Working Paper Series

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

May 2011

This is one in a series of policy working papers, prepared by a group of researchers centered at Cornell University with support from the Park Foundation and the Heinz Endowments, to inform policy makers and citizens about key economic issues related to shale gas drilling and production. Our goal is to look at the big picture, and to insure that people have accessible and relevant information to help them make good decisions at the state and local levels. We hope that our research raises new questions and perspectives, sparks debate, and informs policy.

How Should We Think About the Economic Consequences of Shale Gas Drilling?

Susan Christopherson and Ned Rightor

Summary: What is the issue?

In New York and Pennsylvania, the public debate about the prospect or continuation of high volume hydraulic fracturing for shale gas has revolved around its environmental impacts, particularly its effects on water quality, while taking as a given that exploitation of this new natural gas asset will produce significant economic benefits for the states' economies. If we want to understand how this new kind of natural gas drilling will affect communities in Pennsylvania and New York, the economic impact models that have been used to project potential benefits and job creation give us only a fraction of the information we need. To fully assess the economic effects, policy makers and citizens need to understand what will drive the pace and scale of drilling and the associated boom-bust cycle. This cycle will have implications for jobs, revenues, the cumulative impact of shale gas development, and the longer-term economic development prospects for drilling regions within the Marcellus Shale area.

Keywords

Marcellus Shale, Shale Gas, High Volume Hydraulic Fracturing, Economic Impact, Economic Development, Public Policy

City and Regional Planning
Cornell University · 106 West Sibley Hall · Ithaca, New York 14853
Tel: (607) 255-4331 · Fax: (607) 255-1971 · www.crp.cornell.edu

Authors

Susan Christopherson *is J. Thomas Clark Professor in the Department of City and Regional Planning at Cornell University. She is an Economic Geographer, who has led a series of policy research projects to develop, analyze or evaluate strategies for economic development and job creation in New York State. Her recent book,* Remaking Regional Economies: Power, Labor, and Firm Strategies in the Knowledge Economy *was awarded the 2009 Best Book award by the Regional Studies Association.*

Ned Rightor *is President of New Economy Dynamics LLC, a research and consulting firm focused on workforce development and economic development projects throughout the northeast.*

Introduction

New York and Pennsylvania have a long history of natural gas extraction, including in the Marcellus Shale. Drilling is occurring currently in both states. Recent public concerns about shale gas drilling have revolved primarily around a technology -- high volume hydraulic fracturing (HVHF or "hydro-fracking") -- that uses millions of gallons of water in a drilling process that fractures shale along bores drilled horizontally as well as vertically to extract more gas from formations deep underground. The concerns with this technology have focused particularly on its potential effects on water supplies and quality. This is the central issue addressed in the Supplemental Generic Environmental Impact Statement (SGEIS) being developed by the New York State Department of Environmental Conservation. But the draft SGEIS, released in 2009, takes as a given that while environmental considerations are important, exploitation of this new natural gas asset will produce significant economic benefits for New York's economy, reduce natural gas costs to state residents and industries, and provide for long-term economic development. Media coverage of issues surrounding shale gas development has tended to reinforce this assumption.

Natural resource extraction industries typically play a small role in state economies. Their employment impact is tiny compared to industries such as retail or health services (Headwaters, 2011). On the other hand, these industries have major impacts on the regions where production takes place. Shale gas drilling does bring an economic "boom" to the regions that experience it. As drilling companies move into a community, local expenditures rise on everything from auto parts to pizza and beer. New jobs are created in hotels and retail. Landowners receive royalty payments and have extra spending money in their pockets. This increased economic activity is very welcome in Pennsylvania and New York, especially in light of the "great recession".

To fully assess the economic effects of shale gas drilling, however, policy makers and citizens need information on a wider range of questions: Who will get the jobs that are created? What are the costs of shale gas drilling to the public? How will the costs and benefits be distributed? How will other regional industries, such as tourism, be affected? Where will the royalty money be spent? How long will the boom last, and what happens when it ends?

We have undertaken research to try to answer some of these questions, examining both the short-term (economic impact) and long-term (economic development) consequences of shale gas drilling and production. Our specific goal is to go beyond the narrow models that have been used to predict the economic impact of shale gas drilling, and to look at three issues:

1. How will the pace and scale of shale gas drilling affect the short-term and long-term economic consequences for counties in the Marcellus Shale gas play? What are the implications for job creation, in the short-term and in the long term?

2. What costs do communities face in conjunction with shale gas drilling? What are likely to be the cumulative effects of shale gas drilling and production, not only from the drilling process itself, but also from the industrial infrastructure required to transport and store the gas and to service the wells. How will these costs be affected by the pace and scale of drilling?

3. What evidence is there to tell us about the longer-term consequences of developing an economy dependent on natural resource extraction, and particularly natural gas extraction? What will happen after the boom-bust cycle of drilling ends? How will other key industries be affected?

Our research focuses on Pennsylvania, where Marcellus HVHF drilling has already begun, and on New York, where there is currently a moratorium on high volume hydraulic fracturing. Many states in the US have shale gas plays where HVHF is being used, however, and we can learn from their experience about what to expect, both in the short-term and in the longer-term.

Because we are trying to answer complicated "how" and "why" questions, we use multiple methods including case studies, interviews, and descriptive statistics. Some of the data we gather will be used to inform a dynamic model that will enable us to ask and answer questions about how the pace and scale of drilling could affect economic impacts. Overall, we want our research to inform discussion of the critical policy issues around shale gas drilling.

In this working paper, we lay out a framework for thinking about shale gas drilling and the questions it raises for long-term economic development in the shale gas regions of Pennsylvania and New York. We also present some initial research results that, while not providing definitive answers, substantiate the importance of the key questions we are addressing in this research project.

First, however, we look briefly at whether the choice with which we have been presented is a real choice, and at what economic impact studies can (and cannot) tell us about the economic consequences of shale gas drilling.

I. A Choice Between Economic Development and Environmental Protection?

States have different policies to deal with environmental protection issues that may be raised by economic activities. In Pennsylvania, no state environmental impact process was required before high volume hydro-fracking commenced. The effectiveness of the regulatory regime governing HVHF in Pennsylvania has been the subject of contentious debate because of environmental problems that have emerged with the hydro-fracking boom in the state.

In New York, an evaluation of environmental impact was required prior to the approval of HVHF technology in gas drilling. The State Environmental Quality (SEQR) review process stipulates that "a suitable balance of social, economic and environmental factors be incorporated into the planning and decision-making processes of state, regional and local agencies." [1]

In the Draft SGEIS, the New York Department of Environmental Conservation indicates the need to balance economic development and environmental protection, but assumes that economic benefits will be forthcoming from hydro-fracking for shale gas. Citing a June 2009 report from the New York State Commission on State Asset Maximization, the authors assert that the economic impact of shale gas drilling will be positive and have widespread public benefits:

> *... an increase in natural gas supplies would place downward pressure on natural gas prices, improve system reliability and result in lower energy costs for New Yorkers. In addition, natural gas extraction would create jobs and increase wealth to upstate landowners, and increase State*

[1] A description of the New York State Environmental Quality Review (SEQR) is at: http://www.dec.ny.gov/permits/357.html

> *revenue from taxes and landowner leases and royalties. Development of State-owned lands could provide much needed revenue relief to the State and spur economic development and job creation in economically depressed regions of the State.*
> Department of Environmental Conservation, State of New York (2009:2-5)

The assertion that shale gas drilling will have positive consequences for both New York and Pennsylvania's economies is based on limited evidence -- a set of economic impact models constructed while the New York Draft SGEIS was being prepared. The projections reported in the Draft SGEIS are from a study for Broome County (Weinstein and Clower, 2009) and a study conducted by a group of faculty then associated with Pennsylvania State University (Considine et al, 2009). Similar economic impact models have also been developed to assess the economic impact of HVHF shale gas development for Texas (the Perryman Group, 2008) and West Virginia (Higginbotham et al, 2010), among others.

These models are based on assumptions about the pace of development of shale gas in the US and about how the natural gas market will respond as shale gas becomes an important part of energy picture. To evaluate the claims of economic development and public benefit, we need to look carefully at those assumptions and compare them with industry analyses of how shale gas development is likely to occur. We also need to examine the market conditions and policy environments within which natural gas is produced and distributed.

II. What Can We Learn From Economic Impact Reports?

The idea that dramatic, widespread and long-term economic benefits will accompany shale gas drilling emerged from a set of economic impact reports (EIRs) based on input/output (IO) models that, while providing some useful information, are constructed around assumptions that need to be closely examined. In addition, the economic impact reports that have influenced policy makers and the media do not consider some critical issues, such as the cumulative costs of HVHF to local communities, or the long-term economic prospects for shale gas drilling regions.

Economic analysis based on input/output models can give us some useful predictions about the impact of expenditures that may occur with HVHF shale gas drilling, and project the number of jobs that could develop as a consequence of the inflow of spending into the regional economy. If the analysts constructing the models obtain information that improves on the package of

numbers provided by IMPLAN[2] (for example, clarifying the types of expenditures that will be made by oil and gas companies at each well site), the input/output results can more closely approximate reality.

For policy makers and citizens, the utility of the information provided by these EIRs depends on a clear understanding of the limitations of input/output models and what they can and cannot tell us. For example, while the models estimate the number of jobs that could be created with a certain level of expenditures on each well, they cannot tell us how many actual jobs will be created, who will get those jobs, or what they will pay. The fact that input/output models can only provide job *estimates* is often ignored, and those estimates are portrayed incorrectly as real job numbers. In addition, because of the simplifying assumptions necessary to construct input/output models, they cannot be used to analyze wide-ranging structural changes in a regional economy, such as those that occur in conjunction with hydro-fracking. These kinds of changes might include increased competition for labor across industries or decreased ability to retain or attract other industries because of the noise and pollution associated with HVHF.

In another policy brief in this series, Kay (2010) provides a thorough analysis of the input/output model approach to economic impact prediction, emphasizing that models can produce very different results depending upon the assumptions on which they are built. The most important assumptions affecting the results from these models are those regarding the pace, scale and geographic distribution of drilling activity.

The Broome County economic impact study, for example, was conducted very early in the learning curve on Marcellus shale gas drilling and assumed that hydro-fracking would occur uniformly across the County. More recent analyses of drilling patterns in Pennsylvania demonstrate that this scenario, and the assumptions about expenditures that follow from it, are not realistic. Drilling locations are influenced by infrastructure (pipeline and compressor station) access, by topographic and geologic data used to target ease of drilling and high value results, by political considerations including proximity to potentially sensitive locations such as hospitals and schools, and potentially, by zoning regulation.[3] These locations are very unlikely to be spread evenly across the terrain of a county. Calculating the amount of drilling that will occur by assuming that drilling will take place over every acre of the county produces an

[2] IMPLAN (Impact Analysis for Planning) provides customized regional economic data (not estimated from national averages), which can be used to measure the effect of a change or event (such as a gas boom) on a region's economy.

[3] Whether communities can use zoning regulation to restrict where hydro-fracking occurs is a matter under litigation in Pennsylvania and New York and will be decided in the courts.

unrealistic estimate of the amount of expenditures likely to occur in the county. The authors hedge by presenting a second scenario that cuts the total number of wells to be drilled in the county in half, but this is no more than a "guesstimate." The model's authors do not attempt to determine either the pace or scale of drilling that is likely to occur (based on an analysis of the geographic pattern of drilling in other shale gas plays), or factors likely to affect industry investment in a natural gas market where prices are at historic lows. They in fact assume a full drill out within a short time frame.

In addition, input/output analyses may assume that expenditures associated with the drilling of each well will be made in the region where the drilling occurs. Given the geographic organization of the US oil and gas industry and the concentration of inputs (manufacturing of equipment, drilling labor, engineering services etc.) in Texas and Oklahoma, we can expect that, while there are local industries that *could* provide inputs to the drillers, a high proportion of expenditures associated with drilling will be made outside of New York or Pennsylvania. Again, an input/output model estimates potential regional expenditures. It cannot tell us for certain that the projected expenditures will actually occur in the drilling region.

In another example, although oil and gas companies indicate that the largest portion of their expenditures in Marcellus Shale regions will take the form of payments to landowners (Considine, 2010), we currently have no information to tell us <u>where</u> landowner leasing bonuses or royalty payments will be spent. If land or mineral rights owners live outside the drilling region, it is unlikely that they will spend their payments in the areas where drilling is occurring, though they will be subject to taxes in those areas.

Another limitation of the types of input/output models typically used to measure the economic impact of HVHF is that they are "snap shots" of the regional economy during the entire drilling cycle. Because they are constructed around projected expenditures for the drilling of each well, the models don't tell us about when expenditures will be made and when they will end. They focus attention on the boom period, when money and population are flowing into the region. In reality, the drilling boom phase of the boom-bust cycle that characterizes resource extraction industries may be brief, lasting under ten years. Input/output models tell us nothing about what will happen when drilling ends.

These examples of the limitations of the models that have been used to project the economic impact of shale gas drilling suggest that we need to read the results from these models carefully and skeptically. We need to look at the assumptions behind input/output models to see if they

jibe with what we know about how the industry operates, and if they are realistic about where, when and how drilling and the expenditures associated with it are likely to occur. We also need to get answers to questions that are outside the scope of these models – about cumulative costs to communities and regions, and long-term effects on the regional economy.

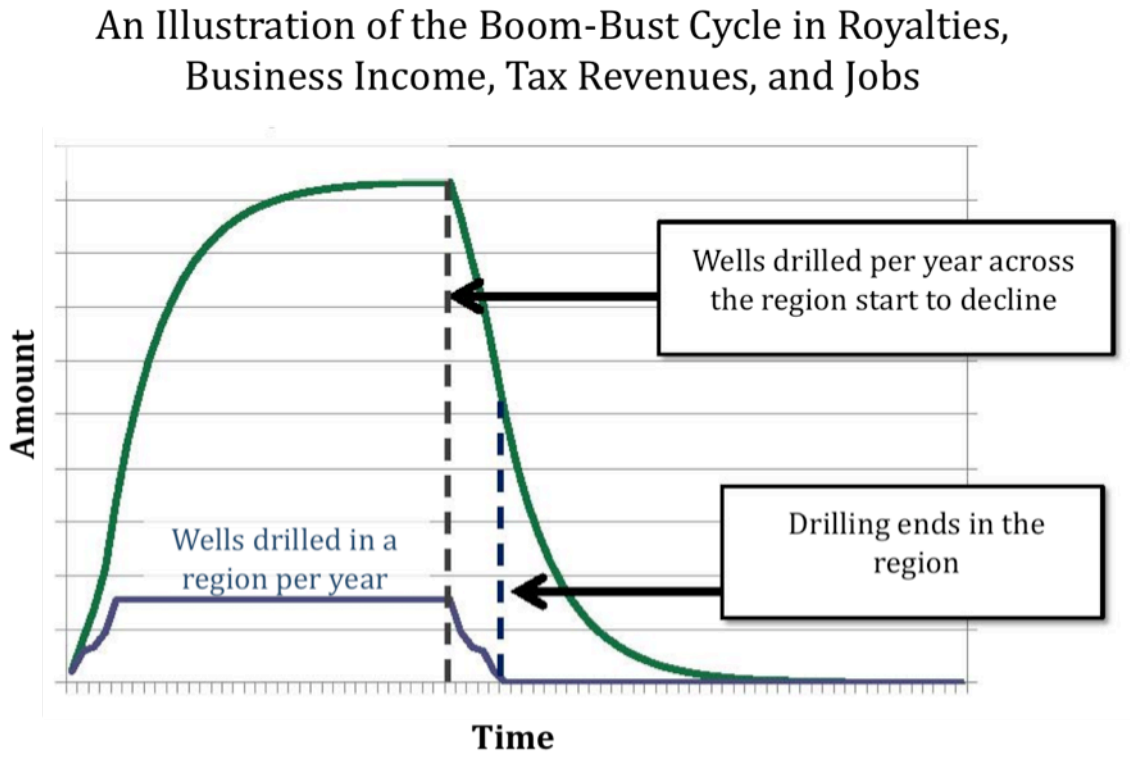
A key question is how fast drilling will proceed and how much drilling there will be. We know that HVHF has environmental and economic effects beyond the well pad, and that those effects are cumulative -- that is, they intensify with increases in the pace and scale of drilling. The amount of road wear, traffic congestion, or public service costs incurred when 10 wells are drilled over a longer period of time differs from the amount incurred when 100 wells are drilled in the same area over a shorter time period.

In the next section we examine why we need to know more about the factors that influence the pace and scale of drilling, in order to understand its impact on the Marcellus region in the next five to seven years, and in the long-term once drilling has declined as a major stimulus to the regional economy.

III. Why We Need to Understand What Influences the Pace and Scale of Drilling and the Boom-Bust Cycle

The extraction of non-renewable natural resources such as natural gas is typically characterized by a "boom-bust" cycle, in which a rapid increase in economic activity is followed by a rapid decrease. The rapid increase occurs when drilling crews and other gas-related businesses move into a region to extract the resource. During this period, population increases and there is a modest increase in jobs outside the extraction industry (Marchand, 2011) in construction, retail and services. When drilling ceases, either temporarily or permanently (because the commercially recoverable resource is depleted), there is an economic "bust". Population and jobs depart the region (Feser and Sweeney, 1999). In the case of HVHF, the pace and scale of drilling will determine the duration of the boom period in the cycle and, because of the costs of boom-bust cycles, communities and states anticipating this kind of economic cycle need to understand what will influence the pace and scale of drilling.

Figure 1:



Adapted from Tim Kelsey (2011), "Annual Royalties in a Community".

There are two ways to understand the pace and scale of drilling in a shale gas play. The first is based on an analysis of total potential natural gas reserves and the capacity of existing or anticipated technologies. According to Penn State geological scientist, Terry Engelder, the Marcellus might contain as much as 500 trillion cubic feet (tcf) of natural gas, and in a 2008 report with Gary Lash of SUNY Fredonia, he estimated that perhaps 10% of that gas (50 tcf) might be recoverable (Engelder and Lash, 2008). The following year, he estimated that recoverable reserves could be as high as 489 tcf (Engelder, 2009). More recent estimates of recoverable gas fall in the 200-300 tcf range. From a geologist's perspective, whatever their assumptions, extraction of these total recoverable reserves could take decades.

The other take on the pace and scale of drilling looks at what are the likely firm strategies in response to their profit opportunities in particular shale plays and overall. For example, given a limited number of drilling rigs, firms will deploy them in those places (within a gas play or across gas plays) where profits are most likely. The question for an energy company is not whether a well is viable in terms of potentially recoverable gas, but whether it is *commercially* viable -- that is, will it make money for the operator (owner of the leases) and the drilling companies. An understanding of the choices made by operators and their subcontractors in a

shale play requires an analysis of the costs and delivery rates of drilling operations, margins of commercial profitability, and corporate financial and competitive relationships.

Production in shale plays is unpredictable and only a small number of wells may be able to produce commercial volumes of gas over time without re-fracking, which is very costly. Evidence from the Barnett and Haynesville shale plays, for example, indicates that high initial production rates may drop off rapidly, making it difficult for operating companies to cover their finding and development costs. Industry investment advisors are cautious about the long-term productivity of the US natural gas plays. Their advice to investors is simple:
"Shale production is characterized by a steep decline curve early in its productive life. The more oil and/or gas that you can make up front the better the economics." (McFarland 2010).

And, according to geologist and investment adviser Arthur Berman (2009), who has analyzed production trends across US shale plays:

> *... most wells do not maintain the hyperbolic decline projection indicated from their first months or years of production. Production rates commonly exhibit abrupt, catastrophic departures from hyperbolic decline as early as 12-18 months into the production cycle but, more commonly, in the fourth or fifth years for the control group. Pressure is drawn down and hydraulically produced fractures close…Workovers and additional fracture stimulations may boost rates back to previous levels, but rarely restore a well to its initial decline trajectory. More often, a steep hyperbolic or exponential terminal decline follows attempts to remedy a well's deteriorating performance.*

The possibility that few wells will exhibit the hyperbolic production curves that are used to describe trends *across* wells in a shale play adds to the uncertainty for investors and operators.[4] And because shale plays may not produce the long-term results indicated by the hyperbolic curves used by the industry to describe production (and encourage investment),[5] adding to the financial risks already attendant to shale gas drilling, the HVHF boom in the US shows evidence of a speculative "bubble".

Financial risk has been exacerbated by the debt-driven character of development in shale plays. Operators have sought to buy up leases and hold them during a period when money and leases can be had cheaply, but this has put them into debt. The short-term prospects for reducing that debt are uncertain because of depressed US gas prices. A typical "boom" occurs during a

[4] The risks and unpredictability of HVHF shale gas drilling are also demonstrated by the 2009 collapse in the levels of drilling activity in the Jonah Field in Colorado (Jacquet/ERG, 2008). Ultimately, these patterns indicate the potential volatility of the drilling phase and the difficulty in making accurate projections about its duration.

[5] Christian (2010) suggests that probability-based estimates for deliverable reserves (as opposed to hyperbolic group curve fitting) would be more informative, given that even small, unpredictable changes in the inputs used to generate hyperbolic curves produce substantially different outcomes.

period when energy prices are high. The current drilling boom, occurring during a period of low natural gas prices, appears to be driven as much by cheap capital and global investment as by anticipated profits from the natural gas itself, if it is sold in the US. And, some financial service firms luring international investment in HVHF shale plays emphasize how this investment will produce short-term revenue gains through an increased pace and scale of drilling.

Despite the financial risks associated with natural gas drilling anywhere in the US, the Marcellus Shale is considered to have among the best "economics" of the large shale gas plays because of the potential richness of its reserves, but also because of low transport costs to the major natural gas markets, inexpensively-acquired leases, and the absence of severance taxes. It also has significant drawbacks because of its proximity to populated areas, and the prospect of regulatory controls over water withdrawal and wastewater disposal as well as on the drilling process itself.

For those living in the Marcellus Shale region, gas operating company assessments of the commercial viability of wells and how to best exploit the resource have important consequences. The evidence from the Barnett shale suggests that individual Marcellus wells may have short production lives. Because the Marcellus Play is large and geologically complex, however, the play as a whole is likely to have natural gas drilling and production over an extended period of time. Individual counties and municipalities within the region are likely to experience accelerated boom and bust cycles, while the region as a whole is industrialized to support continued drilling, storage, and transportation of natural gas. Counties where drilling-related revenues were never realized or now have ended may still be impacted by this regional industrialization, such as truck traffic, gas storage facilities or pipelines. These more widely distributed impacts need to be taken into account when anticipating what effects natural gas drilling will have on communities, their revenues, and the regional labor market, as well as on the environment.

In the next section, we look more closely at some of the costs, attempting to learn from the experience of other shale gas plays.

IV. What Do We Know About the Challenges Facing Local Communities and Regions Where Shale Gas Drilling Occurs?

High volume hydraulic fracturing for shale gas has been taking place for several years in gas plays elsewhere in the US, including Texas, Colorado, North Dakota, and Wyoming. In the Marcellus Shale, hydro-fracking is relatively recent, but even over a short period of time, experience is providing critical lessons. Though each state has a different set of issues because of differences in climate, terrain, proximity of the play to population centers, and the availability of skilled labor, we can draw on the experience of other states to identify common issues that are likely to arise with shale gas extraction using modern hydro-fracking technology, and the pattern of short-term economic impact and long-term economic development consequences from shale gas development.

Predictors of costs to local communities are difficult to assemble because -- with the exception of data on crime statistics -- data must be assembled county-by-county, or locally, agency-by-agency. We do have information from counties in Wyoming and Colorado where the local impacts of rapid development of shale gas have been documented, and anecdotal evidence from counties in the northern tier of Pennsylvania.

Social Impacts

As described in another working paper in this series (Jacquet 2011), the drilling phase of shale gas development usually depends on an out-of-state workforce, except for truck haulers and construction jobs. The direct employment opportunities for locals come from the post-drilling production phase. The faster the pace of drilling, the more that pattern will continue in the Marcellus. That means a sudden influx of young men, some with families, many without. Some will be experienced hands, others will be those drawn to the boom and the prospect of work.

In Sublette County WY, for example:

> *As the number of gas wells drilled per year* (author's emphasis*) exploded from 100 in* (the year) *2000 to more than 500 in 2007, the population of Sublette County swelled by 24%. During that same period, Wyoming's population grew by just 4%, indicating that workers and their families were flocking to the area to meet the new labor demands. The largest increase in population came from teens and young adults, aged 15 to 24, followed by adults aged 25 to 44* (Jacquet 2008).

Communities need more police. Just the truck volume and the need to enforce weight limits should tell you that. Many big trucks on increasingly beat-up roads mean traffic problems and

accidents. Add to that a spike in people unfamiliar with the area and winter driving – more accidents.

> *Traffic on major roads increased, as did the number of traffic accidents, likely due to drilling activity and new residents.*
>
> *Other documented increases occurred in emergency response runs, building permit applications, and arrests* (Ibid.).

The emergency response runs stem from the trucks, the road conditions, drilling accidents, and the population influx generally. And occasionally, the trucks, the beat up roads, the winter, the driver unfamiliar with the area, combine to create an accident that leads to a spill. So "emergency response" includes the response to environmental incidents for which most communities are ill prepared.

Where these new workers move to the region with their families, they will want to put their kids in school.

> *School districts in the county scrambled for classroom space as the number of students and staff increase* (Ibid.).

And, as demand for all manner of good and services increases and local businesses seek to exploit the boom, prices go up – not just for these temporary residents, but for long-time locals as well.

> *Driven by the high wages of workers in the mining sector and their increased demand for goods and services, local prices increased by twice the national rate over the six-year study period* (Ibid.).

This is especially true of rental housing. Rents skyrocket, local renters who cannot afford their apartment any longer are displaced, and may seek housing assistance from local government. The hotels and motels fill up with gas workers.

The increased demand for hotel rooms may benefit hotel and motel owners and local restaurants, but hurts other local businesses that typically serve the interests of a more traditional clientele. In some locations, hotels may have few rooms available for the usual clientele: business travelers, recreation seekers, tourists, hunters, wine aficionados. And, because of the "permanent resident exclusion" from state and local hotel occupancy taxes on longer stays (*more than 30 days in most counties and for the Pennsylvania state room tax, more than 90 days for the New York occupancy and sales taxes*), some of these guests do not pay the tax that helps support tourism activities such as local festivals or heritage projects.

In the long run, given the population declines suffered by many communities in the Marcellus region, this influx of new people may be welcome. Some newcomers may like the area and decide to stay. According to a recent Associated Press story (March 3, 2011), the small state of Wyoming has seen population increases, especially in the Hispanic population, and an unemployment decline over the past decade, especially in communities near gas drilling areas.

But for local governments, this population influx comes with added costs, both in the short run and in the long run. The consistent theme is that local governments – counties, cities, townships, villages – are subjected to a wide range of demands for new services or increased levels of service, and that the administrative capacity, staffing levels, equipment, and outside expertise needed to meet those demands are beyond anything that has been budgeted.

It also should be noted that many residents of communities where drilling is taking place seem surprised by -- and unprepared for -- the changes in their communities. In Bradford County PA, for example, the news that the 2010 census had determined that the population in the County had *declined* by 2% produced strong reactions from some residents facing traffic congestion and rising prices produced by the presence of the transient population connected with drilling. Their comments indicate that they believed that government services would be available to ameliorate the social, economic and congestion problems caused by drilling, and that they expected the resident population to increase faster than the transient population and to increase the tax base. According to one post:

> *"I say good for the people who finally have a decent paying job, good for the people who are seeing an influx in business, and good for those who saw the opportunity of a move if so desired. Just remember, there are still those of us remaining who had nothing to do with any of this. We deal with the traffic, destruction, fear of contamination everyday. Some of us deal with it twofold. We dealt with the windmills and gas industry at the same time. We benefit nothing from any of it. We get no opportunity for natural gas and are still forced to pay premium prices for propane. We get no electricity benefit from the windmills and are still forced to pay Tri County's ridiculous rates. Our trucks are taking a beating every day we have to drive to work. But are forced to deal with it just the same."*

Articles on housing pressures in Bradford County also provide evidence of tensions between long-time residents and the transient drilling-related population. Drillers accuse the residents of greed while residents accuse the drillers of ruining the quality of life in the county and raising the cost of living.

In addition to local issues and concerns, there are also issues that can only be addressed by multi-county regions and by state policy. As we have already indicated, modern shale gas

drilling is likely to have intense local impacts for the drilling period but regional consequences for a longer period as well, because of the industrial activities needed to service the drilling sites.

Infrastructure Impacts

One critical area of impact is on local roads and bridges. As another working paper in our series (Randall, 2010) points out:

> *Dust, noise, and road damage from industry truck travel are tops on the list of citizen complaints in areas where gas is extracted via shale gas drilling. A typical Marcellus well requires 5.6 million gallons of water during the drilling process, in almost all cases delivered by truck. Liquid additives are shipped to the well site in federal DOT-approved plastic containers on flatbed trucks; hydrochloric acid and water are delivered – and flowback is hauled away – in tanker trucks. Millions of gallons of liquid used in the short (weeks-long) initial drilling period account for half of the estimated 890 to 1340 truckloads required per well site. Because of its weight, the impact of water hauled to one site (364 trips) is the equivalent of nearly 3.5 million car trips. Few roads at the town level in New York State have been built to withstand this volume of heavy of truck traffic.*

Pennsylvania state officials report playing catch-up with truck routing in the wake of rural roads sometimes rendered impassable for local motorists or emergency responders, while sources in the Barnett Shale region of Texas cite early deterioration of city streets that increases the burden on taxpayers. That is because, even though access roads to the well sites are built and maintained by the operators, many of the journeys made by all those trucks will be on public roads. Most roads, especially the rural roads that predominate in the Marcellus region, are not designed to withstand the volume or weight of this level of truck traffic (especially under freeze-thaw conditions).

In Pennsylvania, local governments can utilize PennDOT protocols to post weight limits and require permits and bonding of overweight truck operators, an incentive for them to either do the excess maintenance or pay for (documented) damage to the roads. However, operators are inclined to post bonds only in municipalities or counties where they have well sites, while the trucks travel much longer routes through other towns and counties. Their roads are left vulnerable.

Recommendations from those in already developed shale plays center on: (1) Haul Route Management -- the planning, posting, and enforcement of truck routes that minimize the intrusiveness and damage caused by high-volume truck traffic, and (2) local Road Use Agreements (RUAs) or state-level fees that support accelerated road maintenance *while* drilling

or production activity is underway, not just that put things right afterward, and that are secured by adequate bonding provisions.

Haul route management requires planning capacity, additional signage, and law enforcement efforts beyond the normal budget. Both haul route management and a legally defensible RUA need to be supported by a comprehensive traffic impact study, and well-documented baseline data backed by video and photographs of pre-development road conditions. Consistent treatment and costs for all haulers are crucial to defending an RUA in court, so a successful program will rely on specialized legal advice. That means additional staff resources will be required and, for most communities, money for consulting engineers and outside attorneys as well.

Whatever regulation and technical assistance the state may provide, and that is as yet unclear, many of the costs of these efforts still fall on local governments. And, these costs are likely to fall on some localities where drilling makes no appreciable contribution to the economy either through job creation or tax revenues.

As we have indicated, modern shale gas drilling is likely to have both intense local impacts for the drilling period, and regional consequences longer term as well because of the widespread industrialization that accompanies contemporary hydraulic fracturing.

Regional Industrialization

It should be clear that well pads are not the only feature in the industrial landscape brought about by shale gas development. Water extraction sites must be developed to fill trucks transporting water to the well pads. After extraction, the gas has to move from the well sites to the main transmission lines via a network of pipelines and compressor stations. Flowback and produced water from the wells has to be transported to treatment facilities, which must be built to handle any toxic waste present.

These elements of the industrial landscape will be located where geologic or logistical factors dictate, but not necessarily in the jurisdictions where drilling is currently taking place or production (and therefore tax revenue) is being generated. For local governments, the same questions as for well sites or pipeline infrastructure apply to these facilities: Who -- the state or the localities -- is to regulate them, and monitor and enforce the standards; what staffing and resources will that require; and how shall the money to support those efforts be provided?

These facilities typically include:

- "Man camps" (essentially trailer parks) for short-term out-of-state workers
- Depots for equipment
- Staging areas
- Gravel quarries
- Water extraction sites
- Wastewater treatment plants capable of handling toxic material
- Injection wells
- Disposal areas (landfills)
- Gas storage facilities

Connecting all these facilities and services are rail spurs and thousands of heavy trucks.

These industrial facilities create a wide range of potential environmental hazards and stressors, all of which have implications for the regional economy and adjacent industries, such as tourism and agriculture. For example, apart from the dangers inherent in a widespread array of pipes full of methane or in high-pressure equipment generally, noise is a major concern related to compressor stations: they produce noise levels in the 85 to 95 decibel range. These levels are at or above the federal Occupational Safety and Health Administration (OSHA) threshold of safety for an 8-hour day, and compressors work a 24-hour day. These environmental "stressors" can have an effect on adjacent property values or on regional industries, such as the wineries in the Finger Lakes region of New York.

Most regulation of this industrial infrastructure will likely fall to state government or, in some cases such as pipelines, to the federal government (through the US Department of Transportation Pipeline and Hazardous Materials Safety Administration). Localities may have a role in the permitting of pipeline routes along city/county rights-of-way. Local government may also require filings and notice to abutters, and demand incident reporting and filing of as-built drawings for emergency planning.

For compressor stations, local regulation may be able to establish setbacks, maximum noise levels, fencing and landscaping requirements, and enhanced standards for units adjacent to residential areas.

Flowback fluids from the hydro-fracking process or the produced water from producing wells must be removed from the well sites by trucks and transported to treatment facilities or injection wells. These facilities, too, may be subject to permit or construction standards that are set or implemented at the local level.

All of these local or regional activities require expertise, administration, monitoring, and enforcement capacity, and all entail planning and public administration costs.

One example of the impact industrial facilities may have on a region is provided by the proposed Seneca Lake gas storage facility. This facility is being planned by Inergy Midstream, LLC for the former US Salt plant just north of Watkins Glen NY, with underground storage for 1.45 billion cubic feet of natural gas, to which they propose to add an up-to-88.2 million gallon liquid propane storage facility, also underground, plus a 14-acre, 92 million gallon brine pond on the surface.

Why there? – because the site is near the intersection of two gas transmission pipelines and, as a salt mine, is an appropriate natural gas storage site. But Watkins Glen is in Schuyler County, which is not part of the "fairway" – the purported sweet spot for Marcellus drilling in New York, so it is not likely to see a lot of extra tax revenue from well production. Whatever the plant may contribute in the way of local taxes, Watkins Glen currently depends on revenue from Finger Lakes tourism, attendance at the road races, the local wine industry, and agriculture. Consequently, the potential hazards to air or water from such a facility, or the prospect of a fire or explosion, are particularly troubling to local policy makers. On the other side of the equation, this capital-intensive plant operation is expected to produce only 10 jobs after its construction.

Officials in regions already experiencing shale gas drilling encourage planning and the development of fewer, centralized industrial locations for all these functions, in order to minimize the impacts on local communities. Because of the regional extent of hydro-fracking, this planning will necessarily require inter-county cooperation and state assistance.

Finally, the regulation of whatever facilities are constructed will be a responsibility shared between the state and local governments, and localities will have to allocate resources to negotiating with the state – and many departments of state government are involved – for agreements that protect their interests and those of their citizens.

Government Response

As we review the challenges that other shale gas localities faced, here are some of the measures that public officials say they took (or wish they had), requiring additional public resources and staff time.

Citizen Information and Involvement

- Efforts to educate the public and engage the industry.
- Enlisting the local bar association to help landowners understand lease agreements.
- Registering and monitoring landmen operating in the region.
- Assembling data on permits issued and drilling sites, and making it publicly available.
- Involving local real estate companies and state and federal agencies in dealing with the new demand for housing.
- Mediating disputes over housing issues, and providing assistance for displaced renters.

For the Duration of Drilling Activity

- Creating a local Gas Drilling Review Committee to mediate disputes over wells, pipelines, and truck traffic.
- Establishing consistent standards for drill site and infrastructure facility setbacks, the use of fracture ponds, and deadlines for landscaping drill sites.
- Limiting the hours of drilling operations.
- Mitigation of noise, dust, and mud.
- Monitoring and enforcement of new regulations.

As we have outlined elsewhere, administrative costs for all manner of planning, permitting, monitoring, and enforcement activities rise, as does the cost for computer systems to support them. So do demands on the police, courts, jails, services to displaced renters, and other social services. Ditto the school system. Likewise the demands on the public health department, and on the healthcare system generally. The landfill can be a moneymaker, at least until it fills up and has to be replaced. Fire and emergency services must be prepared for the kind of fire, accident, or spill incident that drilling operations can produce, requiring new equipment and training; many communities have volunteer or call operations that may not ever be prepared, or willing, to take on a major HazMat incident.

Public Health departments must be prepared to receive and respond to incident reports and citizen concerns about environmental health issues.

A Clinton County (PA) review of the early impacts on their departments turned up one additional factor in the costs to government: losing their employees to private sector jobs in the gas play. That adds the cost of recruiting and training new staff, and the need to increase salaries to attract or retain them.

All this suggests to local governments two crucial elements of preparation:

1. The need for baseline data. Without the baseline data on roads, water treatment, rents, traffic, use of government equipment, etc., local governments cannot hold the well operators or their subcontractors accountable for the increased cost to local services that their activities generate, nor can they make a good case for relief from the state.
2. The need to budget for future costs. Just as the unfolding of demands on localities from the effects of shale gas development may not correspond to the flow of tax revenue from gas production or lease/royalty payments to landowners, at least under the current tax system, so the effects of shale gas exploration may last far longer than the boom in drilling activity in any given locality. Lowering property taxes during the revenue boom may only lead to hiking them even more when the full effects on local government operations are realized. Better to utilize the variety of budgeting instruments – fiscal impact fees, trust funds, capital reserve funds, and a healthy fund balance – designed to stabilize the tax rate by setting aside monies to defray future costs.

Paying for the Necessary Public Sector Response

This question of public costs attendant to HVHF shale gas development raises the thorny issue of taxation.

Of the 32 natural gas producing states, only four – New York, Pennsylvania, Virginia, and Maryland – do not have a state severance tax. There is now convincing evidence that the exaction of tax revenues is not pivotal to industry decisions about where to drill for natural gas. A study conducted by the state of Wyoming, cited in a recent (2011) report by Headwaters Economics, provides the following reasons:

- Production tax incentives have little effect on where energy companies choose to explore and drill. The oil and natural gas industries are guided chiefly by the location of reserves, and are less able to relocate than are industries with mobile capital resources (such as textile mills or auto-makers).
- Production taxes are deductible from federal income tax liability, so industry does not feel the full benefit of tax increases or pay the full increase in tax hikes. When taxes are raised, revenue is shifted from the federal to the state government, and vice-versa.

- Production taxes are "downstream" taxes, meaning they are levied only on successfully producing wells. As a result, production taxes have little effect on exploration. Tax policy can change the timing of extraction. A tax on reserves in the ground tends to accelerate extraction as energy companies attempt to "mine out from under the tax." Taxes on production (i.e., severance taxes) slow production as industry may hold reserves and wait for high prices or other market advantages.

- Other factors such as price, access to markets (e.g. oil and natural gas pipelines), technology, and regulations have more significant effects on industry activities. Considering tax policy alone cannot fully explain industry choices and the resulting geography and pace of energy exploration and production.

Based on their analysis of the existing research, they conclude: "states and the federal government can raise taxes, at least modestly, without risk of raising consumer prices or reducing domestic production or industry jobs (Headwaters Economics, 2011:39).

New York currently has a local property tax on gas rights, levied by local government assessors on those holding the gas rights after production begins, based on a formulation put out by the NYS Office of Real Property Services to calculate their value consistent with the assessment of other property parcels. By decision of the state's supreme court, Pennsylvania currently prohibits local property tax levies on natural gas holdings.

The advantage of a property tax is that the revenue goes directly to the local governments, where the costs we have just outlined are incurred; no pass-through agreement with the State is required. The disadvantage is that the generation of tax revenue is highly localized and variable from year to year, while the development of a shale gas play and its infrastructure – and the costs associated with it – are geographically widespread and long term. The tax is generated only where gas production is active, and dependent on the volume of gas generated; when the locus of new drilling activity moves on, or the yield declines, so does the tax revenue. If the wells in a locality are not big gas producers, a property tax on gas rights will not be a big producer either. And, if a locality has the mid-stream facilities or pipeline infrastructure or truck volume but no wells, there may be costs from shale gas development but little extra tax revenue to pay those costs.

In a future working paper, we will be examining in more detail the tax options used elsewhere, and the prospects that the current tax structure will pay for the costs of gas drilling in New York and Pennsylvania.

In reviewing what has happened in shale gas plays where public officials have reflected on their experience, planning is a recurring theme, not only for the intense demands of the drilling phase (which get the most attention), but also for the production phase and beyond – the long haul effects. Above all, what the regions that have experienced shale gas development now wish they had done better is planning.

V. What Do We Know About the Long-Term Economic Effects of Shale Gas Development on Local and Regional Economies?

In this working paper, we distinguish between the short-term impacts of HVHF natural gas drilling – on jobs, revenues, and costs to communities – and the long-term consequences for economic development. We define economic development (as distinct from economic *impact*) in terms of indicators that show whether a county or region's population has an improved standard of living, job opportunities, and the kind of diverse economy that can weather downturns in any particular industrial sector.

It is evident that natural gas drilling will create work in the shale gas regions during the drilling phase. The population flowing into the region will create demand for retail businesses and in hospitality industries, such as hotels and restaurants. Construction activity will also increase. Analyses of what kinds of jobs are likely to be produced during the drilling boom underscore that these three sectors are most likely to create jobs outside of the drilling industry itself. However, as Jannette Barth notes in her seminal article (Barth, 2010), there are reasons to be cautious about the natural gas drilling industry as a route to long-term economic development, especially in rural counties. This caution arises from studies that show that rural regions whose economies are dependent on natural resource extraction frequently have poor long-term development outcomes. In some cases, they may end up worse off after a boom-bust cycle than they were before it started.

While this may seem surprising given the economic activity that floods into a region during the drilling phase, there are some readily understandable reasons for poor long-term prospects.

First, the crews who come into a region place demands on a limited housing stock and housing prices rise, driving low income renters to leave the area, and creating a potential labor shortage. We see this type of displacement in Northern Pennsylvania, where low-income families are being displaced by drillers in the local rental markets around the drilling sites (Loewenstein, 2010).

While competition for labor creates some short-term "winners" among locals, such as truck drivers, it also raises costs for other businesses in the region as labor costs for those occupations rise. For example, dairy farmers in Northern Pennsylvania and the Southern Tier of New York, who are already in a marginal economic situation, are being further squeezed because of rising costs for transporting their milk to the dairies. These businesses may go under during the drilling phase, leaving the region with fewer businesses outside of gas drilling, and thus a less diverse and more volatile economy.

Economists refer to the situation in which short-term but high wage resource extraction leads to a poor business climate for other businesses as "crowding out". While "crowding out" particularly affects businesses that require a reliable low cost labor supply (agriculture, tourism, or retirement communities, for example), even higher wage businesses such as manufacturers may be deterred from investing in a resource extraction economy. Higher housing costs, labor competition, and social issues make the resource dependent region less attractive to other employers than alternative locations.

Resource extraction regions are also notable for having serious governance challenges. Volatile revenue leads to poor government planning and a lack of accountability. Yet, demands on government rise and may continue to persist long after the tax revenue from the drilling phase has dried up. When the local boom ends, the human and physical infrastructure built to support a boomtown population is left for a much smaller population to support. As Feser and Sweeney (1999:33) describe in their study of such communities' experience with out-migration and population loss:

> *During the boom period, the county's physical infrastructure was planned and installed to accommodate an expanding population. The nature of infrastructure such as roads, sewer and water facilities, and schools is that once it is built, it generates ongoing maintenance costs (as well as debt service costs) even if consumption of the facilities declines...the departure of mine workers and higher income, mobile professionals left the burden of paying for such costs to the remaining smaller, lower-income, population.*

Finally, although there are some winners in a resource extraction economy, in the long term their numbers appear to be outweighed by the losers. After the initial construction and drilling phases, there are very few well-paying, stable jobs available in the production phase or in the industrial facilities servicing the regional industry (such as gas storage sites). As a result, income inequality tends to increase in natural resource extraction counties.

Long-term negative consequences are not automatic, however. A natural resource, such as natural gas, is an asset. Effective planning to moderate the speed at which the extraction occurs, and to invest the infusion of short-term revenues in longer-term economic development could potentially mitigate the effects of the boom-bust cycle and the "crowding out" phenomenon.

Cautionary Trends from New York and Pennsylvania Gas Drilling Counties

In a future working paper in our series, Christopherson and Knipe (2011) will look at industry, population and income trends in US natural resource extraction regions to see what they might tell us about longer-term economic development prospects for Marcellus Shale regions. For example, counties in New York and Pennsylvania with significant natural gas drilling (1994-2009) are characterized by population loss when compared with similar rural counties in their respective states.

Figure 2:

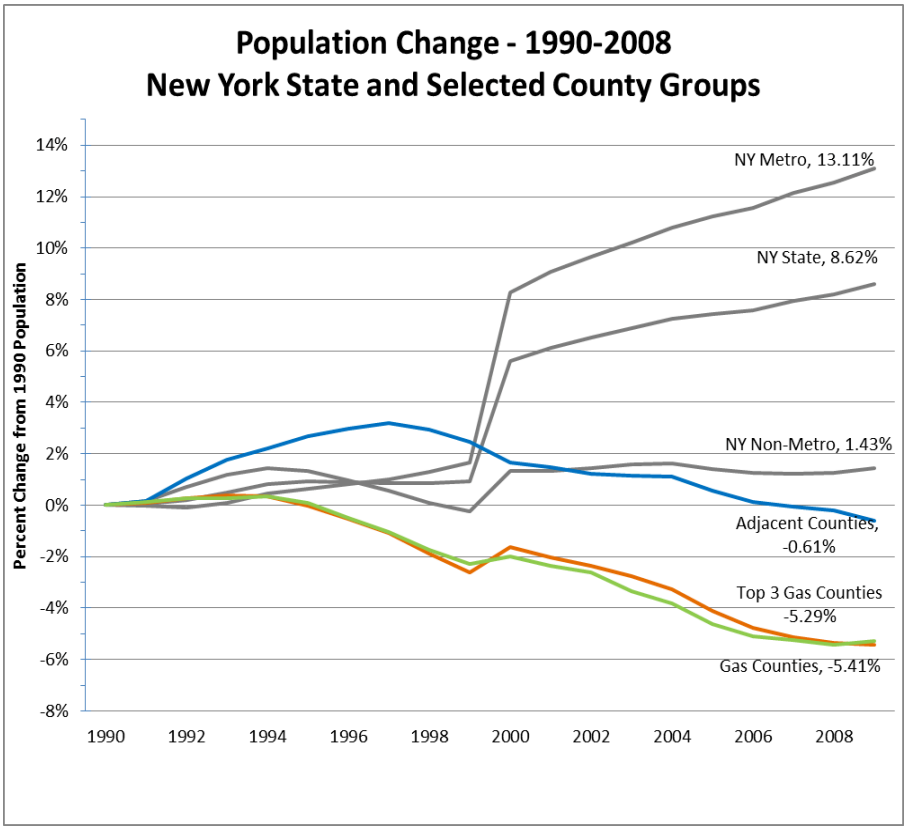
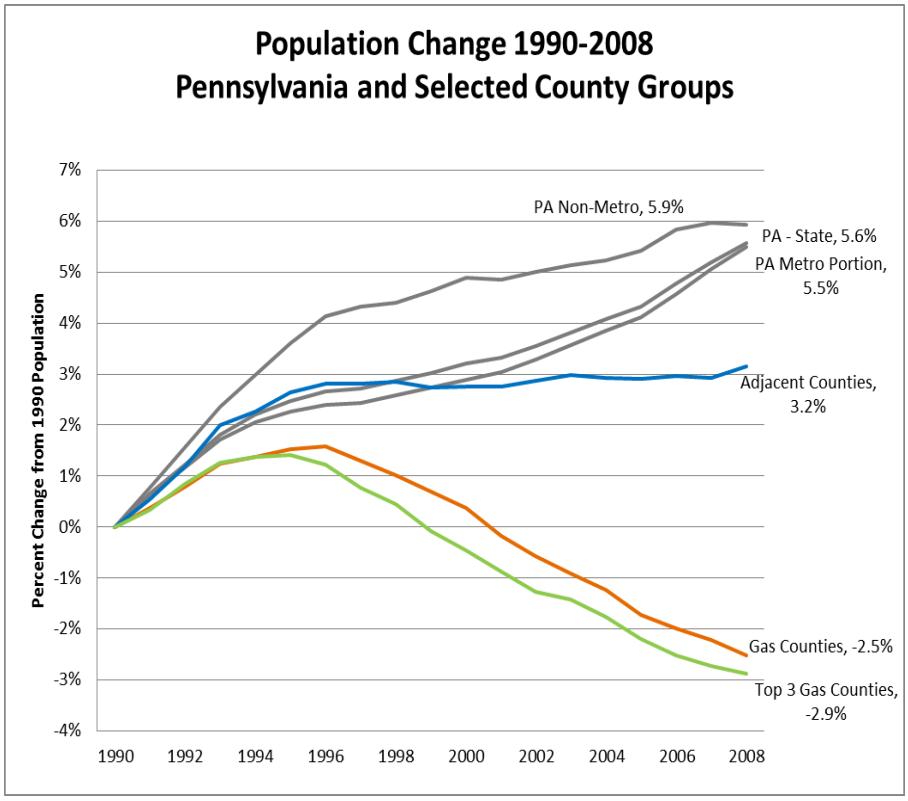


Figure 3:



Evidence from US Counties Specialized in Resource Extraction

Other evidence suggesting caution in projecting long term economic development from natural gas drilling comes from a study of 26 counties in Western States that have based their economic development on the extraction of fossil fuels (natural gas, oil, and coal). This study shows that these counties, which have at least 7% of their total jobs in resource extraction industries, have not performed as well as similar counties without extraction industries (Headwaters, 2009). Both their average annual growth in personal income and their employment growth (1990-2005) were lower than their peer counties without extraction industries. The energy-dependent county economies exhibited a set of similar characteristics. They had:

- Less economic diversity
- Lower levels of educational attainment
- More income inequality between households
- Less ability to attract investment

Also, a majority of the energy industry focused counties (16 of the 26) lost population during this period. Though the reasons for this loss are not fully documented, anecdotal information

suggests that they may include the higher cost of living in these counties and the displacement of residents who do not want to live in an industrialized landscape -- for example, retirees.

In part, the difference between the extraction-focused counties and other counties has emerged because new service-based industries, especially tourism, have been growing in rural Western counties and are creating more jobs than extraction industries. The extraction counties do not attract as many tourism dollars as counties without extraction industries.

The picture is uneven however. While energy extraction counties underperformed in terms of the growth of real personal income, employment, and population, they outperformed their peer counties in terms of growth in earnings per job and per capita income. But for these measures -- average earnings per job and per capita income -- there was only a modest positive difference (0.6% per year from 1990 to 2005) (Headwaters, 2009).

In general, the research that has been done on resource extraction in rural areas offers no guarantee that counties where fossil fuel reserves are developed will have a significant long-term advantage over counties where they are not.

Some Additional Caveats

Of course, every shale play is different. It appears that because of its size and proximity to the Northeast, the Marcellus Play is attracting investment in "moving the infrastructure to the market" -- the pipelines and gas storage facilities that service a regional industry (*American Oil and Gas Reporter*, 2011). These investments can produce a small number of longer-term jobs. For example, the natural gas storage facility projected by INERGY for Watkins Glen, NY (Schuyler County) estimates a final workforce of ten (10) people.

What is not known is how these investments will affect other local industries, such as organic agriculture, tourism or wineries, which are incompatible with heavy industrial land uses. Other policy briefs in our series address these issues.

VI. What is Most Important in Evaluating the Economic Consequences of Shale Gas Drilling?

If we want to understand how natural gas drilling will affect communities in Pennsylvania and New York, the economic impact models that have been used to project potential job creation give us only a fraction of the information we need. As this working paper has indicated, there are major questions about the cumulative costs to communities that come with drilling, and about how the pace and scale of drilling will affect royalty payments and the tax revenues to pay those costs. We are only beginning to assess how drilling will affect other industries located in the Marcellus region, including agriculture and tourism. A realistic assessment of how natural gas drilling will affect the regional economy must have a framework that has been missing from input/output models, one that looks at long-term consequences and cumulative impacts.

Why We Need to Think About the Long-Term

One of the key assumptions underlying our research is that, while investments in a region are necessary for economic development, they are not sufficient. Economic development is about the long-term health and sustainability of communities and regions. Successful economic development is measured by long-term population growth, the presence of a diversified economic base, and a higher standard of living for most of the region's residents, not only in income but also in the quality of public facilities and services and the shared environment. So when we assess how shale drilling will affect our communities and regions, we want to look at both the short term -- economic impact, and the long term -- the potential for economic development.

The evidence from other shale plays (Berman, 2009) and from the broader studies of natural resource dependent economies indicates that we should be cautious about expecting positive long-term outcomes (beyond 5-10 years). Natural resource extraction has a poor record of leading to strong, diversified regional economies. The declining productivity of some shale plays raises questions about what kind of investment in the Marcellus Shale region we can expect beyond a fairly short time frame.

The pace and scale at which drilling occurs appears to be important to long-term outcomes because an accelerated drilling cycle will impose higher costs on communities. At the same time, tax revenue produced by drilling will be short-lived and take the form of a windfall,

which local governments may not be authorized to use to pay for longer-term costs or to make the kinds of investments in infrastructure that could lead to a stronger economy.

Why We Need to Think About the Cumulative Impact

The economic impact reports that have been used to project investment and jobs created from shale gas drilling typically focus on each well as a separate investment node. Without extensive research and modification, these input/output models are not able to account for the cumulative impact on a community or region created by multiple wells. The cumulative impacts include many of the costs borne by communities in gas drilling regions that we have described – new demands on government services, traffic congestion, noise, and social disruption. But as the boom-bust cycle works its way through localities in a gas play, there are also regional cumulative impacts that need to be considered in assessing the costs and benefits.

Why We Need to Think About the Creation of an Industrial Landscape

Shale gas development is already having an economic impact on the counties in New York and Pennsylvania that are part of the Marcellus Shale natural gas play. We see that impact reflected in a growing transient workforce, and increased demand for some goods and services. Hotel rooms are filling up with drillers, and housing prices are rising. Land speculation is occurring. Truck traffic is increasing. Even though New York has not permitted high volume hydraulic fracturing, these effects are spreading over the border from Pennsylvania into New York. So, like it or not, New York is already experiencing the regional consequences of Marcellus Shale drilling.

The regional consequences of shale gas drilling have been neglected because of an emphasis on the drilling process itself and a focus on drill sites, and because regulatory responsibility for industrial activities beyond the well pad is divided among many state and multi-state agencies, and between state and local government. In thinking about what gas drilling means for Pennsylvania and New York, we need to consider *all* the facilities and services that come with drilling: water extraction sites, wastewater disposal sites, gravel pits, staging sites, temporary housing facilities, compressor plants, and gas storage facilities. Linking all these together are pipelines, railroad lines, and many more trucks on the roads. At this time we have no accurate picture of how this regional industrial landscape will evolve or how it will look. It is emerging in Pennsylvania, but again, we have to turn to other shale gas plays that are on the other side of the boom-bust cycle to determine its long-term impact. A thorough understanding of this regional industrial landscape is critical because, while these facilities are capital intensive and

create very few jobs, they may have significant consequences for the development of other regional industries.

VII. What Practices Might Make for Better Policy-Making and Better Outcomes?

An initial assessment of the experiences of other shale plays indicates that two policy approaches to shale gas drilling and production can potentially produce better outcomes.

Moderating the Pace of Resource Extraction

If a state's objective is to derive the maximum benefit from its nonrenewable natural gas resource, a pace and scale of drilling that brings hundreds or thousands of wells on line in a short period of time is not preferable. A slower ramp-up, moderated by the pace of permitting, allows time to develop job training programs and a local business infrastructure, reduce municipal costs through better planning, and provide entrepreneurs opportunity to make use of this low cost energy asset to develop new industries. Unless New York and Pennsylvania are able to devise strategies to use their low cost energy for applications *within* the states, for independent municipal heating and cooling districts for example, or to foster new manufacturing industries, or to explicitly lower the cost of gas to their citizens, the benefits of tapping a large new supply of natural gas in an over-supplied international market will be limited. As it is, no matter what the pace and scale of drilling, there is no guarantee that shale gas extraction in Pennsylvania or New York will result in lower prices for the states' consumers or businesses.

A slow ramp-up would also enable the development of baseline data on environmental conditions that could not only support stronger environmental protections, but also improve accountability. An accelerated drilling cycle, such as that occurring in Pennsylvania, forces counties and municipalities to scale their services and facilities to the "boom"; the predictable "bust" is likely to leave them with excess capacity, and because of population out-migration, with a poorer long-term financial outlook.

Transparency

One of the most common complaints in states and localities affected by natural gas drilling is a lack of information about what is occurring and where. The absence of information causes

consternation and fear among residents of areas affected by drilling, and may provoke antagonistic responses even when they are not warranted.

Policy makers at the state and local levels should make every effort to provide timely information on every aspect of the shale gas development process, beginning with permit applications. An effective transparency policy will require cooperation among agencies responsible for regulating different aspects of the industrial process such as water withdrawal, activities at the drill pad, and distribution and storage facilities.

Of particular importance is the provision of timely information about environmental incidents and accidents, which are certain to occur in industrial processes of the scope of gas drilling in the Marcellus Shale. In another working paper in this series (Riha and Rahm, 2010), the authors lay out an approach to monitoring surface (as distinct from below-ground) drilling-related incidents that is built around a commitment to transparency.

Policy transparency also needs to extend to the financial and fiscal aspects of natural gas drilling. How tax levies are determined, including the calculation of unit of production values, and how the revenues are to be allocated, should be clearly explained to citizens affected by the costs attendant to natural gas drilling.

VIII. The Guiding Principle: Stewardship

In thinking about and responding to the environmental and economic challenges posed by shale gas drilling, elected officials and other policy-makers need to start with the realization that natural gas is a non-renewable resource. Once it is gone, it is gone. Good stewardship from an environmental perspective requires assessing the long-term costs and benefits of HVHF technologies and their implications for the natural and human environment in which gas extraction occurs. Although the economic consequences of HVHF gas drilling have been counter-posed to environmental concerns, we hope that we have demonstrated in this working paper that positive economic outcomes cannot be taken for granted. Thus, elected officials also need to take responsibility for careful management of the local and regional economies affected by HVHF gas drilling and their longer-term sustainability. This means anticipating what may occur in the short-term during a boom, and in the longer-term when drilling ends. Both of these periods will present difficult issues. It is only by anticipating what may occur, planning for change, and communicating a concrete vision for the future that policy-makers can make the kinds of choices that will stand the test of time. There will be no second chances.

References

Associated Press. March 3, 2011. "Wyoming Census: Steep growth in energy boom areas." Printed in the *Billings Gazette* and available at: http://billingsgazette.com/news/state-and-regional/wyoming/article_f8e9a98a-4620-11e0-b408-001cc4c03286.html

Barth, Jannette. 2010. "Unanswered Questions About The Economic Impact of Gas Drilling In the Marcellus Shale: Don't Jump to Conclusions." J.M. Barth & Associates, Inc., March 22.

Banerjee, N. and R. Perez-Pena June 1, 2001. "A Failed Energy Plan Catches up to New York." *New York Times*. Global Edition, New York Region
Available at:
http://query.nytimes.com/gst/fullpage.html?res=9507E0DD173CF932A35755C0A9679C8B63&sec=&spon=&pagewanted=1

Berman, A. 2009. "Lessons from the Barnett Shale suggest caution in other shale plays."
Available at:
http://www.aspousa.org/index.php/2009/08/lessons-from-the-barnett-shale-suggest-caution-in-other-shale-plays/

Christian, M. 2010. "Economic & Market Price Implications." Unpublished manuscript. Carnegie Mellon University. Available from the author.

Considine, Timothy J. 2010. "The Economic Impacts of the Marcellus Shale: Implications for New York, Pennsylvania, and West Virginia." A Report to the American Petroleum Institute. Natural Resource Economics, Inc., Laramie WY.

Considine, Timothy, R. Watson, R. Entler, and J. Sparks. 2009. "An Emerging Giant: Prospects and Economic Impacts of Developing the Marcellus Shale Natural Gas Play." College of Earth & Mineral Sciences, Department of Energy and Mineral Engineering, The Pennsylvania State University.

Engelder T. 2009, "Marcellus 2008: Report card on the breakout year for gas production in the Appalachian Basin." *Fort Worth Basin Oil & Gas Magazine*. August 2009, p. 19-22.
Available at:
http://www.geosc.psu.edu/~jte2/references/link155.pdf

Engelder, Terry and G.G. Lash. 2008. "Marcellus shale play's vast resource potential creating stir in Appalachia." *American Oil and Gas Reporter*, v. 51, n. 6, p. 76-87.

Feser, E. and S. Sweeney. 1999. "Out-migration, Population Decline, and Regional Economic Distress." Report prepared for the U.S. Economic Development Administration, Washington: U.S. Department of Commerce.

Haefele, M. and P. Morton, 2009. "The Influence of the Pace and Scale of Energy Development on Communities: Lessons from the Natural Gas Drilling Boom in the Rocky Mountains." Western Economics Forum, Fall 2009.
Available at:
http://ageconsearch.umn.edu/bitstream/92810/2/0802001.pdf

Headwaters Economics. 2011. Fossil Fuel Extraction and Western Economies. Available at: http://headwaterseconomics.org/energy/western/maximizing-benefits. Downloaded April 26, 2011.

Headwaters Economics 2009. "Fossil Fuel Extraction as a County Economic Development Strategy: Are Energy-focusing Counties Benefiting." Published online: http://headwaterseconomics.org/energy/western/fossil-fuel-extraction/

Higginbotham, Amy, A., Pellillo, T. Gurley-Calvez, and T.S. Witt. 2010. "The Economic Impact of the Natural Gas Industry and the Marcellus Shale Development in West Virginia in 2009." College of Business and Economics, West Virginia University.

Jacquet, Jeffrey. 2011. "Workforce Development Challenges in the Natural Gas Industry." Working Paper Series for *A Comprehensive Economic Impact Analysis of Natural Gas Extraction in the Marcellus Shale*, Cornell University Department of City and Regional Planning. Available at: http://greenchoices.cornell.edu/development/marcellus/policy.cfm

_____2009. "Energy Boomtowns & Natural Gas: Implications for Marcellus Shale Local Governments & Rural Communities." NERCRD Rural Development Paper No. 43, The Northeast Regional Center for Rural Development, The Pennsylvania State University, University Park, PA. Available at: http://nercrd.psu.edu/Publications/rdppapers/rdp43.pdf

_____. 2008. "Sublette County Socioeconomic Impact Study", Phase I Final Report. Prepared for the Sublette County Commissioners. Ecosystem Research Group, Missoula MT.

James, A. and A. Aadland. 2010. "The curse of natural resources: an empirical investigation of U.S.counties." *Resource Energy Economics*. doi:10.1016/j.reseneeco.2010.05.006

Jeffries Research. 2010. "Energy Exploration and Production, Resource Chronicles." New York: Jeffries and Company Inc.

Kay, David. 2010. "The Economic Impact of Marcellus Shale Gas Drilling: What Have We Learned? What are the Limitations?" Working Paper Series for *A Comprehensive Economic Impact Analysis of Natural Gas Extraction in the Marcellus Shale*, Cornell University Department of City and Regional Planning. Available at: http://greenchoices.cornell.edu/development/marcellus/policy.cfm

Kelsey, Timothy. "Marcellus Shale: Economic Development Implications." Presentation to the conference on *A Systems Approach to Energy Transitions: Land, Economic and Community Transformations*, Watkins Glen NY, March 31, 2011. Available from the author (tkelsey@psu.edu).

Loewenstein, James. "Skyrocketing rent in Bradford County: Influx of gas workers creating shortage of affordable housing." *The Daily Review*. January 22, 2010. Available at: http://thedailyreview.com/news/skyrocketing-rent-in-bradford-county-influx-of-gas-workers-creating-shortage-of-affordable-housing-1.563248

Marchand, J. 2011. "Local Labor Market Impacts of Energy Boom Bust Boom in Western Canada," Available form the author at: Department of Economics, University of Alberta, 7-29 HM Tory, Edmonton, AB, Canada, T6G 2H4.

McFarland, Greg. 2010. "Shale Economics: Watch the Curve". *Oil & Gas Evaluation Report*. Website published by Obsidian Energy Company, LLC. March 17.
Available at:
http://www.oilandgasevaluationreport.com/tags/shale-play/

National Conference of State Legislatures. 2011. "Taxing Natural Gas Production" web page charting 2007 data on Natural Gas Producing States.
Available at:
http://www.ncsl.org/?tabid=21582

New York State. 2009. Department of Environmental Conservation. Draft Supplemental Generic Environmental Impact Statement.

Perryman Group. "Drilling for Dollars: An Assessment of the Ongoing and Expanding Economic Impact of Activity in the Barnett Shale on Fort Worth and the Surrounding Area." Presentation at the Barnett Shale Expo, March 2008.
Available at:
http://www.bseec.org/content/2008-economic-impact-report-released-perryman-group

Randall, CJ. 2010. "Hammer Down: A Guide to Protecting Local Roads Impacted by Shale Gas Drilling." Working Paper Series for *A Comprehensive Economic Impact Analysis of Natural Gas Extraction in the Marcellus Shale*, Cornell University Department of City and Regional Planning.
Available at:
http://greenchoices.cornell.edu/development/marcellus/policy.cfm

Riha, Susan and B. Rahm. 2010. "Framework for Assessing Water Resource Impacts from Shale Gas Drilling". Working Paper Series for *A Comprehensive Economic Impact Analysis of Natural Gas Extraction in the Marcellus Shale*, Cornell University Department of City and Regional Planning.
Available at:
http://greenchoices.cornell.edu/development/marcellus/policy.cfm

Rumbach, Andrew. 2011. "Natural Gas Drilling in the Marcellus Shale: Potential Impacts on the Tourism Economy of the Southern Tier." Working Paper Series for *A Comprehensive Economic Impact Analysis of Natural Gas Extraction in the Marcellus Shale*, Cornell University Department of City and Regional Planning.
Available at:
http://greenchoices.cornell.edu/development/marcellus/policy.cfm

Stevens, Scott and V. Kuuskraa. 2009. "Special Report: GAS SHALE—1: Seven plays dominate North America activity." *Oil & Gas Journal*. Volume 107.36, September 28.
Available at:
http://www.ogj.com/index/article-display/8128977500/articles/oil-gas-journal/volume-107/Issue_36/Drilling__Production/Special_Report__GAS_SHALE_1__Seven_plays_dominate_North_America_activity.html

U.S. Energy Information Administration. 2007. "Share of Total U.S. Natural Gas Residential Delivered to Customers."
Available at:
http://tonto.eia.doe.gov/dnav/ng/ng_cons_pns_a_epg0_vrp_pct_a.htm

Weinstein, Bernard L. and T.L. Clower. 2009. “Potential Economic and Fiscal Impacts from Natural Gas Production in Broome County, New York.” Report prepared for Broome County, NY.

Wood, M. and S. Ward. 2009. "Responsible Growth: Protecting the Public Interest with a Natural Gas Severance Tax." Harrisburg: Pennsylvania Budget and Policy Center. Available at: http://www.pennbpc.org/sites/pennbpc.org/files/Responsible Growth - PA Severance Tax.pdf