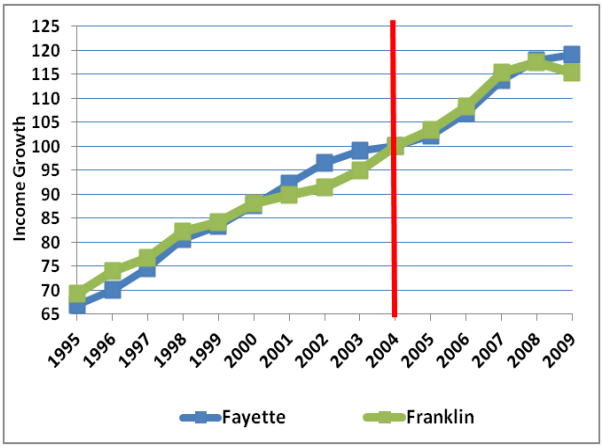

Figure 35: Per Capita Income Growth Comparison Fayette vs. Franklin

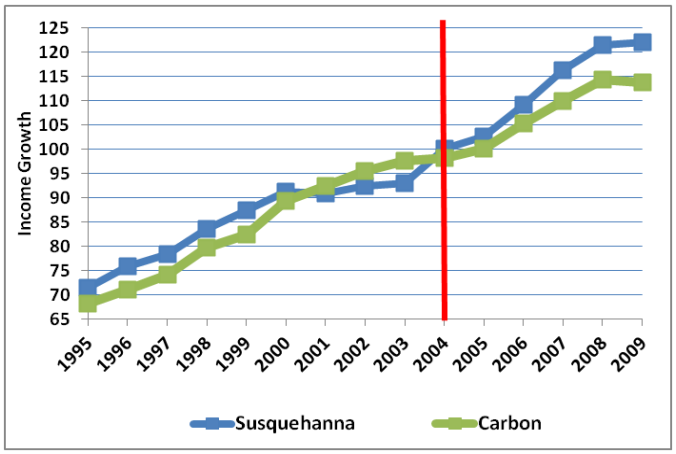

Figure 36: Per Capita Income Growth Comparison Susquehanna vs. Carbon

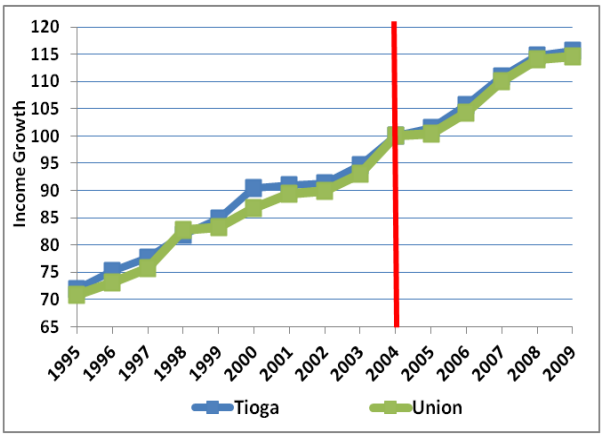

Figure 37: Per Capita Income Growth Comparison Tioga vs. Union

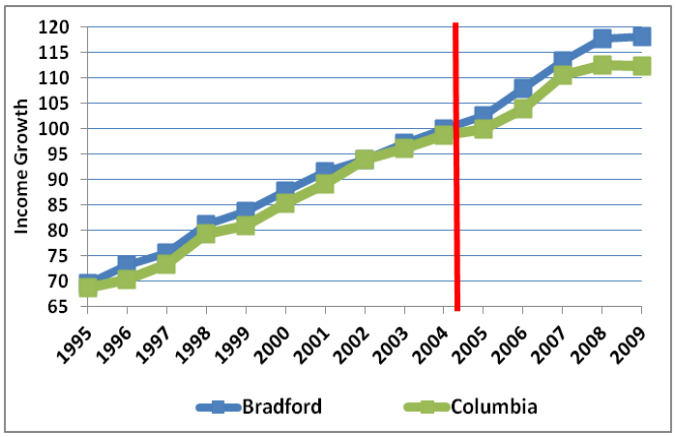

Figure 38: Per Capita Income Growth Comparison Bradford vs. Columbia

Appendix 2: Statistical Methodology

In 2005, drilling began in Pennsylvania in a number of counties with natural gas potential due to the location of resources in the Marcellus shale. The choice of county to develop shale gas was based on the random occurrence of natural resources and not prior economic conditions. However, there may be other inherent county differences between drilling and non-drilling counties. For example, counties with drilling tend to be rural. Likewise, counties tend to have many factors that influence their economic growth such as the quality of its government, distance to urban centers, and educational and demographic attributes of the population. These factors are either constant or change very slowly. We treat these as county fixed effects on county growth.

We want to measure the economic impacts of drilling. Equation 2 shows the impact of the number of wells on the percent employment growth (Y_{i1}) for county i in period 1 (2005-2009). However, the empirical estimation of this impact would not be able to account for county fixed effects (C_i). This could bias the estimates of the impact of drilling by omitting relevant variables that differentiate drilling counties from non-drilling counties. Thus, equation 3 estimates the impact of drilling since 2005 on the difference in employment growth between period 1 and period 0 (2001-2005). The county fixed effect is differenced out and thus there should not be omitted variable bias.

Table 5 shows the results of this estimation using the total number of well drilled since 2005. We also include additional controls to better account for differences in the way larger or wealthier counties may have reacted to shale development, or more importantly, how wealthier or more urban counties were differentially affected by effects of the housing bubble/bust and the Great Recession. Using the total number of wells parameter estimate, Table 5 shows that drilling has a small and statistically insignificant impact on percent employment growth.

$$Y_{i0} = \beta_0 + \beta_1(\text{Number of Wells})_{i0} + C_i + \varepsilon_{i0} \quad (1)$$

$$Y_{i1} = \beta_0 + \beta_1(\text{Number of Wells})_{i1} + C_i + \varepsilon_{i1} \quad (2)$$

$$Y_{i1} - Y_{i0} = \beta_0 + \beta_1(\Delta \text{ Number of Wells}) + \varepsilon_i \quad (3)$$

A similar method is used to empirically estimate the impact of drilling on per capita income with results presented Table 6. In this case, drilling has a statistically significant impact on percent per capita income growth.

2005-09 Percent Employment Growth Minus 2001-05 Percent Employment Growth	Parameter Estimate	t-value
	Difference in Employment Change	
Total Wells 05-09	**1.769E-05**	**1.14**
2001 Log Population	0.023	2.64
2001 Log Per Capita Income	-0.096	-1.55
N	67	
R2	0.118	
Adjusted-R2	0.076	

Table 5: Impact of drilling on employment

2005-2009 Percent Income Growth Minus 2001-05 Percent Income Growth	Parameter Estimate	t-value
	Difference in Income Change	
Total Wells 05-09	**2.515E-05**	**2.11**
2001 Log Population	0.084	2.53
2001 Log Employment	-0.086	-2.76
N	67	
R2	0.205	
Adjusted-R2	0.167	

Table 6: Impact of drilling on income

Another method to develop a counterfactual to compare how drilling counties would have done if there was no drilling is to use a difference in difference approach. The difference in differences approach treats drilling as a treatment in a natural experiment. The difference in differences estimates the causal effect of the difference between the treatment and control group before and after treatment (drilling). This is shown below in equation 4 where i=0 represents non-drilling counties and i=1 represents drilling counties; t=0 is still the first time period (2001-2005) and t=1 is the second time period (2005-2009).

$$[E(Y_{11})-E(Y_{01})] - [E(Y_{10})-E(Y_{00})] \quad (4)$$

To measure the impact of drilling on the employment growth of county i in time period t (Y_{it}), a control group needs to be established (non-drilling counties). This is further expanded in equation (5). The main effect of

Appendix 2: Statistical Methodology

the treatment group, β_1 controls for the difference between the treatment and control in period 0. The main effect of the second period, β_2 controls for the difference between the effects of the second period compared to the first period. The parameter of interest, β_3 estimates equation 4: the impact of the number of wells had on counties since drilling began in 2005. Through asymptotics, it can be shown that the probability limit of the estimate of β_3 is equivalent to equation 4.

$$Y_{it} = \beta_0 + \beta_1(\text{Number of Wells}_{it}) + \beta_2 t + \beta_3(t*\text{Number of Wells}_{it}) + \varepsilon_i \qquad (5)$$

Table 7 shows the empirical estimation of equation 4 for employment growth. The results are similar to those in Table 5 with the impact of drilling on employment being small and statistically insignificant. Table 8 reports the estimates of equation 5 for per capita income growth. Similar to Table 6, it shows that drilling appears to have had a positive statistically significant impact on per capita income growth.

Percent Employment Growth	Parameter Estimate	t-value
Time Period*Total Wells	**1.763E-05**	**0.91**
Time Period	-0.05	-4.12
Total Wells	-3.240E-06	-0.23
Log Population	-0.005	-0.85
Log Per Capita Income	0.066	1.69
N	134	
R2	0.125	
Adjusted-R2	0.091	

Table 7: Impact of drilling on employment

Percent Income Growth	Parameter Estimate	t-value
Time Period*Total Wells	**3.119E-05**	**2.52**
Time Period	0.0253	3.51
Total Wells	-3.310E-06	-0.37
Log Population	0.009	0.55
Log Employment	-0.007	-0.43
N	134	
R2	0.205	
Adjusted-R2	0.167	

Table 8: Impact of drilling on income

Appendix 3: Ohio Environmental Regulatory Authority

Summary of ODNR and Ohio EPA regulatory authority over oil/gas drilling and production activities

	Ohio Department of Natural Resources	Ohio Environmental Protection Agency
Drilling in the shale deposits	✓ Issues permits for drilling oil/gas wells in Ohio. ✓ Sets requirements for proper location, design and construction of wells. ✓ Inspects and oversees drilling activity. ✓ Requires controls and procedures to prevent discharges and releases. ✓ Requires that wells no longer used for production are properly plugged. ✓ Requires registration for facility owners with the capacity to withdraw water at a quantity greater than 100,000 gallons per day.	✓ Requires drillers obtain authorization for construction activity where there is an impact to a wetland, stream, river or other water of the state. ✓ Requires drillers obtain an air permit to install and operate (PTIO) for units or activities that have emissions of air pollutants.
Wastewater and drill cutting management at drill sites	✓ Sets design requirements for on-site pits/lagoons used to store drill cuttings and brine/flowback water. ✓ Requires proper closure of on-site pits/lagoons after drilling is completed. ✓ Sets standards for managing drill cuttings and sediments left on-site.	✓ Requires proper management of solid wastes shipped off-site for disposal.
Brine/flowback water disposal	✓ Regulates the disposal of brine and oversees operation of Class II wells used to inject oil/gas-related waste fluids. ✓ Reviews specifications and issues permits for Class II wells. ✓ Sets design/construction requirements for Class II underground injection wells. ✓ Responds to questions/concerns from citizens regard safety of drinking water from private wells from oil/ natural gas drilling.	
Brine/flowback water hauling	✓ Registers transporters hauling brine and oil/gas drilling-related wastewater in Ohio.	
Pumping water to the drill site from a public water supply system		✓ Requires proper containment devices at the point of connection to protect the public water system.

Source: EPA (2011)

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Quality of life

Canadian firm plans fracking campaign that could require 4 billion gallons of Michigan water

25 June 2013

by **Jeff Alexander**
Bridge Magazine contributor

KALKASKA — A Canadian firm has laid out plans to drill 500 new natural gas wells in Northern Michigan, using a technique that could consume more than 4 billion gallons of groundwater — or about as much water as Traverse City uses in two years.

THIRSTY WORK: The Encana Corp.'s Westerman well in Kalkaska County recently used 8.5 million gallons of water to complete a hydraulic fracturing process. (courtesy photo)

The firm, Encana Corp., will rely on hydraulic fracturing or "fracking," a technique cloaked in controversy that requires large amounts of water, mixed with chemicals and other elements, to break down rock formations and release natural gas. Encana, for example, used 8.5 million gallons of groundwater earlier this month to frack a single gas well, the Westerman in Kalkaska County, east of Traverse City.

Because most of the water used in fracking becomes contaminated and is left in geologic formations deep underground, a recent surge in drilling by Encana and other companies has raised concerns that fracking could drain water from some of the state's best rivers.

Encana recently drilled several new wells into the Collingwood shale formation, which lies about two miles underground. That's the first step in a plan to drill 500 more deep shale wells in the region using fracking, according to company records.

The company's plan to drill several new gas wells near Kalkaska will entail pumping about 300 million gallons of water out of the ground, injecting that water into several gas well bores and then leaving nearly all of the contaminated water in the ground when the fracking is completed, according to state records.

The result: A net loss of up to 300 million gallons of groundwater to the North Branch of the Manistee River, a blue-ribbon trout stream fed almost entirely by groundwater. One of Encana's drilling sites is a half-mile from the Manistee River's North Branch, according to company records.

"If the citizens of Michigan knew corporations were destroying hundreds of millions of gallons of Michigan water – water that is supposedly protected by government for use by all of us – they would be opposing this new kind of completion (fracking) technique," said Paul Brady, a fracking watchdog who lives near Kalkaska. "These deep shale, unconventional wells are using massive amounts of water without adequate testing and solid data on aquifer capacity."

Encana spokesman Doug Hock, however, is optimistic: "Can we access the (deep shale gas) and still protect the environment? Absolutely."

State's monitoring questioned, defended

Michigan's Water Withdrawal Assessment Tool, a computer-based program launched in 2006, was supposed to prevent water withdrawals that could harm streams and rivers. The tool is Michigan's first line of defense against excessive water withdrawals, but it was developed before drillers began using large quantities of water when fracking deep shale gas wells here.

Scientists, lawyers and Michigan courts have said the tool and other state estimates of stream flows are deeply flawed. If true, such a problem could result in the state inadvertently approving large water withdrawals that hurt rivers and streams.

Researchers at Michigan State University recently found several sites where the state's water tool over-estimated the volume of water in small headwater streams that feed the Manistee River.

"In some watersheds, we are seeing that the assumed flows (calculated by the state's water tool) are much higher than we measured. In one case the tool was off by a factor of three," said David Hyndman, a hydrogeologist, professor and chairman of MSU's Department of Geological Sciences.

Those findings were significant for three reasons, Hyndman said: Many of the Collingwood shale gas wells are being drilled in the ecologically fragile headwater areas of rivers; headwater streams are critically important to the health of entire river systems; and the state does little monitoring in headwater streams, where rivers originate.

Government and industry officials defended the state's water assessment tool.

State officials who developed the tool "did error analysis to make sure it was working and everywhere they tested, it worked," said Jill VanDyke, a senior geologist with the Michigan Department of Environmental Quality.

The Water Withdrawal Assessment Tool estimates flows in Michigan's 7,000 streams and river segments using data from river gauges and other information, including geology, soil characteristics, drainage area and precipitation. But only 2 percent of all river and stream segments in Michigan, 147 sites, have gauges that measure actual stream flows. That lack of in-stream data forced the DEQ to base much of the water assessment tool on general environmental conditions and mathematical models.

Dave Hamilton, a former DEQ official who helped develop the water assessment tool, said it takes a "very conservative" approach to ensure that large water withdrawals don't cause adverse impacts.

"Ninety percent of the time there is more water in a stream than what the tool is saying," said Hamilton, who is now a senior policy adviser for The Nature Conservancy's Michigan chapter.

Well uses 3 million gallons from village supplies

State law requires using the tool to screen water withdrawals that exceed 100,000 gallons daily. If the tool raises a red flag, state officials conduct a site visit. Those site visits usually lead to permit approvals, according to DEQ officials.

Since 2008, the DEQ has issued 52 permits for large, fracking-related water withdrawals. Another 17 permits are pending, according to state data.

Tanker trucks were used to ship millions of gallons of water from the nearby villages of Kalkaska and Mancelona to a gas and oil well. (courtesy photo)

Fracking critics said recent problems at the Westerman gas well in Kalkaska County — where water wells didn't produce as predicted and drillers had to truck in 3 million of gallons of water from Kalkaska and Mancelona to complete the fracking process — highlighted flaws in the water assessment tool.

Encana's Hock and DEQ officials blamed the problem on "geologic conditions" unrelated to the water assessment tool.

"Everyone wanted to jump to the conclusion that the (water assessment) tool didn't work and there wasn't adequate water," Hock said. "The tool worked well … it was a matter of really tougher rock than we anticipated."

Industry watchdog Brady said the DEQ is trying to gloss over problems with the water assessment tool.

"Obviously the tool declared that the area had ample water and as we unfortunately found out the tool was inaccurate," said Brady, who has written extensively about fracking on the respectmyplanet.org website.

Concerns about Michigan's ability to accurately predict stream flows aren't new.

In 2005, the DEQ planned to issue a permit allowing an oil company to discharge 1.15 million gallons of slightly contaminated groundwater daily into Kolke Creek, the headwaters of the Au Sable River. The DEQ claimed that the index (or average) flow in Kolke Creek was about 6,000 gallons per minute, enough to dilute the oil company's contaminated water without harming the creek.

As part of a lawsuit challenging the DEQ permit, independent scientists proved that the state's estimate of Kolke Creek's index flow was up to 100 times greater than the actual flow.

A state circuit court concluded that the state's estimate of the flow in Kolke Creek was inaccurate and blocked the proposed discharge of polluted water into creek. The DEQ appealed but the state Court of Appeals upheld the lower court's ruling.

The prospects for natural gas drilling – and the subsequent need for water supplies for fracking – have waxed and waned in Michigan in recent years.

First came a boom of investment in drilling rights on state property as petroleum firms looked **to extend natural gas exploration from Pennsylvania and Ohio into Michigan**.

By late 2012, though, the pace of exploration in Michigan was still far below drilling rates seen in other Great Lakes states and low natural gas prices were seen **as a potential brake on activity**.

That may soon change.

Encana officials said the oil and gas industry wants to export natural gas extracted from shale formations in Michigan and other states to consumers in Asia. Demand for natural gas in China is strong and prices are double the cost of natural gas in the U.S., industry, watchdogs said.

China's government-controlled energy company, Sinopec, has already invested $2.5 billion in a joint venture with Oklahoma-based Devon Energy. Devon has permits to drill several Collingwood shale wells in Northern Michigan, according to state records.

And late last week, Michigan Congressman Fred Upton, R-St. Joseph and chairman of the House's energy panel, touted fracking as an aid in making the **U.S. "energy independent" in natural gas**:

"We're the largest natural gas producer now in the world because of the advances that

"We're the largest natural gas producer now in the world because of the advances that we've done on hydraulic fracking. … We are so rich in that resource."

Jeff Alexander is owner of J. Alexander Communications LLC and the author of "Pandora's Locks: The Opening of the Great Lakes – St. Lawrence Seaway." A former staff writer for the Muskegon Chronicle, Alexander writes **a blog on the Great Lakes**.

29 comments from Bridge readers.

Bruce McFee
June 25, 2013 at 9:37 am

4 billion gallons is equivalent to about 6 hours of water flowing over Niagara Falls.
While that might seem like a lot of water, it would probably occur over several years. It is not the same impact as in Los Angeles where they have diverted the entire Colorado River for their water use.
The dilemma in all this is that we could continue to import energy from countries that have much less interest in protecting the environment. But this means we need a strong military presence to keep that energy supply safe. Or we just bite the bullet and become energy independent.
One piece of good news is that a break through is right around the corner making desalination of sea water more practical.

Jim Olson
June 25, 2013 at 10:42 am

Ten million gallons over 21 days will most likely harm creeks and wetlands in headwaters areas of our lakes and streams or interfere with adjacent farmer who is irrigating crops or nearby landowners who rely on water wells. What the state and industry have to do is do what every other heavy water user does — conduct a pump yield test and monitor groundwater, wetlands, streams, creeks nearby during the test. Industry will know up front whether there is enough water and DEQ and DNR and citizens will know if there is enough water, that there will be no harm or interference.

Karen Dill-Wilson
June 25, 2013 at 12:53 pm

this example is ridiculous. fracking PERMANENTLY removes that water from the consumable water table and makes it toxic. in MI the flow back water that comes up must be disposed of in class II deep injection wells and the rest stays down hole. it's an industry spin tactic: they want to say they use less water than hydro-electric or agriculture but what they DON'T tell you is that it's PERMANENTLY lost and poisoned, unlike other uses. farmers out west are now competing with gas and oil for water usage…who would you rather have water? someone who grows your food or somebody that will poison your water and leave your well dry?

Russ Klettke
September 9, 2013 at 1:23 pm

Tell us about the desalinization. What is just around the corner and what will it cost — and be sure to include the costs of transport of ocean water to inland fracking wells.
Count me skeptical. Particularly when we already have alternative renewable sources of energy that are technologically developed and increasingly used. Given how solar was first used in the 1950s, we probably could have made use of that a long time ago — but the idea of self-generated energy on the rooftops of homes and businesses cede WAY too much control away from large fossil fuel companies.

Mark Knowles

June 25, 2013 at 9:57 am

June 25, 2013 at 9:57 am

Come on local…and state officials…protect the environment…Don't sell it some Oklahoma based.company and the Chinese. Stop selling your sole and protect your people…the streams and lakes of Michigan are far more important than selling natural gas.

Jim Olson
June 25, 2013 at 10:37 am

Jeff and Center for Michigan. Thanks for publishing and distributing this widely. Citizen organizations, and policy organizations like FLOW **http://www.flowforwater.org** have been calling on MDNR and Natural Resources Commission to investigate and require baseline estimates of water withdrawals, diversions, transfers, and losses from the water cycle for over a year. DNR rejected any talks when approached last year to reform its leasing procedures and lease so that right to use necessary water would not transfer until development plan is submitted to MDNR for approval for areas of the state and state land, with estimates and consideration of water loss and community, farmers, landowners, and environmental impacts. It is the only legal and sensible way to address this issue, and must be done immediately before it is too late. MDEQ must not issue permits until all of this has been done, and effects and alternatives fully considered. The state lands and waters under them and running through them, are held by Michigan through DEQ and DNR as trustees for benefit of citizens, not the oil and gas industry. If fracking is allowed at such a large scale, and the jury is still out on this, it should and can only be done after careful pump tests, hydrogeological monitoring of actual flows and levels of streams, wetlands, lakes, groundwater. There is no other way to know what will happen. And if it is not done, it is plainly reckless.

Caroline B Smith
June 25, 2013 at 12:17 pm

What's another 3 or 4 million gallons? Nestle's is also taking a LOT of ground water out of Michigan and selling it back to us from WalMart and many other outlets. Just remember, "THE ONE WITH THE MOST FRESH WATER WINS."

Jeff Alexander
June 25, 2013 at 2:59 pm

Here's a little perspective: According to state data, Nestle's Ice Mountain water bottling plant near Big Rapids pumped 226 million gallons of groundwater last year. At that rate, it would take Nestle roughly 17 years to withdraw the 4 billion gallons of groundwater that Encana Corp. could withdraw and use at 500 natural gas wells that are hydraulically fractured.
State officials also point out that agricultural operations in Berrien County withdraw 10 million gallons of groundwater daily (averaged over the course of a year). At that rate, all of those farms could pump that amount of water (350 million gallons annually) for 11 years before equaling the amount of groundwater that Encana may use at its hydraulically fractured natural gas wells.
There is one other important point to consider, regardless of whether you think the 4 billion gallons of water that Encana might use is a drop in the bucket or a small lake: The vast majority of water used in fracking is left underground or discarded in deep injection wells because it is contaminated with chemicals. So while Traverse City uses 4 billion gallons of water annually, most of that water remains in the water cycle. It goes back into the ground, surface waters or the air after people use it.
Unless recycled, the water that fracking operations pump out of the ground and use to fracture deep shale is taken out of the local, regional or global water cycle. it's gone forever. Just saying.

Tom Matych
June 30, 2013 at 6:03 am

Good job Jeff. The part where there's enough water in the creek to dilute. Isn't this the same reasoning they used way back when for dumping waste from factories in our lakes and rivers? I don't see anything good from

fracking. My well is 166 feet deep. I have good water, they want to drill around here. I refused to sign the

fracking. My well is 100 feet deep, I have good water, they want to drill around here, I refused to sign the contract, my neighbor did sign. I'm 2 miles from the Muskegon river.

LuAnne Kozma
June 25, 2013 at 12:39 pm

The Committee to Ban Fracking in Michigan is conducting a ballot initiative petition drive to ban horizontal hydraulic fracturing to end this practice in Michigan, and to prevent frack wastes from being dumped here. Donate to the campaign and volunteer to collect signatures at: **http://www.letsbanfracking.org**.
We must protect our state from this threat. The water used in fracking is transformed into industrial waste, which is then "disposed of" in injection wells–back into our ground and eventually contaminating our aquifers.
–LuAnne Kozma, campaign director, Committee to Ban Fracking in Michigan

Neil
June 25, 2013 at 1:02 pm

Is it conceivable and feasible to have a water purification plant to process fracking water back to potable drinking water?

Bill
June 25, 2013 at 1:18 pm

Yes. Frack water could be brought back to an acceptable quality but there must be a disposal method for remaining concentrated effluent. Although the fact does not serve naysayer's purposes, water is an almost endlessly renewable resource if we make reasonable efforts.

Jeff Alexander
June 25, 2013 at 3:02 pm

Not likely. However, the water could be recycled and re–used, thereby reducing use. Encana officials said that fracking operations in the water–starved west and southwest recycle the water used to fracture deep shale deposits.

spudnik
June 25, 2013 at 3:19 pm

No. The process is built around exploiting a ton of water and walking away. This water is nothing you'd want to drink after processing. And once these wells start leaking massive amounts of pollutants into our groundwater, guessing these corporations will go out of business. We as a culture will need to wake up before it's too late, but the greed seems to have the upper hand now.

Nancy Shiffler
June 25, 2013 at 3:21 pm

When you run into problems you didn't "anticipate," it's a pretty good sign that it's time to step back and take a longer, more careful look at what you are doing before you start issuing more permits and drilling more wells. The DEQ isn't doing it's job.

Charles Richards
June 25, 2013 at 3:27 pm

"Encana officials said the oil and gas industry wants to export natural gas extracted from shale formations in Michigan and other states to consumers in Asia. Demand for natural gas in China is strong and prices are double the cost of natural gas in the U.S., industry, watchdogs said" This smacks of autarky, a policy that has been proven throughout history to be inimical to human welfare. If the rest of the article is of similar quality, and I suspect it is, then I don't place much value

on it.

Mark L
June 25, 2013 at 5:56 pm

Interesting. A little geometry and one can visualize that the water it took to produce this well is about 1 acre (209 feet square) by 25 feet deep. At around 2.5 feet of precipitation per year in Michigan (NOAA), that would be the entire annual precipitation on 10 acres of land for a year to produce that well. 500 wells then would be 5000 acres or 7.8 square miles worth of annual precipitation out of a watershed to produce? It's not going to dry out the Great lakes, but its a lot of dirty water. The stuff is already toxic after well # 1, and the wells are usually clustered. Why can't it be filtered, reprocessed and re-used in the next hole? "because it's cheaper to inject it" doesn't seem like a very good answer…

Kerry Thompson
June 25, 2013 at 8:08 pm

For a publication that attempts to remain neutral you seem to be in "fear mongering overdrive". We are fracking in several places in Michigan without damage to the environment, We are helping the damaged economy and providing a product for a cost effective price. Benefactors are those land owners that receive dividends every month from the oil companies. Public agencies and charitable organizations are all receiving big dividends from fracking in Michigan. My good friend has a well drilled next to him and the horizontal fracking under him for over a year has not upset his ground water the level of his ponds his fish or his faucet (no gas fumes). The Boy Scout camp down the road has received more revenues from this well than from all of the donors public and private in the last two years combined.
Where are the articles that show the positive benefits of fracking in the state?

David Waymire
June 26, 2013 at 11:46 am

Kerry, the point here isn't that fracking is always bad…it's that it isn't always good, and can have major implications.That is indeed the very definition of neutral reporting, and is far, far from fear mongering.
The massive use of water detailed in this story is a huge change from the "old fracking" that used to consume maybe 100,000 gallons per well. Now we are talking hundreds of millions of gallons from one site, with potential implications for aquifers and small streams and rivers critical to the headwaters of our trout-friendly state. If that kind of withdrawal can be managed, that's one thing. If it is drying up wells, then it needs to be regulated much more strongly. And if it is affecting our blue ribbon trout streams, that needs to stop.

> ### Jim Peters
> June 26, 2013 at 2:44 pm
>
> I think it is important to put a few things into perspective. First, it will take EnCana in my estimation 5 – 10 years or longer to drill the 500 wells and mcuh longer to get them completed and producing. More than likely a disposal well will be drilled on each pad or 1 disposal well located to handle several well pads and connected by pipelines eliminating the need to truck the water. Second, this moves EnCana from the explority phase into developement phase where economics of scale become very important. Third, these wells will likely be drilled over a fairly large geographical area (several different counties) on well pads that may contain 6 – 12 wells per pad. If water withdrawal becomes an issue then water recycling I'm sure will be used. EnCana is saying that they are seeing around 25% of the fracturing fluid returned to the surface so even if they recycle 100% of the returned fluid they will still need new water to continue. In Pennsylvania they are currently recycling 90% of the returned fluid. Pennsylvania has drilled now over 6,000 shale wells. Keep in mind that Pennsylvania has a very limited water supply and it's geology does not support deep disposal wells.

Jim Peters

June 26, 2013 at 3:40 pm

Nobody seems to want to discuss the economic impact of drilling 500 shale wells in the somewhat poor, rural areas of northern Michigan. Roughly, 500 wells at around $10 million per well works out to $5 billion dollars invested. Current unemployment rates in these counties range between 10 and 12%. Those rates would drop considerably not just for those counties but for all surrounding counties as well. It won't turn us into North Dakota where some McDonalds pay up to a $1,500.00 sign on bonus if you will stay for at least 2 weeks but the impact will be felt state wide. Local business will florish, families will move in including children for schools, local tax revenues will surge. The economic impact will last for at least a generation. But the water? We are blessed with a significant amount of fresh, clean water. More regulation needed? Possibly, but I believe it can be done in an environmentally safe matter as it is being done every day in Pennsylvania, North Dakota, Texas, Ohio, Colorado, Oklahoma, Arkansas, Louisiana, West Virginia and soon to be California and Illinois.

Brian W
June 30, 2013 at 11:21 pm

I agree with you Jim, There is a very negative spin here. None of the good that comes from this is being pointed out. I know I make a good living…. Most of the people working on these locations are local, EnCana is very conscious about the enviroment and the impact of its operations. Each person has "stop work authority" and are empowered to use it in the event of a safety or environmental concern. EnCana takes this VERY serious. There are wellbore integrity checks at regular intervals to ensure there will not be migration of fluids into the aquifer.
I also feel the protests are necessary… without them the industry would not be evolving to use safer fluids (Halliburton is a pioneer in fluids derived from the food industry). But big oil needs to know they are being watched.

Brian W
June 30, 2013 at 11:25 pm

This weekend was cherry festival too. I feel the tourism has a very profound effect on the environment. I know the garbage on 131 is up this weekend, is an airshow necessary or a waste of fuel? All the idiots on Torch lake, they dont care about the condition they leave the lakes in….

Tracy Davis
July 10, 2013 at 7:50 pm

Jim,
Nobody seems to want to discuss that while they think Fracking is such a horrible thing for our environment, they still keep driving their SUV's, ATV's, Snowmobiles, Boats etc.

acapoz
June 27, 2013 at 8:44 pm

once the drinking water is depleted, then what?
Fracking isn't about energy independence for Americans, its about profits for oil & gas. They will control the supply & demand to maximize profits. The cost Americans will have to pay in the end is the dependence on bottled water. Fracking will take the bottled water industry to the level of oil & gas profits. Once municipal water supply is depleted from fracking then Americans have no other source than bottled water. And you will pay more for water than for energy.

Kris Olsson
July 1, 2013 at 10:01 am

What is the timeline for a fracked well? Do they use the 8 million gallons or so all at once, or is it over the course of several fracking events? So, for a given well, over what period of time is the water consumed. Also, another question – in

the state online records for oil and gas, is there a way to distinguish the newer hydro fracking type of drilling from the "regular" oil and gas well permitting/plays?

trevor mcnamara
November 5, 2013 at 1:21 pm

frack fracking!

gary Markley
November 14, 2013 at 9:15 am

its a no-brainer. Stop all fracking in the state of Michigan-I can't understand how Michiugan lets money-seeking idiots get away with this. It needs to be illegal.

barbara
November 27, 2013 at 9:48 am

Hamilton Township in Clare Co. needs help. Besides being fracked recently, DCP Midstream wants to put a gas processing facility tucked right in among homes, farms, and a tourist area of lakes. Our township board says we will be sued if we try to stop this. How can you sue a whole community of people?!!! This facility would be the ruination of our area. Noise, increased traffic (trucks), odors, ground water contamination (everyone here is dependent on well water), an unsightly thing for a tourist area, nearby trout streams, etc. and , of course, air pollution are just a few of our concerns. If this facility has to be it should be away from families and farms. We invite anyone who has the time and the concern to write to our local newspapers. The Clare County Cleaver and The Clare Review accept editorials readily on line. We are a poor community and can not fight this alone. Thank you in advance and God bless.....

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The White House

Office of the Press Secretary

For Immediate Release January 24, 2012

Remarks by the President in State of the Union Address

United States Capitol
Washington, D.C.

9:10 P.M. EST

THE PRESIDENT: Mr. Speaker, Mr. Vice President, members of Congress, distinguished guests, and fellow Americans:

Last month, I went to Andrews Air Force Base and welcomed home some of our last troops to serve in Iraq. Together, we offered a final, proud salute to the colors under which more than a million of our fellow citizens fought -- and several thousand gave their lives.

We gather tonight knowing that this generation of heroes has made the United States safer and more respected around the world. (Applause.) For the first time in nine years, there are no Americans fighting in Iraq. (Applause.) For the first time in two decades, Osama bin Laden is not a threat to this country. (Applause.) Most of al Qaeda's top lieutenants have been defeated. The Taliban's momentum has been broken, and some troops in Afghanistan have begun to come home.

These achievements are a testament to the courage, selflessness and teamwork of America's Armed Forces. At a time when too many of our institutions have let us down, they exceed all expectations. They're not consumed with personal ambition. They don't obsess over their differences. They focus on the mission at hand. They work together.

Imagine what we could accomplish if we followed their example. (Applause.) Think about the America within our reach: A country that leads the world in educating its people. An America that attracts a new generation of high-tech manufacturing and high-paying jobs. A future where we're in control of our own energy, and our security and prosperity aren't so tied to unstable parts of the world. An economy built to last, where hard work pays off, and responsibility is rewarded.

We can do this. I know we can, because we've done it before. At the end of World War II, when another generation of heroes returned home from combat, they built the strongest economy and middle class the world has ever known. (Applause.) My grandfather, a veteran of Patton's Army, got the chance to go to college on the GI Bill. My grandmother, who worked on a bomber assembly line, was part of a workforce that turned out the best products on Earth.

The two of them shared the optimism of a nation that had triumphed over a depression and fascism. They understood they were part of something larger; that they were contributing to a story of success that every American had a chance to share -- the basic American promise that if you worked hard, you could do well enough to raise a family, own a home, send your kids to college, and put a little away for retirement.

The defining issue of our time is how to keep that promise alive. No challenge is more urgent. No debate is more important. We can either settle for a country where a shrinking number of people do really well while a growing number of Americans barely get by, or we can restore an economy where everyone gets a fair shot, and everyone does their fair share, and everyone plays by the same set of rules. (Applause.) What's at stake aren't Democratic values or Republican values, but American values. And we have to reclaim them.

Let's remember how we got here. Long before the recession, jobs and manufacturing began leaving our shores. Technology made businesses more efficient, but also made some jobs obsolete. Folks at the top saw their incomes rise like never before, but most hardworking Americans struggled with costs that were growing, paychecks that weren't, and personal debt that kept piling up.

In 2008, the house of cards collapsed. We learned that mortgages had been sold to people who couldn't afford

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January 25, 2012 1:30 AM
2012 State Of The Union Address Enhanced Version

BLOG POSTS ON THIS ISSUE

May 19, 2013 4:33 PM EDT
President Obama Delivers the Commencement Address at Morehouse College
President Obama delivers the commencement address to the 2013 graduates of Morehouse College in Atlanta, GA.

May 18, 2013 7:30 PM EDT
First Lady Delivers Commencement Addresses at Bowie State, Martin Luther King Jr. Magnet High School
First Lady Michelle Obama delivers the commencement addresses at Bowie State University and Martin Luther King Jr. Magnet High School.

May 18, 2013 6:00 AM EDT
Weekly Address: The President Talks About How to Build a Rising, Thriving Middle Class
President Obama talks about his belief that a rising, thriving middle class is the true engine of economic growth, and that to reignite that engine

or understand them. Banks had made huge bets and bonuses with other people's money. Regulators had looked the other way, or didn't have the authority to stop the bad behavior.

It was wrong. It was irresponsible. And it plunged our economy into a crisis that put millions out of work, saddled us with more debt, and left innocent, hardworking Americans holding the bag. In the six months before I took office, we lost nearly 4 million jobs. And we lost another 4 million before our policies were in full effect.

Those are the facts. But so are these: In the last 22 months, businesses have created more than 3 million jobs. (Applause.)

Last year, they created the most jobs since 2005. American manufacturers are hiring again, creating jobs for the first time since the late 1990s. Together, we've agreed to cut the deficit by more than $2 trillion. And we've put in place new rules to hold Wall Street accountable, so a crisis like this never happens again. (Applause.)

The state of our Union is getting stronger. And we've come too far to turn back now. As long as I'm President, I will work with anyone in this chamber to build on this momentum. But I intend to fight obstruction with action, and I will oppose any effort to return to the very same policies that brought on this economic crisis in the first place. (Applause.)

No, we will not go back to an economy weakened by outsourcing, bad debt, and phony financial profits. Tonight, I want to speak about how we move forward, and lay out a blueprint for an economy that's built to last -— an economy built on American manufacturing, American energy, skills for American workers, and a renewal of American values.

Now, this blueprint begins with American manufacturing.

On the day I took office, our auto industry was on the verge of collapse. Some even said we should let it die. With a million jobs at stake, I refused to let that happen. In exchange for help, we demanded responsibility. We got workers and automakers to settle their differences. We got the industry to retool and restructure. Today, General Motors is back on top as the world's number-one automaker. (Applause.) Chrysler has grown faster in the U.S. than any major car company. Ford is investing billions in U.S. plants and factories. And together, the entire industry added nearly 160,000 jobs.

We bet on American workers. We bet on American ingenuity. And tonight, the American auto industry is back. (Applause.)

What's happening in Detroit can happen in other industries. It can happen in Cleveland and Pittsburgh and Raleigh. We can't bring every job back that's left our shore. But right now, it's getting more expensive to do business in places like China. Meanwhile, America is more productive. A few weeks ago, the CEO of Master Lock told me that it now makes business sense for him to bring jobs back home. (Applause.) Today, for the first time in 15 years, Master Lock's unionized plant in Milwaukee is running at full capacity. (Applause.)

So we have a huge opportunity, at this moment, to bring manufacturing back. But we have to seize it. Tonight, my message to business leaders is simple: Ask yourselves what you can do to bring jobs back to your country, and your country will do everything we can to help you succeed. (Applause.)

We should start with our tax code. Right now, companies get tax breaks for moving jobs and profits overseas. Meanwhile, companies that choose to stay in America get hit with one of the highest tax rates in the world. It makes no sense, and everyone knows it. So let's change it.

First, if you're a business that wants to outsource jobs, you shouldn't get a tax deduction for doing it. (Applause.) That money should be used to cover moving expenses for companies like Master Lock that decide to bring jobs home. (Applause.)

Second, no American company should be able to avoid paying its fair share of taxes by moving jobs and profits overseas. (Applause.) From now on, every multinational company should have to pay a basic minimum tax. And every penny should go towards lowering taxes for companies that choose to stay here and hire here in America. (Applause.)

Third, if you're an American manufacturer, you should get a bigger tax cut. If you're a high-tech manufacturer, we should double the tax deduction you get for making your products here. And if you want to relocate in a community that was hit hard when a factory left town, you should get help financing a new plant, equipment, or training for new workers. (Applause.)

So my message is simple. It is time to stop rewarding businesses that ship jobs overseas, and start rewarding companies that create jobs right here in America. Send me these tax reforms, and I will sign them right away. (Applause.)

We're also making it easier for American businesses to sell products all over the world. Two years ago, I set a goal of doubling U.S. exports over five years. With the bipartisan trade agreements we signed into law, we're on and continue to build on the progress we've made over the last four years, we need to invest in three areas: jobs, skills and opportunity.

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track to meet that goal ahead of schedule. (Applause.) And soon, there will be millions of new customers for American goods in Panama, Colombia, and South Korea. Soon, there will be new cars on the streets of Seoul imported from Detroit, and Toledo, and Chicago. (Applause.)

I will go anywhere in the world to open new markets for American products. And I will not stand by when our competitors don't play by the rules. We've brought trade cases against China at nearly twice the rate as the last administration –- and it's made a difference. (Applause.) Over a thousand Americans are working today because we stopped a surge in Chinese tires. But we need to do more. It's not right when another country lets our movies, music, and software be pirated. It's not fair when foreign manufacturers have a leg up on ours only because they're heavily subsidized.

Tonight, I'm announcing the creation of a Trade Enforcement Unit that will be charged with investigating unfair trading practices in countries like China. (Applause.) There will be more inspections to prevent counterfeit or unsafe goods from crossing our borders. And this Congress should make sure that no foreign company has an advantage over American manufacturing when it comes to accessing financing or new markets like Russia. Our workers are the most productive on Earth, and if the playing field is level, I promise you -– America will always win. (Applause.)

I also hear from many business leaders who want to hire in the United States but can't find workers with the right skills. Growing industries in science and technology have twice as many openings as we have workers who can do the job. Think about that –- openings at a time when millions of Americans are looking for work. It's inexcusable. And we know how to fix it.

Jackie Bray is a single mom from North Carolina who was laid off from her job as a mechanic. Then Siemens opened a gas turbine factory in Charlotte, and formed a partnership with Central Piedmont Community College. The company helped the college design courses in laser and robotics training. It paid Jackie's tuition, then hired her to help operate their plant.

I want every American looking for work to have the same opportunity as Jackie did. Join me in a national commitment to train 2 million Americans with skills that will lead directly to a job. (Applause.) My administration has already lined up more companies that want to help. Model partnerships between businesses like Siemens and community colleges in places like Charlotte, and Orlando, and Louisville are up and running. Now you need to give more community colleges the resources they need to become community career centers -– places that teach people skills that businesses are looking for right now, from data management to high-tech manufacturing.

And I want to cut through the maze of confusing training programs, so that from now on, people like Jackie have one program, one website, and one place to go for all the information and help that they need. It is time to turn our unemployment system into a reemployment system that puts people to work. (Applause.)

These reforms will help people get jobs that are open today. But to prepare for the jobs of tomorrow, our commitment to skills and education has to start earlier.

For less than 1 percent of what our nation spends on education each year, we've convinced nearly every state in the country to raise their standards for teaching and learning -- the first time that's happened in a generation.

But challenges remain. And we know how to solve them.

At a time when other countries are doubling down on education, tight budgets have forced states to lay off thousands of teachers. We know a good teacher can increase the lifetime income of a classroom by over $250,000. A great teacher can offer an escape from poverty to the child who dreams beyond his circumstance. Every person in this chamber can point to a teacher who changed the trajectory of their lives. Most teachers work tirelessly, with modest pay, sometimes digging into their own pocket for school supplies -- just to make a difference.

Teachers matter. So instead of bashing them, or defending the status quo, let's offer schools a deal. Give them the resources to keep good teachers on the job, and reward the best ones. (Applause.) And in return, grant schools flexibility: to teach with creativity and passion; to stop teaching to the test; and to replace teachers who just aren't helping kids learn. That's a bargain worth making. (Applause.)

We also know that when students don't walk away from their education, more of them walk the stage to get their diploma. When students are not allowed to drop out, they do better. So tonight, I am proposing that every state -- every state -- requires that all students stay in high school until they graduate or turn 18. (Applause.)

When kids do graduate, the most daunting challenge can be the cost of college. At a time when Americans owe more in tuition debt than credit card debt, this Congress needs to stop the interest rates on student loans from doubling in July. (Applause.)

Extend the tuition tax credit we started that saves millions of middle-class families thousands of dollars, and give more young people the chance to earn their way through college by doubling the number of work-study jobs in

the next five years. (Applause.)

Of course, it's not enough for us to increase student aid. We can't just keep subsidizing skyrocketing tuition; we'll run out of money. States also need to do their part, by making higher education a higher priority in their budgets. And colleges and universities have to do their part by working to keep costs down.

Recently, I spoke with a group of college presidents who've done just that. Some schools redesign courses to help students finish more quickly. Some use better technology. The point is, it's possible. So let me put colleges and universities on notice: If you can't stop tuition from going up, the funding you get from taxpayers will go down. (Applause.) Higher education can't be a luxury — it is an economic imperative that every family in America should be able to afford.

Let's also remember that hundreds of thousands of talented, hardworking students in this country face another challenge: the fact that they aren't yet American citizens. Many were brought here as small children, are American through and through, yet they live every day with the threat of deportation. Others came more recently, to study business and science and engineering, but as soon as they get their degree, we send them home to invent new products and create new jobs somewhere else.

That doesn't make sense.

I believe as strongly as ever that we should take on illegal immigration. That's why my administration has put more boots on the border than ever before. That's why there are fewer illegal crossings than when I took office. The opponents of action are out of excuses. We should be working on comprehensive immigration reform right now. (Applause.)

But if election-year politics keeps Congress from acting on a comprehensive plan, let's at least agree to stop expelling responsible young people who want to staff our labs, start new businesses, defend this country. Send me a law that gives them the chance to earn their citizenship. I will sign it right away. (Applause.)

You see, an economy built to last is one where we encourage the talent and ingenuity of every person in this country. That means women should earn equal pay for equal work. (Applause.) It means we should support everyone who's willing to work, and every risk-taker and entrepreneur who aspires to become the next Steve Jobs.

After all, innovation is what America has always been about. Most new jobs are created in start-ups and small businesses. So let's pass an agenda that helps them succeed. Tear down regulations that prevent aspiring entrepreneurs from getting the financing to grow. (Applause.) Expand tax relief to small businesses that are raising wages and creating good jobs. Both parties agree on these ideas. So put them in a bill, and get it on my desk this year. (Applause.)

Innovation also demands basic research. Today, the discoveries taking place in our federally financed labs and universities could lead to new treatments that kill cancer cells but leave healthy ones untouched. New lightweight vests for cops and soldiers that can stop any bullet. Don't gut these investments in our budget. Don't let other countries win the race for the future. Support the same kind of research and innovation that led to the computer chip and the Internet; to new American jobs and new American industries.

And nowhere is the promise of innovation greater than in American-made energy. Over the last three years, we've opened millions of new acres for oil and gas exploration, and tonight, I'm directing my administration to open more than 75 percent of our potential offshore oil and gas resources. (Applause.) Right now -- right now -- American oil production is the highest that it's been in eight years. That's right -- eight years. Not only that -- last year, we relied less on foreign oil than in any of the past 16 years. (Applause.)

But with only 2 percent of the world's oil reserves, oil isn't enough. This country needs an all-out, all-of-the-above strategy that develops every available source of American energy. (Applause.) A strategy that's cleaner, cheaper, and full of new jobs.

We have a supply of natural gas that can last America nearly 100 years. (Applause.) And my administration will take every possible action to safely develop this energy. Experts believe this will support more than 600,000 jobs by the end of the decade. And I'm requiring all companies that drill for gas on public lands to disclose the chemicals they use. (Applause.) Because America will develop this resource without putting the health and safety of our citizens at risk.

The development of natural gas will create jobs and power trucks and factories that are cleaner and cheaper, proving that we don't have to choose between our environment and our economy. (Applause.) And by the way, it was public research dollars, over the course of 30 years, that helped develop the technologies to extract all this natural gas out of shale rock —- reminding us that government support is critical in helping businesses get new energy ideas off the ground. (Applause.)

Now, what's true for natural gas is just as true for clean energy. In three years, our partnership with the private sector has already positioned America to be the world's leading manufacturer of high-tech batteries. Because of

federal investments, renewable energy use has nearly doubled, and thousands of Americans have jobs because of it.

When Bryan Ritterby was laid off from his job making furniture, he said he worried that at 55, no one would give him a second chance. But he found work at Energetx, a wind turbine manufacturer in Michigan. Before the recession, the factory only made luxury yachts. Today, it's hiring workers like Bryan, who said, "I'm proud to be working in the industry of the future."

Our experience with shale gas, our experience with natural gas, shows us that the payoffs on these public investments don't always come right away. Some technologies don't pan out; some companies fail. But I will not walk away from the promise of clean energy. I will not walk away from workers like Bryan. (Applause.) I will not cede the wind or solar or battery industry to China or Germany because we refuse to make the same commitment here.

We've subsidized oil companies for a century. That's long enough. (Applause.) It's time to end the taxpayer giveaways to an industry that rarely has been more profitable, and double-down on a clean energy industry that never has been more promising. Pass clean energy tax credits. Create these jobs. (Applause.)

We can also spur energy innovation with new incentives. The differences in this chamber may be too deep right now to pass a comprehensive plan to fight climate change. But there's no reason why Congress shouldn't at least set a clean energy standard that creates a market for innovation. So far, you haven't acted. Well, tonight, I will. I'm directing my administration to allow the development of clean energy on enough public land to power 3 million homes. And I'm proud to announce that the Department of Defense, working with us, the world's largest consumer of energy, will make one of the largest commitments to clean energy in history — with the Navy purchasing enough capacity to power a quarter of a million homes a year. (Applause.)

Of course, the easiest way to save money is to waste less energy. So here's a proposal: Help manufacturers eliminate energy waste in their factories and give businesses incentives to upgrade their buildings. Their energy bills will be $100 billion lower over the next decade, and America will have less pollution, more manufacturing, more jobs for construction workers who need them. Send me a bill that creates these jobs. (Applause.)

Building this new energy future should be just one part of a broader agenda to repair America's infrastructure. So much of America needs to be rebuilt. We've got crumbling roads and bridges; a power grid that wastes too much energy; an incomplete high-speed broadband network that prevents a small business owner in rural America from selling her products all over the world.

During the Great Depression, America built the Hoover Dam and the Golden Gate Bridge. After World War II, we connected our states with a system of highways. Democratic and Republican administrations invested in great projects that benefited everybody, from the workers who built them to the businesses that still use them today.

In the next few weeks, I will sign an executive order clearing away the red tape that slows down too many construction projects. But you need to fund these projects. Take the money we're no longer spending at war, use half of it to pay down our debt, and use the rest to do some nation-building right here at home. (Applause.)

There's never been a better time to build, especially since the construction industry was one of the hardest hit when the housing bubble burst. Of course, construction workers weren't the only ones who were hurt. So were millions of innocent Americans who've seen their home values decline. And while government can't fix the problem on its own, responsible homeowners shouldn't have to sit and wait for the housing market to hit bottom to get some relief.

And that's why I'm sending this Congress a plan that gives every responsible homeowner the chance to save about $3,000 a year on their mortgage, by refinancing at historically low rates. (Applause.) No more red tape. No more runaround from the banks. A small fee on the largest financial institutions will ensure that it won't add to the deficit and will give those banks that were rescued by taxpayers a chance to repay a deficit of trust. (Applause.)

Let's never forget: Millions of Americans who work hard and play by the rules every day deserve a government and a financial system that do the same. It's time to apply the same rules from top to bottom. No bailouts, no handouts, and no copouts. An America built to last insists on responsibility from everybody.

We've all paid the price for lenders who sold mortgages to people who couldn't afford them, and buyers who knew they couldn't afford them. That's why we need smart regulations to prevent irresponsible behavior. (Applause.) Rules to prevent financial fraud or toxic dumping or faulty medical devices -- these don't destroy the free market. They make the free market work better.

There's no question that some regulations are outdated, unnecessary, or too costly. In fact, I've approved fewer regulations in the first three years of my presidency than my Republican predecessor did in his. (Applause.) I've ordered every federal agency to eliminate rules that don't make sense. We've already announced over 500 reforms, and just a fraction of them will save business and citizens more than $10 billion over the next five years. We got rid of one rule from 40 years ago that could have forced some dairy farmers to spend $10,000 a year

proving that they could contain a spill -- because milk was somehow classified as an oil. With a rule like that, I guess it was worth crying over spilled milk. (Laughter and applause.)

Now, I'm confident a farmer can contain a milk spill without a federal agency looking over his shoulder. (Applause.) Absolutely. But I will not back down from making sure an oil company can contain the kind of oil spill we saw in the Gulf two years ago. (Applause.) I will not back down from protecting our kids from mercury poisoning, or making sure that our food is safe and our water is clean. I will not go back to the days when health insurance companies had unchecked power to cancel your policy, deny your coverage, or charge women differently than men. (Applause.)

And I will not go back to the days when Wall Street was allowed to play by its own set of rules. The new rules we passed restore what should be any financial system's core purpose: Getting funding to entrepreneurs with the best ideas, and getting loans to responsible families who want to buy a home, or start a business, or send their kids to college.

So if you are a big bank or financial institution, you're no longer allowed to make risky bets with your customers' deposits. You're required to write out a "living will" that details exactly how you'll pay the bills if you fail –- because the rest of us are not bailing you out ever again. (Applause.) And if you're a mortgage lender or a payday lender or a credit card company, the days of signing people up for products they can't afford with confusing forms and deceptive practices -- those days are over. Today, American consumers finally have a watchdog in Richard Cordray with one job: To look out for them. (Applause.)

We'll also establish a Financial Crimes Unit of highly trained investigators to crack down on large-scale fraud and protect people's investments. Some financial firms violate major anti-fraud laws because there's no real penalty for being a repeat offender. That's bad for consumers, and it's bad for the vast majority of bankers and financial service professionals who do the right thing. So pass legislation that makes the penalties for fraud count.

And tonight, I'm asking my Attorney General to create a special unit of federal prosecutors and leading state attorney general to expand our investigations into the abusive lending and packaging of risky mortgages that led to the housing crisis. (Applause.) This new unit will hold accountable those who broke the law, speed assistance to homeowners, and help turn the page on an era of recklessness that hurt so many Americans.

Now, a return to the American values of fair play and shared responsibility will help protect our people and our economy. But it should also guide us as we look to pay down our debt and invest in our future.

Right now, our most immediate priority is stopping a tax hike on 160 million working Americans while the recovery is still fragile. (Applause.) People cannot afford losing $40 out of each paycheck this year. There are plenty of ways to get this done. So let's agree right here, right now: No side issues. No drama. Pass the payroll tax cut without delay. Let's get it done. (Applause.)

When it comes to the deficit, we've already agreed to more than $2 trillion in cuts and savings. But we need to do more, and that means making choices. Right now, we're poised to spend nearly $1 trillion more on what was supposed to be a temporary tax break for the wealthiest 2 percent of Americans. Right now, because of loopholes and shelters in the tax code, a quarter of all millionaires pay lower tax rates than millions of middle-class households. Right now, Warren Buffett pays a lower tax rate than his secretary.

Do we want to keep these tax cuts for the wealthiest Americans? Or do we want to keep our investments in everything else –- like education and medical research; a strong military and care for our veterans? Because if we're serious about paying down our debt, we can't do both.

The American people know what the right choice is. So do I. As I told the Speaker this summer, I'm prepared to make more reforms that rein in the long-term costs of Medicare and Medicaid, and strengthen Social Security, so long as those programs remain a guarantee of security for seniors.

But in return, we need to change our tax code so that people like me, and an awful lot of members of Congress, pay our fair share of taxes. (Applause.)

Tax reform should follow the Buffett Rule. If you make more than $1 million a year, you should not pay less than 30 percent in taxes. And my Republican friend Tom Coburn is right: Washington should stop subsidizing millionaires. In fact, if you're earning a million dollars a year, you shouldn't get special tax subsidies or deductions. On the other hand, if you make under $250,000 a year, like 98 percent of American families, your taxes shouldn't go up. (Applause.) You're the ones struggling with rising costs and stagnant wages. You're the ones who need relief.

Now, you can call this class warfare all you want. But asking a billionaire to pay at least as much as his secretary in taxes? Most Americans would call that common sense.

We don't begrudge financial success in this country. We admire it. When Americans talk about folks like me paying my fair share of taxes, it's not because they envy the rich. It's because they understand that when I get a

tax break I don't need and the country can't afford, it either adds to the deficit, or somebody else has to make up the difference -- like a senior on a fixed income, or a student trying to get through school, or a family trying to make ends meet. That's not right. Americans know that's not right. They know that this generation's success is only possible because past generations felt a responsibility to each other, and to the future of their country, and they know our way of life will only endure if we feel that same sense of shared responsibility. That's how we'll reduce our deficit. That's an America built to last. (Applause.)

Now, I recognize that people watching tonight have differing views about taxes and debt, energy and health care. But no matter what party they belong to, I bet most Americans are thinking the same thing right about now: Nothing will get done in Washington this year, or next year, or maybe even the year after that, because Washington is broken.

Can you blame them for feeling a little cynical?

The greatest blow to our confidence in our economy last year didn't come from events beyond our control. It came from a debate in Washington over whether the United States would pay its bills or not. Who benefited from that fiasco?

I've talked tonight about the deficit of trust between Main Street and Wall Street. But the divide between this city and the rest of the country is at least as bad -- and it seems to get worse every year.

Some of this has to do with the corrosive influence of money in politics. So together, let's take some steps to fix that. Send me a bill that bans insider trading by members of Congress; I will sign it tomorrow. (Applause.) Let's limit any elected official from owning stocks in industries they impact. Let's make sure people who bundle campaign contributions for Congress can't lobby Congress, and vice versa -- an idea that has bipartisan support, at least outside of Washington.

Some of what's broken has to do with the way Congress does its business these days. A simple majority is no longer enough to get anything -- even routine business -- passed through the Senate. (Applause.) Neither party has been blameless in these tactics. Now both parties should put an end to it. (Applause.) For starters, I ask the Senate to pass a simple rule that all judicial and public service nominations receive a simple up or down vote within 90 days. (Applause.)

The executive branch also needs to change. Too often, it's inefficient, outdated and remote. (Applause.) That's why I've asked this Congress to grant me the authority to consolidate the federal bureaucracy, so that our government is leaner, quicker, and more responsive to the needs of the American people. (Applause.)

Finally, none of this can happen unless we also lower the temperature in this town. We need to end the notion that the two parties must be locked in a perpetual campaign of mutual destruction; that politics is about clinging to rigid ideologies instead of building consensus around common-sense ideas.

I'm a Democrat. But I believe what Republican Abraham Lincoln believed: That government should do for people only what they cannot do better by themselves, and no more. (Applause.) That's why my education reform offers more competition, and more control for schools and states. That's why we're getting rid of regulations that don't work. That's why our health care law relies on a reformed private market, not a government program.

On the other hand, even my Republican friends who complain the most about government spending have supported federally financed roads, and clean energy projects, and federal offices for the folks back home.

The point is, we should all want a smarter, more effective government. And while we may not be able to bridge our biggest philosophical differences this year, we can make real progress. With or without this Congress, I will keep taking actions that help the economy grow. But I can do a whole lot more with your help. Because when we act together, there's nothing the United States of America can't achieve. (Applause.) That's the lesson we've learned from our actions abroad over the last few years.

Ending the Iraq war has allowed us to strike decisive blows against our enemies. From Pakistan to Yemen, the al Qaeda operatives who remain are scrambling, knowing that they can't escape the reach of the United States of America. (Applause.)

From this position of strength, we've begun to wind down the war in Afghanistan. Ten thousand of our troops have come home. Twenty-three thousand more will leave by the end of this summer. This transition to Afghan lead will continue, and we will build an enduring partnership with Afghanistan, so that it is never again a source of attacks against America. (Applause.)

As the tide of war recedes, a wave of change has washed across the Middle East and North Africa, from Tunis to Cairo; from Sana'a to Tripoli. A year ago, Qaddafi was one of the world's longest-serving dictators -- a murderer with American blood on his hands. Today, he is gone. And in Syria, I have no doubt that the Assad regime will soon discover that the forces of change cannot be reversed, and that human dignity cannot be denied. (Applause.)

How this incredible transformation will end remains uncertain. But we have a huge stake in the outcome. And while it's ultimately up to the people of the region to decide their fate, we will advocate for those values that have served our own country so well. We will stand against violence and intimidation. We will stand for the rights and dignity of all human beings –- men and women; Christians, Muslims and Jews. We will support policies that lead to strong and stable democracies and open markets, because tyranny is no match for liberty.

And we will safeguard America's own security against those who threaten our citizens, our friends, and our interests. Look at Iran. Through the power of our diplomacy, a world that was once divided about how to deal with Iran's nuclear program now stands as one. The regime is more isolated than ever before; its leaders are faced with crippling sanctions, and as long as they shirk their responsibilities, this pressure will not relent.

Let there be no doubt: America is determined to prevent Iran from getting a nuclear weapon, and I will take no options off the table to achieve that goal. (Applause.)

But a peaceful resolution of this issue is still possible, and far better, and if Iran changes course and meets its obligations, it can rejoin the community of nations.

The renewal of American leadership can be felt across the globe. Our oldest alliances in Europe and Asia are stronger than ever. Our ties to the Americas are deeper. Our ironclad commitment -- and I mean ironclad -- to Israel's security has meant the closest military cooperation between our two countries in history. (Applause.)

We've made it clear that America is a Pacific power, and a new beginning in Burma has lit a new hope. From the coalitions we've built to secure nuclear materials, to the missions we've led against hunger and disease; from the blows we've dealt to our enemies, to the enduring power of our moral example, America is back.

Anyone who tells you otherwise, anyone who tells you that America is in decline or that our influence has waned, doesn't know what they're talking about. (Applause.)

That's not the message we get from leaders around the world who are eager to work with us. That's not how people feel from Tokyo to Berlin, from Cape Town to Rio, where opinions of America are higher than they've been in years. Yes, the world is changing. No, we can't control every event. But America remains the one indispensable nation in world affairs –- and as long as I'm President, I intend to keep it that way. (Applause.)

That's why, working with our military leaders, I've proposed a new defense strategy that ensures we maintain the finest military in the world, while saving nearly half a trillion dollars in our budget. To stay one step ahead of our adversaries, I've already sent this Congress legislation that will secure our country from the growing dangers of cyber-threats. (Applause.)

Above all, our freedom endures because of the men and women in uniform who defend it. (Applause.) As they come home, we must serve them as well as they've served us. That includes giving them the care and the benefits they have earned –- which is why we've increased annual VA spending every year I've been President. (Applause.) And it means enlisting our veterans in the work of rebuilding our nation.

With the bipartisan support of this Congress, we're providing new tax credits to companies that hire vets. Michelle and Jill Biden have worked with American businesses to secure a pledge of 135,000 jobs for veterans and their families. And tonight, I'm proposing a Veterans Jobs Corps that will help our communities hire veterans as cops and firefighters, so that America is as strong as those who defend her. (Applause.)

Which brings me back to where I began. Those of us who've been sent here to serve can learn a thing or two from the service of our troops. When you put on that uniform, it doesn't matter if you're black or white; Asian, Latino, Native American; conservative, liberal; rich, poor; gay, straight. When you're marching into battle, you look out for the person next to you, or the mission fails. When you're in the thick of the fight, you rise or fall as one unit, serving one nation, leaving no one behind.

One of my proudest possessions is the flag that the SEAL Team took with them on the mission to get bin Laden. On it are each of their names. Some may be Democrats. Some may be Republicans. But that doesn't matter. Just like it didn't matter that day in the Situation Room, when I sat next to Bob Gates -- a man who was George Bush's defense secretary -- and Hillary Clinton -- a woman who ran against me for president.

All that mattered that day was the mission. No one thought about politics. No one thought about themselves. One of the young men involved in the raid later told me that he didn't deserve credit for the mission. It only succeeded, he said, because every single member of that unit did their job -- the pilot who landed the helicopter that spun out of control; the translator who kept others from entering the compound; the troops who separated the women and children from the fight; the SEALs who charged up the stairs. More than that, the mission only succeeded because every member of that unit trusted each other -- because you can't charge up those stairs, into darkness and danger, unless you know that there's somebody behind you, watching your back.

So it is with America. Each time I look at that flag, I'm reminded that our destiny is stitched together like those 50 stars and those 13 stripes. No one built this country on their own. This nation is great because we built it together. This nation is great because we worked as a team. This nation is great because we get each other's

backs. And if we hold fast to that truth, in this moment of trial, there is no challenge too great; no mission too hard. As long as we are joined in common purpose, as long as we maintain our common resolve, our journey moves forward, and our future is hopeful, and the state of our Union will always be strong.

Thank you, God bless you, and God bless the United States of America. (Applause.)

END
10:16 P.M. EST

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The White House

Office of the Press Secretary

For Immediate Release December 10, 2012

Remarks by the President at the Daimler Detroit Diesel Plant, Redford, MI

Daimler Detroit Diesel Plant
Redford, Michigan

2:29 P.M. EST

THE PRESIDENT: Hello, Redford! (Applause.) It is good to be back in Michigan. (Applause.) How is everybody doing today? (Applause.)

Now, let me just start off by saying we have something in common – both our teams lost yesterday. (Laughter.) I mean, I would like to come here and talk a little smack about the Bears, but we didn't quite get it done. But it is wonderful to be back. It is good to see everybody in the great state of Michigan. (Applause.)

A few people I want to acknowledge – first of all, the Mayor of Detroit here – Dave Bing is in the house. (Applause.) We've got the Redford Supervisor – Tracey Schultz Kobylarz. (Applause.) We've got some outstanding members of Congress who are here – please give them a big round of applause. (Applause.)

I want to thank Martin for hosting us. I want to thank Jeff and Gibby for giving me a great tour of the factory. (Applause.) I've got to say I love coming to factories.

AUDIENCE MEMBER: I love you!

THE PRESIDENT: I love you. (Applause.)

So in addition to seeing the best workers in the world – (applause) – you've also got all this cool equipment. (Laughter.) I wanted to try out some of the equipment, but Secret Service wouldn't let me. (Laughter.) They said, you're going to drop something on your head, hurt yourself. (Laughter.) They were worried I'd mess something up. And Jeff and Gibby may not admit it, but I think they were pretty happy the Secret Service wouldn't let me touch the equipment. (Laughter.)

Now, it's been a little over a month since the election came to an end. (Applause.) So it's now safe for you to turn your televisions back on. (Laughter.) All those scary political ads are off the air. You can answer your phone again – nobody is calling you in the middle of dinner asking for your support. But, look, I have to admit there's one part of the campaign that I miss, and that is it is a great excuse for me to get out of Washington and come to towns like this and talk to the people who work so hard every day and are looking out for their families and are in their communities, and just having a conversation about what kind of country do we want to be; what kind of country do we want to leave behind for our kids. Because ultimately, that's what this is about.

And I believe – and I've been saying this not just for the last six months or the last year, but ever since I got into public office – I believe America only succeeds and thrives when we've got a strong and growing middle class. (Applause.) That's what I believe. I believe we're at our best when everybody who works hard has a chance to get ahead; that they can get a job that pays the bills; that they've got health care that they can count on; that they can retire with dignity and respect, maybe take a vacation once in a while – nothing fancy, just being able to pack up the kids and go someplace and enjoy time with people that you love; make sure that your kids can go to a good school; make sure they can aspire to whatever they want to be.

That idea is what built America. That's the idea that built Michigan. That's the idea that's at the heart of the economic plan I've been talking about all year long on the campaign trail. I want to give more Americans the chance to earn the skills that businesses are looking for right now, and give our kids the kind of education they need to succeed in the 21st century. I want to make sure America leads the world in research and technology and clean energy. I want to put people back to work rebuilding our roads and our bridges and our schools. (Applause.) That's how we grow an economy.

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President Obama Speaks on the Economy and Middle-Class Tax Cuts

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The President and First Lady deliver remarks to open the 2013 Disabled American Veterans National Convention in Orlando, FL.

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Weekly Address: A Better Bargain for Responsible, Middle Class Homeowners

In this week's address, President Obama says that the housing market is starting to heal, and now it's time to build on that progress by creating a better bargain for responsible, middle-class homeowners.

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I want us to bring down our deficits, but I want to do it in a balanced, responsible way. And I want to reward – I want a tax code that rewards businesses and manufacturers like Detroit Diesel right here, creating jobs right here in Redford, right here in Michigan, right here in the United States of America. (Applause.) That's where we need to go. That's the country we need to build. And when it comes to bringing manufacturing back to America – that's why I'm here today.

Since 1938, Detroit Diesel has been turning out some of the best engines in the world. (Applause.) Over all those years, generations of Redford workers have walked through these doors. Not just to punch a clock. Not just to pick up a paycheck. Not just to build an engine. But to build a middle-class life for their families; to earn a shot at the American Dream.

For seven and a half decades, through good times and bad, through revolutions in technology that sent a lot of good jobs – manufacturing jobs -- overseas, men and women like you, your parents, maybe even your grandparents, have done your part to build up America's manufacturing strength. That's something you can all be proud of. And now you're writing a new proud chapter to that history. Eight years ago, you started building axles here alongside the engines. That meant more work. That meant more jobs. (Applause.) So you started seeing products – more products stamped with those three proud words: Made in America.
Today, Daimler is announcing a new $120 million investment into this plant, creating 115 good, new union jobs building transmissions and turbochargers right here in Redford – (applause) – 115 good new jobs right here in this plant, making things happen. That is great for the plant. It's great for this community. But it's also good for American manufacturing. Soon, you guys will be building all the key parts that go into powering a heavy-duty truck, all at the same facility. Nobody else in America is doing that. Nobody else in North America is doing that.

And by putting everything together in one place, under one roof, Daimler engineers can design each part so it works better with the others. That means greater fuel efficiency for your trucks. It means greater savings for your customers. That's a big deal. And it's just the latest example of Daimler's leadership on this issue.

Last year, I was proud to have your support when we announced the first-ever national fuel-efficiency standards for commercial trucks, which is going to help save consumers money and reduce our dependence on foreign oil. That's good news. (Applause.)

But here's the other reason why what you guys are doing, what Daimler is doing, is so important. For a long time, companies, they weren't always making those kinds of investments here in the United States. They weren't always investing in American workers. They certainly weren't willing to make them in the U.S. auto industry.

Remember, it was just a few years ago that our auto industry was on the verge of collapse. GM, Chrysler were all on the brink of failure. And if they failed, the suppliers and distributors that get their business from those companies, they would have died off, too. Even Ford could have gone down – production halted. Factories shuttered. Once proud companies chopped up and sold off for scraps. And all of you – the men and women who built these companies with your own hands – would have been hung out to dry. And everybody in this community that depends on you – restaurant owners, storekeepers, bartenders – (laughter and applause) – their livelihoods would have been at stake, too.

So I wasn't about to let that happen. I placed my bet on American workers. We bet on American ingenuity. I'd make that same bet any day of the week. (Applause.) Three and a half years later, that bet is paying off. This industry has added over a quarter of a million new jobs. Assembly lines are humming again. The American auto industry is back.

And companies like Daimler know you're still a smart bet. They could have made their investment somewhere else, but they didn't. And if you ask them whether it was a tough call, they'll tell you it wasn't even close. So the word is going out all around the world: If you want to find the best workers in the world, if you want to find the best factories in the world, if you want to build the best cars or trucks or any other product in the world, you should invest in the United States of America. This is the place to be. (Applause.)

See, you're starting to see the competitive balance is tipping a little bit. Over the past few years, it's become more expensive to do business in countries like China. Our workers have become even more productive. Our energy costs are starting to go down here in the United States. And we still have the largest market. So when you factor in everything, it makes sense to invest here, in America.

And that's one of the reasons why American manufacturing is growing at the fastest pace since the 1990s. And thanks in part to that boost in manufacturing, four years after the worst economic crisis of our lifetimes, our economy is growing again. Our businesses have created more than 5.5 million new jobs over the past 33 months. So we're making progress. (Applause.) We're moving in the right direction. We're going forward.

So what we need to do is simple. We need to keep going. We need to keep going forward. We should do everything we can to keep creating good middle-class jobs that help folks rebuild security for their families. (Applause.) And we should do everything we can to encourage companies like Daimler to keep investing in American workers.

And by the way, what we shouldn't do -- I just got to say this – what we shouldn't be doing is trying to take away

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your rights to bargain for better wages and working conditions. (Applause.) We shouldn't be doing that. (Applause.) These so-called "right to work" laws, they don't have to do with economics; they have everything to do with politics. (Applause.) What they're really talking about is giving you the right to work for less money. (Applause.)

You only have to look to Michigan – where workers were instrumental in reviving the auto industry – to see how unions have helped build not just a stronger middle class but a stronger America. (Applause.) So folks from our state's capital, all the way to the nation's capital, they should be focused on the same thing. They should be working to make sure companies like this manufacturer is able to make more great products. That's what they should be focused on. (Applause.) We don't want a race to the bottom. We want a race to the top. (Applause.)

America is not going to compete based on low-skill, low-wage, no workers' rights. That's not our competitive advantage. There's always going to be some other country that can treat its workers even worse. Right?

AUDIENCE: Right!

THE PRESIDENT: What's going to make us succeed is we got the best workers – well trained, reliable, productive, low turnover, healthy. That's what makes us strong. And it also is what allows our workers then to buy the products that we make because they got enough money in their pockets. (Applause.)

So we've got to get past this whole situation where we manufacture crises because of politics. That actually leads to less certainty, more conflict, and we can't all focus on coming together to grow.

AUDIENCE MEMBER: That's right!

THE PRESIDENT: And the same thing – we're seeing the same thing in Washington. I'm sure you've all heard the talk recently about some big deadlines we're facing in a few weeks when it comes to decisions on jobs and investment and taxes. And that debate is going to have a big impact on all of you. Some of you may know this: If Congress doesn't act soon, meaning in the next few weeks, starting on January 1st, everybody is going to see their income taxes go up.

AUDIENCE: No!

THE PRESIDENT: It's true. You all don't like that.

AUDIENCE: No!

THE PRESIDENT: Typical, middle-class family of four will see an income tax hike of around $2,200. How many of you can afford to pay another $2,200 in taxes? Not you?

AUDIENCE: No!

THE PRESIDENT: I didn't think so. You can't afford to lose that money. That's a hit you can't afford to take. And, by the way, that's not a good hit for businesses, either – because if Congress lets middle-class taxes go up, economists will tell you that means people will spend nearly $200 billion less than they otherwise would spend. Consumer spending is going to go down. That means you've got less customers. Businesses get fewer profits. They hire fewer workers. You go in a downward spiral. Wrong idea.

Here is the good news: We can solve this problem. All Congress needs to do is pass a law that would prevent a tax hike on the first $250,000 of everybody's income – everybody. (Applause.) That means 98 percent of Americans – and probably 100 percent of you – (laughter) – 97 percent of small businesses wouldn't see their income taxes go up a single dime. Even the wealthiest Americans would still get a tax cut on the first $250,000 of their income. But when they start making a million, or $10 million, or $20 million you can afford to pay a little bit more. (Applause.) You're not too strapped.

So Congress can do that right now. Everybody says they agree with it. Let's get it done. (Applause.)

So that's the bare minimum. That's the bare minimum we should be doing in order to the grow the economy. But we can do more. We can do more than just extend middle-class tax cuts. I've said I will work with Republicans on a plan for economic growth, job creation, and reducing our deficits. And that has some compromise between Democrats and Republicans. I understand people have a lot of different views. I'm willing to compromise a little bit.

But if we're serious about reducing our deficit, we've also got to be serious about investing in the things that help us grow and make the middle class strong, like education, and research and development, and making sure kids can go to college, and rebuilding our roads and our infrastructure. (Applause.) We've got to do that.

So when you put it all together, what you need is a package that keeps taxes where they are for middle-class families; we make some tough spending cuts on things that we don't need; and then we ask the wealthiest

Americans to pay a slightly higher tax rate. And that's a principle I won't compromise on, because I'm not going to have a situation where the wealthiest among us, including folks like me, get to keep all our tax breaks, and then we're asking students to pay higher student loans. Or suddenly, a school doesn't have schoolbooks because the school district couldn't afford it. Or some family that has a disabled kid isn't getting the help that they need through Medicaid.

We're not going to do that. We're not going to make that tradeoff. That's not going to help us to grow. Our economic success has never come from the top down; it comes from the middle out. It comes from the bottom up. (Applause.) It comes from folks like you working hard, and if you're working hard and you're successful, then you become customers and everybody does well.

Our success as a country in this new century will be defined by how well we educate our kids, how well we train our workers, how well we invent, how well we innovate, how well we build things like cars and engines – all the things that helped create the greatest middle class the world has ever known. That's how you bring new jobs back to Detroit. That's how you bring good jobs back to America. That's what I'm focused on. That's what I will stay relentlessly focused on going forward. (Applause.)

Because when we focus on these things — when we stay true to ourselves and our history, there's nothing we can't do. (Applause.) And if you don't believe me, you need to come down to this plant and see all these outstanding workers.

In fact, as I was coming over here, I was hearing about a guy named Willie. (Applause.) Where's Willie? There's Willie right here. There's Willie. (Applause.) Now, in case you haven't heard of him, they actually call him "Pretty Willie." (Laughter.) Now, I got to say you got to be pretty tough to have a nickname like "Pretty Willie." (Laughter.) He's tough.

On Wednesday, Willie will celebrate 60 years working at Detroit Diesel – 60 years. (Applause.) Willie started back on December 12, 1952. I was not born yet. (Laughter.) Wasn't even close to being born. He made $1.40 an hour. The only time he spent away from this plant was when he was serving our country in the Korean War. (Applause.) So three generations of Willie's family have passed through Detroit Diesel. One of his daughters works here with him right now – is that right? There she is. (Applause.)

In all his years, Willie has been late to work only once. It was back in 1977. (Laughter.) It's been so long he can't remember why he was late – (laughter and applause) – but we're willing to give him a pass.

So Willie believes in hard work. You don't keep a job for 60 years if you don't work hard. Sooner or later, someone is going to fire you if you don't work hard. He takes pride in being part of something bigger than himself. He's committed to family; he's committed to community; he's committed to country. That's how Willie lives his life. That's how all of you live your lives.

And that makes me hopeful about the future, because you're out there fighting every day for a better future for your family and your country. And when you do that, that means you're creating value all across this economy. You're inspiring people. You're being a good example for your kids. That's what makes America great. That's what we have to stay focused on.

And as long as I've got the privilege of serving as your President, I'm going to keep fighting for you. I'm going to keep fighting for your kids. I'm going to keep fighting for an America where anybody, no matter who you are, no matter what you look like, no matter where you come from, you can make it if you try here in America. (Applause.)

Thank you very much, everybody. God bless you. (Applause.)

END
2:51 P.M. EST

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Remarks of President Barack Obama – As Prepared for Delivery
Address to Joint Session of Congress
Tuesday, February 24th, 2009

(en español)

Madame Speaker, Mr. Vice President, Members of Congress, and the First Lady of the United States:

I've come here tonight not only to address the distinguished men and women in this great chamber, but to speak frankly and directly to the men and women who sent us here.

I know that for many Americans watching right now, the state of our economy is a concern that rises above all others. And rightly so. If you haven't been personally affected by this recession, you probably know someone who has – a friend; a neighbor; a member of your family. You don't need to hear another list of statistics to know that our economy is in crisis, because you live it every day. It's the worry you wake up with and the source of sleepless nights. It's the job you thought you'd retire from but now have lost; the business you built your dreams upon that's now hanging by a thread; the college acceptance letter your child had to put back in the envelope. The impact of this recession is real, and it is everywhere.

But while our economy may be weakened and our confidence shaken; though we are living through difficult and uncertain times, tonight I want every American to know this:

We will rebuild, we will recover, and the United States of America will emerge stronger than before.

The weight of this crisis will not determine the destiny of this nation. The answers to our problems don't lie beyond our reach. They exist in our laboratories and universities; in our fields and our factories; in the imaginations of our entrepreneurs and the pride of the hardest-working people on Earth. Those qualities that have made America the greatest force of progress and prosperity in human history we still possess in ample measure. What is required now is for this country to pull together, confront boldly the challenges we face, and take responsibility for our future once more.

Now, if we're honest with ourselves, we'll admit that for too long, we have not always met these responsibilities – as a government or as a people. I say this not to lay blame or look backwards, but because it is only by understanding how we arrived at this moment that we'll be able to lift ourselves out of this predicament.

The fact is, our economy did not fall into decline overnight. Nor did all of our problems begin when the housing market collapsed or the stock market sank. We have known for decades that our survival depends on finding new sources of energy. Yet we import more oil today than ever before. The cost of health care eats up more and more of our savings each year, yet we keep delaying reform. Our children will compete for jobs in a global economy that too many of our schools do not prepare them for. And though all these challenges went unsolved, we still managed to spend more money and pile up more debt, both as individuals and through our government, than ever before.

In other words, we have lived through an era where too often, short-term gains were prized over long-term prosperity; where we failed to look beyond the next payment, the next quarter, or the next election. A surplus became an excuse to transfer wealth to the wealthy instead of an opportunity to invest in our future. Regulations were gutted for the sake of a quick profit at the expense of a healthy market. People bought homes they knew they couldn't afford from banks and lenders who pushed those bad loans anyway. And all the while, critical debates and difficult decisions were put off for some other time on some other day.

Well that day of reckoning has arrived, and the time to take charge of our future is here.

Now is the time to act boldly and wisely – to not only revive this economy, but to build a new foundation for lasting prosperity. Now is the time to jumpstart job creation, re-start lending, and invest in areas like energy, health care, and education that will grow our economy, even as we make hard choices to bring our deficit down. That is what my economic agenda is designed to do, and that's what I'd like to talk to you about tonight.

WATCH THE VIDEO

February 24, 2009 4:30 PM

The President Addresses Joint Session of Congress: February 24, 2009

BLOG POSTS ON THIS ISSUE

January 23, 2013 12:45 PM EST

Fireside Hangouts: Vice President Biden Joins a Conversation on Reducing Gun Violence

On Thursday, January 24 at 1:45 p.m. ET, Vice President Biden will host the latest "Fireside Hangout" – a 21st century take on FDR's famous radio addresses – to talk about reducing gun violence.

January 23, 2013 10:40 AM EST

Surprise! President and Mrs. Obama Greet White House Tour (Bo Was There, Too)

The President and First Lady welcomed the guests with handshakes, hugs and even fistbumps, and Bo was treated to a near-constant stream of affectionate pats and petting.

January 21, 2013 3:26 PM EST

Be a Part of the Next Four Years

The President's second term will offer many ways

It's an agenda that begins with jobs.

As soon as I took office, I asked this Congress to send me a recovery plan by President's Day that would put people back to work and put money in their pockets. Not because I believe in bigger government – I don't. Not because I'm not mindful of the massive debt we've inherited – I am. I called for action because the failure to do so would have cost more jobs and caused more hardships. In fact, a failure to act would have worsened our long-term deficit by assuring weak economic growth for years. That's why I pushed for quick action. And tonight, I am grateful that this Congress delivered, and pleased to say that the American Recovery and Reinvestment Act is now law.

Over the next two years, this plan will save or create 3.5 million jobs. More than 90% of these jobs will be in the private sector – jobs rebuilding our roads and bridges; constructing wind turbines and solar panels; laying broadband and expanding mass transit.

Because of this plan, there are teachers who can now keep their jobs and educate our kids. Health care professionals can continue caring for our sick. There are 57 police officers who are still on the streets of Minneapolis tonight because this plan prevented the layoffs their department was about to make.

Because of this plan, 95% of the working households in America will receive a tax cut – a tax cut that you will see in your paychecks beginning on April 1st.

Because of this plan, families who are struggling to pay tuition costs will receive a $2,500 tax credit for all four years of college. And Americans who have lost their jobs in this recession will be able to receive extended unemployment benefits and continued health care coverage to help them weather this storm.

I know there are some in this chamber and watching at home who are skeptical of whether this plan will work. I understand that skepticism. Here in Washington, we've all seen how quickly good intentions can turn into broken promises and wasteful spending. And with a plan of this scale comes enormous responsibility to get it right.

That is why I have asked Vice President Biden to lead a tough, unprecedented oversight effort – because nobody messes with Joe. I have told each member of my Cabinet as well as mayors and governors across the country that they will be held accountable by me and the American people for every dollar they spend. I have appointed a proven and aggressive Inspector General to ferret out any and all cases of waste and fraud. And we have created a new website called recovery.gov so that every American can find out how and where their money is being spent.

So the recovery plan we passed is the first step in getting our economy back on track. But it is just the first step. Because even if we manage this plan flawlessly, there will be no real recovery unless we clean up the credit crisis that has severely weakened our financial system.

I want to speak plainly and candidly about this issue tonight, because every American should know that it directly affects you and your family's well-being. You should also know that the money you've deposited in banks across the country is safe; your insurance is secure; and you can rely on the continued operation of our financial system. That is not the source of concern.

The concern is that if we do not re-start lending in this country, our recovery will be choked off before it even begins.

You see, the flow of credit is the lifeblood of our economy. The ability to get a loan is how you finance the purchase of everything from a home to a car to a college education; how stores stock their shelves, farms buy equipment, and businesses make payroll.

But credit has stopped flowing the way it should. Too many bad loans from the housing crisis have made their way onto the books of too many banks. With so much debt and so little confidence, these banks are now fearful of lending out any more money to households, to businesses, or to each other. When there is no lending, families can't afford to buy homes or cars. So businesses are forced to make layoffs. Our economy suffers even more, and credit dries up even further.

That is why this administration is moving swiftly and aggressively to break this destructive cycle, restore confidence, and re-start lending.

We will do so in several ways. First, we are creating a new lending fund that represents the largest effort ever to help provide auto loans, college loans, and small business loans to the consumers and entrepreneurs who keep this economy running.

Second, we have launched a housing plan that will help responsible families facing the threat of foreclosure lower their monthly payments and re-finance their mortgages. It's a plan that won't help speculators or that neighbor down the street who bought a house he could never hope to afford, but it will help millions of Americans who are struggling with declining home values – Americans who will now be able to take advantage of the lower

for citizens to participate in conversations with the President and his team about the issues that are most important to them.

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interest rates that this plan has already helped bring about. In fact, the average family who re-finances today can save nearly $2000 per year on their mortgage.

Third, we will act with the full force of the federal government to ensure that the major banks that Americans depend on have enough confidence and enough money to lend even in more difficult times. And when we learn that a major bank has serious problems, we will hold accountable those responsible, force the necessary adjustments, provide the support to clean up their balance sheets, and assure the continuity of a strong, viable institution that can serve our people and our economy.

I understand that on any given day, Wall Street may be more comforted by an approach that gives banks bailouts with no strings attached, and that holds nobody accountable for their reckless decisions. But such an approach won't solve the problem. And our goal is to quicken the day when we re-start lending to the American people and American business and end this crisis once and for all.

I intend to hold these banks fully accountable for the assistance they receive, and this time, they will have to clearly demonstrate how taxpayer dollars result in more lending for the American taxpayer. This time, CEOs won't be able to use taxpayer money to pad their paychecks or buy fancy drapes or disappear on a private jet. Those days are over.

Still, this plan will require significant resources from the federal government – and yes, probably more than we've already set aside. But while the cost of action will be great, I can assure you that the cost of inaction will be far greater, for it could result in an economy that sputters along for not months or years, but perhaps a decade. That would be worse for our deficit, worse for business, worse for you, and worse for the next generation. And I refuse to let that happen.

I understand that when the last administration asked this Congress to provide assistance for struggling banks, Democrats and Republicans alike were infuriated by the mismanagement and results that followed. So were the American taxpayers. So was I.

So I know how unpopular it is to be seen as helping banks right now, especially when everyone is suffering in part from their bad decisions. I promise you – I get it.

But I also know that in a time of crisis, we cannot afford to govern out of anger, or yield to the politics of the moment. My job – our job – is to solve the problem. Our job is to govern with a sense of responsibility. I will not spend a single penny for the purpose of rewarding a single Wall Street executive, but I will do whatever it takes to help the small business that can't pay its workers or the family that has saved and still can't get a mortgage.

That's what this is about. It's not about helping banks – it's about helping people. Because when credit is available again, that young family can finally buy a new home. And then some company will hire workers to build it. And then those workers will have money to spend, and if they can get a loan too, maybe they'll finally buy that car, or open their own business. Investors will return to the market, and American families will see their retirement secured once more. Slowly, but surely, confidence will return, and our economy will recover.

So I ask this Congress to join me in doing whatever proves necessary. Because we cannot consign our nation to an open-ended recession. And to ensure that a crisis of this magnitude never happens again, I ask Congress to move quickly on legislation that will finally reform our outdated regulatory system. It is time to put in place tough, new common-sense rules of the road so that our financial market rewards drive and innovation, and punishes short-cuts and abuse.

The recovery plan and the financial stability plan are the immediate steps we're taking to revive our economy in the short-term. But the only way to fully restore America's economic strength is to make the long-term investments that will lead to new jobs, new industries, and a renewed ability to compete with the rest of the world. The only way this century will be another American century is if we confront at last the price of our dependence on oil and the high cost of health care; the schools that aren't preparing our children and the mountain of debt they stand to inherit. That is our responsibility.

In the next few days, I will submit a budget to Congress. So often, we have come to view these documents as simply numbers on a page or laundry lists of programs. I see this document differently. I see it as a vision for America – as a blueprint for our future.

My budget does not attempt to solve every problem or address every issue. It reflects the stark reality of what we've inherited – a trillion dollar deficit, a financial crisis, and a costly recession.

Given these realities, everyone in this chamber – Democrats and Republicans – will have to sacrifice some worthy priorities for which there are no dollars. And that includes me.

But that does not mean we can afford to ignore our long-term challenges. I reject the view that says our problems will simply take care of themselves; that says government has no role in laying the foundation for our common prosperity.

For history tells a different story. History reminds us that at every moment of economic upheaval and transformation, this nation has responded with bold action and big ideas. In the midst of civil war, we laid railroad tracks from one coast to another that spurred commerce and industry. From the turmoil of the Industrial Revolution came a system of public high schools that prepared our citizens for a new age. In the wake of war and depression, the GI Bill sent a generation to college and created the largest middle-class in history. And a twilight struggle for freedom led to a nation of highways, an American on the moon, and an explosion of technology that still shapes our world.

In each case, government didn't supplant private enterprise; it catalyzed private enterprise. It created the conditions for thousands of entrepreneurs and new businesses to adapt and to thrive.

We are a nation that has seen promise amid peril, and claimed opportunity from ordeal. Now we must be that nation again. That is why, even as it cuts back on the programs we don't need, the budget I submit will invest in the three areas that are absolutely critical to our economic future: energy, health care, and education.

It begins with energy.

We know the country that harnesses the power of clean, renewable energy will lead the 21st century. And yet, it is China that has launched the largest effort in history to make their economy energy efficient. We invented solar technology, but we've fallen behind countries like Germany and Japan in producing it. New plug-in hybrids roll off our assembly lines, but they will run on batteries made in Korea.

Well I do not accept a future where the jobs and industries of tomorrow take root beyond our borders – and I know you don't either. It is time for America to lead again.

Thanks to our recovery plan, we will double this nation's supply of renewable energy in the next three years. We have also made the largest investment in basic research funding in American history – an investment that will spur not only new discoveries in energy, but breakthroughs in medicine, science, and technology.

We will soon lay down thousands of miles of power lines that can carry new energy to cities and towns across this country. And we will put Americans to work making our homes and buildings more efficient so that we can save billions of dollars on our energy bills.

But to truly transform our economy, protect our security, and save our planet from the ravages of climate change, we need to ultimately make clean, renewable energy the profitable kind of energy. So I ask this Congress to send me legislation that places a market-based cap on carbon pollution and drives the production of more renewable energy in America. And to support that innovation, we will invest fifteen billion dollars a year to develop technologies like wind power and solar power; advanced biofuels, clean coal, and more fuel-efficient cars and trucks built right here in America.

As for our auto industry, everyone recognizes that years of bad decision-making and a global recession have pushed our automakers to the brink. We should not, and will not, protect them from their own bad practices. But we are committed to the goal of a re-tooled, re-imagined auto industry that can compete and win. Millions of jobs depend on it. Scores of communities depend on it. And I believe the nation that invented the automobile cannot walk away from it.

None of this will come without cost, nor will it be easy. But this is America. We don't do what's easy. We do what is necessary to move this country forward.

For that same reason, we must also address the crushing cost of health care.

This is a cost that now causes a bankruptcy in America every thirty seconds. By the end of the year, it could cause 1.5 million Americans to lose their homes. In the last eight years, premiums have grown four times faster than wages. And in each of these years, one million more Americans have lost their health insurance. It is one of the major reasons why small businesses close their doors and corporations ship jobs overseas. And it's one of the largest and fastest-growing parts of our budget.

Given these facts, we can no longer afford to put health care reform on hold.

Already, we have done more to advance the cause of health care reform in the last thirty days than we have in the last decade. When it was days old, this Congress passed a law to provide and protect health insurance for eleven million American children whose parents work full-time. Our recovery plan will invest in electronic health records and new technology that will reduce errors, bring down costs, ensure privacy, and save lives. It will launch a new effort to conquer a disease that has touched the life of nearly every American by seeking a cure for cancer in our time. And it makes the largest investment ever in preventive care, because that is one of the best ways to keep our people healthy and our costs under control.

This budget builds on these reforms. It includes an historic commitment to comprehensive health care reform – a down-payment on the principle that we must have quality, affordable health care for every American. It's a commitment that's paid for in part by efficiencies in our system that are long overdue. And it's a step we must

take if we hope to bring down our deficit in the years to come.

Now, there will be many different opinions and ideas about how to achieve reform, and that is why I'm bringing together businesses and workers, doctors and health care providers, Democrats and Republicans to begin work on this issue next week.

I suffer no illusions that this will be an easy process. It will be hard. But I also know that nearly a century after Teddy Roosevelt first called for reform, the cost of our health care has weighed down our economy and the conscience of our nation long enough. So let there be no doubt: health care reform cannot wait, it must not wait, and it will not wait another year.

The third challenge we must address is the urgent need to expand the promise of education in America.

In a global economy where the most valuable skill you can sell is your knowledge, a good education is no longer just a pathway to opportunity – it is a pre-requisite.

Right now, three-quarters of the fastest-growing occupations require more than a high school diploma. And yet, just over half of our citizens have that level of education. We have one of the highest high school dropout rates of any industrialized nation. And half of the students who begin college never finish.

This is a prescription for economic decline, because we know the countries that out-teach us today will out-compete us tomorrow. That is why it will be the goal of this administration to ensure that every child has access to a complete and competitive education – from the day they are born to the day they begin a career.

Already, we have made an historic investment in education through the economic recovery plan. We have dramatically expanded early childhood education and will continue to improve its quality, because we know that the most formative learning comes in those first years of life. We have made college affordable for nearly seven million more students. And we have provided the resources necessary to prevent painful cuts and teacher layoffs that would set back our children's progress.

But we know that our schools don't just need more resources. They need more reform. That is why this budget creates new incentives for teacher performance; pathways for advancement, and rewards for success. We'll invest in innovative programs that are already helping schools meet high standards and close achievement gaps. And we will expand our commitment to charter schools.

It is our responsibility as lawmakers and educators to make this system work. But it is the responsibility of every citizen to participate in it. And so tonight, I ask every American to commit to at least one year or more of higher education or career training. This can be community college or a four-year school; vocational training or an apprenticeship. But whatever the training may be, every American will need to get more than a high school diploma. And dropping out of high school is no longer an option. It's not just quitting on yourself, it's quitting on your country – and this country needs and values the talents of every American. That is why we will provide the support necessary for you to complete college and meet a new goal: by 2020, America will once again have the highest proportion of college graduates in the world.

I know that the price of tuition is higher than ever, which is why if you are willing to volunteer in your neighborhood or give back to your community or serve your country, we will make sure that you can afford a higher education. And to encourage a renewed spirit of national service for this and future generations, I ask this Congress to send me the bipartisan legislation that bears the name of Senator Orrin Hatch as well as an American who has never stopped asking what he can do for his country – Senator Edward Kennedy.

These education policies will open the doors of opportunity for our children. But it is up to us to ensure they walk through them. In the end, there is no program or policy that can substitute for a mother or father who will attend those parent/teacher conferences, or help with homework after dinner, or turn off the TV, put away the video games, and read to their child. I speak to you not just as a President, but as a father when I say that responsibility for our children's education must begin at home.

There is, of course, another responsibility we have to our children. And that is the responsibility to ensure that we do not pass on to them a debt they cannot pay. With the deficit we inherited, the cost of the crisis we face, and the long-term challenges we must meet, it has never been more important to ensure that as our economy recovers, we do what it takes to bring this deficit down.

I'm proud that we passed the recovery plan free of earmarks, and I want to pass a budget next year that ensures that each dollar we spend reflects only our most important national priorities.

Yesterday, I held a fiscal summit where I pledged to cut the deficit in half by the end of my first term in office. My administration has also begun to go line by line through the federal budget in order to eliminate wasteful and ineffective programs. As you can imagine, this is a process that will take some time. But we're starting with the biggest lines. We have already identified two trillion dollars in savings over the next decade.

In this budget, we will end education programs that don't work and end direct payments to large agribusinesses

that don't need them. We'll eliminate the no-bid contracts that have wasted billions in Iraq, and reform our defense budget so that we're not paying for Cold War-era weapons systems we don't use. We will root out the waste, fraud, and abuse in our Medicare program that doesn't make our seniors any healthier, and we will restore a sense of fairness and balance to our tax code by finally ending the tax breaks for corporations that ship our jobs overseas.

In order to save our children from a future of debt, we will also end the tax breaks for the wealthiest 2% of Americans. But let me perfectly clear, because I know you'll hear the same old claims that rolling back these tax breaks means a massive tax increase on the American people: if your family earns less than $250,000 a year, you will not see your taxes increased a single dime. I repeat: not one single dime. In fact, the recovery plan provides a tax cut – that's right, a tax cut – for 95% of working families. And these checks are on the way.

To preserve our long-term fiscal health, we must also address the growing costs in Medicare and Social Security. Comprehensive health care reform is the best way to strengthen Medicare for years to come. And we must also begin a conversation on how to do the same for Social Security, while creating tax-free universal savings accounts for all Americans.

Finally, because we're also suffering from a deficit of trust, I am committed to restoring a sense of honesty and accountability to our budget. That is why this budget looks ahead ten years and accounts for spending that was left out under the old rules – and for the first time, that includes the full cost of fighting in Iraq and Afghanistan. For seven years, we have been a nation at war. No longer will we hide its price.

We are now carefully reviewing our policies in both wars, and I will soon announce a way forward in Iraq that leaves Iraq to its people and responsibly ends this war.

And with our friends and allies, we will forge a new and comprehensive strategy for Afghanistan and Pakistan to defeat al Qaeda and combat extremism. Because I will not allow terrorists to plot against the American people from safe havens half a world away.

As we meet here tonight, our men and women in uniform stand watch abroad and more are readying to deploy. To each and every one of them, and to the families who bear the quiet burden of their absence, Americans are united in sending one message: we honor your service, we are inspired by your sacrifice, and you have our unyielding support. To relieve the strain on our forces, my budget increases the number of our soldiers and Marines. And to keep our sacred trust with those who serve, we will raise their pay, and give our veterans the expanded health care and benefits that they have earned.

To overcome extremism, we must also be vigilant in upholding the values our troops defend – because there is no force in the world more powerful than the example of America. That is why I have ordered the closing of the detention center at Guantanamo Bay, and will seek swift and certain justice for captured terrorists – because living our values doesn't make us weaker, it makes us safer and it makes us stronger. And that is why I can stand here tonight and say without exception or equivocation that the United States of America does not torture.

In words and deeds, we are showing the world that a new era of engagement has begun. For we know that America cannot meet the threats of this century alone, but the world cannot meet them without America. We cannot shun the negotiating table, nor ignore the foes or forces that could do us harm. We are instead called to move forward with the sense of confidence and candor that serious times demand.

To seek progress toward a secure and lasting peace between Israel and her neighbors, we have appointed an envoy to sustain our effort. To meet the challenges of the 21st century – from terrorism to nuclear proliferation; from pandemic disease to cyber threats to crushing poverty – we will strengthen old alliances, forge new ones, and use all elements of our national power.

And to respond to an economic crisis that is global in scope, we are working with the nations of the G-20 to restore confidence in our financial system, avoid the possibility of escalating protectionism, and spur demand for American goods in markets across the globe. For the world depends on us to have a strong economy, just as our economy depends on the strength of the world's.

As we stand at this crossroads of history, the eyes of all people in all nations are once again upon us – watching to see what we do with this moment; waiting for us to lead.

Those of us gathered here tonight have been called to govern in extraordinary times. It is a tremendous burden, but also a great privilege – one that has been entrusted to few generations of Americans. For in our hands lies the ability to shape our world for good or for ill.

I know that it is easy to lose sight of this truth – to become cynical and doubtful; consumed with the petty and the trivial.

But in my life, I have also learned that hope is found in unlikely places; that inspiration often comes not from those with the most power or celebrity, but from the dreams and aspirations of Americans who are anything but ordinary.

I think about Leonard Abess, the bank president from Miami who reportedly cashed out of his company, took a $60 million bonus, and gave it out to all 399 people who worked for him, plus another 72 who used to work for him. He didn't tell anyone, but when the local newspaper found out, he simply said, "I knew some of these people since I was 7 years old. I didn't feel right getting the money myself."

I think about Greensburg, Kansas, a town that was completely destroyed by a tornado, but is being rebuilt by its residents as a global example of how clean energy can power an entire community – how it can bring jobs and businesses to a place where piles of bricks and rubble once lay. "The tragedy was terrible," said one of the men who helped them rebuild. "But the folks here know that it also provided an incredible opportunity."

And I think about Ty'Sheoma Bethea, the young girl from that school I visited in Dillon, South Carolina – a place where the ceilings leak, the paint peels off the walls, and they have to stop teaching six times a day because the train barrels by their classroom. She has been told that her school is hopeless, but the other day after class she went to the public library and typed up a letter to the people sitting in this room. She even asked her principal for the money to buy a stamp. The letter asks us for help, and says, "We are just students trying to become lawyers, doctors, congressmen like yourself and one day president, so we can make a change to not just the state of South Carolina but also the world. We are not quitters."

We are not quitters.

These words and these stories tell us something about the spirit of the people who sent us here. They tell us that even in the most trying times, amid the most difficult circumstances, there is a generosity, a resilience, a decency, and a determination that perseveres; a willingness to take responsibility for our future and for posterity.

Their resolve must be our inspiration. Their concerns must be our cause. And we must show them and all our people that we are equal to the task before us.

I know that we haven't agreed on every issue thus far, and there are surely times in the future when we will part ways. But I also know that every American who is sitting here tonight loves this country and wants it to succeed. That must be the starting point for every debate we have in the coming months, and where we return after those debates are done. That is the foundation on which the American people expect us to build common ground.

And if we do – if we come together and lift this nation from the depths of this crisis; if we put our people back to work and restart the engine of our prosperity; if we confront without fear the challenges of our time and summon that enduring spirit of an America that does not quit, then someday years from now our children can tell their children that this was the time when we performed, in the words that are carved into this very chamber, "something worthy to be remembered." Thank you, God Bless you, and may God Bless the United States of America.

Technical Support Document: -
Social Cost of Carbon for Regulatory Impact Analysis -
Under Executive Order 12866 -

Interagency Working Group on Social Cost of Carbon, United States Government

With participation by

Council of Economic Advisers
Council on Environmental Quality
Department of Agriculture
Department of Commerce
Department of Energy
Department of Transportation
Environmental Protection Agency
National Economic Council
Office of Energy and Climate Change
Office of Management and Budget
Office of Science and Technology Policy
Department of the Treasury

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Executive Summary

Under Executive Order 12866, agencies are required, to the extent permitted by law, "to assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs." The purpose of the "social cost of carbon" (SCC) estimates presented here is to allow agencies to incorporate the social benefits of reducing carbon dioxide (CO_2) emissions into cost-benefit analyses of regulatory actions that have small, or "marginal," impacts on cumulative global emissions. The estimates are presented with an acknowledgement of the many uncertainties involved and with a clear understanding that they should be updated over time to reflect increasing knowledge of the science and economics of climate impacts.

The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change.

This document presents a summary of the interagency process that developed these SCC estimates. Technical experts from numerous agencies met on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key model inputs and assumptions. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions grounded in the existing scientific and economic literatures. In this way, key uncertainties and model differences transparently and consistently inform the range of SCC estimates used in the rulemaking process.

The interagency group selected four SCC values for use in regulatory analyses. Three values are based on the average SCC from three integrated assessment models, at discount rates of 2.5, 3, and 5 percent. The fourth value, which represents the 95th percentile SCC estimate across all three models at a 3 percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution.

Social Cost of CO_2, 2010 – 2050 (in 2007 dollars)

Discount Rate	5%	3%	2.5%	3%
Year	Avg	Avg	Avg	95th
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

I. Monetizing Carbon Dioxide Emissions

The "social cost of carbon" (SCC) is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services. We report estimates of the social cost of carbon in dollars per metric ton of carbon dioxide throughout this document.[1]

When attempting to assess the incremental economic impacts of carbon dioxide emissions, the analyst faces a number of serious challenges. A recent report from the National Academies of Science (NRC 2009) points out that any assessment will suffer from uncertainty, speculation, and lack of information about (1) future emissions of greenhouse gases, (2) the effects of past and future emissions on the climate system, (3) the impact of changes in climate on the physical and biological environment, and (4) the translation of these environmental impacts into economic damages. As a result, any effort to quantify and monetize the harms associated with climate change will raise serious questions of science, economics, and ethics and should be viewed as provisional.

Despite the serious limits of both quantification and monetization, SCC estimates can be useful in estimating the social benefits of reducing carbon dioxide emissions. Under Executive Order 12866, agencies are required, to the extent permitted by law, "to assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs." The purpose of the SCC estimates presented here is to make it possible for agencies to incorporate the social benefits from reducing carbon dioxide emissions into cost-benefit analyses of regulatory actions that have small, or "marginal," impacts on cumulative global emissions. Most federal regulatory actions can be expected to have marginal impacts on global emissions.

For such policies, the benefits from reduced (or costs from increased) emissions in any future year can be estimated by multiplying the change in emissions in that year by the SCC value appropriate for that year. The net present value of the benefits can then be calculated by multiplying each of these future benefits by an appropriate discount factor and summing across all affected years. This approach assumes that the marginal damages from increased emissions are constant for small departures from the baseline emissions path, an approximation that is reasonable for policies that have effects on emissions that are small relative to cumulative global carbon dioxide emissions. For policies that have a large (non-marginal) impact on global cumulative emissions, there is a separate question of whether the SCC is an appropriate tool for calculating the benefits of reduced emissions; we do not attempt to answer that question here.

An interagency group convened on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key inputs and assumptions in order to generate SCC estimates. Agencies that actively participated in the interagency process include the Environmental Protection

[1] In this document, we present all values of the SCC as the cost per metric ton of CO_2 emissions. Alternatively, one could report the SCC as the cost per metric ton of carbon emissions. The multiplier for translating between mass of CO_2 and the mass of carbon is 3.67 (the molecular weight of CO_2 divided by the molecular weight of carbon = 44/12 = 3.67).

Agency, and the Departments of Agriculture, Commerce, Energy, Transportation, and Treasury. This process was convened by the Council of Economic Advisers and the Office of Management and Budget, with active participation and regular input from the Council on Environmental Quality, National Economic Council, Office of Energy and Climate Change, and Office of Science and Technology Policy. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions that are grounded in the existing literature. In this way, key uncertainties and model differences can more transparently and consistently inform the range of SCC estimates used in the rulemaking process.

The interagency group selected four SCC estimates for use in regulatory analyses. For 2010, these estimates are $5, $21, $35, and $65 (in 2007 dollars). The first three estimates are based on the average SCC across models and socio-economic and emissions scenarios at the 5, 3, and 2.5 percent discount rates, respectively. The fourth value is included to represent the higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. For this purpose, we use the SCC value for the 95th percentile at a 3 percent discount rate. The central value is the average SCC across models at the 3 percent discount rate. For purposes of capturing the uncertainties involved in regulatory impact analysis, we emphasize the importance and value of considering the full range. These SCC estimates also grow over time. For instance, the central value increases to $24 per ton of CO_2 in 2015 and $26 per ton of CO_2 in 2020. See Appendix A for the full range of annual SCC estimates from 2010 to 2050.

It is important to emphasize that the interagency process is committed to updating these estimates as the science and economic understanding of climate change and its impacts on society improves over time. Specifically, we have set a preliminary goal of revisiting the SCC values within two years or at such time as substantially updated models become available, and to continue to support research in this area. In the meantime, we will continue to explore the issues raised in this document and consider public comments as part of the ongoing interagency process.

II. Social Cost of Carbon Values Used in Past Regulatory Analyses

To date, economic analyses for Federal regulations have used a wide range of values to estimate the benefits associated with reducing carbon dioxide emissions. In the final model year 2011 CAFE rule, the Department of Transportation (DOT) used both a "domestic" SCC value of $2 per ton of CO_2 and a "global" SCC value of $33 per ton of CO_2 for 2007 emission reductions (in 2007 dollars), increasing both values at 2.4 percent per year. It also included a sensitivity analysis at $80 per ton of CO_2. A domestic SCC value is meant to reflect the value of damages in the United States resulting from a unit change in carbon dioxide emissions, while a global SCC value is meant to reflect the value of damages worldwide.

A 2008 regulation proposed by DOT assumed a domestic SCC value of $7 per ton CO_2 (in 2006 dollars) for 2011 emission reductions (with a range of $0-$14 for sensitivity analysis), also increasing at 2.4 percent per year. A regulation finalized by DOE in October of 2008 used a domestic SCC range of $0 to $20 per ton CO_2 for 2007 emission reductions (in 2007 dollars). In addition, EPA's 2008 Advance Notice of Proposed Rulemaking for Greenhouse Gases identified what it described as "very preliminary" SCC estimates subject to revision. EPA's global mean values were $68 and $40 per ton CO_2 for discount rates of approximately 2 percent and 3 percent, respectively (in 2006 dollars for 2007 emissions).

In 2009, an interagency process was initiated to offer a preliminary assessment of how best to quantify the benefits from reducing carbon dioxide emissions. To ensure consistency in how benefits are evaluated across agencies, the Administration sought to develop a transparent and defensible method, specifically designed for the rulemaking process, to quantify avoided climate change damages from reduced CO_2 emissions. The interagency group did not undertake any original analysis. Instead, it combined SCC estimates from the existing literature to use as interim values until a more comprehensive analysis could be conducted.

The outcome of the preliminary assessment by the interagency group was a set of five interim values: global SCC estimates for 2007 (in 2006 dollars) of $55, $33, $19, $10, and $5 per ton of CO_2. The $33 and $5 values represented model-weighted means of the published estimates produced from the most recently available versions of three integrated assessment models—DICE, PAGE, and FUND—at approximately 3 and 5 percent discount rates. The $55 and $10 values were derived by adjusting the published estimates for uncertainty in the discount rate (using factors developed by Newell and Pizer (2003)) at 3 and 5 percent discount rates, respectively. The $19 value was chosen as a central value between the $5 and $33 per ton estimates. All of these values were assumed to increase at 3 percent annually to represent growth in incremental damages over time as the magnitude of climate change increases.

These interim values represent the first sustained interagency effort within the U.S. government to develop an SCC for use in regulatory analysis. The results of this preliminary effort were presented in several proposed and final rules and were offered for public comment in connection with proposed rules, including the joint EPA-DOT fuel economy and CO_2 tailpipe emission proposed rules.

III. Approach and Key Assumptions

Since the release of the interim values, interagency group has reconvened on a regular basis to generate improved SCC estimates. Specifically, the group has considered public comments and further explored the technical literature in relevant fields. This section details the several choices and assumptions that underlie the resulting estimates of the SCC.

It is important to recognize that a number of key uncertainties remain, and that current SCC estimates should be treated as provisional and revisable since they will evolve with improved scientific and economic understanding. The interagency group also recognizes that the existing models are imperfect and incomplete. The National Academy of Science (2009) points out that there is tension between the goal of producing quantified estimates of the economic damages from an incremental ton of carbon and the limits of existing efforts to model these effects. Throughout this document, we highlight a number of concerns and problems that should be addressed by the research community, including research programs housed in many of the agencies participating in the interagency process to estimate the SCC.

The U.S. Government will periodically review and reconsider estimates of the SCC used for cost-benefit analyses to reflect increasing knowledge of the science and economics of climate impacts, as well as improvements in modeling. In this context, statements recognizing the limitations of the analysis and calling for further research take on exceptional significance. The interagency group offers the new SCC values with all due humility about the uncertainties embedded in them and with a sincere promise to continue work to improve them.

A. Integrated Assessment Models

We rely on three integrated assessment models (IAMs) commonly used to estimate the SCC: the FUND, DICE, and PAGE models.[2] These models are frequently cited in the peer-reviewed literature and used in the IPCC assessment. Each model is given equal weight in the SCC values developed through this process, bearing in mind their different limitations (discussed below).

These models are useful because they combine climate processes, economic growth, and feedbacks between the climate and the global economy into a single modeling framework. At the same time, they gain this advantage at the expense of a more detailed representation of the underlying climatic and economic systems. DICE, PAGE, and FUND all take stylized, reduced-form approaches (see NRC 2009 for a more detailed discussion; see Nordhaus 2008 on the possible advantages of this approach). Other IAMs may better reflect the complexity of the science in their modeling frameworks but do not link physical impacts to economic damages. There is currently a limited amount of research linking climate impacts to economic damages, which makes this exercise even more difficult. Underlying the three IAMs selected for this exercise are a number of simplifying assumptions and judgments reflecting the various modelers' best attempts to synthesize the available scientific and economic research characterizing these relationships.

The three IAMs translate emissions into changes in atmospheric greenhouse concentrations, atmospheric concentrations into changes in temperature, and changes in temperature into economic damages. The emissions projections used in the models are based on specified socio-economic (GDP and population) pathways. These emissions are translated into concentrations using the carbon cycle built into each model, and concentrations are translated into warming based on each model's simplified representation of the climate and a key parameter, climate sensitivity. Each model uses a different approach to translate warming into damages. Finally, transforming the stream of economic damages over time into a single value requires judgments about how to discount them.

Each model takes a slightly different approach to model how changes in emissions result in changes in economic damages. In PAGE, for example, the consumption-equivalent damages in each period are calculated as a fraction of GDP, depending on the temperature in that period relative to the pre-industrial average temperature in each region. In FUND, damages in each period also depend on the rate of temperature change from the prior period. In DICE, temperature affects both consumption and investment. We describe each model in greater detail here. In a later section, we discuss key gaps in how the models account for various scientific and economic processes (e.g. the probability of catastrophe, and the ability to adapt to climate change and the physical changes it causes).

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[2] The DICE (Dynamic Integrated Climate and Economy) model by William Nordhaus evolved from a series of energy models and was first presented in 1990 (Nordhaus and Boyer 2000, Nordhaus 2008). The PAGE (Policy Analysis of the Greenhouse Effect) model was developed by Chris Hope in 1991 for use by European decision-makers in assessing the marginal impact of carbon emissions (Hope 2006, Hope 2008). The FUND (Climate Framework for Uncertainty, Negotiation, and Distribution) model, developed by Richard Tol in the early 1990s, originally to study international capital transfers in climate policy. is now widely used to study climate impacts (e.g., Tol 2002a, Tol 2002b, Anthoff et al. 2009, Tol 2009).

The parameters and assumptions embedded in the three models vary widely. A key objective of the interagency process was to enable a consistent exploration of the three models while respecting the different approaches to quantifying damages taken by the key modelers in the field. An extensive review of the literature was conducted to select three sets of input parameters for these models: climate sensitivity, socio-economic and emissions trajectories, and discount rates. A probability distribution for climate sensitivity was specified as an input into all three models. In addition, the interagency group used a range of scenarios for the socio-economic parameters and a range of values for the discount rate. All other model features were left unchanged, relying on the model developers' best estimates and judgments. In DICE, these parameters are handled deterministically and represented by fixed constants; in PAGE, most parameters are represented by probability distributions. FUND was also run in a mode in which parameters were treated probabilistically.

The sensitivity of the results to other aspects of the models (e.g. the carbon cycle or damage function) is also important to explore in the context of future revisions to the SCC but has not been incorporated into these estimates. Areas for future research are highlighted at the end of this document.

The DICE Model

The DICE model is an optimal growth model based on a global production function with an extra stock variable (atmospheric carbon dioxide concentrations). Emission reductions are treated as analogous to investment in "natural capital." By investing in natural capital today through reductions in emissions—implying reduced consumption—harmful effects of climate change can be avoided and future consumption thereby increased.

For purposes of estimating the SCC, carbon dioxide emissions are a function of global GDP and the carbon intensity of economic output, with the latter declining over time due to technological progress. The DICE damage function links global average temperature to the overall impact on the world economy. It varies quadratically with temperature change to capture the more rapid increase in damages expected to occur under more extreme climate change, and is calibrated to include the effects of warming on the production of market and nonmarket goods and services. It incorporates impacts on agriculture, coastal areas (due to sea level rise), "other vulnerable market sectors" (based primarily on changes in energy use), human health (based on climate-related diseases, such as malaria and dengue fever, and pollution), non-market amenities (based on outdoor recreation), and human settlements and ecosystems. The DICE damage function also includes the expected value of damages associated with low probability, high impact "catastrophic" climate change. This last component is calibrated based on a survey of experts (Nordhaus 1994). The expected value of these impacts is then added to the other market and non-market impacts mentioned above.

No structural components of the DICE model represent adaptation explicitly, though it is included implicitly through the choice of studies used to calibrate the aggregate damage function. For example, its agricultural impact estimates assume that farmers can adjust land use decisions in response to changing climate conditions, and its health impact estimates assume improvements in healthcare over time. In addition, the small impacts on forestry, water systems, construction, fisheries, and outdoor recreation imply optimistic and costless adaptation in these sectors (Nordhaus and Boyer, 2000; Warren

et al., 2006). Costs of resettlement due to sea level rise are incorporated into damage estimates, but their magnitude is not clearly reported. Mastrandrea's (2009) review concludes that "in general, DICE assumes very effective adaptation, and largely ignores adaptation costs."

Note that the damage function in DICE has a somewhat different meaning from the damage functions in FUND and PAGE. Because GDP is endogenous in DICE and because damages in a given year reduce investment in that year, damages propagate forward in time and reduce GDP in future years. In contrast, GDP is exogenous in FUND and PAGE, so damages in any given year do not propagate forward.[3]

The PAGE Model

PAGE2002 (version 1.4epm) treats GDP growth as exogenous. It divides impacts into economic, non-economic, and catastrophic categories and calculates these impacts separately for eight geographic regions. Damages in each region are expressed as a fraction of output, where the fraction lost depends on the temperature change in each region. Damages are expressed as power functions of temperature change. The exponents of the damage function are the same in all regions but are treated as uncertain, with values ranging from 1 to 3 (instead of being fixed at 2 as in DICE).

PAGE2002 includes the consequences of catastrophic events in a separate damage sub-function. Unlike DICE, PAGE2002 models these events probabilistically. The probability of a "discontinuity" (i.e., a catastrophic event) is assumed to increase with temperature above a specified threshold. The threshold temperature, the rate at which the probability of experiencing a discontinuity increases above the threshold, and the magnitude of the resulting catastrophe are all modeled probabilistically.

Adaptation is explicitly included in PAGE. Impacts are assumed to occur for temperature increases above some tolerable level (2°C for developed countries and 0°C for developing countries for economic impacts, and 0°C for all regions for non-economic impacts), but adaptation is assumed to reduce these impacts. Default values in PAGE2002 assume that the developed countries can ultimately eliminate up to 90 percent of all economic impacts beyond the tolerable 2°C increase and that developing countries can eventually eliminate 50 percent of their economic impacts. All regions are assumed to be able to mitigate 25 percent of the non-economic impacts through adaptation (Hope 2006).

The FUND Model

Like PAGE, the FUND model treats GDP growth as exogenous. It includes separately calibrated damage functions for eight market and nonmarket sectors: agriculture, forestry, water, energy (based on heating and cooling demand), sea level rise (based on the value of land lost and the cost of protection),

[3] Using the default assumptions in DICE 2007, this effect generates an approximately 25 percent increase in the SCC relative to damages calculated by fixing GDP. In DICE2007, the time path of GDP is endogenous. Specifically, the path of GDP depends on the rate of saving and level of abatement in each period chosen by the optimizing representative agent in the model. We made two modifications to DICE to make it consistent with EMF GDP trajectories (see next section): we assumed a fixed rate of savings of 20%, and we re-calibrated the exogenous path of total factor productivity so that DICE would produce GDP projections in the absence of warming that exactly matched the EMF scenarios.

ecosystems, human health (diarrhea, vector-borne diseases, and cardiovascular and respiratory mortality), and extreme weather. Each impact sector has a different functional form, and is calculated separately for sixteen geographic regions. In some impact sectors, the fraction of output lost or gained due to climate change depends not only on the absolute temperature change but also on the rate of temperature change and level of regional income.[4] In the forestry and agricultural sectors, economic damages also depend on CO_2 concentrations.

Tol (2009) discusses impacts not included in FUND, noting that many are likely to have a relatively small effect on damage estimates (both positive and negative). However, he characterizes several omitted impacts as "big unknowns": for instance, extreme climate scenarios, biodiversity loss, and effects on economic development and political violence. With regard to potentially catastrophic events, he notes, "Exactly what would cause these sorts of changes or what effects they would have are not well-understood, although the chance of any one of them happening seems low. But they do have the potential to happen relatively quickly, and if they did, the costs could be substantial. Only a few studies of climate change have examined these issues."

Adaptation is included both implicitly and explicitly in FUND. Explicit adaptation is seen in the agriculture and sea level rise sectors. Implicit adaptation is included in sectors such as energy and human health, where wealthier populations are assumed to be less vulnerable to climate impacts. For example, the damages to agriculture are the sum of three effects: (1) those due to the rate of temperature change (damages are always positive); (2) those due to the level of temperature change (damages can be positive or negative depending on region and temperature); and (3) those from CO_2 fertilization (damages are generally negative but diminishing to zero).

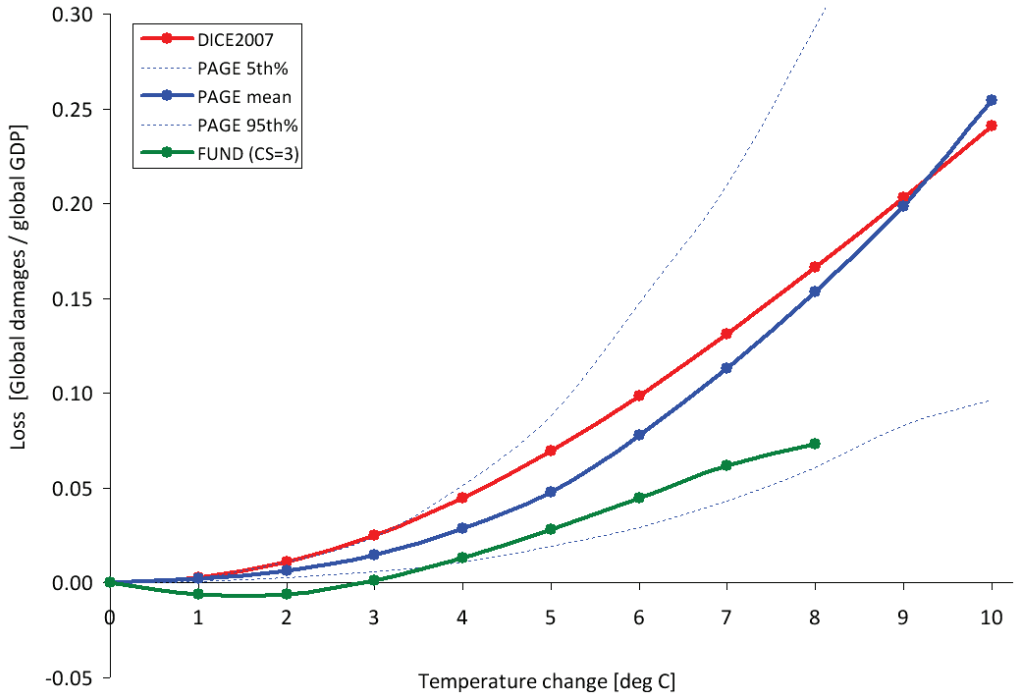
Adaptation is incorporated into FUND by allowing damages to be smaller if climate change happens more slowly. The combined effect of CO_2 fertilization in the agricultural sector, positive impacts to some regions from higher temperatures, and sufficiently slow increases in temperature across these sectors can result in negative economic damages from climate change.

Damage Functions

To generate revised SCC values, we rely on the IAM modelers' current best judgments of how to represent the effects of climate change (represented by the increase in global-average surface temperature) on the consumption-equivalent value of both market and non-market goods (represented as a fraction of global GDP). We recognize that these representations are incomplete and highly uncertain. But given the paucity of data linking the physical impacts to economic damages, we were not able to identify a better way to translate changes in climate into net economic damages, short of launching our own research program.

[4] In the deterministic version of FUND, the majority of damages are attributable to increased air conditioning demand, while reduced cold stress in Europe, North America, and Central and East Asia results in health benefits in those regions at low to moderate levels of warming (Warren et al., 2006).

Figure 1A: Annual Consumption Loss as a Fraction of Global GDP in 2100 Due to an Increase in Annual - Global Temperature in the DICE, FUND, and PAGE models[5]



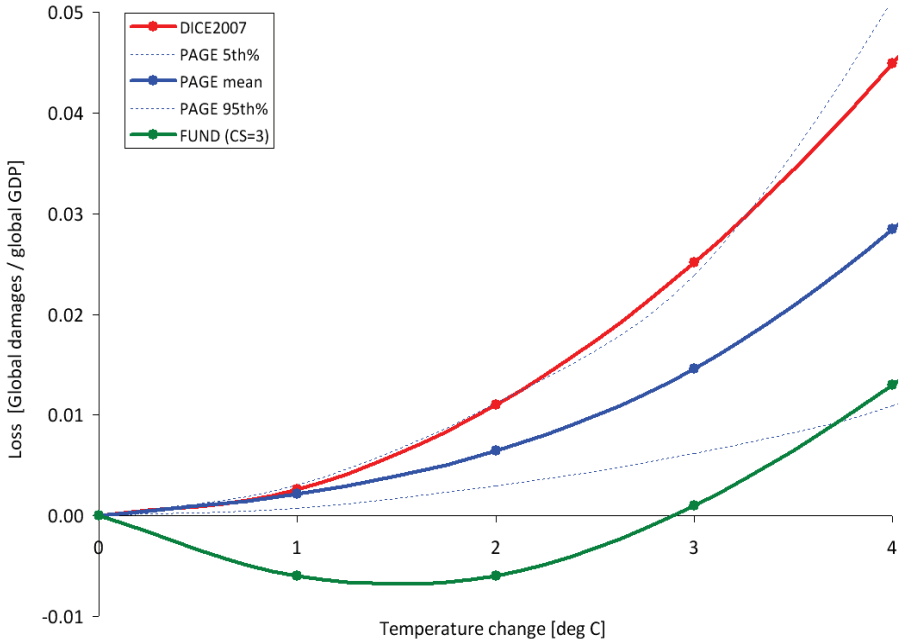
The damage functions for the three IAMs are presented in Figures 1A and 1B, using the modeler's default scenarios and mean input assumptions. There are significant differences between the three models both at lower (figure 1B) and higher (figure 1A) increases in global-average temperature.

The lack of agreement among the models at lower temperature increases is underscored by the fact that the damages from FUND are well below the 5th percentile estimated by PAGE, while the damages estimated by DICE are roughly equal to the 95th percentile estimated by PAGE. This is significant because at higher discount rates we expect that a greater proportion of the SCC value is due to damages in years with lower temperature increases. For example, when the discount rate is 2.5 percent, about 45 percent of the 2010 SCC value in DICE is due to damages that occur in years when the temperature is less than or equal to 3 °C. This increases to approximately 55 percent and 80 percent at discount rates of 3 and 5 percent, respectively.

These differences underscore the need for a thorough review of damage functions—in particular, how the models incorporate adaptation, technological change, and catastrophic damages. Gaps in the literature make modifying these aspects of the models challenging, which highlights the need for additional research. As knowledge improves, the Federal government is committed to exploring how these (and other) models can be modified to incorporate more accurate estimates of damages.

[5] The x-axis represents increases in annual, rather than equilibrium, temperature, while the y-axis represents the annual stream of benefits as a share of global GDP. Each specific combination of climate sensitivity, socio-economic, and emissions parameters will produce a different realization of damages for each IAM. The damage functions represented in Figures 1A and 1B are the outcome of default assumptions. For instance, under alternate assumptions, the damages from FUND may cross from negative to positive at less than or greater than 3 °C.

Figure 1B: Annual Consumption Loss for Lower Temperature Changes in DICE, FUND, and PAGE -



B. Global versus Domestic Measures of SCC

Because of the distinctive nature of the climate change problem, we center our current attention on a global measure of SCC. This approach is the same as that taken for the interim values, but it otherwise represents a departure from past practices, which tended to put greater emphasis on a domestic measure of SCC (limited to impacts of climate change experienced within U.S. borders). As a matter of law, consideration of both global and domestic values is generally permissible; the relevant statutory provisions are usually ambiguous and allow selection of either measure.[6]

Global SCC

Under current OMB guidance contained in Circular A-4, analysis of economically significant proposed and final regulations from the domestic perspective is required, while analysis from the international perspective is optional. However, the climate change problem is highly unusual in at least two respects. First, it involves a global externality: emissions of most greenhouse gases contribute to damages around the world even when they are emitted in the United States. Consequently, to address the global nature of the problem, the SCC must incorporate the full (global) damages caused by GHG emissions. Second, climate change presents a problem that the United States alone cannot solve. Even if the United States were to reduce its greenhouse gas emissions to zero, that step would be far from enough to avoid substantial climate change. Other countries would also need to take action to reduce emissions if

[6] It is true that federal statutes are presumed not to have extraterritorial effect, in part to ensure that the laws of the United States respect the interests of foreign sovereigns. But use of a global measure for the SCC does not give extraterritorial effect to federal law and hence does not intrude on such interests.

significant changes in the global climate are to be avoided. Emphasizing the need for a global solution to a global problem, the United States has been actively involved in seeking international agreements to reduce emissions and in encouraging other nations, including emerging major economies, to take significant steps to reduce emissions. When these considerations are taken as a whole, the interagency group concluded that a global measure of the benefits from reducing U.S. emissions is preferable.

When quantifying the damages associated with a change in emissions, a number of analysts (e.g., Anthoff, et al. 2009a) employ "equity weighting" to aggregate changes in consumption across regions. This weighting takes into account the relative reductions in wealth in different regions of the world. A per-capita loss of $500 in GDP, for instance, is weighted more heavily in a country with a per-capita GDP of $2,000 than in one with a per-capita GDP of $40,000. The main argument for this approach is that a loss of $500 in a poor country causes a greater reduction in utility or welfare than does the same loss in a wealthy nation. Notwithstanding the theoretical claims on behalf of equity weighting, the interagency group concluded that this approach would not be appropriate for estimating a SCC value used in domestic regulatory analysis.[7] For this reason, the group concluded that using the global (rather than domestic) value, without equity weighting, is the appropriate approach.

Domestic SCC

As an empirical matter, the development of a domestic SCC is greatly complicated by the relatively few region- or country-specific estimates of the SCC in the literature. One potential source of estimates comes from the FUND model. The resulting estimates suggest that the ratio of domestic to global benefits of emission reductions varies with key parameter assumptions. For example, with a 2.5 or 3 percent discount rate, the U.S. benefit is about 7-10 percent of the global benefit, on average, across the scenarios analyzed. Alternatively, if the fraction of GDP lost due to climate change is assumed to be similar across countries, the domestic benefit would be proportional to the U.S. share of global GDP, which is currently about 23 percent.[8]

On the basis of this evidence, the interagency workgroup determined that a range of values from 7 to 23 percent should be used to adjust the global SCC to calculate domestic effects. Reported domestic values should use this range. It is recognized that these values are approximate, provisional, and highly speculative. There is no a priori reason why domestic benefits should be a constant fraction of net global damages over time. Further, FUND does not account for how damages in other regions could affect the United States (e.g., global migration, economic and political destabilization). If more accurate methods for calculating the domestic SCC become available, the Federal government will examine these to determine whether to update its approach.

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[7] It is plausible that a loss of $X inflicts more serious harm on a poor nation than on a wealthy one, but development of the appropriate "equity weight" is challenging. Emissions reductions also impose costs, and hence a full account would have to consider that a given cost of emissions reductions imposes a greater utility or welfare loss on a poor nation than on a wealthy one. Even if equity weighting—for both the costs and benefits of emissions reductions—is appropriate when considering the utility or welfare effects of international action, the interagency group concluded that it should not be used in developing an SCC for use in regulatory policy at this time.

[8] Based on 2008 GDP (in current US dollars) from the *World Bank Development Indicators Report*.

C. Valuing Non-CO_2 Emissions

While CO_2 is the most prevalent greenhouse gas emitted into the atmosphere, the U.S. included five other greenhouse gases in its recent endangerment finding: methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. The climate impact of these gases is commonly discussed in terms of their 100-year global warming potential (GWP). GWP measures the ability of different gases to trap heat in the atmosphere (i.e., radiative forcing per unit of mass) over a particular timeframe relative to CO_2. However, because these gases differ in both radiative forcing and atmospheric lifetimes, their relative damages are not constant over time. For example, because methane has a short lifetime, its impacts occur primarily in the near term and thus are not discounted as heavily as those caused by longer-lived gases. Impacts other than temperature change also vary across gases in ways that are not captured by GWP. For instance, CO_2 emissions, unlike methane and other greenhouse gases, contribute to ocean acidification. Likewise, damages from methane emissions are not offset by the positive effect of CO_2 fertilization. Thus, transforming gases into CO_2-equivalents using GWP, and then multiplying the carbon-equivalents by the SCC, would not result in accurate estimates of the social costs of non-CO_2 gases.

In light of these limitations, and the significant contributions of non-CO_2 emissions to climate change, further research is required to link non-CO_2 emissions to economic impacts. Such work would feed into efforts to develop a monetized value of reductions in non-CO_2 greenhouse gas emissions. As part of ongoing work to further improve the SCC estimates, the interagency group hopes to develop methods to value these other greenhouse gases. The goal is to develop these estimates by the time we issue revised SCC estimates for carbon dioxide emissions.

D. Equilibrium Climate Sensitivity

Equilibrium climate sensitivity (ECS) is a key input parameter for the DICE, PAGE, and FUND models.[9] It is defined as the long-term increase in the annual global-average surface temperature from a doubling of atmospheric CO_2 concentration relative to pre-industrial levels (or stabilization at a concentration of approximately 550 parts per million (ppm)). Uncertainties in this important parameter have received substantial attention in the peer-reviewed literature.

The most authoritative statement about equilibrium climate sensitivity appears in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC):

> *Basing our assessment on a combination of several independent lines of evidence…including observed climate change and the strength of known feedbacks simulated in [global climate models], we conclude that the global mean equilibrium warming for doubling CO_2, or 'equilibrium climate*

[9] The equilibrium climate sensitivity includes the response of the climate system to increased greenhouse gas concentrations over the short to medium term (up to 100-200 years), but it does not include long-term feedback effects due to possible large-scale changes in ice sheets or the biosphere, which occur on a time scale of many hundreds to thousands of years (e.g. Hansen et al. 2007).

sensitivity', is likely to lie in the range 2 °C to 4.5 °C, with a most likely value of about 3 °C. Equilibrium climate sensitivity is very likely larger than 1.5 °C. [10]

For fundamental physical reasons as well as data limitations, values substantially higher than 4.5 °C still cannot be excluded, but agreement with observations and proxy data is generally worse for those high values than for values in the 2 °C to 4.5 °C range. (Meehl et al., 2007, p 799)

After consulting with several lead authors of this chapter of the IPCC report, the interagency workgroup selected four candidate probability distributions and calibrated them to be consistent with the above statement: Roe and Baker (2007), log-normal, gamma, and Weibull. Table 1 included below gives summary statistics for the four calibrated distributions.

Table 1: Summary Statistics for Four Calibrated Climate Sensitivity Distributions

	Roe & Baker	Log-normal	Gamma	Weibull
Pr(ECS < 1.5°C)	0.013	0.050	0.070	0.102
Pr(2°C < ECS < 4.5°C)	0.667	0.667	0.667	0.667
5th percentile	1.72	1.49	1.37	1.13
10th percentile	1.91	1.74	1.65	1.48
Mode	2.34	2.52	2.65	2.90
Median (50th percentile)	3.00	3.00	3.00	3.00
Mean	3.50	3.28	3.19	3.07
90th percentile	5.86	5.14	4.93	4.69
95th percentile	7.14	5.97	5.59	5.17

Each distribution was calibrated by applying three constraints from the IPCC:

(1) a median equal to 3°C, to reflect the judgment of "a most likely value of about 3 °C";[11]
(2) two-thirds probability that the equilibrium climate sensitivity lies between 2 and 4.5 °C; and
(3) zero probability that it is less than 0°C or greater than 10°C (see Hegerl et al. 2006, p. 721).

We selected the calibrated Roe and Baker distribution from the four candidates for two reasons. First, the Roe and Baker distribution is the only one of the four that is based on a theoretical understanding of the response of the climate system to increased greenhouse gas concentrations (Roe and Baker 2007,

[10] This is in accord with the judgment that it "is likely to lie in the range 2 °C to 4.5 °C" and the IPCC definition of "likely" as greater than 66 percent probability (Le Treut et al.2007). "Very likely" indicates a greater than 90 percent probability.

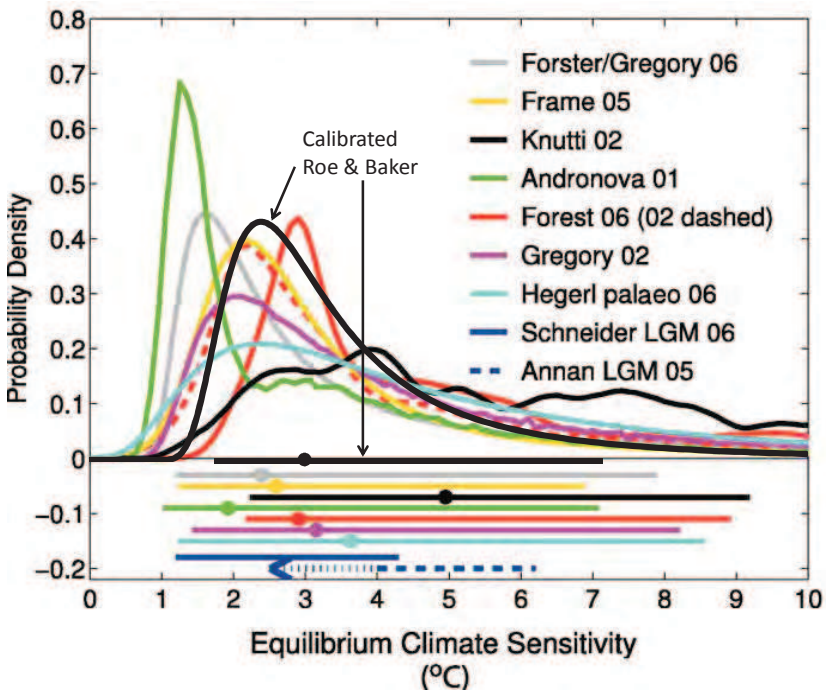
[11] Strictly speaking, "most likely" refers to the mode of a distribution rather than the median, but common usage would allow the mode, median, or mean to serve as candidates for the central or "most likely" value and the IPCC report is not specific on this point. For the distributions we considered, the median was between the mode and the mean. For the Roe and Baker distribution, setting the median equal to 3°C, rather than the mode or mean, gave a 95th percentile that is more consistent with IPCC judgments and the literature. For example, setting the mean and mode equal to 3°C produced 95th percentiles of 5.6 and 8.6 °C, respectively, which are in the lower and upper end of the range in the literature. Finally, the median is closer to 3°C than is the mode for the truncated distributions selected by the IPCC (Hegerl, et al., 2006); the average median is 3.1 °C and the average mode is 2.3 °C, which is most consistent with a Roe and Baker distribution with the median set equal to 3 °C.

Roe 2008). In contrast, the other three distributions are mathematical functions that are arbitrarily chosen based on simplicity, convenience, and general shape. The Roe and Baker distribution results from three assumptions about climate response: (1) absent feedback effects, the equilibrium climate sensitivity is equal to 1.2 °C; (2) feedback factors are proportional to the change in surface temperature; and (3) uncertainties in feedback factors are normally distributed. There is widespread agreement on the first point and the second and third points are common assumptions.

Second, the calibrated Roe and Baker distribution better reflects the IPCC judgment that "values substantially higher than 4.5°C still cannot be excluded." Although the IPCC made no quantitative judgment, the 95th percentile of the calibrated Roe & Baker distribution (7.1 °C) is much closer to the mean and the median (7.2 °C) of the 95th percentiles of 21 previous studies summarized by Newbold and Daigneault (2009). It is also closer to the mean (7.5 °C) and median (7.9 °C) of the nine truncated distributions examined by the IPCC (Hegerl, et al., 2006) than are the 95th percentiles of the three other calibrated distributions (5.2-6.0 °C).

Finally, we note the IPCC judgment that the equilibrium climate sensitivity "is very likely larger than 1.5°C." Although the calibrated Roe & Baker distribution, for which the probability of equilibrium climate sensitivity being greater than 1.5°C is almost 99 percent, is not inconsistent with the IPCC definition of "very likely" as "greater than 90 percent probability," it reflects a greater degree of certainty about very low values of ECS than was expressed by the IPCC.

Figure 2: Estimates of the Probability Density Function for Equilibrium Climate Sensitivity (°C)



To show how the calibrated Roe and Baker distribution compares to different estimates of the probability distribution function of equilibrium climate sensitivity in the empirical literature, Figure 2 (below) overlays it on Figure 9.20 from the IPCC Fourth Assessment Report. These functions are scaled

to integrate to unity between 0 °C and 10 °C. The horizontal bars show the respective 5 percent to 95 percent ranges; dots indicate the median estimate.[12]

E. Socio-Economic and Emissions Trajectories

Another key issue considered by the interagency group is how to select the set of socio-economic and emissions parameters for use in PAGE, DICE, and FUND. Socio-economic pathways are closely tied to climate damages because, all else equal, more and wealthier people tend to emit more greenhouse gases and also have a higher (absolute) willingness to pay to avoid climate disruptions. For this reason, we consider how to model several input parameters in tandem: GDP, population, CO_2 emissions, and non-CO_2 radiative forcing. A wide variety of scenarios have been developed and used for climate change policy simulations (e.g., SRES 2000, CCSP 2007, EMF 2009). In determining which scenarios are appropriate for inclusion, we aimed to select scenarios that span most of the plausible ranges of outcomes for these variables.

To accomplish this task in a transparent way, we decided to rely on the recent Stanford Energy Modeling Forum exercise, EMF-22. EMF-22 uses ten well-recognized models to evaluate substantial, coordinated global action to meet specific stabilization targets. A key advantage of relying on these data is that GDP, population, and emission trajectories are internally consistent for each model and scenario evaluated. The EMF-22 modeling effort also is preferable to the IPCC SRES due to their age (SRES were developed in 1997) and the fact that 3 of 4 of the SRES scenarios are now extreme outliers in one or more variables. Although the EMF-22 scenarios have not undergone the same level of scrutiny as the SRES scenarios, they are recent, peer-reviewed, published, and publicly available.

To estimate the SCC for use in evaluating domestic policies that will have a small effect on global cumulative emissions, we use socio-economic and emission trajectories that span a range of plausible scenarios. Five trajectories were selected from EMF-22 (see Table 2 below). Four of these represent potential business-as-usual (BAU) growth in population, wealth, and emissions and are associated with CO_2 (only) concentrations ranging from 612 to 889 ppm in 2100. One represents an emissions pathway that achieves stabilization at 550 ppm CO_2e (i.e., CO_2-only concentrations of 425 – 484 ppm or a radiative forcing of 3.7 W/m^2) in 2100, a lower-than-BAU trajectory.[13] Out of the 10 models included in the EMF-22 exercise, we selected the trajectories used by MiniCAM, MESSAGE, IMAGE, and the optimistic scenario from MERGE. For the BAU pathways, we used the GDP, population, and emission trajectories from each of these four models. For the 550 ppm CO_2e scenario, we averaged the GDP, population, and emission trajectories implied by these same four models.

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[12] The estimates based on instrumental data are from Andronova and Schlesinger (2001), Forest et al. (2002; dashed line, anthropogenic forcings only), Forest et al. (2006; solid line, anthropogenic and natural forcings), Gregory et al. (2002a), Knutti et al. (2002), Frame et al. (2005), and Forster and Gregory (2006). Hegerl et al. (2006) are based on multiple palaeoclimatic reconstructions of north hemisphere mean temperatures over the last 700 years. Also shown are the 5-95 percent approximate ranges for two estimates from the last glacial maximum (dashed, Annan et al. 2005; solid, Schneider von Deimling et al. 2006), which are based on models with different structural properties.

[13] Such an emissions path would be consistent with widespread action by countries to mitigate GHG emissions, though it could also result from technological advances. It was chosen because it represents the most stringent case analyzed by the EMF-22 where all the models converge: a 550 ppm, not to exceed, full participation scenario.

Table 2: Socioeconomic and Emissions Projections from Select EMF-22 Reference Scenarios -

Reference Fossil and Industrial CO_2 Emissions ($GtCO_2$/yr) -

EMF – 22 Based Scenarios	2000	2010	2020	2030	2050	2100
IMAGE	26.6	31.9	36.9	40.0	45.3	60.1
MERGE Optimistic	24.6	31.5	37.6	45.1	66.5	117.9
MESSAGE	26.8	29.2	37.6	42.1	43.5	42.7
MiniCAM	26.5	31.8	38.0	45.1	57.8	80.5
550 ppm average	26.2	31.1	33.2	32.4	20.0	12.8

Reference GDP (using market exchange rates in trillion 2005$)[14]

EMF – 22 Based Scenarios	2000	2010	2020	2030	2050	2100
IMAGE	38.6	53.0	73.5	97.2	156.3	396.6
MERGE Optimistic	36.3	45.9	59.7	76.8	122.7	268.0
MESSAGE	38.1	52.3	69.4	91.4	153.7	334.9
MiniCAM	36.1	47.4	60.8	78.9	125.7	369.5
550 ppm average	37.1	49.6	65.6	85.5	137.4	337.9

Global Population (billions)

EMF – 22 Based Scenarios	2000	2010	2020	2030	2050	2100
IMAGE	6.1	6.9	7.6	8.2	9.0	9.1
MERGE Optimistic	6.0	6.8	7.5	8.2	9.0	9.7
MESSAGE	6.1	6.9	7.7	8.4	9.4	10.4
MiniCAM	6.0	6.8	7.5	8.1	8.8	8.7
550 ppm average	6.1	6.8	7.6	8.2	8.7	9.1

We explore how sensitive the SCC is to various assumptions about how the future will evolve without prejudging what is likely to occur. The interagency group considered formally assigning probability weights to different states of the world, but this proved challenging to do in an analytically rigorous way given the dearth of information on the likelihood of a full range of future socio-economic pathways.

There are a number of caveats. First, EMF BAU scenarios represent the modelers' judgment of the most likely pathway absent mitigation policies to reduce greenhouse gas emissions, rather than the wider range of possible outcomes. Nevertheless, these views of the most likely outcome span a wide range,

[14] While the EMF-22 models used market exchange rates (MER) to calculate global GDP, it is also possible to use purchasing power parity (PPP). PPP takes into account the different price levels across countries, so it more accurately describes relative standards of living across countries. MERs tend to make low-income countries appear poorer than they actually are. Because many models assume convergence in per capita income over time, use of MER-adjusted GDP gives rise to projections of higher economic growth in low income countries. There is an ongoing debate about how much this will affect estimated climate impacts. Critics of the use of MER argue that it leads to overstated economic growth and hence a significant upward bias in projections of greenhouse gas emissions, and unrealistically high future temperatures (e.g., Castles and Henderson 2003). Others argue that convergence of the emissions-intensity gap across countries at least partially offset the overstated income gap so that differences in exchange rates have less of an effect on emissions (Holtsmark and Alfsen, 2005; Tol, 2006). Nordhaus (2007b) argues that the ideal approach is to use superlative PPP accounts (i.e., using cross-sectional PPP measures for relative incomes and outputs and national accounts price and quantity indexes for time-series extrapolations). However, he notes that it important to keep this debate in perspective; it is by no means clear that exchange-rate-conversion issues are as important as uncertainties about population, technological change, or the many geophysical uncertainties.

from the more optimistic (e.g. abundant low-cost, low-carbon energy) to more pessimistic (e.g. constraints on the availability of nuclear and renewables).[15] Second, the socio-economic trajectories associated with a 550 ppm CO_2e concentration scenario are not derived from an assessment of what policy is optimal from a benefit-cost standpoint. Rather, it is indicative of one possible future outcome. The emission trajectories underlying some BAU scenarios (e.g. MESSAGE's 612 ppm) also are consistent with some modest policy action to address climate change.[16] We chose not to include socio-economic trajectories that achieve even lower GHG concentrations at this time, given the difficulty many models had in converging to meet these targets.

For comparison purposes, the Energy Information Agency in its 2009 Annual Energy Outlook projected that global carbon dioxide emissions will grow to 30.8, 35.6, and 40.4 gigatons in 2010, 2020, and 2030, respectively, while world GDP is projected to be $51.8, $71.0 and $93.9 trillion (in 2005 dollars using market exchange rates) in 2010, 2020, and 2030, respectively. These projections are consistent with one or more EMF-22 scenarios. Likewise, the United Nations' 2008 Population Prospect projects population will grow from 6.1 billion people in 2000 to 9.1 billion people in 2050, which is close to the population trajectories for the IMAGE, MiniCAM, and MERGE models.

In addition to fossil and industrial CO_2 emissions, each EMF scenario provides projections of methane, nitrous oxide, fluorinated greenhouse gases, and net land use CO_2 emissions out to 2100. These assumptions also are used in the three models while retaining the default radiative forcings due to other factors (e.g. aerosols and other gases). See the Appendix for greater detail.

F. Discount Rate

The choice of a discount rate, especially over long periods of time, raises highly contested and exceedingly difficult questions of science, economics, philosophy, and law. Although it is well understood that the discount rate has a large influence on the current value of future damages, there is no consensus about what rates to use in this context. Because carbon dioxide emissions are long-lived, subsequent damages occur over many years. In calculating the SCC, we first estimate the future damages to agriculture, human health, and other market and non-market sectors from an additional unit of carbon dioxide emitted in a particular year in terms of reduced consumption (or consumption equivalents) due to the impacts of elevated temperatures, as represented in each of the three IAMs. Then we discount the stream of future damages to its present value in the year when the additional unit of emissions was released using the selected discount rate, which is intended to reflect society's marginal rate of substitution between consumption in different time periods.

For rules with both intra- and intergenerational effects, agencies traditionally employ constant discount rates of both 3 percent and 7 percent in accordance with OMB Circular A-4. As Circular A-4 acknowledges, however, the choice of discount rate for intergenerational problems raises distinctive

[15] For instance, in the MESSAGE model's reference case total primary energy production from nuclear, biomass, and non-biomass renewables is projected to increase from about 15 percent of total primary energy in 2000 to 54 percent in 2100. In comparison, the MiniCAM reference case shows 10 percent in 2000 and 21 percent in 2100.

[16] For example, MiniCAM projects if all non-US OECD countries reduce CO_2 emissions to 83 percent below 2005 levels by 2050 (per the G-8 agreement) but all other countries continue along a BAU path CO_2 concentrations in 2100 would drop from 794 ppmv in its reference case to 762 ppmv.

problems and presents considerable challenges. After reviewing those challenges, Circular A-4 states, "If your rule will have important intergenerational benefits or costs you might consider a further sensitivity analysis using a lower but positive discount rate in addition to calculating net benefits using discount rates of 3 and 7 percent." For the specific purpose of developing the SCC, we adapt and revise that approach here.

Arrow et al. (1996) outlined two main approaches to determine the discount rate for climate change analysis, which they labeled "descriptive" and "prescriptive." The descriptive approach reflects a positive (non-normative) perspective based on observations of people's actual choices—e.g., savings versus consumption decisions over time, and allocations of savings among more and less risky investments. Advocates of this approach generally call for inferring the discount rate from market rates of return "because of a lack of justification for choosing a social welfare function that is any different than what decision makers [individuals] actually use" (Arrow et al. 1996).

One theoretical foundation for the cost-benefit analyses in which the social cost of carbon will be used—the Kaldor-Hicks potential-compensation test—also suggests that market rates should be used to discount future benefits and costs, because it is the market interest rate that would govern the returns potentially set aside today to compensate future individuals for climate damages that they bear (e.g., Just et al. 2004). As some have noted, the word "potentially" is an important qualification; there is no assurance that such returns will actually be set aside to provide compensation, and the very idea of compensation is difficult to define in the intergenerational context. On the other hand, societies provide compensation to future generations through investments in human capital and the resulting increase in knowledge, as well as infrastructure and other physical capital.

The prescriptive approach specifies a social welfare function that formalizes the normative judgments that the decision-maker wants explicitly to incorporate into the policy evaluation—e.g., how inter-personal comparisons of utility should be made, and how the welfare of future generations should be weighed against that of the present generation. Ramsey (1928), for example, has argued that it is "ethically indefensible" to apply a positive pure rate of time preference to discount values across generations, and many agree with this view.

Other concerns also motivate making adjustments to descriptive discount rates. In particular, it has been noted that the preferences of future generations with regard to consumption versus environmental amenities may not be the same as those today, making the current market rate on consumption an inappropriate metric by which to discount future climate-related damages. Others argue that the discount rate should be below market rates to correct for market distortions and uncertainties or inefficiencies in intergenerational transfers of wealth, which in the Kaldor-Hicks logic are presumed to compensate future generations for damage (a potentially controversial assumption, as noted above) (Arrow et al. 1996, Weitzman 1999).

Further, a legitimate concern about both descriptive and prescriptive approaches is that they tend to obscure important heterogeneity in the population. The utility function that underlies the prescriptive approach assumes a representative agent with perfect foresight and no credit constraints. This is an artificial rendering of the real world that misses many of the frictions that characterize individuals' lives

and indeed the available descriptive evidence supports this. For instance, many individuals smooth consumption by borrowing with credit cards that have relatively high rates. Some are unable to access traditional credit markets and rely on payday lending operations or other high cost forms of smoothing consumption. Whether one puts greater weight on the prescriptive or descriptive approach, the high interest rates that credit-constrained individuals accept suggest that some account should be given to the discount rates revealed by their behavior.

We draw on both approaches but rely primarily on the descriptive approach to inform the choice of discount rate. With recognition of its limitations, we find this approach to be the most defensible and transparent given its consistency with the standard contemporary theoretical foundations of benefit-cost analysis and with the approach required by OMB's existing guidance. The logic of this framework also suggests that market rates should be used for discounting future consumption-equivalent damages. Regardless of the theoretical approach used to derive the appropriate discount rate(s), we note the inherent conceptual and practical difficulties of adequately capturing consumption trade-offs over many decades or even centuries. While relying primarily on the descriptive approach in selecting specific discount rates, the interagency group has been keenly aware of the deeply normative dimensions of both the debate over discounting in the intergenerational context and the consequences of selecting one discount rate over another.

Historically Observed Interest Rates

In a market with no distortions, the return to savings would equal the private return on investment, and the market rate of interest would be the appropriate choice for the social discount rate. In the real world risk, taxes, and other market imperfections drive a wedge between the risk-free rate of return on capital and the consumption rate of interest. Thus, the literature recognizes two conceptual discount concepts—the consumption rate of interest and the opportunity cost of capital.

According to OMB's Circular A-4, it is appropriate to use the rate of return on capital when a regulation is expected to displace or alter the use of capital in the private sector. In this case, OMB recommends Agencies use a discount rate of 7 percent. When regulation is expected to primarily affect private consumption—for instance, via higher prices for goods and services—a lower discount rate of 3 percent is appropriate to reflect how private individuals trade-off current and future consumption.

The interagency group examined the economics literature and concluded that the consumption rate of interest is the correct concept to use in evaluating the benefits and costs of a marginal change in carbon emissions (see Lind 1990, Arrow et al 1996, and Arrow 2000). The consumption rate of interest also is appropriate when the impacts of a regulation are measured in consumption (-equivalent) units, as is done in the three integrated assessment models used for estimating the SCC.

Individuals use a variety of savings instruments that vary with risk level, time horizon, and tax characteristics. The standard analytic framework used to develop intuition about the discount rate typically assumes a representative agent with perfect foresight and no credit constraints. The risk-free rate is appropriate for discounting certain future benefits or costs, but the benefits calculated by IAMs are uncertain. To use the risk-free rate to discount uncertain benefits, these benefits first must be

transformed into "certainty equivalents," that is the maximum certain amount that we would exchange for the uncertain amount. However, the calculation of the certainty-equivalent requires first estimating the correlation between the benefits of the policy and baseline consumption.

If the IAM projections of future impacts represent expected values (not certainty-equivalent values), then the appropriate discount rate generally does not equal the risk-free rate. If the benefits of the policy tend to be high in those states of the world in which consumption is low, then the certainty-equivalent benefits will be higher than the expected benefits (and vice versa). Since many (though not necessarily all) of the important impacts of climate change will flow through market sectors such as agriculture and energy, and since willingness to pay for environmental protections typically increases with income, we might expect a positive (though not necessarily perfect) correlation between the net benefits from climate policies and market returns. This line of reasoning suggests that the proper discount rate would exceed the riskless rate. Alternatively, a negative correlation between the returns to climate policies and market returns would imply that a discount rate below the riskless rate is appropriate.

This discussion suggests that both the post-tax riskless and risky rates can be used to capture individuals' consumption-equivalent interest rate. As a measure of the post-tax riskless rate, we calculate the average real return from Treasury notes over the longest time period available (those from Newell and Pizer 2003) and adjust for Federal taxes (the average marginal rate from tax years 2003 through 2006 is around 27 percent).[17] This calculation produces a real interest rate of about 2.7 percent, which is roughly consistent with Circular A-4's recommendation to use 3 percent to represent the consumption rate of interest.[18] A measure of the post-tax risky rate for investments whose returns are positively correlated with overall equity market returns can be obtained by adjusting pre-tax rates of household returns to risky investments (approximately 7 percent) for taxes yields a real rate of roughly 5 percent.[19]

The Ramsey Equation

Ramsey discounting also provides a useful framework to inform the choice of a discount rate. Under this approach, the analyst applies either positive or normative judgments in selecting values for the key parameters of the Ramsey equation: η (coefficient of relative risk aversion or elasticity of the marginal utility of consumption) and ρ (pure rate of time preference).[20] These are then combined with g (growth

[17] The literature argues for a risk-free rate on government bonds as an appropriate measure of the consumption rate of interest. Arrow (2000) suggests that it is roughly 3-4 percent. OMB cites evidence of a 3.1 percent pre-tax rate for 10-year Treasury notes in the A-4 guidance. Newell and Pizer (2003) find real interest rates between 3.5 and 4 percent for 30-year Treasury securities.

[18] The positive approach reflects how individuals make allocation choices across time, but it is important to keep in mind that we wish to reflect preferences for society as a whole, which generally has a longer planning horizon.

[19] Cambell et al (2001) estimates that the annual real return from stocks for 1900-1995 was about 7 percent. The annual real rate of return for the S&P 500 from 1950 – 2008 was about 6.8 percent. In the absence of a better way to population-weight the tax rates, we use the middle of the 20 – 40 percent range to derive a post-tax interest rate (Kotlikoff and Rapson 2006).

[20] The parameter ρ measures the *pure rate of time preference*: people's behavior reveals a preference for an increase in utility today versus the future. Consequently, it is standard to place a lower weight on utility in the future. The parameter η captures *diminishing marginal utility*: consumption in the future is likely to be higher than consumption today, so diminishing marginal utility of consumption implies that the same monetary damage will

rate of per-capita consumption) to equal the interest rate at which future monetized damages are discounted: $\rho + \eta \cdot g$.[21] In the simplest version of the Ramsey model, with an optimizing representative agent with perfect foresight, what we are calling the "Ramsey discount rate," $\rho + \eta \cdot g$, will be equal to the rate of return to capital, i.e., the market interest rate.

A review of the literature provides some guidance on reasonable parameter values for the Ramsey discounting equation, based on both prescriptive and descriptive approaches.

- η. Most papers in the climate change literature adopt values for η in the range of 0.5 to 3 (Weitzman cites plausible values as those ranging from 1 to 4), although not all authors articulate whether their choice is based on prescriptive or descriptive reasoning.[22] Dasgupta (2008) argues that η should be greater than 1 and may be as high as 3, since η equal to 1 suggests savings rates that do not conform to observed behavior.

- ρ. With respect to the pure rate of time preference, most papers in the climate change literature adopt values for ρ in the range of 0 to 3 percent per year. The very low rates tend to follow from moral judgments involving intergenerational neutrality. Some have argued that to use any value other than $\rho = 0$ would unjustly discriminate against future generations (e.g., Arrow et al. 1996, Stern et al. 2006). However, even in an inter-generational setting, it may make sense to use a small positive pure rate of time preference because of the small probability of unforeseen cataclysmic events (Stern et al. 2006).

- g. A commonly accepted approximation is around 2 percent per year. For the socio-economic scenarios used for this exercise, the EMF models assume that g is about 1.5-2 percent to 2100.

Some economists and non-economists have argued for constant discount rates below 2 percent based on the prescriptive approach. When grounded in the Ramsey framework, proponents of this approach have argued that a ρ of zero avoids giving preferential treatment to one generation over another. The choice of η has also been posed as an ethical choice linked to the value of an additional dollar in poorer

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cause a smaller reduction of utility for wealthier individuals, either in the future or in current generations. If $\eta = 0$, then a one dollar increase in income is equally valuable regardless of level of income; if $\eta = 1$, then a one percent increase in income is equally valuable no matter the level of income; and if $\eta > 1$, then a one percent increase in income is less valuable to wealthier individuals.

[21] In this case, g could be taken from the selected EMF socioeconomic scenarios or alternative assumptions about the rate of consumption growth.

[22] Empirical estimates of η span a wide range of values. A benchmark value of 2 is near the middle of the range of values estimated or used by Szpiro (1986), Hall and Jones (2007), Arrow (2007), Dasgupta (2006, 2008), Weitzman (2007, 2009), and Nordhaus (2008). However, Chetty (2006) developed a method of estimating η using data on labor supply behavior. He shows that existing evidence of the effects of wage changes on labor supply imposes a tight upper bound on the curvature of utility over wealth (CRRA < 2) with the mean implied value of 0.71 and concludes that the standard expected utility model cannot generate high levels of risk aversion without contradicting established facts about labor supply. Recent work has jointly estimated the components of the Ramsey equation. Evans and Sezer (2005) estimate $\eta = 1.49$ for 22 OECD countries. They also estimate $\rho = 1.08$ percent per year using data on mortality rates. Anthoff, et al. (2009b) estimate $\eta = 1.18$, and $\rho = 1.4$ percent. When they multiply the bivariate probability distributions from their work and Evans and Sezer (2005) together, they find $\eta = 1.47$, and $\rho = 1.07$.

countries compared to wealthier ones. Stern et al. (2006) applies this perspective through his choice of ρ = 0.1 percent per year, η = 1 and g = 1.3 percent per year, which yields an annual discount rate of 1.4 percent. In the context of permanent income savings behavior, however, Stern's assumptions suggest that individuals would save 93 percent of their income.[23]

Recently, Stern (2008) revisited the values used in Stern et al. (2006), stating that there is a case to be made for raising η due to the amount of weight lower values place on damages far in the future (over 90 percent of expected damages occur after 2200 with η = 1). Using Stern's assumption that ρ = 0.1 percent, combined with a η of 1.5 to 2 and his original growth rate, yields a discount rate greater 2 percent.

We conclude that arguments made under the prescriptive approach can be used to justify discount rates between roughly 1.4 and 3.1 percent. In light of concerns about the most appropriate value for η, we find it difficult to justify rates at the lower end of this range under the Ramsey framework.

Accounting for Uncertainty in the Discount Rate

While the consumption rate of interest is an important driver of the benefits estimate, it is uncertain over time. Ideally, we would formally model this uncertainty, just as we do for climate sensitivity. Weitzman (1998, 2001) showed theoretically and Newell and Pizer (2003) and Groom et al. (2006) confirm empirically that discount rate uncertainty can have a large effect on net present values. A main result from these studies is that if there is a persistent element to the uncertainty in the discount rate (e.g., the rate follows a random walk), then it will result in an effective (or certainty-equivalent) discount rate that declines over time. Consequently, lower discount rates tend to dominate over the very long term (see Weitzman 1998, 1999, 2001; Newell and Pizer 2003; Groom et al. 2006; Gollier 2008; Summers and Zeckhauser 2008; and Gollier and Weitzman 2009).

The proper way to model discount rate uncertainty remains an active area of research. Newell and Pizer (2003) employ a model of how long-term interest rates change over time to forecast future discount rates. Their model incorporates some of the basic features of how interest rates move over time, and its parameters are estimated based on historical observations of long-term rates. Subsequent work on this topic, most notably Groom et al. (2006), uses more general models of interest rate dynamics to allow for better forecasts. Specifically, the volatility of interest rates depends on whether rates are currently low or high and variation in the level of persistence over time.

While Newell and Pizer (2003) and Groom et al (2006) attempt formally to model uncertainty in the discount rate, others argue for a declining scale of discount rates applied over time (e.g., Weitzman 2001, and the UK's "Green Book" for regulatory analysis). This approach uses a higher discount rate

[23] Stern (2008) argues that building in a positive rate of exogenous technical change over time reduces the implied savings rate and that η at or above 2 are inconsistent with observed behavior with regard to equity. (At the same time, adding exogenous technical change—all else equal—would increase g as well.)

initially, but applies a graduated scale of lower discount rates further out in time.[24] A key question that has emerged with regard to both of these approaches is the trade-off between potential time inconsistency and giving greater weight to far future outcomes (see the EPA Science Advisory Board's recent comments on this topic as part of its review of their *Guidelines for Economic Analysis*).[25]

The Discount Rates Selected for Estimating SCC

In light of disagreement in the literature on the appropriate market interest rate to use in this context and uncertainty about how interest rates may change over time, we use three discount rates to span a plausible range of certainty-equivalent constant discount rates: 2.5, 3, and 5 percent per year. Based on the review in the previous sections, the interagency workgroup determined that these three rates reflect reasonable judgments under both descriptive and prescriptive approaches.

The central value, 3 percent, is consistent with estimates provided in the economics literature and OMB's Circular A-4 guidance for the consumption rate of interest. As previously mentioned, the consumption rate of interest is the correct discounting concept to use when future damages from elevated temperatures are estimated in consumption-equivalent units. Further, 3 percent roughly corresponds to the after-tax riskless interest rate. The upper value of 5 percent is included to represent the possibility that climate damages are positively correlated with market returns. Additionally, this discount rate may be justified by the high interest rates that many consumers use to smooth consumption across periods.

The low value, 2.5 percent, is included to incorporate the concern that interest rates are highly uncertain over time. It represents the average certainty-equivalent rate using the mean-reverting and random walk approaches from Newell and Pizer (2003) starting at a discount rate of 3 percent. Using this approach, the certainty equivalent is about 2.2 percent using the random walk model and 2.8 percent using the mean reverting approach.[26] Without giving preference to a particular model, the average of the two rates is 2.5 percent. Further, a rate below the riskless rate would be justified if climate investments are negatively correlated with the overall market rate of return. Use of this lower value also responds to certain judgments using the prescriptive or normative approach and to ethical objections that have been raised about rates of 3 percent or higher.

[24] For instance, the UK applies a discount rate of 3.5 percent to the first 30 years; 3 percent for years 31 - 75; 2.5 percent for years 76 - 125; 2 percent for years 126 - 200; 1.5 percent for years 201 - 300; and 1 percent after 300 years. As a sensitivity, it recommends a discount rate of 3 percent for the first 30 years, also decreasing over time.

[25] Uncertainty in future damages is distinct from uncertainty in the discount rate. Weitzman (2008) argues that Stern's choice of a low discount rate was "right for the wrong reasons." He demonstrates how the damages from a low probability, catastrophic event far in the future dominate the effect of the discount rate in a present value calculation and result in an infinite willingness-to-pay for mitigation today. Newbold and Daigneault, (2009) and Nordhaus (2009) find that Weitzman's result is sensitive to the functional forms chosen for climate sensitivity, utility, and consumption. Summers and Zeckhauser (2008) argue that uncertainty in future damages can also work in the other direction by increasing the benefits of waiting to learn the appropriate level of mitigation required.

[26] Calculations done by Pizer et al. using the original simulation program from Newell and Pizer (2003).

IV. Revised SCC Estimates

Our general approach to estimating SCC values is to run the three integrated assessment models (FUND, DICE, and PAGE) using the following inputs agreed upon by the interagency group:

- A Roe and Baker distribution for the climate sensitivity parameter bounded between 0 and 10 with a median of 3 °C and a cumulative probability between 2 and 4.5 °C of two-thirds.
- Five sets of GDP, population and carbon emissions trajectories based on EMF-22.
- Constant annual discount rates of 2.5, 3, and 5 percent.

Because the climate sensitivity parameter is modeled probabilistically, and because PAGE and FUND incorporate uncertainty in other model parameters, the final output from each model run is a distribution over the SCC in year *t*.

For each of the IAMS, the basic computational steps for calculating the SCC in a particular year *t* are:

1. Input the path of emissions, GDP, and population from the selected EMF-22 scenarios, and the extrapolations based on these scenarios for post-2100 years.

2. Calculate the temperature effects and (consumption-equivalent) damages in each year resulting from the baseline path of emissions.

    a. In PAGE, the consumption-equivalent damages in each period are calculated as a fraction of the EMF GDP forecast, depending on the temperature in that period relative to the pre-industrial average temperature in each region.
    b. In FUND, damages in each period depend on both the level and the rate of temperature change in that period.
    c. In DICE, temperature affects both consumption and investment, so we first adjust the EMF GDP paths as follows: Using the Cobb-Douglas production function with the DICE2007 parameters, we extract the path of exogenous technical change implied by the EMF GDP and population paths, then we recalculate the baseline GDP path taking into account climate damages resulting from the baseline emissions path.

3. Add an additional unit of carbon emissions in year *t*. (The exact unit varies by model.)

4. Recalculate the temperature effects and damages expected in all years beyond *t* resulting from this adjusted path of emissions, as in step 2.

5. Subtract the damages computed in step 2 from those in step 4 in each year. (DICE is run in 10 year time steps, FUND in annual time steps, while the time steps in PAGE vary.)

6. Discount the resulting path of marginal damages back to the year of emissions using the agreed upon fixed discount rates.

7. Calculate the SCC as the net present value of the discounted path of damages computed in step 6, divided by the unit of carbon emissions used to shock the models in step 3.

8. Multiply by 12/44 to convert from dollars per ton of carbon to dollars per ton of CO_2 (2007 dollars) in DICE and FUND. (All calculations are done in tons of CO_2 in PAGE).

The steps above were repeated in each model for multiple future years to cover the time horizons anticipated for upcoming rulemaking analysis. To maintain consistency across the three IAMs, climate damages are calculated as lost consumption in each future year.

It is important to note that each of the three models has a different default end year. The default time horizon is 2200 for PAGE, 2595 for DICE, and 3000 for the latest version of FUND. This is an issue for the multi-model approach because differences in SCC estimates may arise simply due to the model time horizon. Many consider 2200 too short a time horizon because it could miss a significant fraction of damages under certain assumptions about the growth of marginal damages and discounting, so each model is run here through 2300. This step required a small adjustment in the PAGE model only. This step also required assumptions about GDP, population, and greenhouse gas emission trajectories after 2100, the last year for which these data are available from the EMF-22 models. (A more detailed discussion of these assumptions is included in the Appendix.)

This exercise produces 45 separate distributions of the SCC for a given year, the product of 3 models, 3 discount rates, and 5 socioeconomic scenarios. This is clearly too many separate distributions for consideration in a regulatory impact analysis.

To produce a range of plausible estimates that still reflects the uncertainty in the estimation exercise, the distributions from each of the models and scenarios are equally weighed and combined to produce three separate probability distributions for SCC in a given year, one for each assumed discount rate. These distributions are then used to define a range of point estimates for the global SCC. In this way, no integrated assessment model or socioeconomic scenario is given greater weight than another. Because the literature shows that the SCC is quite sensitive to assumptions about the discount rate, and because no consensus exists on the appropriate rate to use in an intergenerational context, we present SCCs based on the average values across models and socioeconomic scenarios for each discount rate.

The interagency group selected four SCC values for use in regulatory analyses. Three values are based on the average SCC across models and socio-economic and emissions scenarios at the 2.5, 3, and 5 percent discount rates. The fourth value is included to represent the higher-than-expected economic impacts from climate change further out in the tails of the SCC distribution. For this purpose, we use the SCC value for the 95th percentile at a 3 percent discount rate. (The full set of distributions by model and scenario combination is included in the Appendix.) As noted above, the 3 percent discount rate is the central value, and so the central value that emerges is the average SCC across models at the 3 percent discount rate. For purposes of capturing the uncertainties involved in regulatory impact analysis, we emphasize the importance and value of considering the full range.

As previously discussed, low probability, high impact events are incorporated into the SCC values through explicit consideration of their effects in two of the three models as well as the use of a probability density function for equilibrium climate sensitivity. Treating climate sensitivity probabilistically results in more high temperature outcomes, which in turn lead to higher projections of damages. Although FUND does not include catastrophic damages (in contrast to the other two models), its probabilistic treatment of the equilibrium climate sensitivity parameter will directly affect the non-catastrophic damages that are a function of the rate of temperature change.

In Table 3, we begin by presenting SCC estimates for 2010 by model, scenario, and discount rate to illustrate the variability in the SCC across each of these input parameters. As expected, higher discount rates consistently result in lower SCC values, while lower discount rates result in higher SCC values for each socioeconomic trajectory. It is also evident that there are differences in the SCC estimated across the three main models. For these estimates, FUND produces the lowest estimates, while PAGE generally produces the highest estimates.

Table 3: Disaggregated Social Cost of CO_2 Values by Model, Socio-Economic Trajectory, and Discount Rate for 2010 (in 2007 dollars)

	Discount rate:	**5%**	**3%**	**2.5%**	**3%**
Model	*Scenario*	Avg	Avg	Avg	95th
DICE	IMAGE	10.8	35.8	54.2	70.8
	MERGE	7.5	22.0	31.6	42.1
	Message	9.8	29.8	43.5	58.6
	MiniCAM	8.6	28.8	44.4	57.9
	550 Average	8.2	24.9	37.4	50.8
PAGE	IMAGE	8.3	39.5	65.5	142.4
	MERGE	5.2	22.3	34.6	82.4
	Message	7.2	30.3	49.2	115.6
	MiniCAM	6.4	31.8	54.7	115.4
	550 Average	5.5	25.4	42.9	104.7
FUND	IMAGE	-1.3	8.2	19.3	39.7
	MERGE	-0.3	8.0	14.8	41.3
	Message	-1.9	3.6	8.8	32.1
	MiniCAM	-0.6	10.2	22.2	42.6
	550 Average	-2.7	-0.2	3.0	19.4

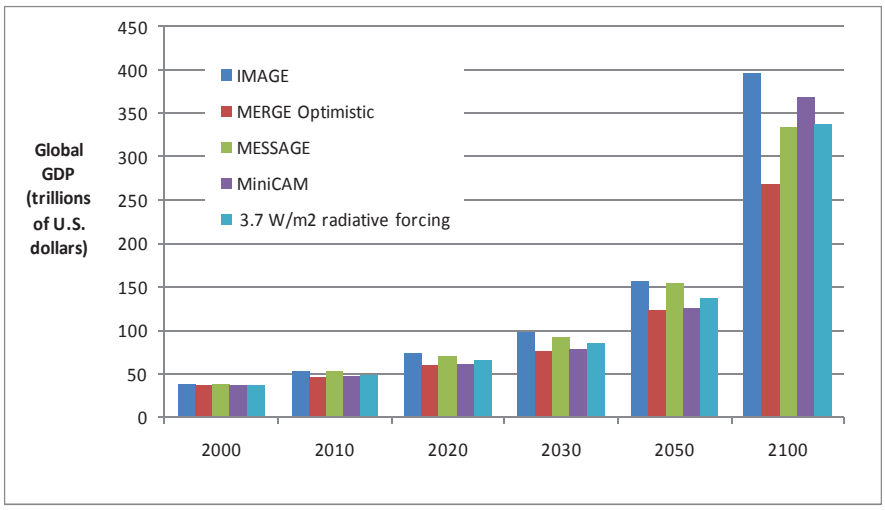
These results are not surprising when compared to the estimates in the literature for the latest versions of each model. For example, adjusting the values from the literature that were used to develop interim

SCC values to 2007 dollars for the year 2010 (assuming, as we did for the interim process, that SCC grows at 3 percent per year), FUND yields SCC estimates at or near zero for a 5 percent discount rate and around $9 per ton for a 3 percent discount rate. There are far fewer estimates using the latest versions of DICE and PAGE in the literature: Using similar adjustments to generate 2010 estimates, we calculate a SCC from DICE (based on Nordhaus 2008) of around $9 per ton for a 5 percent discount rate, and a SCC from PAGE (based on Hope 2006, 2008) close to $8 per ton for a 4 percent discount rate. Note that these comparisons are only approximate since the literature generally relies on Ramsey discounting, while we have assumed constant discount rates.[27]

The SCC estimates from FUND are sensitive to differences in emissions paths but relatively insensitive to differences in GDP paths across scenarios, while the reverse is true for DICE and PAGE. This likely occurs because of several structural differences among the models. Specifically in DICE and PAGE, the fraction of economic output lost due to climate damages increases with the level of temperature alone, whereas in FUND the fractional loss also increases with the rate of temperature change. Furthermore, in FUND increases in income over time decrease vulnerability to climate change (a form of adaptation), whereas this does not occur in DICE and PAGE. These structural differences among the models make FUND more sensitive to the path of emissions and less sensitive to GDP compared to DICE and PAGE.

Figure 3 shows that IMAGE has the highest GDP in 2100 while MERGE Optimistic has the lowest. The ordering of global GDP levels in 2100 directly corresponds to the rank ordering of SCC for PAGE and DICE. For FUND, the correspondence is less clear, a result that is to be expected given its less direct relationship between its damage function and GDP.

Figure 3: Level of Global GDP across EMF Scenarios



[27] Nordhaus (2008) runs DICE2007 with ρ = 1.5 and η = 2. The default approach in PAGE2002 (version 1.4epm) treats ρ and η as random parameters, specified using a triangular distribution such that the min, mode, and max = 0.1, 1, and 2 for ρ, and 0.5, 1, and 2 for η, respectively. The FUND default value for η is 1, and Tol generates SCC estimates for values of ρ = 0, 1, and 3 in many recent papers (e.g. Anthoff et al. 2009). The path of per-capita consumption growth, g, varies over time but is treated deterministically in two of the three models. In DICE, g is endogenous. Under Ramsey discounting, as economic growth slows in the future, the large damages from climate change that occur far out in the future are discounted at a lower rate than impacts that occur in the nearer term.

Table 4 shows the four selected SCC values in five year increments from 2010 to 2050. Values for 2010, 2020, 2040, and 2050 are calculated by first combining all outputs (10,000 estimates per model run) from all scenarios and models for a given discount rate. Values for the years in between are calculated using a simple linear interpolation.

Table 4: Social Cost of CO_2, 2010 – 2050 (in 2007 dollars)

Discount Rate	5%	3%	2.5%	3%
Year	Avg	Avg	Avg	95th
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

The SCC increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change. Note that this approach allows us to estimate the growth rate of the SCC directly using DICE, PAGE, and FUND rather than assuming a constant annual growth rate as was done for the interim estimates (using 3 percent). This helps to ensure that the estimates are internally consistent with other modeling assumptions. Table 5 illustrates how the growth rate for these four SCC estimates varies over time. The full set of annual SCC estimates between 2010 and 2050 is reported in the Appendix.

Table 5: Changes in the Average Annual Growth Rates of SCC Estimates between 2010 and 2050

Average Annual Growth	**5%**	**3%**	**2.5%**	**3.0%**
Rate (%)	Avg	Avg	Avg	95th
2010-2020	3.6%	2.1%	1.7%	2.2%
2020-2030	3.7%	2.2%	1.8%	2.2%
2030-2040	2.7%	1.8%	1.6%	1.8%
2040-2050	2.1%	1.4%	1.1%	1.3%

While the SCC estimate grows over time, the future monetized value of emissions reductions in each year (the SCC in year *t* multiplied by the change in emissions in year *t*) must be discounted to the present to determine its total net present value for use in regulatory analysis. Damages from future emissions should be discounted at the same rate as that used to calculate the SCC estimates themselves to ensure internal consistency—i.e., future damages from climate change, whether they result from emissions today or emissions in a later year, should be discounted using the same rate. For example,

climate damages in the year 2020 that are calculated using a SCC based on a 5 percent discount rate also should be discounted back to the analysis year using a 5 percent discount rate.[28]

V. Limitations of the Analysis

As noted, any estimate of the SCC must be taken as provisional and subject to further refinement (and possibly significant change) in accordance with evolving scientific, economic, and ethical understandings. During the course of our modeling, it became apparent that there are several areas in particular need of additional exploration and research. These caveats, and additional observations in the following section, are necessary to consider when interpreting and applying the SCC estimates.

Incomplete treatment of non-catastrophic damages. The impacts of climate change are expected to be widespread, diverse, and heterogeneous. In addition, the exact magnitude of these impacts is uncertain because of the inherent complexity of climate processes, the economic behavior of current and future populations, and our inability to accurately forecast technological change and adaptation. Current IAMs do not assign value to all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature (some of which are discussed above) because of lack of precise information on the nature of damages and because the science incorporated into these models understandably lags behind the most recent research. Our ability to quantify and monetize impacts will undoubtedly improve with time. But it is also likely that even in future applications, a number of potentially significant damage categories will remain non-monetized. (Ocean acidification is one example of a potentially large damage from CO_2 emissions not quantified by any of the three models. Species and wildlife loss is another example that is exceedingly difficult to monetize.)

Incomplete treatment of potential catastrophic damages. There has been considerable recent discussion of the risk of catastrophic impacts and how best to account for extreme scenarios, such as the collapse of the Atlantic Meridional Overturning Circulation or the West Antarctic Ice Sheet, or large releases of methane from melting permafrost and warming oceans. Weitzman (2009) suggests that catastrophic damages are extremely large—so large, in fact, that the damages from a low probability, catastrophic event far in the future dominate the effect of the discount rate in a present value calculation and result in an infinite willingness-to-pay for mitigation today. However, Nordhaus (2009) concluded that the conditions under which Weitzman's results hold “are limited and do not apply to a wide range of potential uncertain scenarios."

Using a simplified IAM, Newbold and Daigneault (2009) confirmed the potential for large catastrophe risk premiums but also showed that the aggregate benefit estimates can be highly sensitive to the shapes of both the climate sensitivity distribution and the damage function at high temperature changes. Pindyck (2009) also used a simplified IAM to examine high-impact low-probability risks, using a right-skewed gamma distribution for climate sensitivity as well as an uncertain damage coefficient, but in most cases found only a modest risk premium. Given this difference in opinion, further research in this area is needed before its practical significance can be fully understood and a reasonable approach developed to account for such risks in regulatory analysis. (The next section discusses the scientific evidence on catastrophic impacts in greater detail.)

[28] However, it is possible that other benefits or costs of proposed regulations unrelated to CO_2 emissions will be discounted at rates that differ from those used to develop the SCC estimates.

Uncertainty in extrapolation of damages to high temperatures: The damage functions in these IAMs are typically calibrated by estimating damages at moderate temperature increases (e.g., DICE was calibrated at 2.5 °C) and extrapolated to far higher temperatures by assuming that damages increase as some power of the temperature change. Hence, estimated damages are far more uncertain under more extreme climate change scenarios.

Incomplete treatment of adaptation and technological change: Each of the three integrated assessment models used here assumes a certain degree of low- or no-cost adaptation. For instance, Tol assumes a great deal of adaptation in FUND, including widespread reliance on air conditioning ; so much so, that the largest single benefit category in FUND is the reduced electricity costs from not having to run air conditioning as intensively (NRC 2009).

Climate change also will increase returns on investment to develop technologies that allow individuals to cope with adverse climate conditions, and IAMs to do not adequately account for this directed technological change.[29] For example, scientists may develop crops that are better able to withstand higher and more variable temperatures. Although DICE and FUND have both calibrated their agricultural sectors under the assumption that farmers will change land use practices in response to climate change (Mastrandrea, 2009), they do not take into account technological changes that lower the cost of this adaptation over time. On the other hand, the calibrations do not account for increases in climate variability, pests, or diseases, which could make adaptation more difficult than assumed by the IAMs for a given temperature change. Hence, models do not adequately account for potential adaptation or technical change that might alter the emissions pathway and resulting damages. In this respect, it is difficult to determine whether the incomplete treatment of adaptation and technological change in these IAMs under or overstate the likely damages.

Risk aversion: A key question unanswered during this interagency process is what to assume about relative risk aversion with regard to high-impact outcomes. These calculations do not take into account the possibility that individuals may have a higher willingness to pay to reduce the likelihood of low-probability, high-impact damages than they do to reduce the likelihood of higher-probability but lower-impact damages with the same expected cost. (The inclusion of the 95th percentile estimate in the final set of SCC values was largely motivated by this concern.) If individuals do show such a higher willingness to pay, a further question is whether that fact should be taken into account for regulatory policy. Even if individuals are not risk-averse for such scenarios, it is possible that regulatory policy should include a degree of risk-aversion.

Assuming a risk-neutral representative agent is consistent with OMB's Circular A-4, which advises that the estimates of benefits and costs used in regulatory analysis are usually based on the average or the expected value and that "emphasis on these expected values is appropriate as long as society is 'risk neutral' with respect to the regulatory alternatives. While this may not always be the case, [analysts] should in general assume 'risk neutrality' in [their] analysis."

Nordhaus (2008) points to the need to explore the relationship between risk and income in the context of climate change across models and to explore the role of uncertainty regarding various parameters in

[29] However these research dollars will be diverted from whatever their next best use would have been in the absence of climate change (so productivity/GDP would have been still higher).

the results. Using FUND, Anthoff et al (2009) explored the sensitivity of the SCC to Ramsey equation parameter assumptions based on observed behavior. They conclude that "the assumed rate of risk aversion is at least as important as the assumed rate of time preference in determining the social cost of carbon." Since Circular A-4 allows for a different assumption on risk preference in regulatory analysis if it is adequately justified, we plan to continue investigating this issue.

V. A Further Discussion of Catastrophic Impacts and Damage Functions

As noted above, the damage functions underlying the three IAMs used to estimate the SCC may not capture the economic effects of all possible adverse consequences of climate change and may therefore lead to underestimates of the SCC (Mastrandrea 2009). In particular, the models' functional forms may not adequately capture: (1) potentially discontinuous "tipping point" behavior in Earth systems, (2) inter-sectoral and inter-regional interactions, including global security impacts of high-end warming, and (3) limited near-term substitutability between damage to natural systems and increased consumption.

It is the hope of the interagency group that over time researchers and modelers will work to fill these gaps and that the SCC estimates used for regulatory analysis by the Federal government will continue to evolve with improvements in modeling. In the meantime, we discuss some of the available evidence.

Extrapolation of climate damages to high levels of warming

The damage functions in the models are calibrated at moderate levels of warming and should therefore be viewed cautiously when extrapolated to the high temperatures found in the upper end of the distribution. Recent science suggests that there are a number of potential climatic "tipping points" at which the Earth system may exhibit discontinuous behavior with potentially severe social and economic consequences (e.g., Lenton et al, 2008, Kriegler et al., 2009). These tipping points include the disruption of the Indian Summer Monsoon, dieback of the Amazon Rainforest and boreal forests, collapse of the Greenland Ice Sheet and the West Antarctic Ice Sheet, reorganization of the Atlantic Meridional Overturning Circulation, strengthening of El Niño-Southern Oscillation, and the release of methane from melting permafrost. Many of these tipping points are estimated to have thresholds between about 3 °C and 5 °C (Lenton et al., 2008). Probabilities of several of these tipping points were assessed through expert elicitation in 2005–2006 by Kriegler et al. (2009); results from this study are highlighted in Table 6. Ranges of probability are averaged across core experts on each topic.

As previously mentioned, FUND does not include potentially catastrophic effects. DICE assumes a small probability of catastrophic damages that increases with increased warming, but the damages from these risks are incorporated as expected values (i.e., ignoring potential risk aversion). PAGE models catastrophic impacts in a probabilistic framework (see Figure 1), so the high-end output from PAGE potentially offers the best insight into the SCC if the world were to experience catastrophic climate change. For instance, at the 95th percentile and a 3 percent discount rate, the SCC estimated by PAGE across the five socio-economic and emission trajectories of $113 per ton of CO_2 is almost double the value estimated by DICE, $58 per ton in 2010. We cannot evaluate how well the three models account for catastrophic or non-catastrophic impacts, but this estimate highlights the sensitivity of SCC values in the tails of the distribution to the assumptions made about catastrophic impacts.

Table 6: Probabilities of Various Tipping Points from Expert Elicitation -

Possible Tipping Points	Duration before effect is fully realized (in years)	Additional Warming by 2100		
		0.5-1.5 C	1.5-3.0 C	3-5 C
Reorganization of Atlantic Meridional Overturning Circulation	about 100	0-18%	6-39%	18-67%
Greenland Ice Sheet collapse	at least 300	8-39%	33-73%	67-96%
West Antarctic Ice Sheet collapse	at least 300	5-41%	10-63%	33-88%
Dieback of Amazon rainforest	about 50	2-46%	14-84%	41-94%
Strengthening of El Niño-Southern Oscillation	about 100	1-13%	6-32%	19-49%
Dieback of boreal forests	about 50	13-43%	20-81%	34-91%
Shift in Indian Summer Monsoon	about 1	Not formally assessed		
Release of methane from melting permafrost	Less than 100	Not formally assessed.		

PAGE treats the possibility of a catastrophic event probabilistically, while DICE treats it deterministically (that is, by adding the expected value of the damage from a catastrophe to the aggregate damage function). In part, this results in different probabilities being assigned to a catastrophic event across the two models. For instance, PAGE places a probability near zero on a catastrophe at 2.5 °C warming, while DICE assumes a 4 percent probability of a catastrophe at 2.5 °C. By comparison, Kriegler et al. (2009) estimate a probability of at least 16-36 percent of crossing at least one of their primary climatic tipping points in a scenario with temperatures about 2-4 °C warmer than pre-Industrial levels in 2100.

It is important to note that crossing a climatic tipping point will not necessarily lead to an economic catastrophe in the sense used in the IAMs. A tipping point is a critical threshold across which some aspect of the Earth system starts to shifts into a qualitatively different state (for instance, one with dramatically reduced ice sheet volumes and higher sea levels). In the IAMs, a catastrophe is a low-probability environmental change with high economic impact.

Failure to incorporate inter-sectoral and inter-regional interactions

The damage functions do not fully incorporate either inter-sectoral or inter-regional interactions. For instance, while damages to the agricultural sector are incorporated, the effects of changes in food supply on human health are not fully captured and depend on the modeler's choice of studies used to calibrate the IAM. Likewise, the effects of climate damages in one region of the world on another region are not included in some of the models (FUND includes the effects of migration from sea level rise). These inter-regional interactions, though difficult to quantify, are the basis for climate-induced national and economic security concerns (e.g., Campbell et al., 2007; U.S. Department of Defense 2010) and are particularly worrisome at higher levels of warming. High-end warming scenarios, for instance, project water scarcity affecting 4.3-6.9 billion people by 2050, food scarcity affecting about 120 million

additional people by 2080, and the creation of millions of climate refugees (Easterling et al., 2007; Campbell et al., 2007).

Imperfect substitutability of environmental amenities

Data from the geological record of past climate changes suggests that 6 °C of warming may have severe consequences for natural systems. For instance, during the Paleocene-Eocene Thermal Maximum about 55.5 million years ago, when the Earth experienced a geologically rapid release of carbon associated with an approximately 5 °C increase in global mean temperatures, the effects included shifts of about 400-900 miles in the range of plants (Wing et al., 2005), and dwarfing of both land mammals (Gingerich, 2006) and soil fauna (Smith et al., 2009).

The three IAMs used here assume that it is possible to compensate for the economic consequences of damages to natural systems through increased consumption of non-climate goods, a common assumption in many economic models. In the context of climate change, however, it is possible that the damages to natural systems could become so great that no increase in consumption of non-climate goods would provide complete compensation (Levy et al., 2005). For instance, as water supplies become scarcer or ecosystems become more fragile and less bio-diverse, the services they provide may become increasingly more costly to replace. Uncalibrated attempts to incorporate the imperfect substitutability of such amenities into IAMs (Sterner and Persson, 2008) indicate that the optimal degree of emissions abatement can be considerably greater than is commonly recognized.

VI. Conclusion

The interagency group selected four SCC estimates for use in regulatory analyses. For 2010, these estimates are $5, $21, $35, and $65 (in 2007 dollars). The first three estimates are based on the average SCC across models and socio-economic and emissions scenarios at the 5, 3, and 2.5 percent discount rates, respectively. The fourth value is included to represent the higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. For this purpose, we use the SCC value for the 95th percentile at a 3 percent discount rate. The central value is the average SCC across models at the 3 percent discount rate. For purposes of capturing the uncertainties involved in regulatory impact analysis, we emphasize the importance and value of considering the full range. These SCC estimates also grow over time. For instance, the central value increases to $24 per ton of CO_2 in 2015 and $26 per ton of CO_2 in 2020.

We noted a number of limitations to this analysis, including the incomplete way in which the integrated assessment models capture catastrophic and non-catastrophic impacts, their incomplete treatment of adaptation and technological change, uncertainty in the extrapolation of damages to high temperatures, and assumptions regarding risk aversion. The limited amount of research linking climate impacts to economic damages makes this modeling exercise even more difficult. It is the hope of the interagency group that over time researchers and modelers will work to fill these gaps and that the SCC estimates used for regulatory analysis by the Federal government will continue to evolve with improvements in modeling.

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Appendix

Table A1: Annual SCC Values: 2010–2050 (in 2007 dollars)

Discount Rate	5%	3%	2.5%	3%
Year	Avg	Avg	Avg	95th
2010	4.7	21.4	35.1	64.9
2011	4.9	21.9	35.7	66.5
2012	5.1	22.4	36.4	68.1
2013	5.3	22.8	37.0	69.6
2014	5.5	23.3	37.7	71.2
2015	5.7	23.8	38.4	72.8
2016	5.9	24.3	39.0	74.4
2017	6.1	24.8	39.7	76.0
2018	6.3	25.3	40.4	77.5
2019	6.5	25.8	41.0	79.1
2020	6.8	26.3	41.7	80.7
2021	7.1	27.0	42.5	82.6
2022	7.4	27.6	43.4	84.6
2023	7.7	28.3	44.2	86.5
2024	7.9	28.9	45.0	88.4
2025	8.2	29.6	45.9	90.4
2026	8.5	30.2	46.7	92.3
2027	8.8	30.9	47.5	94.2
2028	9.1	31.5	48.4	96.2
2029	9.4	32.1	49.2	98.1
2030	9.7	32.8	50.0	100.0
2031	10.0	33.4	50.9	102.0
2032	10.3	34.1	51.7	103.9
2033	10.6	34.7	52.5	105.8
2034	10.9	35.4	53.4	107.8
2035	11.2	36.0	54.2	109.7
2036	11.5	36.7	55.0	111.6
2037	11.8	37.3	55.9	113.6
2038	12.1	37.9	56.7	115.5
2039	12.4	38.6	57.5	117.4
2040	12.7	39.2	58.4	119.3
2041	13.0	39.8	59.0	121.0
2042	13.3	40.4	59.7	122.7
2043	13.6	40.9	60.4	124.4
2044	13.9	41.5	61.0	126.1
2045	14.2	42.1	61.7	127.8
2046	14.5	42.6	62.4	129.4
2047	14.8	43.2	63.0	131.1
2048	15.1	43.8	63.7	132.8
2049	15.4	44.4	64.4	134.5
2050	15.7	44.9	65.0	136.2

This Appendix also provides additional technical information about the non-CO_2 emission projections used in the modeling and the method for extrapolating emissions forecasts through 2300, and shows the full distribution of 2010 SCC estimates by model and scenario combination.

1. Other (non-CO_2) gases

In addition to fossil and industrial CO_2 emissions, each EMF scenario provides projections of methane (CH_4), nitrous oxide (N_2O), fluorinated gases, and net land use CO_2 emissions to 2100. These assumptions are used in all three IAMs while retaining each model's default radiative forcings (RF) due to other factors (e.g., aerosols and other gases). Specifically, to obtain the RF associated with the non-CO_2 EMF emissions only, we calculated the RF associated with the EMF atmospheric CO_2 concentrations and subtracted them from the EMF total RF.[30] This approach respects the EMF scenarios as much as possible and at the same time takes account of those components not included in the EMF projections. Since each model treats non-CO_2 gases differently (e.g., DICE lumps all other gases into one composite exogenous input), this approach was applied slightly differently in each of the models.

FUND: Rather than relying on RF for these gases, the actual emissions from each scenario were used in FUND. The model default trajectories for CH_4, N_20, SF_6, and the CO_2 emissions from land were replaced with the EMF values.

PAGE: PAGE models CO_2, CH_4, sulfur hexafluoride (SF_6), and aerosols and contains an "excess forcing" vector that includes the RF for everything else. To include the EMF values, we removed the default CH_4 and SF_6 factors[31], decomposed the excess forcing vector, and constructed a new excess forcing vector that includes the EMF RF for CH_4, N_20, and fluorinated gases, as well as the model default values for aerosols and other factors. Net land use CO_2 emissions were added to the fossil and industrial CO_2 emissions pathway.

DICE: DICE presents the greatest challenge because all forcing due to factors other than industrial CO_2 emissions is embedded in an exogenous non-CO_2 RF vector. To decompose this exogenous forcing path into EMF non-CO_2 gases and other gases, we relied on the references in DICE2007 to the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (AR4) and the discussion of aerosol forecasts in the IPCC's Third Assessment Report (TAR) and in AR4, as explained below. In DICE2007, Nordhaus assumes that exogenous forcing from all non-CO_2 sources is -0.06 W/m^2 in 2005, as reported in AR4, and increases linearly to 0.3 W/m^2 in 2105, based on GISS projections, and then stays constant after that time.

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[30] Note EMF did not provide CO_2 concentrations for the IMAGE reference scenario. Thus, for this scenario, we fed the fossil, industrial and land CO_2 emissions into MAGICC (considered a "neutral arbiter" model, which is tuned to emulate the major global climate models) and the resulting CO_2 concentrations were used. Note also that MERGE assumes a neutral biosphere so net land CO_2 emissions are set to zero for all years for the MERGE Optimistic reference scenario, and for the MERGE component of the average 550 scenario (i.e., we add up the land use emissions from the other three models and divide by 4).

[31] Both the model default CH_4 emissions and the initial atmospheric CH_4 is set to zero to avoid double counting the effect of past CH_4 emissions.

According to AR4, the RF in 2005 from CH_4, N_20, and halocarbons (approximately similar to the F-gases in the EMF-22 scenarios) was 0.48 + 0.16 + 0.34 = 0.98 W/m^2 and RF from total aerosols was -1.2 W/m^2. Thus, the -.06 W/m^2 non-CO_2 forcing in DICE can be decomposed into: 0.98 W/m^2 due to the EMF non-CO_2 gases, -1.2 W/m^2 due to aerosols, and the remainder, 0.16 W/m^2, due to other residual forcing.

For subsequent years, we calculated the DICE default RF from aerosols and other non-CO_2 gases based on the following two assumptions:

(1) RF from aerosols declines linearly from 2005 to 2100 at the rate projected by the TAR and then stays constant thereafter, and
(2) With respect to RF from non-CO_2 gases not included in the EMF-22 scenarios, the share of non-aerosol RF matches the share implicit in the AR4 summary statistics cited above and remains constant over time.

Assumption (1) means that the RF from aerosols in 2100 equals 66 percent of that in 2000, which is the fraction of the TAR projection of total RF from aerosols (including sulfates, black carbon, and organic carbon) in 2100 vs. 2000 under the A1B SRES emissions scenario. Since the SRES marker scenarios were not updated for the AR4, the TAR provides the most recent IPCC projection of aerosol forcing. We rely on the A1B projection from the TAR because it provides one of the lower aerosol forecasts among the SRES marker scenarios and is more consistent with the AR4 discussion of the post-SRES literature on aerosols:

Aerosols have a net cooling effect and the representation of aerosol and aerosol precursor emissions, including sulphur dioxide, black carbon and organic carbon, has improved in the post-SRES scenarios. Generally, these emissions are projected to be lower than reported in SRES. {WGIII 3.2, TS.3, SPM}.[32]

Assuming a simple linear decline in aerosols from 2000 to 2100 also is more consistent with the recent literature on these emissions. For example, Figure A1 shows that the sulfur dioxide emissions peak over the short-term of some SRES scenarios above the upper bound estimates of the more recent scenarios.[33] Recent scenarios project sulfur emissions to peak earlier and at lower levels compared to the SRES in part because of new information about present and planned sulfur legislation in some developing countries, such as India and China.[34] The lower bound projections of the recent literature have also shifted downward slightly compared to the SRES scenario (IPCC 2007).

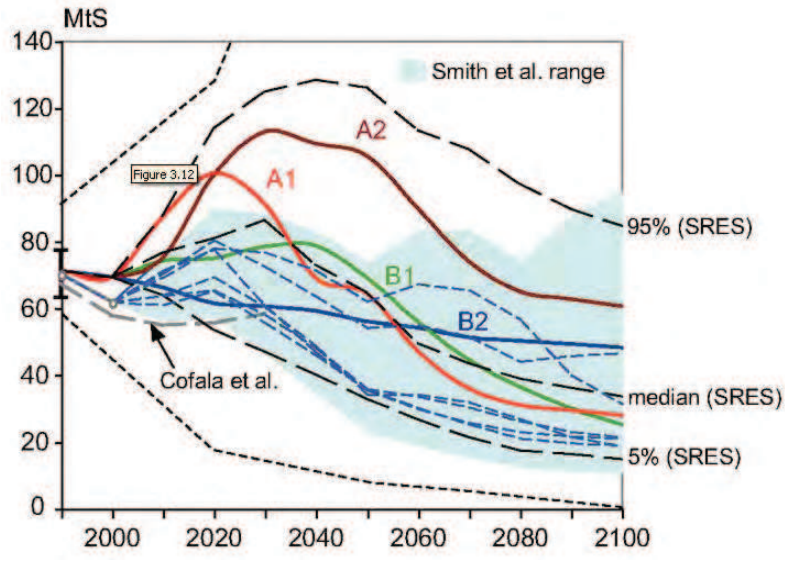
[32] AR4 Synthesis Report, p. 44, http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

[33] See Smith, S.J., R. Andres, E. Conception, and J. Lurz, 2004: Historical sulfur dioxide emissions, 1850-2000: methods and results. Joint Global Research Institute, College Park, 14 pp.

[34] See Carmichael, G., D. Streets, G. Calori, M. Amann, M. Jacobson, J. Hansen, and H. Ueda, 2002: Changing trends in sulphur emissions in Asia: implications for acid deposition, air pollution, and climate. Environmental Science and Technology, 36(22):4707- 4713; Streets, D., K. Jiang, X. Hu, J. Sinton, X.-Q. Zhang, D. Xu, M. Jacobson, and J. Hansen, 2001: Recent reductions in China's greenhouse gas emissions. Science, 294(5548): 1835-1837.

With these assumptions, the DICE aerosol forcing changes from -1.2 in 2005 to -0.792 in 2105 W/m^2; forcing due to other non-CO_2 gases not included in the EMF scenarios declines from 0.160 to 0.153 W/m^2.

Figure A1: Sulphur Dioxide Emission Scenarios -



Notes: Thick colored lines depict the four SRES marker scenarios and black dashed lines show the median, 5th and 95th percentile of the frequency distribution for the full ensemble of 40 SRES scenarios. The blue area (and the thin dashed lines in blue) illustrates individual scenarios and the range of Smith et al. (2004). Dotted lines indicate the minimum and maximum of SO_2 emissions scenarios developed pre-SRES.
Source: IPCC (2007), AR4 WGIII 3.2, http://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch3-ens3-2-2-4.html.

Although other approaches to decomposing the DICE exogenous forcing vector are possible, initial sensitivity analysis suggests that the differences among reasonable alternative approaches are likely to be minor. For example, adjusting the TAR aerosol projection above to assume that aerosols will be maintained at 2000 levels through 2100 reduces average SCC values (for 2010) by approximately 3 percent (or less than $2); assuming all aerosols are phased out by 2100 increases average 2010 SCC values by 6-7 percent (or $0.50-$3)–depending on the discount rate. These differences increase slightly for SCC values in later years but are still well within 10 percent of each other as far out as 2050.

Finally, as in PAGE, the EMF net land use CO_2 emissions are added to the fossil and industrial CO_2 emissions pathway.

2. - Extrapolating Emissions Projections to 2300

To run each model through 2300 requires assumptions about GDP, population, greenhouse gas emissions, and radiative forcing trajectories after 2100, the last year for which these projections are available from the EMF-22 models. These inputs were extrapolated from 2100 to 2300 as follows:

1. Population growth rate declines linearly, reaching zero in the year 2200.
2. GDP/ per capita growth rate declines linearly, reaching zero in the year 2300.
3. The decline in the fossil and industrial carbon intensity (CO_2/GDP) growth rate over 2090-2100 is maintained from 2100 through 2300.
4. Net land use CO_2 emissions decline linearly, reaching zero in the year 2200.
5. Non-CO_2 radiative forcing remains constant after 2100.

Long run stabilization of GDP per capita was viewed as a more realistic simplifying assumption than a linear or exponential extrapolation of the pre-2100 economic growth rate of each EMF scenario. This is based on the idea that increasing scarcity of natural resources and the degradation of environmental sinks available for assimilating pollution from economic production activities may eventually overtake the rate of technological progress. Thus, the overall rate of economic growth may slow over the very long run. The interagency group also considered allowing an exponential decline in the growth rate of GDP per capita. However, since this would require an additional assumption about how close to zero the growth rate would get by 2300, the group opted for the simpler and more transparent linear extrapolation to zero by 2300.

The population growth rate is also assumed to decline linearly, reaching zero by 2200. This assumption is reasonably consistent with the United Nations long run population forecast, which estimates global population to be fairly stable after 2150 in the medium scenario (UN 2004).[35] The resulting range of EMF population trajectories (Figure A2) also encompass the UN medium scenario forecasts through 2300 – global population of 8.5 billion by 2200, and 9 billion by 2300.

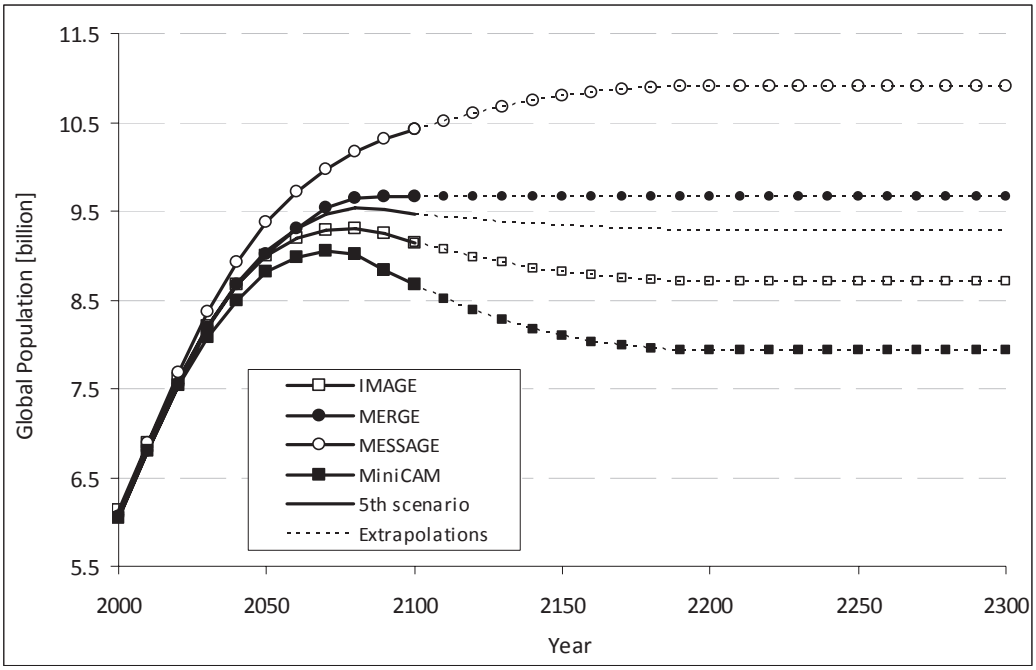
Maintaining the decline in the 2090-2100 carbon intensity growth rate (i.e., CO_2 per dollar of GDP) through 2300 assumes that technological improvements and innovations in the areas of energy efficiency and other carbon reducing technologies (possibly including currently unavailable methods) will continue to proceed at roughly the same pace that is projected to occur towards the end of the forecast period for each EMF scenario. This assumption implies that total cumulative emissions in 2300 will be between 5,000 and 12,000 GtC, which is within the range of the total potential global carbon stock estimated in the literature.

Net land use CO_2 emissions are expected to stabilize in the long run, so in the absence of any post 2100 projections, the group assumed a linear decline to zero by 2200. Given no a priori reasons for assuming a long run increase or decline in non-CO_2 radiative forcing, it is assumed to remain at the 2100 levels for each EMF scenario through 2300.

Figures A2-A7 show the paths of global population, GDP, fossil and industrial CO_2 emissions, net land CO_2 emissions, non-CO_2 radiative forcing, and CO_2 intensity (fossil and industrial CO_2 emissions/GDP) resulting from these assumptions.

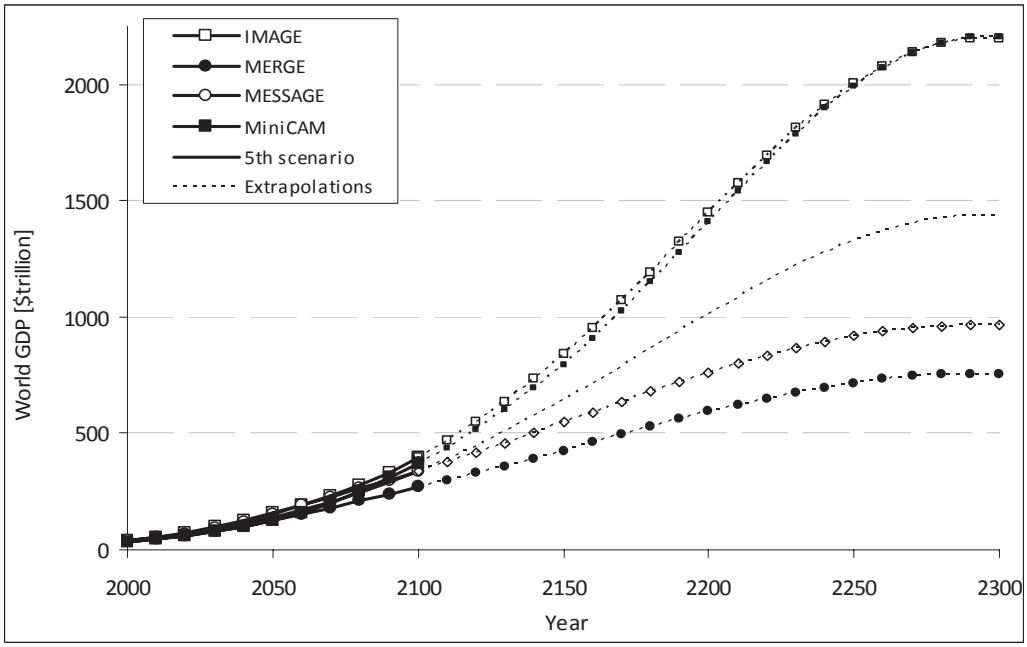
[35] United Nations. 2004. *World Population to 2300*.
http://www.un.org/esa/population/publications/longrange2/worldpop2300final.pdf

Figure A2. Global Population, 2000-2300 (Post-2100 extrapolations assume the population growth - rate changes linearly to reach a zero growth rate by 2200.) -



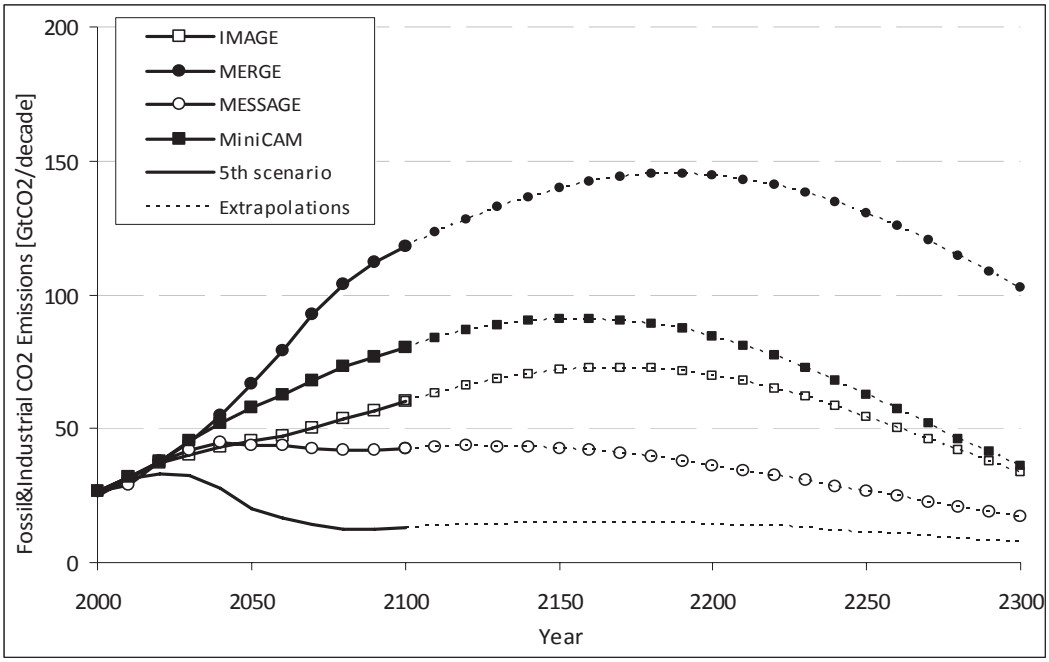
Note: In the fifth scenario, 2000-2100 population is equal to the average of the population under the 550 ppm CO_2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Figure A3. World GDP, 2000-2300 (Post-2100 extrapolations assume GDP per capita growth declines linearly, reaching zero in the year 2300)



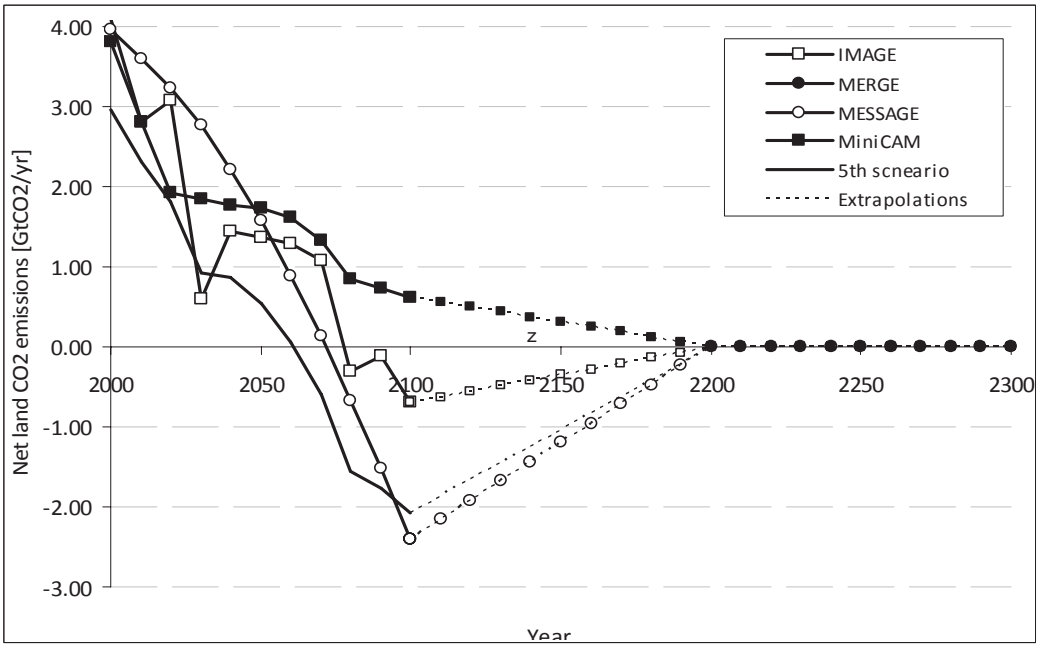
Note: In the fifth scenario, 2000-2100 GDP is equal to the average of the GDP under the 550 ppm CO_2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Figure A4. Global Fossil and Industrial CO_2 Emissions, 2000-2300 (Post-2100 extrapolations assume growth rate of CO_2 intensity (CO_2/GDP) over 2090-2100 is maintained through 2300.)



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO2e, full-participation, not-to-exceed scenarios considered by each of the four models.

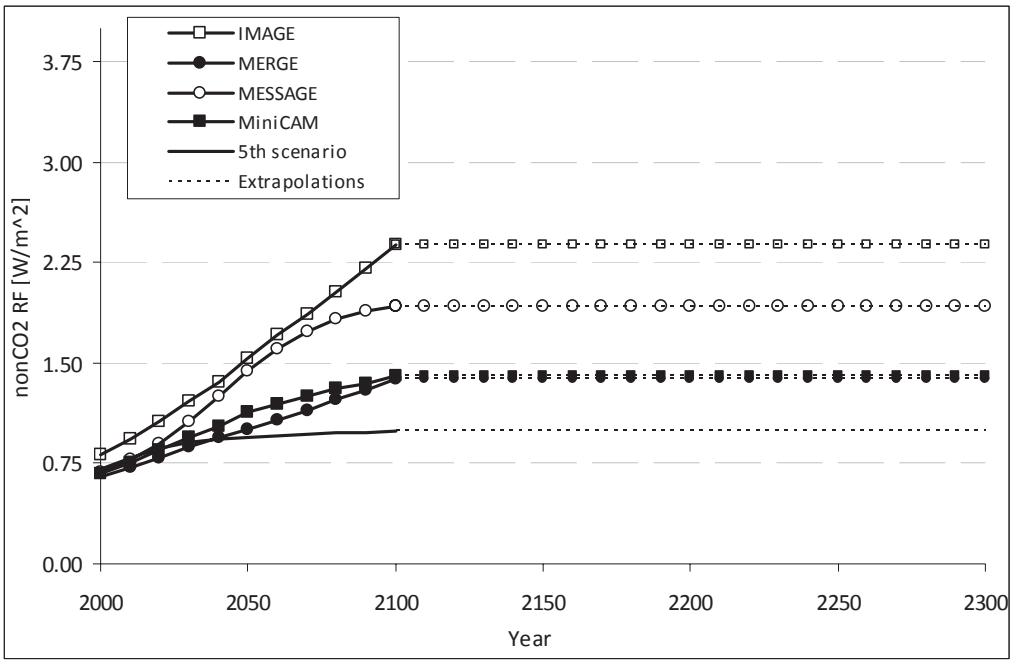
Figure A5. Global Net Land Use CO_2 Emissions, 2000-2300 (Post-2100 extrapolations assume emissions decline linearly, reaching zero in the year 2200)[36]



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO2e, full-participation, not-to-exceed scenarios considered by each of the four models.

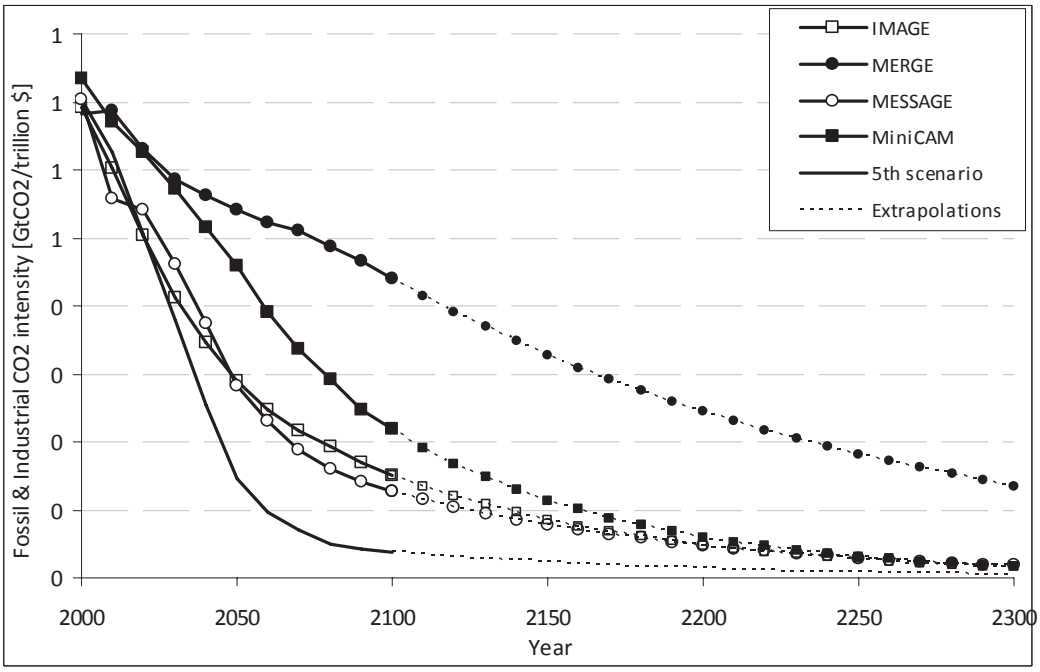
[36] MERGE assumes a neutral biosphere so net land CO_2 emissions are set to zero for all years for the MERGE Optimistic reference scenario, and for the MERGE component of the average 550 scenario (i.e., we add up the land use emissions from the other three models and divide by 4).

Figure A6. Global Non-CO_2 Radiative Forcing, 2000-2300 (Post-2100 extrapolations assume constant non-CO_2 radiative forcing after 2100.)



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Figure A7. Global CO_2 Intensity (fossil & industrial CO_2 emissions/GDP), 2000-2300 (Post-2100 extrapolations assume decline in CO_2/GDP growth rate over 2090-2100 is maintained through 2300.)



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO_2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Table A2. 2010 Global SCC Estimates at 2.5 Percent Discount Rate (2007$/ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario						**PAGE**				
IMAGE	3.3	5.9	8.1	13.9	28.8	65.5	68.2	147.9	239.6	563.8
MERGE optimistic	1.9	3.2	4.3	7.2	14.6	34.6	36.2	79.8	124.8	288.3
Message	2.4	4.3	5.8	9.8	20.3	49.2	50.7	114.9	181.7	428.4
MiniCAM base	2.7	4.6	6.4	11.2	22.8	54.7	55.7	120.5	195.3	482.3
5th scenario	2.0	3.5	4.7	8.1	16.3	42.9	41.5	103.9	176.3	371.9
Scenario						**DICE**				
IMAGE	16.4	21.4	25	33.3	46.8	54.2	69.7	96.3	111.1	130.0
MERGE optimistic	9.7	12.6	14.9	19.7	27.9	31.6	40.7	54.5	63.5	73.3
Message	13.5	17.2	20.1	27	38.5	43.5	55.1	75.8	87.9	103.0
MiniCAM base	13.1	16.7	19.8	26.7	38.6	44.4	56.8	79.5	92.8	109.3
5th scenario	10.8	14	16.7	22.2	32	37.4	47.7	67.8	80.2	96.8
Scenario						**FUND**				
IMAGE	-33.1	-18.9	-13.3	-5.5	4.1	19.3	18.7	43.5	67.1	150.7
MERGE optimistic	-33.1	-14.8	-10	-3	5.9	14.8	20.4	43.9	65.4	132.9
Message	-32.5	-19.8	-14.6	-7.2	1.5	8.8	13.8	33.7	52.3	119.2
MiniCAM base	-31.0	-15.9	-10.7	-3.4	6	22.2	21	46.4	70.4	152.9
5th scenario	-32.2	-21.6	-16.7	-9.7	-2.3	3	6.7	20.5	34.2	96.8

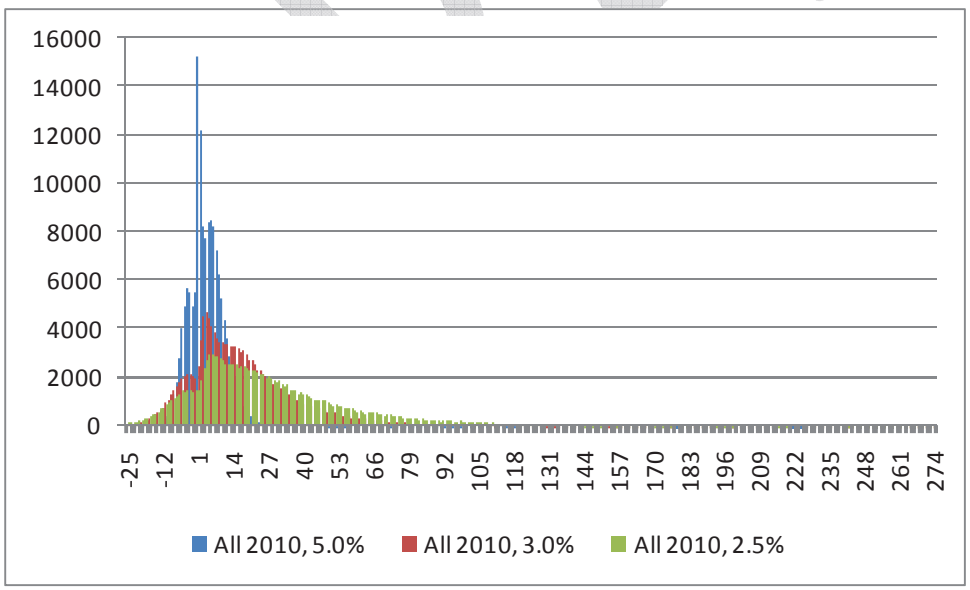
Table A3. 2010 Global SCC Estimates at 3 Percent Discount Rate (2007$/ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario						**PAGE**				
IMAGE	2.0	3.5	4.8	8.1	16.5	39.5	41.6	90.3	142.4	327.4
MERGE optimistic	1.2	2.1	2.8	4.6	9.3	22.3	22.8	51.3	82.4	190.0
Message	1.6	2.7	3.6	6.2	12.5	30.3	31	71.4	115.6	263.0
MiniCAM base	1.7	2.8	3.8	6.5	13.2	31.8	32.4	72.6	115.4	287.0
5th scenario	1.3	2.3	3.1	5	9.6	25.4	23.6	62.1	104.7	222.5
Scenario						**DICE**				
IMAGE	11.0	14.5	17.2	22.8	31.6	35.8	45.4	61.9	70.8	82.1
MERGE optimistic	7.1	9.2	10.8	14.3	19.9	22	27.9	36.9	42.1	48.8
Message	9.7	12.5	14.7	19	26.6	29.8	37.8	51.1	58.6	67.4
MiniCAM base	8.8	11.5	13.6	18	25.2	28.8	36.9	50.4	57.9	67.8
5th scenario	7.9	10.1	11.8	15.6	21.6	24.9	31.8	43.7	50.8	60.6
Scenario						**FUND**				
IMAGE	-25.2	-15.3	-11.2	-5.6	0.9	8.2	10.4	25.4	39.7	90.3
MERGE optimistic	-24.0	-12.4	-8.7	-3.6	2.6	8	12.2	27	41.3	85.3
Message	-25.3	-16.2	-12.2	-6.8	-0.5	3.6	7.7	20.1	32.1	72.5
MiniCAM base	-23.1	-12.9	-9.3	-4	2.4	10.2	12.2	27.7	42.6	93.0
5th scenario	-24.1	-16.6	-13.2	-8.3	-3	-0.2	2.9	11.2	19.4	53.6

Table A4. 2010 Global SCC Estimates at 5 Percent Discount Rate (2007$/ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario						**PAGE**				
IMAGE	0.5	0.8	1.1	1.8	3.5	8.3	8.5	19.5	31.4	67.2
MERGE optimistic	0.3	0.5	0.7	1.2	2.3	5.2	5.4	12.3	19.5	42.4
Message	0.4	0.7	0.9	1.6	3	7.2	7.2	17	28.2	60.8
MiniCAM base	0.3	0.6	0.8	1.4	2.7	6.4	6.6	15.9	24.9	52.6
5th scenario	0.3	0.6	0.8	1.3	2.3	5.5	5	12.9	22	48.7
Scenario						**DICE**				
IMAGE	4.2	5.4	6.2	7.6	10	10.8	13.4	16.8	18.7	21.1
MERGE optimistic	2.9	3.7	4.2	5.3	7	7.5	9.3	11.7	12.9	14.4
Message	3.9	4.9	5.5	7	9.2	9.8	12.2	15.4	17.1	18.8
MiniCAM base	3.4	4.2	4.7	6	7.9	8.6	10.7	13.5	15.1	16.9
5th scenario	3.2	4	4.6	5.7	7.6	8.2	10.2	12.8	14.3	16.0
Scenario						**FUND**				
IMAGE	-11.7	-8.4	-6.9	-4.6	-2.2	-1.3	0.7	4.1	7.4	17.4
MERGE optimistic	-10.6	-7.1	-5.6	-3.6	-1.3	-0.3	1.6	5.4	9.1	19.0
Message	-12.2	-8.9	-7.3	-4.9	-2.5	-1.9	0.3	3.5	6.5	15.6
MiniCAM base	-10.4	-7.2	-5.8	-3.8	-1.5	-0.6	1.3	4.8	8.2	18.0
5th scenario	-10.9	-8.3	-7	-5	-2.9	-2.7	-0.8	1.4	3.2	9.2

Figure A8. Histogram of Global SCC Estimates in 2010 (2007$/ton CO_2), by discount rate



* The distribution of SCC values ranges from -$5,192 to $66,116 but the X-axis has been truncated at approximately the 1st and 99th percentiles to better show the data.

Table A5. Additional Summary Statistics of 2010 Global SCC Estimates -

Discount rate:	5%				3%				2.5%			
Scenario	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis
DICE	9.0	13.1	0.8	0.2	28.3	209.8	1.1	0.9	42.2	534.9	1.2	1.1
PAGE	6.5	136.0	6.3	72.4	29.8	3,383.7	8.6	151.0	49.3	9,546.0	8.7	143.8
FUND	-1.3	70.1	28.2	1,479.0	6.0	16,382.5	128.0	18,976.5	13.6	150,732.6	149.0	23,558.3

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