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A Comprehensive Economic Impact Analysis of Natural Gas Extraction in the Marcellus Shale

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The Economic Impact of Marcellus Shale Gas Drilling What Have We Learned? What are the Limitations?

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Summary: What is the issue?

Several studies have projected large positive economic impacts of shale gas development in the Marcellus region. To make informed choices for their communities, policy makers need to understand the strengths and limitations of these studies. Most importantly, they need to understand that there is a tenuous relationship between positive economic impacts in the short run and long term economic development based on an extractive, exhaustible natural resource. In addressing the relationship, proactive policy can make a difference.

Keywords

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Introduction

For several years, the prospects for energy development from gas deposits in tight shale formations have riveted the attention of natural gas industry boosters and detractors across the US. In southern and western shale-rich states, the shift towards shale gas production is

definitively underway, if yet in its early stages. In New York in early 2011, unconventional shale gas drilling has remained on hold as debates over the pros and cons of a nascent 21st Century gas rush are fiercely engaged. In New York as well as in Pennsylvania, where shale gas drilling has only recently begun, the extensive Marcellus Shale formation is at the center of policy attention. Few natural resource issues have moved from obscurity to center stage in so dramatic a fashion and within such a short time frame.

Extractive natural resource development has frequently been described as transformative to regions that experience it (Bridge 2004; Power 1996; Sweeney 2010). Many citizens believe that the future of New York's economy, environment, character, and quality of life are at stake because of the geographic breadth of the Marcellus natural gas play and the anticipated scale and pace of its development. Environmental issues, especially those involving water, are currently being intensively scrutinized. However, in this brief we focus our attention on the economy.[2] Our primary goal is to review the existing research into the likely economic implications of shale gas development and to raise questions about what policy makers need to know.[3]

We highlight four key issues that have not been adequately addressed by existing economic impact models but which are critical to understanding the economic consequences of shale gas drilling.

- First: we examine existing studies of the economic impacts of shale gas operations, focusing on those that have been referenced in New York State's still evolving environmental impact assessment documents. Because these studies involve projections based on models, we look carefully at several central assumptions that qualify the applicability of the models.
- Second: we discuss the most critical factor that will affect the regional and local economy – the uncertain pace, scale and geographic pattern of drilling operations, and

the associated need to better understand oil and gas company decisions about where, when and how many wells to drill.[4]

- Third: we highlight the need to better understand the economic behavior of landowners who receive a significant fraction of the gas company local spending through leasing bonuses and royalties.
- Fourth: we review the long-term economic prospects for regions dependent on natural resource extraction industries. In particular, we consider the relevance of substantial research that points to the possibility of diminished long-term economic prospects for regions or communities that become overly dependent on natural resource extraction industries.

We conclude that existing evidence about the Marcellus shale gas operations is inadequate to make predictions about the numbers of jobs that will be created, business expansion, or revenue generation with high levels of confidence. Gas development will direct new money into the region, and the prospects for substantial short-term economic gain for some local businesses and property owners are real. Many economic development opportunities will also arise. On the other hand, mixed economic results are likely even in the short run. The rising tide is not likely to lift all boats: there will be losing constituencies among communities and individuals who are displaced or left behind. Moreover, the experience of many economies based on extractive industries is a warning that their short-term gains frequently fail to translate into lasting, community-wide economic development. Most alarmingly, in recent decades credible research evidence has grown showing that resource dependent communities can and often do end up worse off than they would have been without exploiting their extractive sector reserves. When the metaphorical economic waters recede, the flotsam left behind can in some circumstances be seen more as the aftermath of a flood than of a rising tide.

In the end, it seems clear that neither riches nor ruin are inevitable. The academic consensus is that the quality of policy and governance makes an important difference for realization of an extractive industry's long-term economic development potential. The prospects for positive

economic impacts in the short run should not blind policy makers to the potential for long term harm to overall economic development outcomes, especially when responsibly proactive policies may reduce and even reverse this risk.

What is Economic Impact Analysis and How Do We Evaluate the Findings?

Based on the projected size of the resource and anticipated flow of new money into the region, a large positive economic significance of Marcellus shale gas for the region as well as for individual landowners and communities has tended to be taken for granted by policy makers and the press. Even somewhat critical coverage often starts with statements like, "Nearly everyone appreciates the economic benefits derived from the development of… the Marcellus".[5] Studies focused on the regional economic impacts of shale drilling in several producing states have reinforced this predilection by quantifying large positive impacts.[6]

Almost all existing studies employ a well-established method (input-output analysis) that measures changes in the level of product and service sales and how that translates into changes into new jobs (employment) and income (wages) (Miller and Blair 2009). The underlying objective of this method is to estimate the level of overall economic activity associated with increased regional production or sales of particular services or products (such as shale gas), calculating the difference from what would otherwise be expected if the increases did not occur. The term economic impact is thus typically used to refer to the economic contribution a given investment, policy or project may make to the existing local economy.[7]

Input-output analyses of the natural gas industry typically start with the observation that each well drilled is associated with an infusion of dollars to the regional economy. With each well, industry capitalizes on its earlier exploration and leasing expenditures by purchasing some of its drilling-related goods and services from local businesses and workers; eventually local expenditures pertaining to well production, reclamation and well closure will follow. Each producing well also prompts delivery of a stream of payments to government in taxes and of

royalties to local landowners who (depending on assumptions) spend some or all of that money locally. Each of these infusions of funding in turn stimulates increased economic activity, or "multiplier" effects on spending, in industries outside the gas extraction sector itself.

Concerns relevant to all input-output studies

In assessing an economic impact model, we can't just look at the end result -- the jobs and revenue numbers that are produced by the model. We also need to pay careful attention to the assumptions underlying the model. Of course, all models have strengths and weaknesses in their assumptions, so we need to determine how severe the weaknesses are in a particular context to make a judgment about the model's usefulness or predictive ability. The strengths of economic impact analyses based on simple input-output modeling assumptions include:

- The relative simplicity, familiarity, and widespread use of the models that make them easy to use and to critique.

- The fact that input-output models are based on descriptive accounting "snapshots" of the economy at one particular point in time and have the related and important strength of reflecting the complex existing web of purchase and sales relationships, or input and output linkages, between all economic sectors.

The limitations of these models include:

- The constraints on the ability of basic input-output models to evaluate economic circumstances in which change in the economy has been or will be rapid and large. In the Marcellus Shale case, this is a particularly relevant concern because of the continuing evolution and application of new drilling technologies on the one hand and the likelihood that boom/bust effects will lead to localized and abrupt effects on prices in factor and input markets (eg. effects on lease prices, housing markets, labor markets as are already seen in Pennsylvania).

• Assumptions about the independence of impacts over time -- the economic effects of drilling activity that occurs in one year are assumed not to interact with those occurring in subsequent years; ie. overlapping or cumulative economic effects are ignored.

• The close tie between input-output modeling and the economic base theory of economic development which privileges exports as the engine of economic growth. This theoretical framework has been sharply and repeatedly challenged for its overly narrow formulation of growth dynamics, its limited prescriptions for policy, and its anemic ability to explain growth empirically.[8]

• Over-simplification of the economy such that certain (so called general equilibrium) economic relationships involving supply and demand effects are assumed away, leading to the result that any increase in drilling will lead to more growth as an inevitability rather than as an empirical proposition to be tested.

• The fact that several important "built-in" model parameters – most importantly those that indicate the proportion of goods and services in every economic sector that will be purchased locally – are costly-to-validate estimates. These estimates may incorporate significant estimation errors for a given industry, particularly in a regional or county level model.

• The difficulty, grounded largely in a lack of available data, of applying this type of analysis at the sub-county or individual community levels, a fact that exacerbates several of the other named limitations. This difficulty is of considerable significance in the case of the Marcellus shale where impacts are likely to be different and unevenly distributed across urban and rural localities.

Economic Impact Studies of the Marcellus Shale

In the next sections we look at several economic impact studies that have been influential in supporting the public perception that Marcellus gas will have large positive economic benefits for the regions in which drilling is occurring. To a greater or lesser extent, all the points we

raised about the general strengths and weakness of economic impact models apply to the economic impact studies of the Marcellus shale.

The Broome County Marcellus Economic Impact Study

The Draft SGEIS released by New York State (NYSDEC 2009) features brief highlights of the only study of the possible impacts of shale development on the New York economy that was then available. This impact study was prepared for the Broome County Legislature in 2009 by two Texas based economists (Weinstein and Clower 2009). Noting that about 10-20% of the Marcellus formation lies within New York State, the authors restricted the scope of their analysis to the economic and fiscal impacts of Marcellus gas extraction anticipated in Broome County alone. Of the studies considered in this report, the Broome County Marcellus Economic Impact Study is the most dependent on "back-of-the-envelope" calculations and rough assumptions.

As suggested earlier, the most important factor to consider in a study of the impact of Marcellus Shale gas drilling is natural gas production rates. Whether simply assumed or based on sophisticated estimates or calculations, the quantity and timing of gas production must be specified as a first step in an impact analysis. Only after this step is completed are the results introduced into a model of the regional economy to determine how the entire regional economy is affected by changes in the natural gas sector. In this study, as in all the studies reviewed in this report, MIG's IMPLAN economic modeling system and data sets are used for the economy-wide economic analysis.

Two Scenarios Drive Analysis

The Broome County study authors proposed two basic drilling scenarios. First, they assumed that the entire area of the county would be available for drilling. Presuming that an average of six wells would be drilled per 640-acre (square mile) section, 4,296 wells were calculated to be "hypothetically" possible with blanket penetration. Noting that "downtown Binghamton or the town squares of other communities" are unlikely to host drilling operations, the authors

rounded this number of wells downward slightly to 4,000. However, they softened this qualification by suggesting to readers in a footnote that horizontal drilling might make gas under urban centers accessible for extraction.

An essential further assumption was that the wells would all be drilled at a steady pace over an upcoming single decade, ie. 400 wells each year. With little information to go on, no effort was made to assess whether this density and pace of drilling would be politically, economically, environmentally, or technically feasible throughout the entire county. Aside from the "downtown" issue, for this scenario no opportunities or constraints were considered relating to leasing patterns, current land uses, regulatory regimes, corporate goals, landowner preferences, vertical versus horizontal well distribution and productivity, drilling rig capacities and availability, pipeline construction and rights of way, future gas prices, geologic and topographic variation or any other factors that are likely to affect the ten year drilling profile. However, a second scenario does assume without further discussion that just half that total number of wells (2,000) would be drilled. Both scenarios are appropriately presented as hypotheticals rather than as efforts at contingent prediction; little or no justification of either scenario or its likelihood was offered.[9]

To derive an economic value of the gas produced from the wells, the authors next estimated a value per well by multiplying projected prices of gas times the anticipated quantity of gas per well, resulting in ten-year gross revenues per well of $9.3 million, or revenues of $37.2 billion for 4,000 wells. Production and revenues beyond a ten-year time horizon are not considered. Though standard Energy Information Administration (EIA) sources for projections of future natural gas prices were used, no attempt was made to account for the inherent volatility and uncertainty of prices in this sector. It is worth noting in this context that current EIA natural gas price projections are significantly lower (by 9-14% between 2011 and 2020)[10] than those that were available at the time of the study. The overall revenue projections contrast with assumed expenditures of $3.5 million on average to complete each Marcellus well. This translates to total expenditures of $7 and $14 billion for the two drilling scenarios respectively. These figures are

based on early drilling costs reported by a single firm (Chesapeake Energy). While not inconsistent with other early cost estimates, the implications of variations from this single estimate are not evaluated. In practice, costs will vary by company, type, length, and location of wells. Also important are timing and the related issues of where drillers are on their Marcellus "learning curve", plus the likely price pressures rapidly accelerated drilling would put on some factor (e.g. labor and land rent) and input (e.g. hydraulic fracturing services) markets.

How Economy-wide Impacts are Estimated

Both the gross revenue and drilling expenditure numbers just discussed were simulated as a stimulus to the Broome County economy using the MIG/IMPLAN derived input-output model. In the case of the expenditure impact, the entire reported expenditure of $3.5 million per well appears to be treated as though it is spent on Broome County businesses in the gas extraction sector. This is an assumption essential to the expenditure results shown. However, not enough detail is presented about the expenditures or the way they are introduced to the model to determine whether this assumed expenditure pattern can withstand closer scrutiny.

The initial impacts introduced into the model produce small "multiplier" effects on the economy county-wide. The modeling effort indicates that the total impact of $7.6/15.3 billion in economic activity over ten years and 813/1,627 jobs (averaged per year) is overwhelmingly attributable to the $7/14 billion of assumed expenditures by shale gas drilling enterprises in the County. The multiplier is very small (at 1.08, slightly greater than the minimum possible of 1.0) mostly because, as the authors note, of the absence of a supply chain or range of natural gas industry support companies in Broome County.[11] Instead, in the short run at least most expenditures on equipment and services would benefit those locations, such as Texas and Oklahoma, where support companies are concentrated. The authors imply that in the longer term the multiplier might increase as support company presence grew in Broome County. The extent of growth it might be realistic to expect would be subject to quite a few contingencies which are not addressed by the study.

This expenditure-based estimate of impacts appears to account for only the business-to-business purchases made directly, or stimulated indirectly, by the gas industry.[12] The authors also present a second set of impact estimates based on the revenues associated with the drilling levels they have assumed. The revenue estimates of impact are larger than the expenditure impacts because they include all the business-to-business expenditure effects plus additional effects associated with increased labor income, profits to local business owners, returns to corporate and real property owners (including interest, profits, rents, royalties, etc.) and others like government who have a claim on some share of total revenues. To reiterate this point: the impacts reported for the expenditure data are actually a portion of, and are again incorporated into, the larger-by-definition impacts reported for the revenue projections.

Among the revenue impacts reported for the two basic scenarios are $21/41 billion in economic activity over ten years and 2,190/4,380 jobs supported per year. The authors explicitly note that IMPLAN's default parameters for this model estimate that "about 15 percent of the spending associated with natural gas production activities will stay in the local economy". Presumably as a result of this small fraction, a very small overall multiplier effect is again in evidence, with economy-wide effects on economic activity projected to be only 11% higher than the assumed initial stimulus. Unfortunately, as noted earlier regarding the expenditures, no clear information is provided on how the initial stimulus is introduced into the model, or how this treatment might have differed between the initial revenue and expenditure impacts. This makes it difficult to assess the technical validity of the results. In any event, it is unlikely that a model based on historical industry averages adequately reflect the reality of a rapidly evolving industry over its first few years in a new location. This applies in particular to the treatment of bonus and royalty payments to landowners – a factor which proves to make an enormous difference to results in studies from other states.

Summary

In sum, these results are based on rough and ready assumptions and calculations. Simplistic assumptions about drilling rates thus serve as the foundation of the analysis, and are translated

into initial economic impacts primarily through very early and hence tentative Marcellus well yield information. The resulting gas quantities are then combined with projections of gas prices over a decade. Although their treatment of lease and royalty payments to landowners is unclear, the study authors probably correctly estimate high "economic leakage" rates (low local expenditures by the industry). This makes sense for a newly developing industry in a single county economy. As a result, the multipliers are small and total results are overwhelming dominated by the assumptions about the numbers of wells that will be drilled over the decade.

Perhaps surprisingly, the Broome study authors do not take advantage of a key strength of input-output type models, namely their ability to highlight the distribution of impacts across different economic sectors or household income classes. In addition, aside from a minimal justification of the two drilling rate scenarios that drive the entire analysis, no effort was made to assess the sensitivity of the results to alternative assumptions.

Some of the limitations of this study were unavoidable given the fact that the analysis was done prior to the benefit of extensive experience with drilling in the Marcellus or related empirical data. Moreover, the analysis was presumably intended as a first cut exploration of economic impacts rather than the final word on the subject. Whatever functions it may have served when the study was undertaken, much has been learned since it was completed and it has only modest enduring usefulness for understanding the likely economic impacts of shale gas drilling on Broome County.

The "Emerging Giant" Study of the Pennsylvania Economy

Another economic impact study was briefly cited by the New York Draft SGEIS to substantiate the public benefit of shale gas drilling. Completed by economist Tim Considine and colleagues, the cited August 2009 "emerging giant" study of the Pennsylvania economy is one of a series of IMPLAN based economic impact analyses of Marcellus Shale gas development potential that has been produced by Considine since 2006. This study in particular stimulated significant controversy in both New York and Pennsylvania. However, the points of controversy regarding

the study are largely unrelated to the quantitative results summarized in the Draft SGEIS.[13] In summary, these results are that "the Marcellus gas industry generated $2.3 billion in total value, added more than 29,000 jobs, and $240 million in state and local taxes in 2008. With a substantially higher pace of development expected in 2009, economic output will top $3.8 billion, state and local tax revenues will be more than $400 million, and total job creation will exceed 48,000."

Because drilling had already commenced in Pennsylvania in 2008, when the economic impact study was conducted, it begins with an effort to measure existing economic activity associated with Marcellus drilling. The primary source of economic data was a survey returned by seven of the 45 firms reported to have drilled in the Pennsylvania Marcellus (with more vertical than horizontal wells, however) at the time. The data for these firms indicated in part that the number of wells recorded by the state undercounted actual drilling activity by 18%. State and survey data combined to adjust for the undercount provide an estimate of 364 wells drilled during 2008.[14] The authors estimate that the seven responding firms were responsible for a large majority - nearly three-fifths (59%) - of all the wells drilled in that year.

The survey of the seven firms also collected data on company expenditures on payroll, purchases from vendors, payments to landowners, and payments to government, leading to an estimate of 2008 industry spending of just over $3 billion, or about $8.5 million per well. The data on location of purchases from the local economy showed that only three sectors (mining, construction, and wholesale trade) provided 86% of the product and service purchases from local businesses.

The survey results also indicated that 95% of total industry spending occurred within Pennsylvania, which seems extraordinarily high until an explanation emerges from closer inspection. About two-thirds of total reported industry spending in 2008 went directly to Pennsylvania landowners. This proportion reflects the importance of leasing activity at this stage in the cycle of the development of the Marcellus play. Lease and bonus payments also

explain high per well costs. This expenditure pattern would be unlikely to be sustained over time. For example, after the leasing phase of the cycle tapers off, drilling ramps up and purchases from industry support businesses and royalty payments to landowners with productive wells accelerate. As mineral rights acquisition activity declines, so will overall front-end lease payments. These observations point to a general caution about the need to carefully attend to the patterns of drilling and related payments since they are likely to shift over the several stages of development of a play. Cost/revenue projections in particular (especially when calculated per drilled and/or producing well) need to consider that there will be changes over the full drilling/development cycle. Unfortunately, little empirical evidence about revenue pattern changes over the life of a play appears to be available.

Given the dominance of lease, bonus and royalty spending in overall gas company expenditures, the question of landowner economic behavior is of signal importance in interpreting the economic impacts predicted in the "Emerging Giant" study. The authors appropriately account for the fact that landowner receipts do not fully translate into disposable income that is available for consumers to spend. They use a regional average correction factor to adjust total income to disposable income. However, as discussed in more detail below in relation to a more recent three state study also authored by Considine, a more fundamental and less defensible assumption is that landowners treat this "windfall" of revenues like an increase in income rather than like an increase in wealth. This is very important, because many studies show that the propensity to consume out of wealth is much less than out of income, especially in the short term. However, it is also true that there is little more than anecdotal information about actual landowner/lessor spending behavior so far. Information is even thinner about how these windfalls might be managed differently over time as the large initial bonus and royalty payments dwindle over a short span of years to a much smaller and then negligible stream of incoming revenues.

To begin to address this lack of good information, a group of Pennyslvania State University researchers is currently engaged in conducting a study of the spending patterns of landowners

who have leased gas rights. According to one of these researchers, their work has so far highlighted several further concerns that indicate the several Considine studies probably over-estimate the extent to which landowner revenues will benefit the local or even state economy. They raise the question, "Who owns the land, and thus who are the recipients of gas company payments?" Many owners of Pennsylvania gas rights are not, in fact, local or even necessarily Pennsylvania residents. Thus, royalty and other payments to landowners accrue to a) the state general fund for all drilling on state forest or game land, b) nonresident owners of many second homes and undeveloped land owned for recreational purposes, and c) nonlocal owners of mineral rights that have been severed from the surface rights over past decades or who have recently moved from their properties while retaining their mineral rights. Though these issues may well be important quantitatively in many local areas, the extent of severed rights in particular is very difficult to estimate empirically because of the lack of easily accessible records.[15]

The probable exaggeration of short-term landowner spending is important in the overall study for another reason. The study estimates that approximately $2.18 billion dollars are spent "directly" by industry on the local economy. Using a model of the state economy, the study then calculates that this direct spending stimulated an additional $2.05 billion of new output, equivalent to an overall impact multiplier of 1.94. Accounting for the strong possibility that landowners did not all spend their lease revenue portion of that $2.18 billion instate in the same way they spend their paychecks, there ought to be a corresponding (and almost certainly downward) adjustment to the $2.05 billion in additional output as well.

In further analysis by the study authors, economic impacts on the Pennsylvania economy were projected into the future, with an estimate that more than 1,000 wells would be drilled in 2010 with annual increases reaching over 2,800 per year by 2020. The study bases its projections on the relatively strong historical statistical relationship that was in evidence between drilling rates and natural gas prices in the Barnett Shale. Although there is little in the way of obviously better statistical evidence to go on for quantitative projections, there are several reasons for

great caution in applying this relationship to the Marcellus, especially in the shorter term. Exploratory drilling in the Barnett began in the early 1980's, horizontal hydraulic fracturing in the late 1990's, with significant production from horizontal wells in about 2003. The study's estimated statistical relationship is based on the period 1993-2008 (14 data points), a period of rapid evolution and experimentation in drilling technology and effectiveness that may or may not appropriately reflect the Marcellus context.

More importantly, recently increasing attention has been paid to various drivers of the current drilling pace in Pennsylvania that are not directly related to current natural gas prices. They include the gas operator's need to initiate production or risk losing or having to renegotiate leases on less favorable terms ("hold by production"); the smoothing effects of futures markets for gas; production incentives related to joint venture agreements, the internationalization of capital investment in shale gas drilling, capitalization strategies that emphasize production over profit, and other aspects of the restructuring of industry ownership and diversification of some gas companies into natural gas liquids; and continuation of the exploratory phase of drilling as well drilling technology, Marcellus productivity, and regional geology continue to be assessed. All these explain higher drilling activity during a recession than the rock bottom market prices alone would predict.[16]

Finally, the "Emerging Giant" study, which was undertaken during a boom period, assumes relatively high gas prices and increases (eg. $6.7/mcf in 2010 including a 90 cent Marcellus location premium, "gradually rising thereafter"). These are higher prices than have been experienced in fact. Moreover, actual drilling rates are somewhat higher than predicted by the model (1,454 Marcellus wells actually drilled as of the end of 2010; "over 1,000" were predicted) despite the reality of a prolonged price slump. This indicates empirically that while erroneous assumptions in the model may have compensated for each other to some extent, the simple theoretical relationship that informs the model, namely between price and drilling rates, does not seem reassuringly robust at least over some phases of the highly volatile natural gas price cycle.

The Pennsylvania, New York, and West Virginia Marcellus Economic Impact Study

Although it was released after the Draft SGEIS was completed, we also consider an additional economic impact study. This study builds on the earlier studies focused on Pennsylvania. It is significant because it explicitly considers the potential impacts of future gas drilling in New York as well as in currently operating Marcellus Shale states. This "Three State" study (Considine 2010) estimates the economic impacts of Marcellus development activity for the two states with active Marcellus drilling during 2009 (Pennsylvania and West Virginia). Based on gas drilling and production forecasts, it further projects the associated economic impacts for all three states including New York through 2020.

As always, the assumptions and estimates about the size of the initial or direct impacts of gas drilling are central to the analysis. As in the "Emerging Giants" study, the estimates of industry spending for Pennsylvania are based on expenditures reported via a survey of natural gas production companies active in Pennsylvania in 2008 and 2009. The author uses the survey data to estimate industry spending in Pennsylvania of $3.2/4.5 billion in total for 2008/2009. It is important to underscore that even as estimated overall industry expenditures rose by 41% from one year to the next, the largest single component of this expenditure for both years was again for lease and bonus payments (57/38% for 2008/2009 respectively), with an additional 1% for royalties.[17] As emphasized earlier, this empirical data reinforces the importance of understanding how company expenditure patterns will rise and fall, and shift across different subcomponents such as landowners and gas industry service companies, during the evolving development of a gas play.

This estimate of industry spending provides the data for the initial economic change that is entered into the input-output model to project its impacts on the Pennsylvania economy. In a procedural improvement over the Broome county study, Considine's series of studies do not assume that the IMPLAN default databases accurately represent current shale drilling technology and purchasing patterns. Instead, he and his co-authors follow best practice

procedures to introduce a new industry into the state model based on its unique purchasing patterns. To accomplish this, purchasing information was collected via the survey of gas industry companies for the "Emerging Giant" report. This data was used in that report and again in the 2010 three-state study. The survey requested summary information on purchases from all of the respondents' suppliers including the supplying firm's location, the dollar amounts involved, and a description of their purchases. The surveyed firms also provided information about their relevant payrolls, payments to land owners (lease, bonus payments and royalties) and taxes paid. Although this approach followed procedural best practice for input-output model refinements, it is unclear whether the data collected from seven firms accurately reflects the spending patterns of the entire and still evolving industry. As noted in relation to the earlier study, these companies reported that more than 95% of total spending occurs inside Pennsylvania, a result explained only by the finding that fully 69% of total in-state spending (65% of total spending) reported in the survey went directly to landowners and mineral rights owners who are assumed to be in-state residents.

Also as previously discussed, because of the significant proportions of industry payments that are received by landowners, the treatment of these expenditures is especially important. As in the "Emerging Giants" study, Considine adjusts the landowner payments for taxes to arrive at an estimate of disposable income that is assumed to be spent according to national patterns of consumer spending. He makes a further assumption that is arguably inconsistent with the short term input-output framework within which the study is presented. As a reminder, he treats all royalty and bonus receipts by landowners as current income rather than as an increment to wealth. As such, he assumes that it will be spent in the year received and in essentially the same proportions as income from the workplace. Special vacation trips, additional car purchases, new trust accounts for children, large investments in mutual funds, bathroom remodeling or second home purchases and the like are not considered.

In contrast, a similar economic study of the Haynesville Shale made a sharply different assumption (Scott 2009). To estimate economy-wide impacts, Haynesville landowner receipts

were treated as additions to wealth such that, in the conservative base case analysis, only 5% of the value of this new wealth was assumed to be spent on consumption by landowner households. Considine's assumption unrealistically boosts the assumed direct economic impact for any year, especially compared to the base case propensity to spend out of wealth assumption used in the Haynesville study. Moreover, because consumers purchase goods and services from a comprehensive array of economic sectors, the distribution of multiplier impacts across the economy is more dispersed than would otherwise be the case. On the other hand, the Haynesville study for its part does not consider that the 95% of the new wealth that was assumed to be saved in the year it was received might boost spending in future years. As a general conclusion, it is clear that better estimates of the propensity of landowners to spend their bonus and royalty incomes are essential to improved economic impact analysis. It is not a comfortable stretch to simply assume that rural landowners and mineral rights owners would spend royalty payments in the same manner as the average consumer, or as would typical winners in the lottery or stock market. The previously mentioned Penn State University study of Pennsylvania landowners will take some significant preliminary steps in helping to remedy this knowledge gap when it is completed.

Considine's IMPLAN analysis in the "Three State" study concludes that the initial or direct effects of $3.8 billion in industry and landowner spending generate $7.2 billion in gross output, $3.9 billion in value added, and over 44,000 jobs statewide. In terms of multipliers, this indicates that for every $1 that the Marcellus industry spends in Pennsyvlania, $1.90 of total gross output or sales is generated and for every $1 million of gross output created by natural gas 6.2 jobs are created. Considine suggests that differences between these multipliers and similar ones found in studies from other states (his output multiplier is higher, while his job multiplier is mid-range) are due to his "detailed expenditure analysis in our benchmark year 2008 based upon company accounting data". We suspect that the differences have as much or more to do with his treatment of landowner income and the different sizes and structures of the other economies studied.

Because Marcellus production in New York was on hold, the "Three States" study only considers impacts on New York State as part of its projections for the future. Considine reasonably ties this future to various scenarios regarding the number of wells drilled for 2011, 2015 and 2020, noting in passing that, "Assessing the odds favoring any one of these three scenarios is difficult." Citing policy and geologic/economic considerations, he suggests that development in New York, if it occurs, would not be as widespread or aggressive as in Pennsylvania, though it would probably mimic that state's split between vertical and horizontal wells. In his Low Development Scenario, he assumes very conservatively that no wells will be drilled in New York over the next decade (versus 1220/1353/1465 for these years in PA, 227/252/273 in WV). He focuses most attention on the Medium Development Scenario which shows 42/314/340 wells drilled in New York (versus 2019/2239/2424 in PA, and 376/417/452 in WV), a relatively modest scale compared to Pennsylvania, though apparently assumed to concentrate in a small number of Southern Tier counties. The High Development scenario shows 52/406/502 wells in New York (2211/2903/3587 in PA, 464/609/752 in WV). The number of wells drilled is based on manipulations of the same statistical model critiqued previously that relates well drilling numbers to natural gas prices. The scenarios are varied further by assumptions about well yields, with averages of 1.5 billion cubic feet assumed in the Low, 2.0 in the Medium, and 2.8 in the High Development scenarios.

Based on the Medium Development Scenario, the study projects that in New York in 2015 $1.9 billion in company spending will generate $3 billion in total economic activity, and that 8,196 jobs created directly by company spending (primarily in mining and construction, but also substantially in wholesale and retail trade, and in health and social services) will generate a total of almost 16,000 jobs statewide (most of the additional jobs are in health and social services and retail trade). As we have emphasized in this report, it appears that the distribution of company spending to landowners and its treatment is very important for the results. In these scenarios, 39%/34%/40% of total company spending is presumed to go directly to landowners in 2011/2015/2020, with the lease share declining as the royalty share rises. The same critiques

raised earlier apply about whether these funds will be spent locally/in-state or should be best treated as increments to income or to wealth.

Finally, it should be mentioned that Considine's "Three State" study also uses IMPLAN modeling capacities in a further analysis to link the three state economies via data on their interstate trade flows, ie. he employs a form of multiregional input-output analysis. This reduces the amount of spending estimated to leak entirely from the three state system of economies, which in turn increases the estimates of economic activity in each state.

Summary

In sum, Considine's relatively well documented "Three State" study involves a more sophisticated analysis than the Broome County study and goes to some length to develop a range of possible future impact scenarios, accounting for such factors as future natural gas prices, well depletion rates, and the splits between horizontal and vertical wells. It also improves on key default parameters in IMPLAN with primary survey data. While these estimates and assumptions about the future may prove incorrect, the use of a range of three development scenarios helps bracket the possibilities and draws attention to the significance of uncertainties. Apart from the generic concerns about the blind spots endemic to all input-output analysis discussed at the beginning of this report, the most important critique of this study has to do with the estimation and treatment of bonus, lease and royalty payments to landowners and other mineral rights owners.

Summary Evaluation of Impact Studies: Drilling Rates, Landowner Revenues Drive Study Results

The factors that most drive the economic impact study results in all of the studies reviewed are the dollar value and quantity of, and production timelines for, the gas that will be extracted and sold to consumers. These quantities are inextricably linked to drilling rates, whether they are already observed for the past, or projected or assumed for the future. However, even in more mature shale gas fields, only the early stages of a full development cycle have so far been

observed. The Marcellus play is still in the very earliest phases of exploration and production. Thus, assumptions or observations supporting the estimates of the drilling rates and their determinants still involve significant uncertainty, are controversial, and deserve great scrutiny in any evaluation of the results and predictions made in these studies. For example, some contrarian industry analysts argue that the Barnett and Haynesville production evidence accumulated to date points strongly to the conclusion that economically recoverable shale gas reserves may be dramatically lower and more geographically concentrated than those that were quickly accepted by many, including both those advocating for and opposed to gas development, in the industry and general public (Berman 2010). At this point, no single perspective can be said to have a lock on the "right" estimate of the number of wells that will be drilled or the estimated ultimate recovery rates of shale gas; thus any economic impact analyst faces a formidable challenge right from the start.

Nearly as important as assumptions about the development of the play as a whole are the assumptions and estimates made about who has claims on the revenue streams generated by gas production. Particularly critical are: 1) the revenue split between people and businesses located inside versus outside the region, and 2) the split within the region between landowners and drilling related businesses. Only after these initial parameters are specified, whether again by observation, projection, or simple assumption, do other technical factors associated with the economic model of the regional economy become relevant.

What Critical Issues Are Not Adequately Addressed by Input-Output Models?

The economic impact analyses reviewed above provide at best a simplistic picture of the economic development consequences of investment connected with tight shale natural gas drilling operations. They do not adequately explore several serious economic issues that policy makers need to consider in crafting effective responses to gas drilling. In the following sections, we delve further into the two issues just highlighted: 1) how the pace, scale and distribution of

drilling are likely to affect the distribution of costs and benefits to local communities where drilling is occurring; and 2) how the economic benefits, which accrue in the first instance to land owners and businesses that supply the gas industry, will affect regional expenditure patterns and the capture of gas industry investment. We also return to another topic mentioned at the outset of the report: the evidence that regions dependent on resource extraction industries have poor prospects for long term economic development, particularly without thoughtful and proactive policy interventions in place before extraction begins.

The Pace, Scale and Geography of Drilling: Regions and Communities

We have emphasized that the pace, scale and geographic distribution of drilling will determine the economic impacts, both positive and negative, on communities in the Marcellus Shale gas play region. Several key factors influencing the pace and scale of drilling are outside the control of state and local policy makers. They include market forces and knowledge about the detailed geology of much of the Marcellus region. The overall trajectories of these factors remain uncertain. Nevertheless, while acknowledging uncertainty, state and local policy makers can influence and regulate gas company as well as consumer behavior directly. They have the powers to tax, regulate, monitor, subsidize and/or negotiate for mitigation of various kinds of costs and a greater share of benefits. Some of the boundaries of these powers are currently being shaped and tested at federal, state and local levels. In any event, many financial, capital, and land use planning powers that can be used to manage the indirect consequences of drilling if not the drilling itself are fully accessible to capable governments. What is less clear is how many of the affected governments will have adequate access to the capabilities and actions needed to meet the governance challenges and opportunities that will arise.

Geography matters in assessing pace and scale impacts

Though the arc of some kind of economic boom and bust cycle is implicit in the very definition of an exhaustible resource, within the overall Marcellus region the recoverable resource is so large that extractive activity could fairly be anticipated over multiple decades. The regional economic effects, including in select communities that serve as regional service centers and

economic hubs, might be similarly sustained over multiple decades. There are already indications that Pittsburgh, for example, will play a major role of this type for the Marcellus. Moreover, on a multi-state regional basis encompassing multiple metro and other urbanized areas, a large and diversified economy already exists and is unlikely to develop an outsized dependency on natural gas production. In contrast, any boom/bust drilling cycle for smaller individual communities, their residents, and many local land owners would likely be very much more telescoped in time and proportionately dramatic in scale. Though drilling and production strategies in the Marcellus are still evolving, it seems logical that actual drilling activity would be locally most intensive for several years (rather than decades), then move on. Because company payments to local businesses and landowners are dominated by activities immediately before, during, and after drilling, the injection of funds to local economies tends to closely follow the intensity of drilling itself.

Despite manifest uncertainties at both the local and regional levels, the cumulative market value of the hypothetical quantities of recoverable Marcellus gas is notable, even applying modest assumed future natural gas prices. Total value estimates span many billions of dollars to conceivably some trillions at the high end. Even spread out over many years of production, these numbers loom especially large during troubled economic times and in regional economies where economic stagnation or decline have persisted over many years.

Turning this hypothetical value into economic reality implies, however, extensive well drilling throughout vast expanses of the multi-state Marcellus region. Considine's "Emerging Giant" study speculates about drilling of up to approximately 30,000 wells by 2020. Substantial as this number appears at first glance, this projection may be far less than half the total number of wells that would be required in the longer term to support the highest ultimate recovery figures that have so far been proposed.[18] Nevertheless, it is precisely the number and uniform distribution of the wells evoked in these projections that raises the specter of widespread risks of water contamination, land and habitat disruption, housing shortages, and community

stressors alongside the positive assumptions about landowner riches, jobs, and community wealth creation.

At least during the extended drilling phase of any Marcellus gas development, it seems inevitable that natural gas industry-related drilling activities would penetrate large swaths of a mostly rural landscape. While drilling has begun to appear in suburban and even urban contexts in the South, it is already clear that drilling in many more densely populated communities of the Northeast will face significant barriers. With well pad density anticipated for the time being at something between 1 and 16 per square mile,[19] many critics anticipate widespread "industrialization" of the rural farm and forest landscapes common to much of the region. Other industry critics argue, in partial contrast, that despite the vast physical expanse of the Marcellus shale resource, drilling will not be profitable outside of geographically concentrated regions of highest productivity. For example, one review of several developing shale plays categorizes three typical resource grades, each likely to experience different drilling patterns over time and space: a highly productive "compact core sweet-spot", a "reasonably sized average productivity area", and a more extensive low productivity "fringe area, often called the goat pasture." (Kuuskraa and Stevens 2009). Whichever analysis turns out to be correct for the Marcellus, there is little doubt the overall numbers and pattern over time and space of wells drilled will trigger the most significant economic, environmental, and social impacts that will accumulate with Marcellus shale gas development.

The Landowner Windfall – What Does It Mean for Economic Impact and Long Term Development?

In the studies we reviewed as well as in studies from other states, landowner lease and bonus payments (not just drilling industry salaries and input purchases from local businesses) constitute a very large and even dominant fraction of local spending by gas companies. This is true especially in phases of development where leasing (early on) or royalty payments (eg. when economic conditions lead to drilling slowdowns, or as the play is eventually exhausted) rather than current drilling activity dominate. It is even truer in a region new to gas

development which lacks an existing cluster of gas industry support businesses. In either case, the split between gas company spending on landowners and on local businesses inevitably adjusts as gas field development matures through several phases over time. Clearly, the prominence of payments to landowners is derived from the need for energy companies to lease land from many private landowners. From an economic development perspective, this distinguishes Marcellus Shale development in important ways from that in most western states, where energy development is more heavily concentrated on public lands.

Local economic development strategies that ignore landowner behavior will likely overlook multiple factors of critical importance for economic development. This will be especially the case where and when gas industry companies pay out more to local land owners than they do to local business. Most local landowners can be expected to have a relatively high propensity to spend gas company payments locally or in near-by urban centers compared to gas industry service companies. As noted, little to no systematic empirical evidence yet exists on the economic behavior of different kinds of landowners who have received substantial leasing, or ultimately more importantly, royalty payments. Regardless, a proactive economic development strategy would seek opportunities to capture a greater share of landowner spending. In summary, these observations underscore the critical importance for the future regional economy of developing better information and policies that account for a) landowner spending patterns of both royalty and lease payments and b) shifts in the local patterns of gas company spending over time.

Other Distributional Effects

While shale gas development critics generally acknowledge the influx of dollars to local landowners and businesses, they challenge the extent to which local gas extraction actually channels economic benefits to more than a minority of property owners, businesses, and workers who live in the community, and especially to those who lived there prior to the onset of gas development. One signal concern is distributional, about whether benefits are limited to the few or are experienced community-wide. Again, more information is needed about where

drilling is most likely to occur and who the owners of the leasing rights to these properties have been, are, and will be in the future. Another concern is about "leakage": how much of the money that flows into the community is either not respent locally or in fact accrues to nonlocal or temporary residents and firms in even the first instance? While programs like IMPLAN include default estimates of leakage from each sector of the economy, local validation of the plausibility of these generic estimates is important and often worth investment in research about the most intensively involved business sectors.

Even more fundamental than the critique of minimal or uneven benefit, critics have raised concerns about the extent to which gas development might lead to concrete economic losses for some or even most local businesses and residents across many economic sectors.[20] Certain kinds of losses could be related to increased competition with the gas industry for scarce economic inputs such as housing, labor or materials. According to this dynamic, numerous industry sectors or subsectors (e.g. tourism, light industry, agriculture, or construction), some with longer term development potential, are "crowded out" of the regional market as their costs of doing business increase. These crowding out effects are typically transmitted through increased market prices, for example for hotel rooms, trucking or accounting services. Some of these effects may be reversible as the gas industry fluctuates and inevitably declines, but others represent wasted investment and longer term lost opportunity, especially when existing skilled workers and an viable or latent nexus of synergistic businesses are displaced. Price effects are theoretically capable of being captured in some kinds of standard economic models that are more sophisticated than basic input-output models. Empirical research of a number of industries along these lines has found that input-output multipliers often overestimate actual economic growth due to these kinds of effects. Unfortunately, this kind of analysis is rarely practical at the community as opposed to regional scale. Finally, even if not directly associated through employment or ownership with industries subject to these kinds of crowding out or price effects, some community members, especially those on fixed incomes, renters, or others hurt by local price inflation, stand to suffer economic harm.

Another type of loss would not be transmitted through the same kinds of price signals and are much harder to predict with the standard analytic tools of economics and regional science. Examples include the potential effects on tourist, organic farming, and other businesses whose viability is anchored in the existing character and reputation of communities, water and environmental quality, and regional landscapes. While such effects will almost certainly be seen to some extent, the actual extent is very hard to evaluate. The essential difficulties here are first, in establishing and quantifying possible effects of drilling on the tangible and intangible entities such as reputation, regional "brand", and landscape quality, and second, once such links are established, predicting their economic consequences.

Questions About Long Term Economic Development in Regional Economies Dependent on Resource Extraction

While no study exists that has made a comprehensive effort to identify or quantify possible economic losses associated with shale gas development there are several streams of literature focused on the relation between longer term economic development and specialization in primary sectors like farming, forestry and mining. The first tradition focuses on studies of the observed economic performance of regional economies in the United States that are dependent on extractive resources. Although individual results show a mix of beneficial and harmful results, many studies determine that resource dependent economies tend to perform less well than others. In this tradition, one recent study considered 26 western counties that have concentrated on fossil fuel extraction from public lands for economic development, concluding that at least in recent years such counties have increasingly underperformed economically compared to less energy industry focused counties (Headwaters Economics 2008). Another older benchmark review of 19 separate studies of mining-dependent rural economies concluded that, "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." (Freudenburg and Wilson 2002)

Since the mid-1990's an extensive body of empirical research has also investigated the existence and dynamics of the so-called "resource curse" (Sachs and Warner 1995; Ross 1999). This literature was stimulated by the observation that many developing and some developed countries with rich natural resource endowments had, contrary to prevailing economic development theory, shown poor economic growth results over time. While there is ongoing debate over the existence, prevalence and specific mechanisms of a "resource curse", there is widespread consensus in the developing country literature that a resource curse exists but is not inevitable (Sinnot et al., 2010). Moreover, it is typically attributed to a combination of effects that involve both systematic failures of governance and policy as well as economic incentives to allocate "too many" resources to the extractive sectors of the economy (akin to "crowding out").

In 1999, Michael Ross summarized the curse literature to date by noting, "There is now strong evidence that states with abundant resource wealth perform less well than their resource poor counterparts, but there is little agreement on why this occurs." He drew attention to the most common rationales proffered to explain why a curse might exist. It is worth examining these to see which are more or less likely to be even relevant to the effect of gas development on regional economies in the United States.

Four of the groups of reasons summarized by Ross are economic. These are 1) a decline in terms of trade for primary commodities, 2) the instability of international commodity markets (making government revenues & foreign exchange unstable and investment risky), 3) the poor economic linkages between resource and nonresource sectors, especially as external investors remove profits from the local economy, and 4) the "Dutch Disease" that associates resource boom economies with a) increases in the exchange rate, making other domestic exports more expensive, and b) increased competition with other domestic sectors for scarce capital and labor.

In terms of their translatability to a subnational and domestic context, only some of these reasons are even theoretically relevant. The terms of trade logic is completely inapplicable. In

contrast, the instability of commodity prices is partially salient, especially as both government revenues and investment risk are affected by unstable prices in regional markets. The linkage argument also seems potentially relevant insofar as nonlocal firms are likely to come into a region only temporarily, extract profits along with the gas, and be likely to purchase only a limited array of local goods and services lacking a well developed economy of strong, locally well linked sectors (again, the share of expenditures going to local landowners vs. local firms would have important implications). Part of the Dutch Disease argument also seems potentially relevant. Though the increased cost of domestic currency is obviously not relevant at a regional level, we have already discussed how tighter competition of the resource sector for factors of production is quite likely to crowd out competing sectors, at least during some time periods in the adaptation of the local economy.

Ross observes, in review, that proactive government policies could, in any event, ameliorate most or all of these economic resource curse problems. Consequently, "The failure of states to take measures that could change resource abundance from a liability to an asset has become the most puzzling part of the resource curse." Overall, the subsequent empirical literature has focused heavily on issues of governance. Ross himself emphasizes five explanations concerned with political and governance phenomena. Several seem unrelated to the context of regional economies in a developed country; others appear to have potential relevance. Among these, Ross identifies 1) cognitive explanations, which contend that resource booms produce a sort of short sightedness among policy makers (get rich quick mentality, laziness, excessive optimism followed by frantic retrenchment); 2) societal explanations, which argue that resource exports tend to empower sectors, classes or interest groups that favor growth impeding policies (e.g. firms and workers in the resource sectors accrue the power to maintain government policies investment, tax and trade policies that benefit them preferentially), and 3) related state centered explanations which contend that resource booms tend to weaken governing institutions by reducing financial accountability to the full range of domestic constituencies, i.e. place government more fully at the service of the extractive sector alone rather than society as whole.

Perhaps of most significance for the Marcellus shale economies are several recent subnational empirical studies of the resource curse phenomenon, three of which have investigated the issue within the United States using both state and county level data sets. Each of these studies (James and Aadland 2010; Papyrakis and Gerlagh 2007; Johnson 2003; Libman 2010) finds evidence that some version of a resource curse is detectable within a subnational economy, and that poor governance and crowding out effects are contributing factors of varying importance. Papyrakis and Gelragh optimistically conclude that, "prudent economic policies and cautious planning can reverse the pattern". However, none of these studies consider the unique attributes of natural gas production or the Marcellus shale resource as compared to the other "natural resources" included in them. Even granting the "curse" effect, the empirical specification of how much dependence on a single sector of the economy constitutes "overdependence" is not explicitly addressed. Thus, the question of the applicability of this work to development of the Marcellus remains an important open question that merits further sustained research.

Conclusions

Communities do not face a dogmatically predetermined outcome regarding the long-term economic development implications of drilling in their communities. Those starry eyed by the prospect of previously unimagined community wealth and those fearful of the certainty of economic decline are each looking into futures that are possible, but most likely exaggerated and more importantly not written in stone. The lesson of the economic impact studies, despite their limitations, is that large scale natural gas drilling would bring a wave of new money to the region. This money would increase the wealth and income of various individuals and communities at least during parts of the Marcellus development cycle.

Even abstracting from the possible worst environmental consequences of extensive drilling, it would also bring new risks and most unavoidably, significant change. Whether natural gas development would lead to economic diversification or overspecialized dependency is an important economic development concern. In relatively diverse local economies, both industry

and consumer spending would be more likely to be locally retained, leading to larger multiplier effects. In such local economies, the gas industry would also be more likely to contribute to diversity and to lessen the potential for instability associated with concentration and overdependence on a commodity famous for price volatility in the short run and depletion in the long run. Even in smaller rural economies without much existing economic diversity, gas development might offer the possibilty of a diversification strategy. However, in such places the potential for a hard boom bust cycle, and for the gas industry's competition with pre-existing economic anchors, may be the greatest. For some individuals and communities, the wave of big money would likely rise and fall with an abruptness that many would find deleterious even as for others, the wave would be more sustained and positive.

The resource curse and boom/bust literature suggests that communities with anemic governance, and with little capacity to do more than let the volatility of the boom/bust cycle passively wash over them, can face a sobering and diminished future, especially in the longer term. The less well prepared or well positioned are likely to be left pondering the meaning of the words of Sheik Yamani, former oil minister for Saudi Arabia: "All in all, I wish we had discovered water." On the other hand, individuals and communities with the wherewithal to capitalize on the large influx of money passing through their communities have the potential to see significant, sustained economic benefits. These communities will understand the transitory and fluctuating nature of extractive wealth, and negotiate smartly and toughly with the gas companies. They will have plans and capacity to in the first place maximize their access to the flows passing through. In the second place they will develop the management strategies to invest boom revenues wisely. They will develop appropriate mitigation, land use and long term capital planning, taxation and investment strategies, and aggressively seek to diversify and stabilize their economies. First and foremost, they will recognize that they cannot vest their future in an industry guaranteed to eventually disappear.

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[2] Of course, the realms are not independent, as economic activity of various kinds can affect environmental quality, and changes in environmental quality can affect the health of the economy.

[3] Our limited scope focuses on regional economic development issues rather than larger policy issues such as what energy development strategies are "most appropriate" at either a regional or national scale. Even within this limitation, we do not directly address several significant policy-relevant topics to which we wish at least to draw attention because they are related in the first instance to economic development and are definitely deserving of further consideration. Foremost among these are the implications of the Marcellus Shale gas resource for 1) natural gas and other energy users in their roles as consumers, and 2) the potential influence on firm retention and/or attraction of development of a local energy resource.

[4] For a discussion focused on the importance of the pace and scale of change in gas drilling cycles, and recommendations that the pace be slowed down to mitigate negative aspects of the boom/bust phenomenon, see Haefele and Morton (2009).

[5] See Hargreaves (2010).

[6] These studies are included in the references. Several 2008/9 impact studies have received most attention. The Fort Worth area economy was reported to have seen gains of $11 billion in annual output (8.5% of total output) and 111,131 jobs (6.8% of total jobs) in 2008 associated with development of the Barnett Shale (Perryman 2009); in Louisiana the Haynesville Shale was linked to $2.4 billion in new business sales and 32,742 new jobs within the state of Louisiana (Scott 2009); in Arkansas's Fayetteville

Shale, natural gas extraction was associated with statewide impacts of $2.6 billion and employment of 9,533 people (Center for Business and Economic Research, 2008). A study of the West Virginia economy concluded that a $371 million 2008 impact on output, associated with more than 2,000 jobs, would increase to $2.9 billion in output and almost 17,000 jobs by 2020 (National Energy Technology Lab 2010). More recently, the Eagle Ford shale were estimated to create close to $1.3 billion of gross state product impact, support 12,601 full-time jobs, and add $2.9 billion in total economic output to the Texas economy (Center for Community and Business Research 2011). Pennsylvania and New York studies of the Marcellus are discussed below.

[7] Economic impact analysis should not be confused with cost benefit analysis. The latter focuses on measures of economic value (e.g. how much goods and services, including those like environmental quality for which markets may not exist, are actually worth), the former on indicators of economic activity (e.g. jobs and incomes). Fiscal impact analysis is often related directly to economic impact analysis. Starting with estimates of changing levels of economic activity, it looks at the implications for public sector costs and revenues. The economic impact studies reviewed here include fiscal analyses, but we do not attend to them other than to note that 1) the fiscal results are driven by the other economic impact results, 2) the studies do not take into account many of the cost and revenue implications that are distinctive to shale gas development, and 3) they are of limited use in differentiating impacts by each of the government jurisdictions affected.

[8]Recently, the work of Kilkenny and Partridge (2009) econometrically investigated the dependence of rural development on employment in traditional rural export sectors in the United States, concluding that, "The results reject the hypothesis that emphasizing traditional export employment results in rural growth." These results are grounded in export base theory that is broader than but applicable to the "resource curse" literature reviewed later in this paper.

[9] Pennsylvania provides some context. In 2009, 763 Marcellus wells were drilled statewide, with the largest concentration (138) in Washington County. Drilling accelerated in 2010. In 2010, 1,454 Marcellus wells had been drilled, with the largest concentrations in Bradford (386) and Tioga (266) counties. (See http://www.dep.state.pa.us/dep/deputate/minres/oilgas/BOGM%20Website%20Pictures/2009/Marcellus%20Wells%20permitted-drilled%20Jan-Dec%202009.jpg and http://www.dep.state.pa.us/dep/deputate/minres/oilgas/2010%20Wells%20Drilled%20by%20County.htm accessed 4/4/2010) Both counties are more rural than Broome County, with 62% and 59% greater land masses respectively and populations much less than half as large.

[10] See http://www.eia.doe.gov/oiaf/forecasting.html (accessed 12/10/2010)

[11] The 2008 Broome County MIG/IMPLAN model, for example, excludes the "Support activities for oil and gas operations" sector entirely due to a lack of transactions attributable to businesses classified in that sector.

[12] We tried to reproduce the analysis of impacts on the Broome County economy using the 2008 MIG/IMPLAN modeling system and data. A $7 billion dollar shock over ten years to the "Extraction of Oil and Gas" sector yields $8.3 billion in total output (967 jobs per year) including only business to business effects. The same shock to the "Oil and Gas Drilling" sector yields $7.8 billion in total output over the decade (1,325 jobs each year). These results suggest the report authors built a slightly different

version of the model than ours, but probably modeled the impact as a shock to one or both of these sectors.

[13] Most of the criticism of this study was related to its promotional tone, its simultaneous use of a Penn State University cover and financial sponsorship by the Marcellus Shale Committee (an industry sponsored organization), and the section of the study that sharply criticized the wisdom of the governor's proposed severance tax and environmental regulation of the gas industry. A revised version was later issued under a different cover without the tax analysis.

[14] The state currently shows 196 Marcellus wells were drilled throughout Pennsylvania in 2008. (See http://www.dep.state.pa.us/dep/deputate/minres/oilgas/2008%20Wells%20Drilled%20by%20County.htm accessed 12/20/2010) Applying the suggested 18.2% adjustment to this number of wells yields 232 wells, far less than the 364 wells used in the study. The reason for the difference in the DEP well count used in the study and that noted here is unclear. However, the impact based on 364 wells is obviously far greater than for 232.

[15] Tim Kelsey, personal email communication (February 17, 2011).

[16] An exploration of these essential issues is beyond the scope of this paper. However, there is much discussion of them in the industry blogosphere (eg. http://blogs.oilandgasinvestor.com/blog/2011/03/15/shale-gas-jvs-will-keep-gas-within-46-range-for-a-long-time/) and by industry analysts such as Tudor Pickering (see http://www.spegcs.org/attachments/studygroups/2/2010_01_Bus%20Dev%20-%20TPH%20Danny%20Rathan.pdf on joint ventures), Ben Smith (see eg. http://www.firstenercastfinancial.com/forums/natural-gas/1699-held-production.html on hold by production), and skeptic Arthur Berman (see eg. http://www.theoildrum.com/node/6785 on production over profit). (All accessed 4/1/2011)

[17] Estimates of total spending in 2008 are somewhat greater, and payments to landowners somewhat lower, in the more recent survey compared to the earlier survey. Presumably, this is due to differences in which companies responded and the completeness and accuracy of responses reported in the two surveys.

[18] Naïve estimates based on the extent of the entire Marcellus (95,000 sq. mi.) and reported well densities of 4-16 wells per square mile arrive at a range of 380,000 – 1,520,000 possible wells (NETL 2010b). A recent West Virginia study suggests 30,000 to 60,000 "proration units" (one well per unit) are possible over time in West Virginia alone (NETL 2010a). Engelder's (2009) well known 489 TCF estimate of recoverable gas appears to be based on the assumption that over 50,000 square mile sections of varying degrees of gas productivity would be drilled over 50 years, generally with 8 wells per section (presumably from a common drilling pad); hundreds of thousands of individual wells are again implied. A similar informal industry calculation using somewhat different simplifying assumptions (half of the 95,000 square mile formation is developed with 47,500 drill sites, with 8 to 16 wells per square mile unit) also points to hundreds of thousands of wells (Spigelmyer undated). As noted earlier, however, others (Berman 2010; also personal email communication April 4, 2011) have argued vigorously that only a fraction of these wells are likely to be profitable economically without large increases in the price of gas.

[19] Following current trends, the pattern of one pad with multiple wells is likely to prevail for economic and regulatory reasons, suggesting density near or even below the lowest end of this range are most likely. However, in some circumstances involving local circumstances, a cost-benefit shift favoring vertical drilling, evolution of extraction technology, and/or the potential use of infill wells in various locations, more dense drilling might become more economically advantageous.

[20] Barth (2010), for example, concludes that, "In reality, the economic impact may very well be negative. And the likelihood is that gas drilling would adversely affect other economic activities such as tourism and sport fishing and hunting. To some extent gas drilling and these other industries are likely to be mutually exclusive. The net effect is what must be considered." Measuring or predicting this "net effect" is far from a straightforward task, especially since much of the economic boost related to drilling will come via short term boom/bust cycles in a region that has struggled long term with outmigration and disinvestment trends.