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An Analysis of the Economic Potential for Shale Formations in Ohio

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Ohio Shale Coalition

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I. Executive Summary

For the first time in over 100 years, Ohio finds itself on the threshold of not only being self-sufficient in the production of oil and gas, but also possibly even being a hydrocarbon exporter. This dramatic renaissance in Ohio's oil and gas industry comes courtesy of new drilling and completion technologies that has enabled oil and gas producers to extract hydrocarbons from shale reservoirs that heretofore were considered uneconomical to produce, due to the impermeability of the shale formations.

The new technologies that have enabled the rapid growth of shale development – horizontal drilling and improved hydraulic fracturing techniques – will require considerable investment by producing companies in Ohio. The first major investment to be made is the acquisition of mineral rights. Mineral leases are currently being acquired with bonus and royalty rates never before seen in Ohio. Notwithstanding these very high rates, leasing has been robust, with some 3 million plus acres of mineral rights acquired in the last several years, and ongoing land operations show no immediate sign of abatement. Lease bonuses have averaged around $2500/acre, and royalty rates have averaged around 15%, although both have been higher in the most prospective areas of Ohio.

The second major investment that will be made in Ohio relates to road and bridge upgrades associated with drilling wells. The heavy equipment needed to bring in drilling equipment and to haul water and other materials requires heavy-duty roads to be built and maintained. An estimated $1.1 million dollars is likely to be expended, on average, by producing companies in road and bridge upgrades for each drilling location. Producing companies will use "pads" from which they will drill as many as six to eight wells each. Road upgrades will be required for each pad, and probably multiple times. Construction jobs for road upgrades are expected to go predominantly to Ohio suppliers and laborers.

Drilling and completing wells will comprise the third, and most significant, expenditure by oil and gas companies in Ohio. Wells are expected to cost between $5 million

Background

Cleveland State University, Ohio State University and Marietta College (the "Study Team") were jointly asked by the Ohio Shale Coalition, led by the Ohio Chamber of Commerce, to investigate the nature and amount of economic activity that is likely to be spurred by this development. The Study Team undertook to evaluate the economic impact by collecting data, preparing models, and implementing the most commonly accepted software in economic development circles for studying economic impact. Since drilling and production data from the Utica shale is at the time of this publication unavailable, the Study Team relied upon a combination of interviews with industry experts and executives, the examination of prior studies in other shale plays, and interviews with government executives to build a model for likely development scenarios in Ohio. The study looks at the economic impact of shale development for the years 2011 to 2014.

Because data are just beginning to become available, the Study Team has generally been conservative in its estimates. As more and better data become available, the models can be updated, and a more accurate view of the economic activity associated with shale formation can be developed.

and $6 million each to drill and complete. Drilling started off slowly in Ohio in 2011, with 33 total wells drilled, and only 4 placed into production. However drilling is expected to ramp up quickly, with over one thousand wells a year being drilled by 2014. This means that by 2014, over $6 billion dollars will be spent on drilling and completing wells in Ohio. Ohio's service industry will need time to catch up with Pennsylvania and other oil and gas producing states, so Ohio will likely see no more than 50% of this investment stay in Ohio during the early stages of the Utica Shale development.

The fourth and final aspect of expenditure in Ohio to be considered in this study was for the post-production stage of development. Once the production is placed on line, there must be a "midstream" infrastructure in place to transport the hydrocarbons to a processing facility, or directly to a market. One feature of the Utica Shale is that, unlike the nearby Marcellus Shale, it produces both liquids and natural gas. Even the natural gas produced contains large volumes of liquids contained in suspension in the gas stream. These liquids are valuable and can be separated from the "dry" gas (methane) through processing and fractionation procedures. All of this requires building an elaborate gathering pipeline system, compressors, processing plants, fractionation plants, storage facilities, and railroad loading terminals. Most of this will be done in Ohio. However only portions of the materials and labor for this construction will be Ohio-based. Only those portions that are estimated to be Ohio-based were used in the modeling. It was assumed for estimating midstream build out that by 2014 there would be a need for infrastructure sufficient to handle a throughput of 1.5 billion cubic feet of natural gas per day in Ohio from the Utica.

The Study Team modeled production of both liquids and natural gas produced at the well for royalty and tax purposes. Production was modeled based upon a combination of estimates for drilling and production rates for the Utica, relying upon geological and petroleum engineering experts at Marietta College and from the State of Ohio Geological Survey. Estimates were based upon an average of the likely mixture of liquids and natural gas produced at the well, understanding that these mixtures are likely to vary significantly from well to well.

Based upon the anticipated spending in Ohio for leasing, road construction, drilling and completing wells, and building of post-production natural gas infrastructure, the Study Team modeled a likely economic development impact for the State of Ohio as a result of the development of the Utica Shale for the years 2011-2014. The results of this model are set forth in the following table:

Economic Impact due to Increased Demand in Ohio as a Result of Utica Shale Development

	2011	2012	2013	2014
Value Added	$162,030,036	$878,982,133	$2,980,378,198	$4,857,632,095
Employment	2,275	12,150	40,606	65,680
Labor Income	$99,758,497	$571,543,463	$1,994,216,405	$3,298,757,195
Output	$291,574,770	$1,667,574,417	$5,823,268,396	$9,642,544,988
Total State and Local Taxes	$16,522,865	$73,422,148	$271,539,607	$433,528,922

The output measures the total value added by increased economic activity as a result of the shale development, plus the value of intermediary goods. The output is the economic development number most policy makers look to for guidance as to the economic impact of a particular industry. The calculations include not only the direct effects of the expenditures, but also the indirect (subsequent business) and induced (household spending) effects. The models indicate that outputs are expected to amount to nearly ten billion dollars per year by 2014, with another $500 million in tax revenue generated. It is expected that these numbers are likely to continue in this range in the years following 2014, although leasing and midstream infrastructure activity will significantly slow down.

The $229.6 million investment in oil and gas development in the Utica play in 2011 had an immediate impact on Ohio's economy, resulting in the state's Gross Product, as measured by Value Added, increasing by $162 million in that year. This translated into 2,275 jobs, and nearly $100 million in increased labor income. By 2014 the incremental economic activity in the state of Ohio from that year's expected expenditure of $6.4 billion in oil and gas field development is expected to result in 65,680 jobs and $3.3 billion in labor income, or an average income of $50,225 per job. The model shows average labor income rising over time as the work shifts from leasing and road construction to drilling and infrastructure maintenance.

Nearly 17 percent of the increase in the number of jobs triggered by the development of Ohio's Utica Shale deposits will come from oil and gas field service companies, with employment doubling between 2013 and 2014. The average earnings for this group are $69,000 per year. The largest growth in employment will be in construction-related trades as wells are drilled and midstream facilities are constructed. Nearly 11,000 local construction jobs will be created as new manufacturing facilities and other nonresidential structures are constructed, which includes midstream infrastructure, as well as pipelines and roads and bridges. These will pay an average of $48,000 per position. Truck drivers will be in great demand as servicing companies, wholesalers, delivery services, and construction companies ramp up their employment to meet demand. Expected average labor income is nearly $53,000.

The model estimates that by 2014 over 1,500 jobs for engineers and architects will be established, as will 1,000 environmental compliance technicians. There will be demand for more than 1,800 office workers along with nearly 500 technical consultants. The leasing and contracting work will help turn around a soft market for attorneys, with nearly 841 positions expected to open. The highest paid in this sector are the managers, with average labor income of $109,000, followed by those who provide consulting services at $75,000. A related source of employment will be of "landmen," a career unique to the oil and gas and mining industries. More than 2,100 people in the real estate industry, with average incomes of nearly $70,000, will be engaged as a result of the Utica development.

The development of the Utica formation will also result in increased land and property values throughout the region. This will not only be due to the direct economic activity triggered by drilling and building out supporting infrastructure, but will also be due to the increased value of housing and general commercial structures throughout the eastern half of the state as employment increases and wages and incomes rise.

Gross State (or Domestic) Product is expected to increase by $4.9 billion in 2014 due to the development of the Utica formation as an energy resource. This is equal to a 1 percent increase in the real value of Ohio's Gross State Product – greater than the average annual growth rate in Ohio for the past 13 years (0.6%).

The oil and gas "downstream" industry – that industry that relates to the consumption of hydrocarbons -- was not modeled in this study. However the Study Team did examine generally downstream opportunities for Ohio as a result of the Utica Shale development, and includes herewith a discussion.

Because Ohio's shale industry is in its early stages, data is incomplete. It is expected that as data becomes available, the models may be updated to reflect the better data and to provide a more accurate picture of the economic impact the development of the Utica Shale in Ohio. It is also important to note that the study term only goes to 2014, at which time the industry will likely yet be growing in Ohio. Accordingly, a significant part of the economic development growth may occur after the study date conclusion.

II. Introduction

Oil and gas exploration in Ohio dates back to the late 1800's, when John D. Rockefeller created the first major integrated oil firm, the Standard Oil Company, originally headquartered in Cleveland. Notwithstanding its lead role in founding the oil and gas industry, Ohio has since played a far less significant role in hydrocarbon exploration and extraction – simply because Ohio was not rich in readily accessible reserves. Ohio imports a high percentage of its oil and gas, and has done so for a long time. In the process, it exports a good deal of its wealth. Over half of the American trade deficit is generated by the purchase of foreign oil,[1] and Ohio, which reached peak oil some 50 years before Texas and Louisiana, is responsible for a nontrivial share of this deficit.

This may be about to change. For the first time in over 100 years, Ohio finds itself on the threshold of not only being self-sufficient in the production of oil and gas, but it may even become an exporter. This is because thousands of feet below the eastern half of the state lies a shale formation, commonly called the Utica Shale,[2] that promises to be a major source of hydrocarbon production for the next 30 plus years. This formation contains reserves of as much as 5 billion barrels of oil and 15 trillion cubic feet of natural gas. Moreover, another shale layer beneath the Utica – the Lower Huron formation – may also be capable of producing fossil fuels in commercial quantities.[3]

Shale strata such as the Utica and the Marcellus, which extends into Ohio from Pennsylvania and West Virginia, have long been known to be organically rich, yet

[1] "America's Trade Deficit: Oil and the Current Account, " *The Economist*, February 10, 2010, http://www.economist.com/blogs/freeexchange/2010/02/americas_trade_deficit.

[2] In Ohio the Utica Shale coexists with the Point Pleasant formation, another organic rich shale formation. It is believed that the latter formation will be the more productive of the two shale formations in Ohio. However since the Point Pleasant formation is principally found only in Ohio, and the Utica is the better-known formation, the Utica and Point Pleasant formations will hereinafter be referred to jointly as the "Utica." The Marcellus Shale formation, which produces natural gas economically in Pennsylvania and West Virginia, also exists in Ohio, but is generally considered too shallow and/or too thin to be economically productive, except in the most eastern counties of Ohio. *See* Figure 1 for a map showing the geographic relationship of the likely productive areas of the Utica and Marcellus shale in Ohio.

[3] "Natural Gas, oil reserves Are Big, Ohio Is Estimating," *Ohio.com*, November 2, 2011, http://www.ohio.com/news/local/natural-gas-oil-reserves-are-big-ohio-is-estimating-1.243256 (quoting reserves estimated by the chief geologist for the Ohio Geological Survey).

formerly were too expensive to exploit. This is because shale is both deep and impermeable (i.e., incapable of flowing hydrocarbons trapped in its pore spaces into a well bore). Historically, shale has been looked upon by petroleum geologists principally as an impermeable "cap rock" that serves to trap hydrocarbons found in more permeable sandstone or limestone reservoirs. Conventional oil and gas exploration has targeted sandstone or limestone formations for this reason. However recent advances in drilling and completion techniques have resolved the impermeability problem, enabling organically rich shale formations to produce hydrocarbons in commercial quantities. As a result, Ohio now finds itself positioned to once again become a major oil and gas producing province. The potential economic impact of this development is the subject matter of this report.

At the time this report is being published, only a handful of wells have been completed in the Utica Shale in Ohio, although many more have been permitted. Few production numbers have been made publicly available. Accordingly, projections for oil and gas production to be realized in Ohio from shale formations are at best speculative. Nevertheless, flow tests and public announcements suggest that early prognostications of significant potential for oil and gas production are on target.

Fossil fuels comprise the most basic and critical energy resource that fuels the Ohio economy. But oil and gas provide more than the energy that powers our manufacturing, heats our homes and drives our transportation. Hydrocarbons also comprise the principal feedstock for the petrochemical industry, which plays a key role in the day-to-day functioning of society and represents a significant portion of the Ohio economy and key to our manufacturing and agricultural sectors.

Understanding the economic impact of a potential new source of hydrocarbons in Ohio is complex, particularly in light of the speculative nature of the early, but promising, production numbers. Nevertheless, certain assumptions can be made and estimates of the oil and gas production potential can be calculated. Those assumptions and estimates are set forth in this report. The focus for this report has been on the following economic impacts resulting from oil and gas production from the Utica Shale:

1. The development of a service industry associated with exploration, drilling, completion, and production of hydrocarbons from shale formations (i.e. the "upstream" aspects of the oil and gas business);
2. The development of the service industry associated with the gathering, transportation and distribution of hydrocarbons (i.e. the "midstream" aspects of the oil and gas business); and
3. Specific cases of Ohio industries that will be affected by shale formation development, including those industries that consume oil and gas in their operations as either a feedstock or as a source of fuel or power (i.e. the "downstream" aspects of the oil and gas business).

In addition, the economists and other professionals from Cleveland State University, Marietta College, and The Ohio State University (hereinafter, the "Study Team") have considered likely tax generation scenarios based upon projected production and commercial activity in Ohio associated with the Utica Shale formation development. The sections herein discuss the history of the Utica Shale development in Ohio and the impact this development is likely to have relative to the Ohio economy.

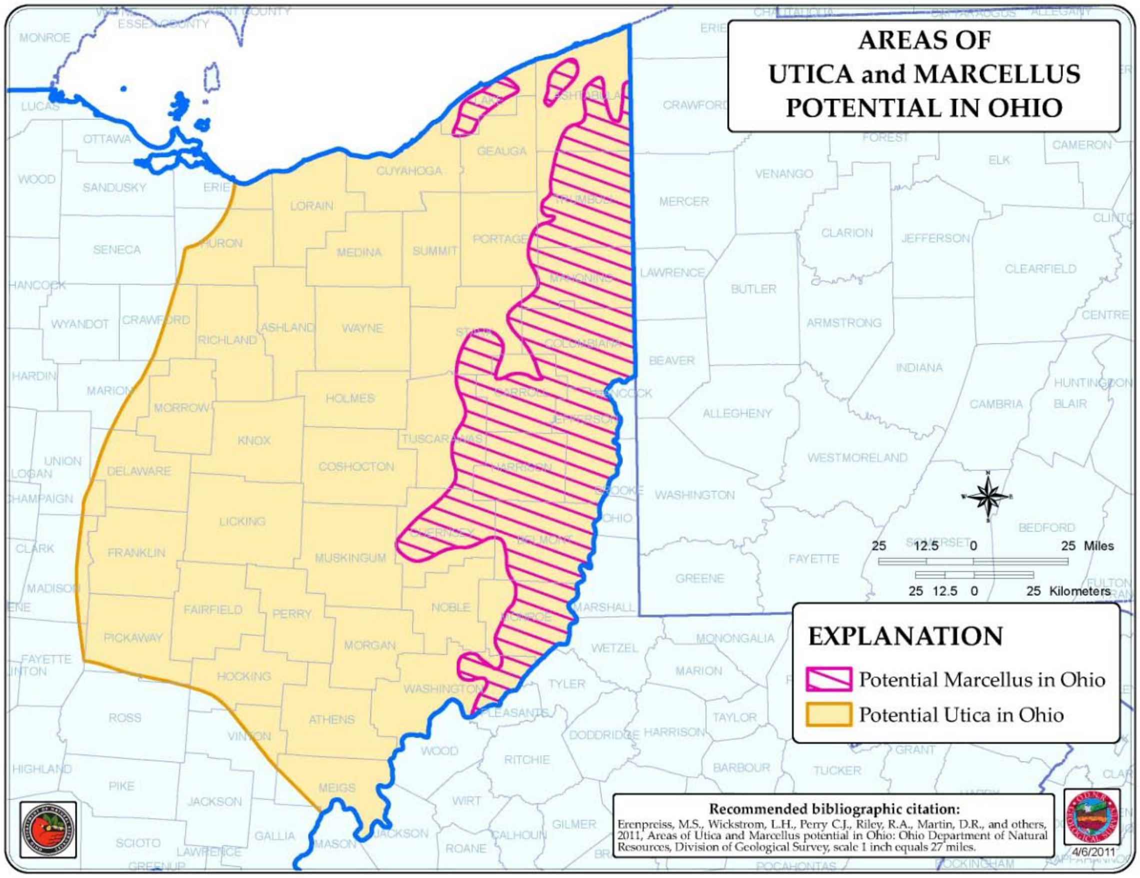


Figure 1: Geographic extent of the potentially productive areas in Ohio for the Utica and Marcellus Shale formations (courtesy of the Ohio Department of Natural Resources, Division of Geological Survey)

III. Shale Development and the Hydrocarbons Sector

Were it not for the Natural Gas Policy Act (NGPA) of 1978, shale and other "unconventional" resources might still rest undisturbed today. Enacted a few years after Middle Eastern exporters shut off oil shipments to the United States and other western nations, thereby causing energy prices to skyrocket, this legislation did away with a comprehensive set of regulations governing pricing and production. In effect, a nationwide market for natural gas was created largely by guaranteeing universal access to the interstate pipeline system at fees approved by the Federal Energy Regulatory Commission (FERC). This deregulation encouraged energy companies to seek out and extract gas from resources such as low permeability sandstones, coal seams, the Devonian shale formation, and deep reservoirs. Even more consequential has been the development and adoption of technology needed to exploit deposits formerly regarded as economically unfeasible, including shale formations.[4]

[4] Examples of technological advances include improvements in hydraulic fracturing ("fracking"), which has been used since the late 1940s to extract hydrocarbons from impermeable geologic strata, as well as horizontal drilling, which is an alternative to the vertical boring that the oil and gas industry had relied on since its earliest days in places like Ohio and Pennsylvania. There also have been great strides in

These formations remained largely undeveloped as recently as 2001, when horizontal drilling first jump-started the extraction of natural gas from the Barnett "play" in northern Texas. Since then, as horizontal drilling has become commonplace and as hydraulic fracturing methods have improved, other deposits have been tapped, including the Haynesville in Louisiana and Arkansas and the Marcellus in Pennsylvania and neighboring states. Shale's share of natural gas production, which was just 4 percent in 2004, currently is approaching 30 percent.[5] All signs point to continued growth in shale gas output for decades to come – growth that will more than make up for decreasing supplies from conventional fields, on land and offshore.[6]

A. Supply and Price Impacts to Date

As long as declines in conventional supplies were not being offset by increased gas extraction from shale and other unconventional deposits, inflation-adjusted (or real) prices were on an upward trajectory, as had been predicted in a widely-read report on energy published soon after passage of the NGPA.[7] Real prices rose during the 1990s, when drilling in many places remained tightly restricted and when the production of electricity using gas-fired generators (which are highly efficient[8]) was rising at a fast clip. Also, natural gas continued to grow more expensive after the turn of the twenty-first century. Reflecting on trends in supply and prices, Federal Reserve Chairman Alan Greenspan spoke out in 2004 about the need that he and many others saw to construct a large number of coastal terminals capable of receiving liquefied natural gas (LNG) from other countries. Along with other experts and policy-makers, America's central banker was convinced that imports must go up, to make up for dwindling domestic production.[9]

Not only did real prices rise as the years passed, but markets for natural gas occasionally suffered dramatic swings. With production and processing concentrated along the Gulf Coast, prices routinely shot up whenever a major storm struck the region. For example, Hurricanes Katrina and Rita disrupted industry operations during the latter part of 2005. causing prices to rise above $11.50 per million British thermal units (MMBTU).[10] Prices spiked again three years later – exceeding $10 per MMBTU during the first half of 2008, when crude oil was changing hands for as much as $146 per barrel.

Shale gas supplies have increased significantly in the past few years, both in absolute terms and relative to total domestic production of natural gas. As a result – and as a result of the recession that has moderated demand -- prices have held steady at low levels, never exceeding $4 per MMBTU since late 2008. This reflects the overriding importance of continuing U.S. shale development on the decoupling of gas and oil markets. Spikes in oil prices no

seismic reflection technology, which uses sound waves to locate promising resources with great precision, as well as micro-seismic technology, to guide hydrocarbon extraction from those deposits.

[5] "The future of natural gas: Coming soon to a terminal near you," *The Economist*, August 6, 2011. http://www.economist.com/node/21525381.

[6] U.S. Energy Information Agency, *Annual Energy Outlook 2011 with Projections to 2035*,Washington, p. 3.

[7] Bupp and Schuller (1979), *Natural gas: How to slice a shrinking pie*.

[8] Ridley (2011), *The shale gas shock*.

[9] "Greenspan: Natural gas imports must grow," *Associated Press,* April 17, 2004, http://www.msnbc.msn.com/id/4845905/ns/business-oil_and_energy/t/greenspan-natural-gas-imports-must-grow/.

[10] Consumers are accustomed to volumetric pricing of natural gas, rather than pricing based on energy-content. However, this content varies, from 1.01 to 1.07 MMBTU per thousand cubic feet. A price of $4 per MMBTU is equivalent to $3.88 per thousand cubic feet for gas with 1.03 MMBTU per thousand cubic feet.

longer result in comparable increases in the price of gas. To the contrary, natural gas has remained consistently inexpensive during the last three years, irrespective of what has happened in the oil market. During this period, the ratio of oil prices to gas prices has consistently stayed at elevated levels – levels not seen since the late 1970s and early 1980s, when oil prices surged in the wake of the Iranian Revolution.

B. Market and Price Adjustments to Come

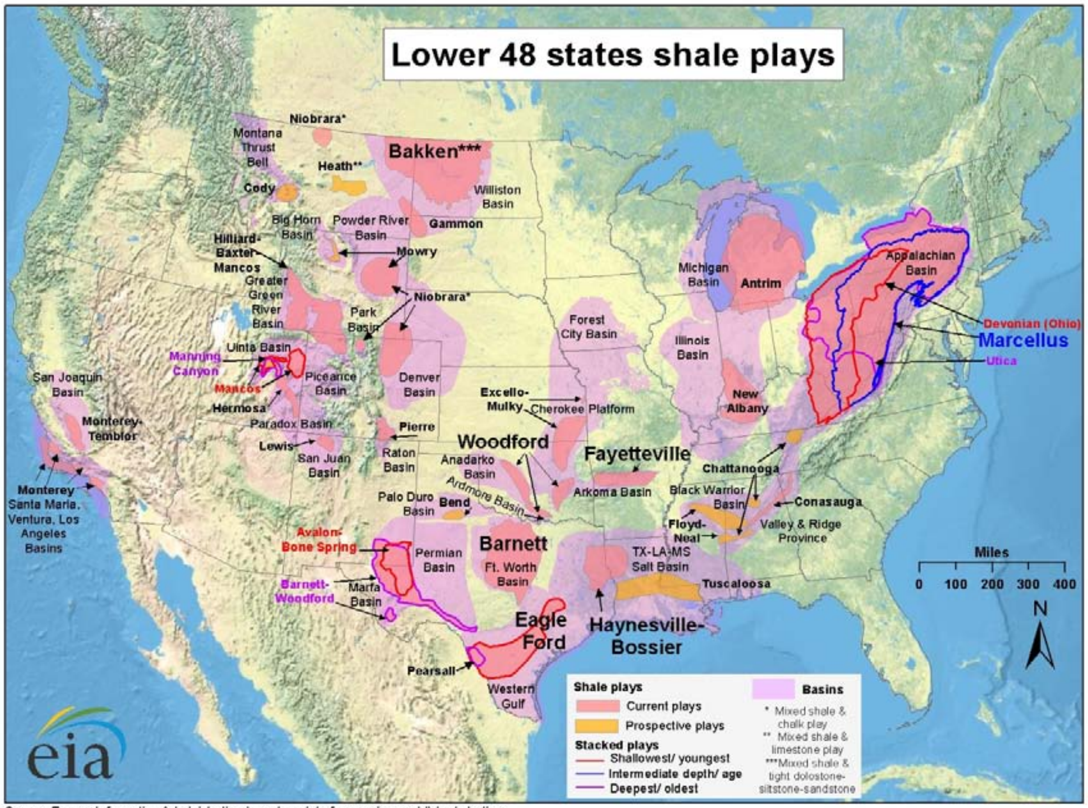
Invariably, consumers gain much more than anyone else when resources become less scarce due to technological improvement, especially if market forces guide the improvement. The agricultural economy is illustrative in this regard. Since the middle of the twentieth century, better ways have been found to raise crops and livestock. With food supplies increasing faster than food demand – during a period when human numbers have gone up at unprecedented rates – prices have gone down, much to the relief and benefit of consumers around the world. Cheaper food has provided an enormous stimulus to economic development as well, above and beyond the benefits of improved agricultural technology captured by farmers.[11]

Market-guided technological improvement has had analogous consequences in the natural gas sector. Deregulation has stimulated technological advances needed to make natural gas much more plentiful. To be sure, energy companies, which are largely responsible for these advances, have benefited insofar as costs of production have declined. However they also have seen the price of their output fall. Meanwhile, the same price reductions represent an unqualified gain for consumers.

By no means have gas prices finished adjusting to improvements in the technology for finding and extracting hydrocarbons from shale and other unconventional geologic formations. Incentives to produce electricity at gas-fired generators are strengthening. With added post-production infrastructure, homes currently heated with fuel oil will switch to natural gas. The same is true of the rewards for running fleet vehicles – for example, buses and mail trucks that can return regularly to central facilities for refueling – on compressed natural gas. As firms, households, and public agencies respond to incentives to use more natural gas, prices should begin to firm up, and eventually increase.

There are also potential sources of upward pressure on prices from outside the United States. Except for coal, this country has not been a net exporter of hydrocarbons for years. Yet foreign sales could approach or even outpace imports in the future if U.S. gas production continues to increase and if investments needed for the production and export of LNG are made.

[11] Southgate, Graham, and Tweeten (2011), *The World Food Economy*.



Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

Figure 2. Map of the geographical extent of the major shale formations in the United States (Energy Information Agency)

Shale formations, which appear to be widely distributed throughout the world, are now being exploited, or are about to be, in a handful of other nations such as Poland (which may have Europe's largest reserves), South Africa, and China.[12] But even though drilling in these countries has yet to add significantly to energy supplies, U.S. extraction of natural gas from shale is having noticeable effects in foreign markets already.

In particular, the LNG formerly slated for delivery to this country is instead going elsewhere. One consequence of this has been to diminish Europe's dependence on Russia´s Gazprom, which in the past supplied energy only under long-term contracts at prices pegged to the market value of crude oil – the most remuneration that a monopolistic supplier could hope to receive. Increased LNG availability has enabled some European customers to win agreement from Gazprom to use spot-market prices for LNG when calculating the value of up to 15 percent of the gas delivered via the Russian firm's pipelines. This represents an important saving for the customers since spot-market prices are considerably lower than oil-referenced prices.[13]

[12] *The Economist*, August 6, 2011.

[13] *The Economist*, August 6, 2011.

C. Development of the Utica Shale Formation

Development of new markets of gas, both in the United States and in other countries, will require time and a monetary investment. Before these markets materialize, gas will remain cheap and companies currently specialized in that fuel will have incentives to diversify output. The drive for diversification explains the presence of these companies in the Eagle Ford play of south Texas. This formation yields ethane and other natural gas liquids (NGLs)[14], which the chemical industry uses as a feedstock, and crude oil in addition to the dry gas (i.e., primarily methane) used to heat homes and power generators. Likewise, there is substantial interest in the Bakken formation of western North Dakota, which is an important source of oil, as well as the portion of the Utica formation that lies under the eastern third of Ohio, which is expected to yield dry gas, natural gas liquids, and crude oil.

No more than a year ago, expectations of shale development in Ohio focused largely on the Marcellus. However, it became clear in 2011 that Marcellus-related drilling is unlikely to happen very far west of the state's borders with Pennsylvania and West Virginia. In contrast, drilling in the Utica Shale is happening in a much larger area, including around Canton, in northeast Ohio, and even approaching Columbus's easternmost suburbs, among other places. In late July, Chesapeake Energy, which is the second-leading U.S. producer of natural gas, announced that shale deposits worth up to $20 billion underlie the 1.25 million acres it has leased in the state.[15] Since this announcement, articles about the Utica play in Ohio have appeared frequently in the local and national press.

Permitting data issued by the Ohio Department of Natural Resources (ODNR) underscore the importance of shale development in this state, particularly in the Utica play. As of early January 2012, five permits had been issued for vertical wells to be drilled into the Marcellus formation. Operations were proceeding at two of these five sites, mainly for the sake of resource assessment. Permits also had been issued for 11 horizontal wells penetrating the same formation. Actual production is under way at three of these locations and there is active drilling at another three. Most of the 16 Marcellus sites are on or close to Ohio´s border with West Virginia, in Belmont, Carroll, Harrison, Jefferson, and Monroe Counties.[16]

Development of the Utica Shale got a later start than drilling into this state´s portion of the Marcellus. However, more wells now penetrate the Utica formation, with a larger area affected. All told, 143 vertical and horizontal wells have been permitted (meaning more than 70 wells total), although only four so far have been placed into production. Moreover, initial results that Chesapeake released in September 2011 for three of its Utica wells demonstrate the formation's importance –

[14] Natural gas liquids (NGLs) are liquid hydrocarbons carried in suspension in the natural gas stream. The size of the hydrocarbon molecules found in an oil and gas reservoir varies significantly within the reservoir, and from well to well. The smallest molecule, methane (CH4) is typically what is known as natural gas. However heavier and more complex molecules can remain in suspension, even after the natural gas stream reaches atmospheric temperatures and pressures. These heavier hydrocarbons – such as ethane, propane, butane, and natural gasoline – all have added value to the producer if found in significant enough volumes within the gas stream.

[15] "Driller touts Ohio's gas and oil," *Columbus Dispatch*, July 29, 2011, http://www.dispatch.com/content/stories/business/2011/07/29/driller-touts-ohios-gas-and-oil.html.

[16] Ohio Department of Natural Resources, "Oil and Natural Gas Well and Shale Development Resources," http://www.ohiodnr.com/oil/shale/tabid/23174/Default.aspx.

not just as a source for dry gas, but for liquids as well. Peak daily production was reported at 3.1 million cubic feet (MMCF) of gas and 1,105 barrels of liquids (oil and NGLs) at one of two wells in Carroll County and 3.8 MCF of gas and 980 barrels at the other. Peak daily output at another well, in Harrison County, is appreciably higher at 9.5 MCF of gas and 1,425 barrels of liquid per day.[17]

At any oil or gas well, production drops from the initial peaks, sometimes very quickly. This is certainly true of horizontal wells drilled into shale formations such as the Utica. But even if the initial flow tests turn out to overstate likely production rates for the first year (as they usually do), the initial results appear to demonstrate that Ohio´s gas and oil industry has embarked on a major expansion.

D. Impact on Fossil Fuel Prices in Ohio

All else remaining the same, increased local supplies of fossil fuels ought to reduce what Ohioans pay for energy and other related inputs. This will not be because oil and gas extraction from the Utica and other formations will be sizable enough relative to overall supplies to have a significant influence on reference prices in national markets. Instead, prices charged in Ohio will be affected insofar as movement toward energy self-sufficiency for the state lowers expenditures on bringing in fossil fuels from other places.

Among others, the President of BP-Husky, a company that owns a pair of refineries in Ohio (subsection VII-A), observed that a sizable portion of the crude oil refined in the state is piped in from coastal import terminals or from producing areas elsewhere in North America.[18] Although this requires expenditures on transmission, prices of crude oil in the state have been lower during the past three years than prices along the coast, which are directly influenced by supply and demand in global markets. To be specific, prices charged in Ohio were on average $1.21/barrel lower than Gulf Coast prices in 2008, $1.42/barrel lower in 2009, and $2.89/barrel lower in 2010, according to reports issued by the Energy Information Agency (EIA) of the U.S. Department of Energy. At the very least, increased oil availability due to shale development in Ohio ought to prevent this gap from closing. In other words, crude oil should remain relatively cheap in the state thanks to hydrocarbon extraction from the Utica Shale.

As is the case with crude oil, moving natural gas from place to place is expensive, so being able to tap into local supplies has important benefits. For example, gas prices in Ohio used to exceed the U.S. reference price – charged at Henry Hub, Louisiana – by $1.00 per MMBTU or more, mainly due to transmission costs. But according to data on prices compiled by the EIA, the average gap during the past three years or so has been just $0.50 per MMBTU. As production ramps up in the Utica, this gap might vanish entirely.

Energy buyers in Ohio will benefit in other ways from local hydrocarbon development. Pipeline fees, which must be paid in order to bring in gas from other states, are expected to decline by as much as $30 million due to shale development.[19] Also,

[17] Ohio Manufacturers´ Association Energy Management, "Initial Output of First Three Ohio Utica Shale Wells: Wow!" http://www.ohiomfg.com/communities/energy/. These are reports of flow tests, which generally are not reliable for projecting ultimate production.

[18] Mark Dangler, remarks as panelist during Ohio Governor's 21st Century Energy and Economic Summit, Columbus, September 21, 2011.

[19] Kleinhenz and Associates (2011), "Ohio's Natural Gas and Crude Oil Exploration and Production Industry and the Emerging Utica Gas Formation: Economic Impact Study," prepared for Ohio Oil and Gas Energy Education Program (OOGEEP), http://ooga.org/our-industry/economic-impact/.

reliable supplies of gas from wells nearby diminish the need for gas reservoir capacity, which is filled up during warm months when demand ebbs and then depleted when demand peaks during the winter. Storage costs likely to be avoided in Ohio due to increased gas extraction from the Utica Shale and other formations will be approximately $35 million per year. [20] Moreover, local consumers will be somewhat insulated from some of the variation in prices that occurs in national and international markets. They will not have to pay as much for natural gas, for example, during episodes of spiking prices.[21]

Finally, natural gas liquid prices used to be tightly linked to dry gas prices. However, this linkage has weakened somewhat in recent years.[22] Further weakening might occur during the years to come as shale development increases the availability of ethane, which is costlier to transport than methane. In places such as Ohio where ethane will become relatively abundant as the Utica is developed, NGL prices could fall noticeably below local methane prices as well as NGL prices in other parts of the United States. As discussed in subsection VII-C, this could provide a boost for Ohio´s petrochemical and polymer industries.

Projecting the effects of the development of shale formation on Ohio industries is not part of this Study.[23] However there can be little doubt that what may well prove to be the most important economic impact derived from the exploitation of shale formations will be the development of a long-term, inexpensive source of natural gas and natural gas liquids to fuel the Ohio economy.

IV. Geology and Reservoir Characteristics of the Utica Shale in Ohio

The remnants of ocean-beds hundreds of millions years old, shale formations thousands of feet under the surface of eastern Ohio contain vast amounts of organic matter in the form of hydrocarbons. Over geologic time, some hydrocarbons migrated into shallower more porous and permeable rock formations, primarily sandstone and limestone, where they have been produced from vertical wells dating back to the late 1800's. However the vast majority of the hydrocarbons remain trapped in the shale, in microscopic and interconnected pore spaces of such low permeability that they could not be produced by conventional oil and gas well drilling techniques. Horizontal drilling technology and multi-stage fracturing methods, however, have provided the keys to unlocking the potential for producing oil and gas in commercial quantities from shale.

The Utica Shale is found approximately 2,000 feet below the Marcellus Shale in Ohio, with depths to the base of the formation ranging from 3,000 feet in the central part of the state to 9,000 feet in the eastern part. The thickness of the rock ranges from 200 to 400 feet across the areas currently targeted for exploration. The Utica Shale in the areas where it is expected to be productive is an organically-rich and thermally-mature dark grey shale. Production from the shale at this point in time is thought to range from dry gas in the deeper eastern portion of the state, to wet gas moving west towards the center of the state, to oil in the central portion of the

[20] Kleinhenz and Associates (2011), p. 45.
[21] Kleinhenz and Associates (2011), pp. 50-61.
[22] American Chemistry Council (2011), "Shale Gas and New Petrochemicals Investment: Benefits for the Economy, Jobs, and U.S. Manufacturing," p. 14.
[23] Kleinhenz and Associates (2011) did undertake an analysis of the likely affects that lower and more stable natural gas prices will have on Ohio industries, pp. 33-61.

state, where the formation becomes both shallower and thinner. The production potential of the shale west of the center of the state is thought to be low.

Thermal maturity of the shale formation controls the nature of production as gas or liquid. The more mature the shale, the more likely that the shale will yield dry gas (i.e., methane) instead of oil. Accordingly, the less mature western side of the Utica, which is shallower and has not baked under high temperatures and pressures for as long as has the eastern side, is expected to be rich in oil and natural gas liquids. The oil produced is expected to be a light, sweet crude, which is the easiest to transport and refine and considered to have the highest value among the forms of oil produced.[24] While liquids generally have more value than does natural gas, liquids are more difficult to produce from impermeable rocks.

Oil has no energy of its own to drive production, but rather derives the energy from natural gas dissolved in it under pressure. Typically, the deeper the rock formation containing the oil and gas, the greater will be the pressure in the reservoir. As the Utica Shale gets shallower moving from east to west across Ohio, pressures may become insufficient to produce commercial quantities of hydrocarbons. [25] This is in contrast to drilling in the eastern part of the state, where formation pressures should be higher, but where the cost of drilling deeper into the earth to reach the Utica formation will be higher too. Deeper wells require more time to drill, more materials such as drill pipe and casing, and higher costs for processes like hydraulic fracturing, all adding significantly to the cost of drilling and completion operations.

Other variables affecting production include unit thickness and the organic content of the shale formation. The thicker the unit, the greater the volume of oil and gas potentially present in the reservoir, and the more likely commercial quantities of hydrocarbons can be recovered from a horizontal well bore. The potential for commercial oil and gas production is, accordingly, favored on the eastern side of Ohio, where the Utica is generally thicker.

Finally, production capability may be controlled by the organic content of the Utica Shale. The greater the organic content (i.e. the amount of hydrocarbon material present in the pore spaces of the rock), the greater will be the potential for oil and gas production from the shale. It is uncertain how that organic content will vary. [26] There is still considerable uncertainty as to what will be found in wells drilled as far north as Ashtabula County, for instance, and this will remain a question until wells are drilled and better reservoir data is obtained and analyzed.

A. Reservoir Characteristics of the Utica Shale

At the time of the release of this report, seven wells had been drilled and completed into the Utica Shale in Ohio, four of which

[24] The crude is estimated to have an API degree rating of 40 to 41 (based in principal part upon viscosity), which is considered to be in the range of the most valuable crude oil. (Interview with Larry Wickstrom).

[25] At depths to the Utica decrease, as will be found in central Ohio (3000 feet or less), there may be an issue as to whether there is sufficient pressure to drive enough oil from the rock for the economics to work for horizontal wells. (Interview with Larry Wickstrom).

[26] Publically available data indicate the TOC values for the Point Pleasant-Utica Shale range as high as 7.28. See: http://www.dnr.state.oh.us/Portals/10/Energy/Utica/Utica_SourceRock_Analysis_Data_12_13_2011.xls. The Ohio Geological Survey is currently working on a study of new TOC data, which will be the subject of a future report. Rex Energy reported a TOC for the Utica of between 2.4 and 3.7% in Carroll County. *See* "Rex Energy to Purchase Utica Shale Leases in Ohio," *Utica Shale*, August 2, 2011, http://shale.typepad.com/utica_shale/porosity/.

have been placed into production. However production data is proprietary at this point, other than announced production figures from initial flow tests – figures that may be unreliable as a tool for predicting the expected ultimate recovery (EUR) from a given well.[27] Nevertheless, some credible estimates can be made as to EUR, and as to decline curves (the rate of production decline in a well) based upon what we know about other shale formations, such as the Marcellus Shale in Pennsylvania and the Eagle Ford Shale in Texas.[28] Moreover, flow tests provide some insight as to the likely initial production expectations, at least insofar as the mix of oil, condensate, natural gas liquids and natural gas, if not the actual likely production volume itself. Those estimates are set forth in Table 1 as follows:

[27] Producing companies are required to report annual production figures to the State of Ohio as part of their compliance requirements for paying severance taxes. The first Utica Shale production numbers are expected to available in March 2012.

[28] The Study Team's analysis of projected production was led by Dr. Robert Chase, chairman of the department of Petroleum Engineering and Geology, at Marietta College, Marietta, Ohio. The analysis included, in addition to the reports about the Marcellus, Eagle Ford and other shale development, interviews with upstream and midstream companies, and with the Ohio Geological Survey.

Table 1. Average Anticipated Annual Production Per Well (after processing)

Year	Liquids (MBBL)	Gas (MMCF)
First Year Production	99	70
Second Year	69	49
Third Year	54	38
Fourth Year	45	33
Expected Ultimate Recovery	833	598

However for severance and ad valorem tax calculations, a determination of volumes of hydrocarbons must be made at the wellhead. For this purpose, the Study Team's experts estimate that the liquid content (i.e. the hydrocarbons produced as in a liquid form in the field) will be roughly 90% of the numbers set forth in Table 1 for liquids. The other 10% will be produced as natural gas and later recovered from that gas stream in processing operations. When natural gas is processed, it typically undergoes 33% shrinkage when the liquids are separated out. Accordingly, for those calculations, the natural gas numbers set forth in Table 1 will be increased by 50% to estimate the volume of gas produced in the field. Those numbers are set forth in Table 2, below. The numbers from Table 2 are used for most of the projections in this Study.

Table 2: Average Anticipated Annual Production Per Well *(at the well head)*

Year	Liquids (MBBL)	Gas (MMCF)
First Year Production	90	105
Second Year	62	74
Third Year	49	57
Fourth Year	41	50
Expected Ultimate Recovery	750	897

B. Anticipated Drilling Activity in the Utica

Drilling in shale formations is typically conducted in a manner more similar to offshore drilling than to traditional onshore drilling. That is, drilling is conducted from a central location, called a "pad", which operates like an offshore platform, and has as many as 6 to 8 slots available from which to drill new wells. Use of the central pad reduces not only the cost of drilling, but also the surface and environmental impact because the number of traditional well sites is reduced significantly. Once a site is selected for the pad, some 3-5 acres of land is cleared for the ancillary equipment required for drilling. A typical well takes about two months to drill, depending upon the vertical depth and horizontal outreach. It is not uncommon for a producer to first drill a vertical "exploratory" well so as to obtain critical reservoir rock and fluid property data necessary for planning and constructing the horizontal wells. Accordingly, one might expect to see as many vertical slots for vertical sections of the wells as for horizontal. In this study six wells are assumed as the average number of wells drilled from a single pad. Under current permitting protocols, one can expect to see for this pad six permits for vertical sections of the wells and six more permits for horizontal sections of the wells, with the vertical permit usually obtained in advance of the horizontal permits. It is commonplace for producers to drill the vertical and horizontal sections of wells separately, thereby requiring two permits for one well.[29]

Another characteristic of shale drilling is that, unlike conventional reservoirs, the shale formations are ubiquitous, and productive in some amount everywhere within the basin. Indeed, the "success rate" for shale drilling has been estimated to be approximately 98%[30] -- a remarkable number for the high risk, high reward oil and gas industry. This also controls drilling strategy, as the wells generally cost about the same amount to drill (estimated to be around $5-6 million per horizontal well, including vertical section of the well and completion costs) and the anticipated recovery can be reasonably well quantified. The price for the sale of the hydrocarbons, however, is not so easily quantified, at least beyond a few years. The recent drop in prices for natural gas provides a reminder of just how risky shale drilling can be, despite the relatively low risk of a mechanical or reservoir failure. Companies that have invested heavily in leases may have to defer drilling until prices improve. It is also why we might reasonably expect that drilling activity will move forward quickly in the Utica, since prices for oil and natural gas liquids remain high.

Two other factors that influence drilling activity are, first, the availability of rigs and, second, the availability of midstream infrastructure to transport and process the natural gas, oil and natural gas liquids. For purposes of this study, drilling rigs are considered to be available to undertake a drilling program similar to those seen for the Marcellus Shale in Pennsylvania and the Eagle Ford Shale in Texas. The lack of infrastructure in Ohio, however, may cause the drilling rates to be slower than what might be normally expected for an oil-rich play. In the Eagle Ford, another oil-rich setting, drilling ramped up more rapidly than it did in the Marcellus. Texas has more pre-existing infrastructure than does Pennsylvania or Ohio, and the lack of infrastructure in Ohio may slow down drilling activity in the Utica Shale. On the other hand, the fact that the Utica is rich in liquids, together with the fact that the companies drilling in the Utica tend be very large, we might reasonably expect a more rapid development of midstream infrastructure and subsequent drilling program in Ohio than that seen for the Marcellus. Moreover, with the recent announcement from the Chesapeake on plans to redirect drilling towards more liquids-rich fields, Ohio might see more drilling rigs moving to the Utica development than was initially anticipated. All things considered, the Study Team estimated the following drilling activity for Ohio in the next several years:

[29] The State of Ohio provides a well numbering system whereby horizontal and vertical sections of the same well will have related permit designations, making it clear where two permits relate to the same well. The State may change its permit numbering system to do away with multiple permitting of the same well.

[30] Kleinhentz and Associate (2011), p. 14 (projecting a 98% "completion rate"). Success, of course, is a relative term. Just because a well is completed does not make it necessarily "successful." A successful discovery of hydrocarbons may not translate to a commercial success when gas prices are depressed, as they have been in early 2012.

Table 3: Projection of Wells Drilled

Year	Number of Wells	Total Wells in Production
2011 (actual)	33	4
2012	160	193
2013	650	843
2014	1,075	1,918

While speculative, these numbers are in keeping with other projections for Ohio.[31] They are also more conservative than those seen at a comparable stage in the development of the Eagle Ford.[32] The time frame contemplated in this study – 2011 to 2014 -- will not likely see the peak of drilling and production activity. If drilling follows the pattern of the Eagle Ford, it is likely to level off at between 1000 and 2000 wells per year after 2014. Accordingly, this study will not likely capture the full economic development opportunity for Ohio, which is anticipated to happen some time after 2014.[33] As additional data become available, new iterations of the model can be undertaken, and the study can be updated. A better understanding of the economic impact will be available when better data are available, and new models are generated.

Additionally, one cannot simply divide the number of wells by six to estimate the number of pads anticipated and the amount of site preparation work or the miles of gathering lines built. Because producers need to hold acreage to satisfy lease terms, they may drill only one well (or even just a vertical section of a well) on a pad initially to identify production sufficient to hold the unit rather than drill all six wells consecutively from the pad. They will then return later to drill all the other wells. Moreover, producers do not always assemble the acreage necessary to drill six wells from a pad. Accordingly, drilling units will likely be smaller - in the range of 640 to 800 acres rather than the preferred size of 1280 acres. As a result, we are likely to see fewer wells per pad during early stages of development.

Finally, projecting wells drilled is not the same as projecting wells producing. Aside from the projected 2% failure rate (which is regarded as minimal in this Study), there is a delay between drilling and production. This is a result not only of the time required to complete a well after drilling, but also the time it takes to build post-production infrastructure. Accordingly, while some 33 wells were drilled in 2011, only seven wells were completed, and only four were placed into production. For the purposes of this Study, actual wells in production were used for the first year in calculating volume of production; actual wells completed were used for the expenditures on completions; and actual wells drilled were assumed for the expenditures on site preparation and drilling. Thereafter, it is assumed that all wells were in production for the entire year. This inevitably leads to a modest overestimation in production numbers for 2012-2014, since the delay is unaccounted for.

[31] Kleinhentz and Associates (2011), for instance, projected 27 drilling wells for 2011 and ended with drilling 1,644 wells for 2015, p. 16.

[32] The Eagle Ford saw the following drilling numbers during the first three years of development: 107, 230, and 918. Center for Community and Business Research (2011), *Economic Impact of the Eagle Ford Shale*. University of Texas at San Antonio Institute of Economic development.

[33] Larry Wickstrom estimates the "take off" date to be in the 2014 to 2015 time period, by which time the midstream infrastructure should be well in place.

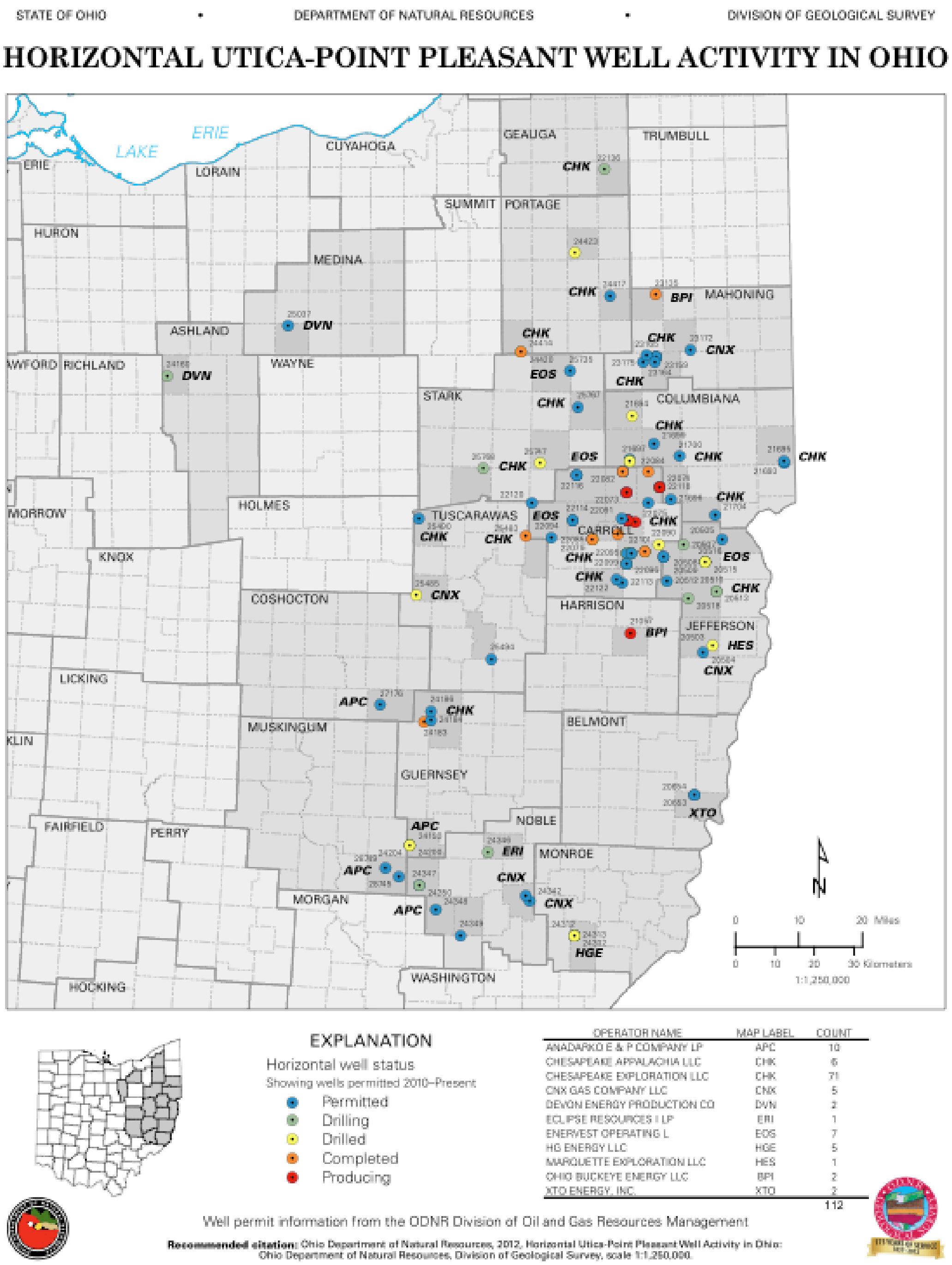


Figure 3. Permitting activity for the Utica Formation in Ohio (Courtesy of the Ohio Department of Natural Resources, Division of Geology).

C. Anticipated Throughput

The throughput volume is determined by multiplying the number of wells drilled in a given year by average production for the year. For instance, if there are ten wells drilled in year one and twenty in year two, the throughput for year two is:

(10)(average second year production) + (20)(average first year production)

Throughput is normally expressed as a "per day" volume, and is arrived at by dividing the total production for the year by 365. So to arrive at the estimated second year average daily throughput, you would divide the result of the above calculation by 365. Throughput is important for not only determining royalties and taxes, but also for determining the likely midstream infrastructure build up.

Using the average production scenarios from Table 2 at the well head and the average drilling scenarios from Table 3 set forth above, the Study Team was able to project a likely throughput. The throughput is useful for projecting severance taxes, since it reflects production at the well. However using it to project midstream investment this early in the development of a reservoir requires some difficult estimations, since the sorts of investments that will be made will vary depending upon the nature of the production in addition to the volumes produced.[34] For purposes of simplicity, and because so little is known about what to expect in the way of post-production infrastructure to deal with liquids in the field, the Study Team has considered liquids as if they were produced principally in the form of natural gas to estimate a likely build out of a midstream infrastructure.[35] Accordingly, even though by the year 2014, the natural gas portion of throughput is projected in this study to be only about half a billion cubic feet per day (Bcf/day), for purposes of estimating midstream infrastructure build out, the Study Team assumed a throughput in 2014 of 1.5 Bcf/day. This number was chosen to account for the expectation that throughput will not likely peak until several years after 2014, and that some build out will occur in anticipation of later peak production. The higher number is also conservative because liquid infrastructure is not included in this study. More information acquired from drilling and production reports will enable better modeling in the future.

V. Methodological Strategies and Literature Review

With the fossil fuels sector expanding in various parts of the United States thanks to shale development, a number of studies have been undertaken to estimate the resulting effects on employment and economic output. Input-output (I-O) models have been used in most of these studies.[36]

These models are designed to describe linkages along the supply chain for industries being studied in an economy – an economy that is defined in geographic

[34] Kleinhentz assumed that only natural gas would be produced from the Utica, but accounted for the additional value of the liquids contained in the gas stream by multiplying the value of the production by a factor of 1.2 (Kleinhentz and Associate, 2011, p. 19).

[35] Part of the problem with estimating the required liquids infrastructure is that, absent a pipeline, the liquids can be trucked. It is difficult to determine when, if ever, there will be sufficient liquid production in the field to justify the building of a pipeline. However Ohio's trucking industry and its construction industry, at least for storage facilities, if not for pipelines, will be impacted by production from shale formations. The Study Team has not attempted to separately estimate those impacts.

[36] Higginbotham, et al. (2010); Peach, et al. (2009); The Pennsylvania Economy League of Southwestern Pennsylvania, LLC (2008); Snead (2002), etc.

terms, such as a city, a state, or perhaps an entire nation. These linkages comprise the basis for estimating:

direct effects (or impacts), which relate to the economic activity created as an industry being studied buys goods and services from other sectors;

indirect effects, which are registered as the firms that provide goods and services to that same industry make their own purchases; and

induced effects, which result as the industry's employees spend some or all of their wages.

As they analyze each of these impacts, I-O researchers must deal with two basic and interrelated issues. One issue has to do with transfers, which can be inter-sectoral or inter-regional. The other relates to the "leakage" of impacts, to places outside of a particular municipality or state.

Transfers refer to expenditures that are not true economic impacts yet frequently positively accounted for in studies concerned with a specific economic locale. There are three possible cases to be considered given an increase in drilling activity in Ohio. The first occurs when drilling attracts workers from outside of the state who mostly reside out of state (as frequently happens with drilling crews). In this case Ohio will lose some of the direct economic benefits and will gain only a portion of the induced spending that takes place in the state. This relates to economic leakages that are discussed in the following paragraph. The second occurs when workers transfer into the industry from other industries within the state. If so, employment will have shifted from one industry to another, increasing labor costs for existing employers as new workers are attracted into Ohio's workforce, and muting the positive employment impacts from the drilling. This is sometimes called a substitution effect. Input-output models cannot account for substitution effects and possible supply constraints in the labor force due to the way these models are constructed. The third occurs when drilling activity shifts from one state into another. From a national perspective there is no net increase in economic activity, just a shift form one place to another, from the perspective of the receiving state there are measurable benefits.

Leakage can be understood with reference to those same workers. Particularly if they have close relatives in their places of origin, they are apt to send large shares of their earnings back home. This means that those earnings do not circulate in the local economy. Rather than creating induced economic effects in the immediate region, they comprise leakage, and so tend to be ignored in an I-O study with a local focus.

Leakage diminishes an industry's regional multipliers. This is true of the output multiplier, which indicates additions to output throughout the local economy that result from a one-dollar increase in the industry's output. It is also true of the employment multiplier, which represents the gains in employment throughout the local economy resulting from the same one-dollar increase in the industry's output.

In one of the more widely cited studies of shale development, which was sponsored by the Marcellus Shale Coalition (MSC) in Pennsylvania,[37] leakage was determined on the basis of detailed examination of itemized expenditures made by seven shale gas producers. Although 36 producers were active in the commonwealth at the time of the study, the seven that provided data accounted for 59 percent of all wells drilled in the Marcellus formation. As underscored

[37] Considine, et al. (2009), *An Emerging Giant: Prospects and Economic Impacts of Developing the Marcellus Shale Natural Gas Play,* *http://alleghenyconference.org/PDFs/PELMisc/PSUStudyMarcellusShale072409.PDF*.

in a published review of the MSC study, expenditures data (complete with names and addresses of suppliers) comprise proprietary information, of the sort rarely acquired by researchers who lack a direct connection to the industry.[38]

The authors of the MSC study apparently counted a payment as leaked only if it went to an address outside Pennsylvania. However, some out-of-state companies had set up local offices to coordinate the activities of non-Pennsylvanian employees temporarily assigned to rigs and other facilities in the commonwealth. If a large portion of the wages and salaries earned by these employees was being dispatched quickly from Pennsylvania, rather than being spent there, leakage probably was under-estimated, thereby leading to an exaggeration of the economic impacts in the commonwealth.

During the early years of Pennsylvania's shale gas industry, bonuses received by households that sold subsurface mineral rights were the source of a large share of total economic impacts. These bonuses, like windfall earnings, are comparable to an increase in household wealth resulting from a rise in the stock market. And as a rule, households benefiting either from the former windfall or the latter capital gains do not greatly alter their consumption decisions. This is the reason why it was assumed (perhaps conservatively) that just 5 percent of bonus income would be spent in-state in an economic analysis of shale gas extraction in Louisiana.[39] The authors of the MSC study assumed that a much larger share of this sort of income would be spent immediately and within Pennsylvania – an assumption that affected estimates of economic impacts.[40]

Different conclusions about local spending of bonus payments have been reached in other analyses of Marcellus Shale development in Pennsylvania. In one study, data on the ownership of surface land-rights were collected, which revealed that the state government possesses nearly one-sixth of total acreage and that people from outside the commonwealth hold another 7.5 percent. The disbursement of public monies differs substantially from the consumption patterns of households. In addition, all but a fraction of the bonuses and royalties paid to the owners of sub-surface rights who do not reside in Pennsylvania is spent outside the commonwealth. Pointing out that many of these rights were severed from surface rights years or even decades ago, the investigators posited that ownership of sub-surface rights is at least double the share for surface ownership, which implies that 15 percent or more of bonuses and royalties constitute leakage.[41]

Due to bonus and royalty payments from oil and gas producers, household incomes have gone up substantially in some parts of Ohio. However, doubts have been expressed about the number of jobs likely to result from shale development. On the basis of a statistical analysis using data from a mix of counties in Pennsylvania, some with elevated levels of gas drilling and others with little such activity, one pair of investigators concluded that employment will grow modestly in Ohio as a result of the development of the Utica.[42]

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[38] Kinnaman (2011), *The Economic Impact of Shale Gas Extraction: A Review of Existing Studies*.

[39] Scott (2009), *The Economic Impact of the Haynesville Shale on the Louisiana Economy in 2008.* http://dnr.louisiana.gov/assets/docs/mineral/haynesvilleshale/loren-scott-impact2008.pdf.

[40] Kinnamann (2011).

[41] Kelsey, et al. (2011), *Economic Impacts of Marcellus Shale in Pennsylvania: Employment and Income in 2009*, http://www.msetc.org/docs/EconomicImpactFINALAugust28.pdf.

[42] Weinstein and Partridge (2011), *The Economic Value of Shale Natural Gas in Ohio*. pp. 15-16.

Other investigators offer different estimates. In a study commissioned by the Ohio Oil and Gas Energy Education Program (OOGEEP) and completed in 2011, Kleinhenz and Associates estimated that 204,000 jobs could be "created or supported" by 2015 due to leasing, drilling, and related activity in the Utica play.[43] This finding is based on expenditure patterns, forecasts of drilling and production levels, and other information provided by OOGEEP members when development of the Utica was still at an early stage.

The study by Kleinhenz and Associates addresses other consequences of shale energy development aside from expanded employment. For example, they estimated that annual savings resulting from the substitution of locally-produced gas for fuel purchased from non-Ohio sources would amount to $718 million – not counting $30 million per annum that would no longer go to interstate pipeline fees.[44] Additionally, Ohio consumers would benefit because the increased availability of local natural gas would reduce storage costs (incurred during summer months, when heating-related demand ebbs) while also helping to insulate gas-buyers from price fluctuations. Each of these benefits is related to hydrocarbon extraction from the Utica formation, which could well exceed the levels currently anticipated.

In must be kept in mind that the majority of I-O studies estimate only a part of the total economic impact, mainly omitting effects that are hard to measure with traditional data sources or those that require broader investigation employing such costly methods of data gathering as interviews, surveys, and in-depth investigation of industry data.

Many studies use conservative estimates and assumptions to calculate economic impacts if data are insufficient. For example Higginbotham et al. (2010) cite insufficient data as the reason for omitting bonus and royalty payments to landowners, pipelines, processing, and severance taxes from their study, even while they acknowledged that the economic impact of these would likely be substantial. Even when data are available, there is no single study that can account for all the economic effects from shale development, be they positive or negative.

Most studies of the burgeoning natural gas industry employ a survey of producing companies and industry experts, requesting information on spending data for several categories, including exploration, drilling, pipelines and processing plant construction, and lease and royalty payments. The majority of these studies[45] use "input-output" based modeling to analyze the economic impacts of the industry's activities on the given region.

In a few cases the data needed for I-O modeling were obtained or estimated without engagement of industry, using tax records of companies and surveys of citizens.[46] Some studies[47] employ a methodology of quasi-experimental design, comparing regions with the oil and gas shale development to oil and gas regions that did not have any shale development, using the latter regions as the control group.[48]

[43] Kleinhenz and Associates (2011).

[44] Kleinhenz and Associates (2011).

[45] Considine, et al. (2011); Scott, et al. (2010); Higginbotham, et al. (2010); Peach, et al. (2009); The Pennsylvania Economy League of Southwestern Pennsylvania, LLC (2008), McDonald (2007); Snead (2002); etc.

[46] Considine, et al. (2011); Kelsey, et al. (2011); Kleinhenz and Associates (2011); Peach, et al. (2009); Peach, et al. (2009); The Pennsylvania Economy League of Southwestern Pennsylvania, LLC (2008); McDonald, et al. (2007); etc.

[47] The Perryman Group (2011); Downen, et al. (2009).

[48] Marcellus Shale Education & Training Center (MSETC) (2011), *Economic Impact of Marcellus Shale in Pennsylvania: Employment and Income in 2009,*

The industry sectors examined in these input-output based studies were, unsurprisingly, similar between most studies. Reports either listed North American Industrial Classification Sectors (NAICS) categorizing industry expenditures, or utilized industry sectors included in the IMPLAN system. Industries commonly listed in the economic impact studies include: oil and gas extraction, drilling oil and gas wells, support activities for oil and gas operations, and oil and gas pipeline and related structures construction. Additional categories included natural gas distribution, oil and gas field machinery and equipment manufacturing, and pipeline transportation of natural gas. Most reports are focused on the broader regional or statewide economic effects, concentrating on the number of jobs supported by new investments and additional outputs and/or value added created in the respective regions. Many studies deliberated on the effects of lease and royalty payments received in the region and additional taxes paid by businesses and land owners.

Estimating oil and gas development expenditures for use in economic impact modeling is a complicated process. Many reports adopted different assumptions on the array of expenditures made by oil and gas developments across these industries. For example, estimates generated by industry surveys for expenditures on lease bonuses varied widely. West Virginia producers indicated an average of 139 acres leased per well, at a price of $914 per acre. Landowner websites for that state have reported that lease bonuses range between $300 and $2,500 per acre, depending on the region. Pennsylvania estimates have assumed wells required approximately 640 acres at a price of $2,500 per acre. Landowners in Pennsylvania report receiving up to $5,750 per acre, with the price increasing substantially between 2006 and 2009.[49]

Several lessons can be learned from this example. The data differ by the regions and these differences are influenced by the land market in different regions and states, specific geological conditions of the particular deposits, existing state and jurisdictional normative requirements, and the economic costs of the unit development on a particular field and even particular well. For this example, the fundamental knowledge of economic impact methodology based on input-output modeling requires answering a question from three major perspectives: (1) how much money was paid and how much of this was spent in the region of study, (2) what was the spending pattern for the population group that received this extra income, and (3) how did the spending pattern change across multiple years for which the money was received and for which economic impact was calculated. To model the impact correctly, the researcher will need to know the average income of the population that received this additional income, and to then rely on the model to calculate the average spending pattern of that population group for that specific region.

Previous studies provide two sorts of guidance for this study. First, previous research points to assumptions and methodological issues that ought to be considered. Second, the prior studies

www.msetc.org; and Weinstein and Partridge (2011), http://aede.osu.edu.

[49] Payments peaked in 2009 at $2.17 billion but have dropped off sharply since then, estimated to amount to less than $500 million in 2012. These payments do not go exclusively to private individuals. The State of Pennsylvania owns and leases mineral rights to the natural gas industry as well. The State collected $4.3 million in lease payments in 2007, and that number increased to over $190 million in 2008. In addition, corporations own mineral rights, and are also less likely to redistribute dollars earned from leases and bonuses into the local economy.

identify solutions for problems that can be replicated, and identify pitfalls that can be and have been avoided in this study. This study represents the response to the research question based on the professional experience of the Study Team, but much of the insight developed for the models came from a review of previous studies.

The distinctive feature of this study is timing. The incipient state of development for shale in Ohio controls the nature of the data collected, and presents problems not encountered in the other studies. Many of the assumptions in this study are based on data and guidance provided by the representatives of various state and local government agencies, oil and gas producing companies, midstream companies, and companies that represent service industries for the upstream and midstream businesses. Some of these assumptions are based on experts' experience acquired from conducting similar business in other states and with other industries. All the data collected for this study, however, contain some degree of speculation.

VI. The Economic Impact of Shale Formation Development in Ohio

A. The Research Question and Approach Taken

The Study Team was asked to estimate the near-term economic impact of the Utica Shale development in Ohio through 2014. Actual permit data was used to document activities in 2011. Activities for 2012 through 2014 were projected based on interview data and development patterns observed in similar shale fields in the United States.

Estimating the value of output and the number of jobs that are created and supported by this new and growing industry is inherently uncertain. First, shale oil and gas development is new to the state of Ohio. It is much easier to extrapolate impacts from an established industry or set of economic activities than for one that is being created from nearly whole cloth. Second, much remains unknown about the geology involved and the way in which markets for the products will develop. Therefore a conservative approach is taken herein to measuring the likely impacts. The Study Team has developed an impact model that is designed for updating over regular intervals as new and more precise information becomes available. Better data about the nature of oil and gas production, production decline curves, and the spending patterns of the upstream, midstream, and downstream portions of the oil and gas industry will also improve estimates of the amount of projected output and of the number of jobs directly created or supported by the prospective expansion of the oil and gas industry in Ohio.

Information about the Utica Shale formation in Eastern Ohio is developing rapidly, yet we are in the early stages of knowledge about the scope of the potential development of this energy field. Additionally, much of the information about the industry remains proprietary and will be revealed in part over the next year. The Study Team is taking what may be considered to be a Bayesian approach to modeling the likely economic impacts.[50] A Bayesian strategy uses the impact model as a decision support tool rather than as a definitive point estimate. The estimates produced by the model reflect the best data

[50] A nontechnical history of Bayes' Theorem and its role as a critical foundation of decision theory can be found in McGrayne (2011), *The Theory that Would Not Die.* While the model used herein is not a direct application of the mathematics of Bayes' Theorem it is applied in the spirit of the theorem and of decision theory.

available, mixing in a set of plausible assumptions about the pace of development and the amount of liquids, gas, and oil the wells may produce, as well as the of the prices the products will earn and the value mineral leases will acquire. At the risk of making the Study burdensome to read, the Study Team has been as transparent and explicit about the assumptions made as possible, realizing that the estimated impacts will become more accurate over time as information improves. In short, as more publicly available data on the production of oil and gas and the nature of the geology becomes available, the estimates will improve.

There is information that is known; information that is not known presently, but will be revealed in the near future; information we know that we do not know; and information that will become known but is not expected. A good decision-support tool is one that is flexible enough to incorporate all four types of information. Because of the great amount of uncertainty about the scope and quality of the shale field the Study Team elected to be very conservative in making its estimates of the economic impacts that will derive from the development of the energy resources that are trapped in Ohio's shale formations but are providing a model that can be regularly updated.

B. Gathering the Information: Business Factors Leading to the Production and Spending Assumptions

Collecting information and creating assumptions for this study occurred in several stages. The Study Team relied upon the expert opinions of specialists in the field because drilling and production data were not available for Ohio's Utica formation.[51] This included multiple interviews of government officials, university professors, service and midstream company executives, producing company executives, trade association executives, and a review of the work of economists who have conducted studies on oil and gas development in other states.[52] When hard data were available it was incorporated into the model.

As the likely pace and scope of the economic development from Utica Shale became evident, four important considerations were instructive for developing the model:

(1) The type of product expected from Utica Shale will be very different from that obtained from the Marcellus Shale;

(2) Operations in Ohio will be undertaken by major oil and gas production companies for the next several years[53];

[51] The best approach to collecting data is to survey oil and gas producing companies for actual data regarding future investment plans. This was unsuccessful, as producers were reluctant to share investment plans at this stage of the field's development. Even event the release of aggregated data can create a competitive disadvantage for companies that disclose. The current and recent leasing activity in Ohio is such that vast sums of money are being invested into leaseholds and subleases on property already held by producers. However during this period of high stakes, active deal making by and between producing companies, information is hard to come by, and confidentiality is a business requirement. This is in stark contrast to the data available for the studies on the economic impact for Pennsylvania's Marcellus shale. The study group for the Marcellus Shale impact had access to years of drilling and production data (collected mainly through surveys), much of which was, if not in the public domain, at least well known within the oil and gas industry. The first Marcellus well in Pennsylvania that employed advanced drilling techniques was completed in 2004 and the first economic impact study based on industry data was published in 2009 (Considine, 2009). By comparison, the first well on Ohio's Utica shale was drilled in 2010, and already in 2011, the first industry-data-based study was published a year later (Kleinhentz and Associate, 2011).

[52] Due to the highly sensitive nature of much of the subject matter covered in the interviews direct attribution has not been made.

[53] The size of the investment and the expertise required to lease land, drill and complete wells and to

(3) The proximity of a skilled workforce from the Marcellus Shale development in Pennsylvania and in West Virginia will affect job development in Ohio; and

(4) The current post-production infrastructure in Ohio is insufficient to handle the anticipated hydrocarbon throughput likely to be generated from the Utica Shale development.

Most experts agree that the nature of the Utica Shale production will speed up the development process in Ohio. With depressed natural gas prices (caused in principal part by the influx of shale gas from the Marcellus), producing companies find that natural gas streams that contain liquids in suspension are considerably more profitable to produce.[54] Production from the Utica Shale is expected to be rich in valuable natural gas liquids, condensate and oil. Higher potential profits will stimulate companies to invest resources in the Utica Shale development at pace exceeding the early history of the Marcellus. The higher liquid content of the Eagle Ford Shale in Texas generated exactly that sort of rapid development.[55] Indeed, the largest player in the shale development industry, Chesapeake Energy Company, has already announced that it is redirecting its drilling activities away from the "dry gas" arena towards those shale formations that contain large volumes of natural gas liquids.[56]

Another factor that supports rapid Utica development is the presence of large, deep-pocketed operating companies. Unlike in Pennsylvania, where early Marcellus Shale drilling was primarily done by smaller-scale players, well permitting in Ohio has been largely undertaken by such industry giants as Chesapeake Exploration, LLC, Devon Energy Production Company, and Anadarko Exploration and Production Company, (Figure 3). Chesapeake, the nation's second largest producer of natural gas, has announced that it has acquired mineral leases for some 1.5 million acres of land in eastern Ohio.[57] Chesapeake's holdings are by far the largest leasehold in Ohio. Moreover, companies like Chesapeake and Devon have been actively bringing in joint venture partners with cash reserves to form well-financed consortiums to develop the Utica Shale.[58]

develop post production infrastructure for Utica operations is such that the traditional smaller oil and gas operating companies in Ohio have not been active in drilling wells in the shale. Many such companies have, however, retained an interest in the operations through the subleasing of deep rights on existing leases. Those companies are likely to eventually gain the capability of drilling and operating Utica wells in Ohio.

[54] See Section II herein for a more detailed explanation of the nature of Utica production.

[55] *See* footnote 34 herein for the early drilling rates for the Eagle Ford.

[56] "Chesapeake to shift focus from natural gas to oil, liquid drilling," *Columbus Business First*, January 23, 2012, http://www.bizjournals.com/columbus/news/2012/01/23/chesapeake-to-increase-liquid-gas.html.

[57] "Chesapeake Analysts Wary of High Debt, Falling Prices for Natural Gas," *Business Journal Daily*, January 16, 2012.

[58] For example, Chesapeake sold a working interest in its Ohio operations to Total for $2.03 billion (*Bloomberg*, January 4, 2012, http://www.bloomberg.com/news/2012-01-03/energy-giants-undeterred-by-quakes-seek-shale-stakes-in-runway-to-growth-.html). Devon formed a similar relationship with the Chinese energy company Sinopec International Petroleum Exploration & Production Corporation (SIPC) (*Marcellus Drilling News*, January 3, 2012, http://marcellusdrilling.com/2012/01/china-makes-2-2b-investment-in-u-s-shale-including-utica/), and CONSOL Energy formed a joint venture with Hess Corporation to drilling in the western portion of Tuscarawas County, Ohio.

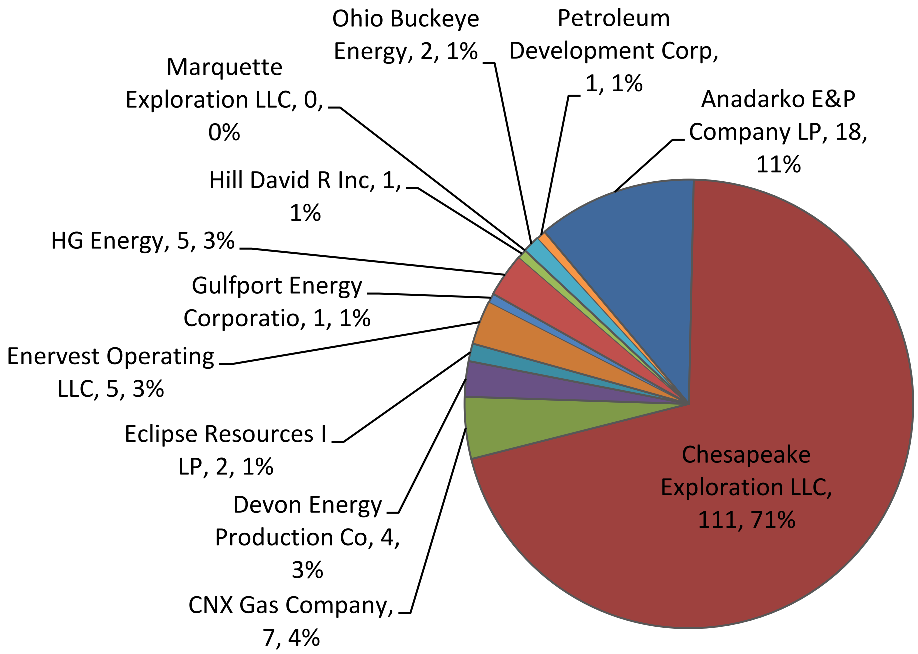

Figure 4: Wells Permitted by Company, Utica Shale, OH, 2011

The proximity of the Utica development to Pennsylvania's Marcellus Shale fields has elicited two lines of thought about the likely effects on the Ohio labor market. On one hand, pre-existing infrastructure, expertise and corporate offices in and around southwest Pennsylvania will likely accelerate the pace of drilling and production in Ohio. On the other hand, this same proximity may also inhibit early growth in jobs and tax revenue because there is less need for companies to establish a logistical presence in Ohio. A service company might, for instance, open a business office in Ohio, while keeping its regional hub for operations in Pennsylvania or West Virginia. Both neighboring states have a large trained labor force ready and able to respond to the needs of oil and gas production in Ohio – a workforce that will be mobile and perhaps faced with a dramatic decrease of activity in the Marcellus with the recent drop in dry gas prices. So while this work force may help to accelerate Utica development, it may also act to slow down engagement of local supply companies and workers, creating leakages of investments into the neighboring state economies.

The last business factor that influenced the economic modeling is the absence of sufficient post-production pipeline infrastructure to accommodate prospective Utica development. Growth of drilling and producing in the Utica Shale may be constrained by the lack of enough gathering lines to take away dry gas and a lack of processing plants to recover the liquid product. In places where natural gas contains large volumes of natural gas liquids in suspension, producers will build short gathering lines in the field to transport the hydrocarbons to a bigger line owned by a "midstream" company – that is, a company that provides hydrocarbon gathering and processing services. The midstream company picks up the hydrocarbons near the field in tributary lines that feed a trunk line, the gas is then compressed and delivered to a processing plant. Both producing companies and midstream companies are involved in constructing and maintaining gathering lines, while a midstream company typically owns the trunk lines and processing plant.[59]

The costs of building post-production infrastructure are considerable. Midstream companies, as a result, like to have a sure customer before they build those facilities. As a consequence, midstream and producing companies are caught in a "chicken and egg" investment game, each trying to get the other to commit resources first to reduce the risk of over-committing.[60] Producers who want infrastructure developed rapidly will share drilling and production projections with midstream companies under a nondisclosure agreement to encourage them to build the necessary infrastructure. Even so, under the best of circumstances completion of infrastructure typically lags production by six months, and under less favorable circumstances by two years.

The general lack of post-production infrastructure in Ohio becomes more problematic the farther west one travels from Marcellus country. Geologists expect that the higher oil and liquid content production will be to the western side of the Utica play (that is, in central Ohio).[61] Therefore, the parts of the state with the weakest field infrastructure are likely to be drilled first. Some experts believe these post-production infrastructure complications might be a factor that causes the Utica's development in Ohio to fall short of what has been seen in the Eagle Ford in Texas where existing infrastructure was in place. Nevertheless, that same remote early development may also lead to more Ohio residents being employed, because the existing workforce in Pennsylvania and West Virginia do not live within easy commuting distance of the places in Ohio where field development is most likely to begin.

C. Economic Impact Modeling Methodology

Version 3.0 of the IMPLAN input-output software was used to model the economic impact of developing Ohio's Utica Shale deposits. The model estimates the economic impact of shale energy development from 2011 to 2014. These are based on observed development activity in 2011 and projected activity from 2012 to 2014.

The input-output model measures how the economy will respond to the expansion of a specific industry. For example, growing demand for hydrocarbons may cause producing companies to increase activity, and in the process invest in drilling and creating midstream infrastructure and hire

[59] Fully integrated oil and gas companies, such as Shell Oil Company, Exxon-Mobil, and Chevron, Inc. may own gathering lines and processing facilities, and will also provide services to other producers for a fee. At the time this report is being written none of the major integrated oil and gas companies have permitted wells in Ohio, or have publicly disclosed plans to do so. Some have, however discussed introducing new downstream industries in Ohio, such as a proposed Ethylene plant Shell Oil has been considering ("Shell Oil Cracker Plant Eyed by Ohio for Utica Shale Field," *Columbus Business First*, September 30, 2001, http://www.bizjournals.com/columbus/print-edition/2011/09/30/shell-oil-cracker-plant-eyed-by-ohio.html?page=all).

[60] Some midstream industries are willing to build an infrastructure on "speculation," meaning that the company takes the risk that it may not get enough contracts to transport or process hydrocarbons to recoup its investments. This of course is the preferred strategy of the producers, because this encourages a more rapid development of post-production infrastructure, and a more favorable environment in which to commit resources to drilling. Midstream companies that do this enjoy a considerable "first mover" advantage, so they are willing to consider taking on this risk.

[61] *See* Section IV herein for a general discussion of anticipated geology of the Utica.

more people. The first round of industry expansion is a *direct effect* from the investment. The producing companies may also contract out to suppliers, such as drilling and service companies, and those suppliers may in turn contract to others for parts and services, such as sand, pipe, cement and energy. This can be thought of as purchases made in the supply chain that are an *indirect* result of the demand to drill the well. There is a third round of spending that must also be captured. This is the spending that comes from existing and new employees of producing companies and their suppliers. This is consumer spending that is *induced* by the spending of the employees and all who serve them, from hotels and restaurants to barbers and grocery stores.

The ratio of the total effect, that is the sum of direct, indirect and induced spending, to the change in demand is called a "regional multiplier," and is defined by IMPLAN as "Total production requirements within the Study Area for every unit of production sold to Final Demand." Conceptually, the multiplier can be expressed as:

(Direct Effect + Indirect Effect + Induced Effect)/Direct Effect.[62]

There are limits to any model and impact modeling is no exception. One major assumption that is part of the arithmetic of an input-output model is that the model cannot account for scale economies. Think of an input-output model as a Betty Crocker recipe. If you want to bake 100 cakes, according to the cookbook you take the ingredient list and multiply by 100. There is no room for substituting one ingredient for another and there are no savings in ingredients as the baking operation gets bigger—you cannot even use bigger pans. The same holds true for drilling wells. The model assumes that the ingredient list for one well is strictly proportional to the ingredient list for 100 wells.

Difficulties caused by the inability of input-output models to handle scale economies are less important for capital-intensive industries, such as the oil and gas industry, because of the fixed nature of the investment. This is especially true with drilling sites where five-acre drilling pads are replicated and spread out over a large area and the cost of gathering lines and trunk lines are estimated by their lengths.

The economic impact of developing Ohio's shale oil and gas resources is measured in terms of the effect of direct, indirect, and induced spending on five variables: output, value added, employment, labor income, and taxes. They are defined as follows:

Output: Additional value of goods and services produced in the region as a result of the expenditures by oil and gas producers and midstream companies involved in Utica Shale development.

Value-added: Additional output created in the region as a result of the expenditures of oil and gas producers and midstream companies *less the value of intermediary goods*.[63]

[62] There is significantly more complexity to the multiplier effect and the regional purchase coefficients, depending on four measures of economic impact: output, value added, labor income, and employment. For example, an output multiplier of 1.5 indicates that for every million dollars of new output placed into the economy, an additional $500,000 worth of activity in the region of study has taken place as a result. Input-output models have inherent limitations. Similar to REMI, IMPLAN assumes a uniform national production technology and uses the regional purchase coefficient approach to regionalize the model's technical coefficients.

[63] Intermediary goods and services—such as energy, materials, and purchased services—are purchased for the production of other goods and services rather than for final consumption.

Employment: The number of additional jobs created in the region as a result of the expenditures of oil and gas producers and midstream companies.

Labor income: Additional household earnings created in the region due to the expenditures of oil and gas producers and midstream companies.

Tax impact: Additional federal, state, and local tax revenues collected in the region as a result of the expenditures of oil and gas producers and midstream companies.

D. Data Assumptions Made

Four non-overlapping, or mutually exclusive, categories of spending related to Utica Shale oil and gas development were defined:

- Payments of bonuses, royalties and right-of-ways to landowners;
- Pre-drilling road construction;
- Drilling and completion of wells; and
- Post-production infrastructure.

This four-part format for categorizing expenditures relates to a standard oil and gas accounting device called an "authority for expenditure," or AFE. AFEs are issued by producing companies for various activities, but most importantly, for estimating the total cost of drilling and completing a well, which is the most expensive part of developing an oil and gas field. An industry AFE for drilling and completing a horizontal Utica well in Ohio in 2011 was acquired, providing not only a cost estimate but also an inventory of materials and services required to support the AFE. This inventory allows for more precise estimates of the employment levels associated with a well-drilling operation in the Utica formation. The AFE does not capture all of the pre-drilling or post-production costs, nor did it capture lease bonus and royalty costs.[64] Accordingly, those costs have been modeled separately to complete the four general sources of spending.

In addition to the AFE, estimates for the other categories came from over 25 interviews with representatives of the producing companies, midstream industry, service industries, as well as specialists from the Ohio Department of Natural Resources, Ohio Department of Taxation, and JobsOhio.[65] The Study Team also consulted published economic impact studies that relate to the development of resulting from other domestic shale formations to obtain relevant data.

Five categories of development activity were modeled using the projected spending:

(1) Drilling and completing wells;

(2) Building and maintaining midstream infrastructure;

(3) Road construction and maintenance;

(4) Income from bonuses, royalty and right-of-way payments; and

(5) Taxes paid to the state and local governments.

Drilling and completing wells

The estimates for drilling and completion of wells were developed on a per-well basis, as was the operational costs of maintaining the well after drilling. Estimation of road and bridge improvements was determined on a "per pad" basis. The estimates for the midstream infrastructure and right-of-way

[64] Producing companies also prepare AFEs for certain post-production activities, but none were made available. Instead, interviews provided the information on expenditures of the midstream and post-production activities.

[65] Due to confidentiality requirements, the names of the companies interviewed cannot be divulged.

payments were based upon a combination of estimates for the number of pads (or drilling sites) and for the amount of hydrocarbon throughput expected by 2014 (the last study year). A calculation of lease bonuses and royalties was based on results from other studies, together with the recent history of leasing in the state of Ohio. A projection of tax revenues for state and local governments was based on the results from the economic impact calculations imbedded in IMPLAN, together with direct calculations on taxes specific to oil and gas, such as ad valorem and severance taxes.

The estimated average cost of drilling and completing a single horizontal well is $5.75 million. The AFE provided detailed expenditures itemized for tangible, or capital, costs and intangible, or disposable costs involved in drilling and completing the well. Disposable costs associated with drilling a well include renting a drilling rig, purchasing drill bits, and the cost associated with processing and disposal of liquid and solid waste. They also include costs of preparing the drilling site and payments for legal, environmental, and engineering services associated with a specific well.[66] The biggest expenditures included cost of fracturing, water disposal, well testing, installation of a "Christmas tree," and post-production site cleaning. Both phases of drilling and completion include significant costs for renting rigs and cementing services. The largest item of capital or tangible costs associated with drilling and completing a Utica well is the cost of steel well casing.

Many itemized expenditures in the AFE describe the services purchased from oil field service companies. Interviews with both producers and industry experts assessed the likelihood that Ohio-based companies would perform these services. Only those purchases made from Ohio-based servicing companies were included in the economic impact model. Services likely to be outsourced to non-Ohio companies were treated in the modeling as leakages, or imports, and their associated expenditures were excluded from the model. This was true even if the out-of-state servicing company is expected to establish a sales and servicing office in the state. Daily expenditures of workers from non-Ohio companies for time spent in Ohio to conduct services for drilling and completion of wells were also not included because most of that labor will be from out of state and their pay and most of their personal expenditures will remain out of state.

For each type of expenditure related to drilling and completion an estimate was made of the share of expenditures likely to be made in Ohio. It was assumed that as more specialized labor becomes trained and available in Ohio, there would be a gradual increase in the percentage of Ohio-based workers employed by the oil and gas producers and service companies. Four general categories of services were established, based on the percent of the expenditures expected in Ohio:

(1) Greater than ninety percent of purchases made from Ohio-based service providers (environmental and land services, road construction and site preparation);

(2) Roughly fifty percent of the purchases will be made from Ohio-based services (control of solids and cementing);

[66] Detailed components of each phase of drilling for a single well is listed in Hefley et al. (2011). AFEs are not entirely uniform. Some phases of the AFE used in this Study differ slightly from those contained in the Hefley report. For example, currently Ohio regulations do not allow for the construction of ponds for holding waste-water at the drilling site, so that activity would not be included on an Ohio Utica AFE. The reliance on only one industry AFE for this Study creates additional risk that certain costs may be overlooked or may prove inaccurate. However the Study Team's experts determined that the AFE used is a good estimate.

(3) Roughly twenty-five percent of the purchases will be made from Ohio-based sources (drilling mud, and supervision and consulting);

(4) Less than ten percent of the services will from Ohio-based sources (coring, perforating, renting of rigs).

It is expected that purchases from Ohio-based companies will increase over time as labor is trained and enters the work force. These projections vary, increasing from 25% to 75% depending on complexity of training labor for specialized drilling and well completion technologies. The Study Team estimated that on average 58.2% of all drilling and well completion costs will go to Ohio-based companies today. This is expected to grow over the next three years to 70%.[67]

The total expenditures for drilling and completion was estimated by multiplying the projected number of wells over the average expenditures for drilling and completion adjusted by the percentages of expenditures that are likely to be paid to Ohio service companies. For 2011, the Study Team used ODNR data on 26 drilled wells, 3 drilled and completed wells, and 4 drilled, completed and producing wells and included only relevant costs for these wells in the 2011 estimates. For 2012 to 2014, it was assumed that all projected wells will be drilled, completed and will be producing in the year they were projected to be drilled. No adjust was made for unproductive wells (based on the Marcellus and early Utica experience these are assumed to be negligible) or for the lag of production after the well is completed. The total direct expenditure for services and labor in Ohio associated with the drilling and completing of wells in the economic impact modeling was estimated to be $54.1 million in 2011; $535.7 million in 2012; $2,395.7 million in 2013, and $4,324.7 million in 2014. This totals to $7.3 billion over the four years of this study period.

The cost of drilling and completing wells includes expenditures for site preparation and building access roads. Other off-pad expenses, such as road upgrades and the construction of gathering lines by midstream producers, are calculated separately.

As noted earlier in this report it was estimated that 23 well pads would be completed in 2011, 105 in 2012, 325 in 2013, and 418 in 2014.

[67] According to the opinion of experts, smaller producing companies might contract with more Ohio-based service industries and workers than might the large companies, which tend to have long-term standing relationships with out-of-state service firms. On the other hand, the large companies might have more resources to train Ohio-based employees over the next 2-5 years, whereas the smaller companies might only be able to employ Ohio workers if they already have appropriate skills.

Figure 6. Drilling site for shale formation (courtesy of Chesapeake Exploration, LLC)

Roads

Each component of the road upgrades and the midstream infrastructure was evaluated by experts who assessed the needs for physical infrastructure based on the anticipated number of drilling sites and the volume of expected hydrocarbon production over the next three years. Road upgrades included bridges and culverts, as required to support trucks carrying heavy equipment for drilling operations. The components of the midstream infrastructure included gathering lines, lateral and trunk lines, transmission lines, compressor stations, processing plants, fractionation plants, liquids storage facilities, and railroad terminals for loading liquids.

The estimated number of wells for 2011 and 2012 were calculated by assuming that the average number of wells per drilling pad will be 1.52. It was further assumed that the number of wells per pad would increase to 2.0 in 2013 and 2.5 in 2014.[68] Applying the well-per-pad ratios to the number of pads expected to be constructed over the next three years allowed for an estimate of the cost of associated gathering lines and road construction.

It was estimated that an average of one mile of road, two culverts and one bridge will be upgraded for each pad built. According to the experts interviewed, one mile of full road replacement will cost roughly $750,000, one bridge upgrade will costs $250,000, and two culvert upgrades

[68] For the reasons discussed in Section II, herein, it is anticipated that there will not be the full six wells per pad during the early years of Utica development. Producing companies will likely come back later and drill the remaining wells, as land positions and economics support.

will cost $100,000. Therefore, the total cost to upgrade road infrastructure in preparation for drilling amounts to $1.1 million per pad.

According to the information gathered through interviews expenses for materials and equipment range from 40 to 60 percent of the total expenditure for construction, acquiring rights-of-way account for approximately 10 percent, and labor costs accounted for the remainder of the expected road building construction costs. Ninety percent of the materials for constructing roads and bridges are expected to be supplied by Ohio-based companies, as is all of the construction labor.

Gathering lines

Post-production gathering lines may be owned either by a producing company or by a midstream company. Usually the producing company will build gathering lines from the pad to some point near the field where a midstream company will connect thereto with its own gathering line. That line will in turn be connected to a larger lateral pipeline. At this point compression will be boosted so that the gas can be transported at higher pressure in a still larger line (sometimes called a "trunk line"). Where liquids are suspended in the gas stream (as is the case for the Utica), there will usually be a processing plant at the end of the trunk line to extract those liquids. There will also typically be a still larger interstate transmission line that takes methane from the tailgate of the processing plant. The cost of gathering lines, trunk lines and transmission lines vary, principally due to the size of the line and the need for compression. Larger diameter lines cost more. The Study Team estimated the average well pad requires four miles of gathering pipeline,[69] with the cost of the pipeline at $120,000 per diameter-inch-mile. Accounting for an 8-inch pipe from the well pad to the trunk line, the cost of gathering lines averages $4.48 million per pad.

[69] Some experts opined that the length of gathering lines per pad in remote locations can reach up to 25 miles.

Figure 7. Gathering Line Interconnect (Courtesy of M3 Midstream, LLC)

Larger pipelines and more compression are required for the lateral and trunk gathering lines. However calculations for the required large pipeline capacity, along with supplemental compressor stations and storage facilities, require an estimate of hydrocarbon throughput rather than the number of pads. Using estimates of experts and recent reports, the Study Team estimated the cost for large diameter pipelines (up to 20 inches) to be $140,000 per diameter-inch-mile, totaling at $1.4 million for a 12-inch line per mile and $2.4 million for a 20-inch line per mile. Relying on industry expertise, the Study Team estimated that throughput of one billion cubic feet of natural gas per day (BCFD) would require roughly 170 miles of lateral pipelines and 30 miles of trunk pipelines. Accordingly, the total cost to build lateral and trunk lines will be approximately $310 million per BCFD of throughput.

Natural gas is transmitted through the trunk lines at high pressure, which requires construction of compressor stations across the trunk lines. Based on the opinion of midstream experts, three compressor stations will be needed for each BCFD of product throughput, each with three large-capacity compressors. The estimated cost of one compressor station (with three large compressors) is $10 million.[70]

[70] Transmission lines, which are found downstream of the processing plants, may or may not have to be built in Ohio. It is also possible that existing lines may have to reverse their direction of flow. Either would require a major construction undertaking in Ohio. However the uncertainty is such that the Study Team assumed that no new transmission lines would be built before 2014. The Midstream experts interviewed believe that if there will be a need for additional transmission lines going through Ohio, the large 36-inch diameter pipeline will cost approximately $4.5 million per mile for one BCFD of natural gas throughput.

Figure 8. Compressor being installed (Courtesy of M3 Midstream, LLC)

Midstream infrastructure: Processing and fractionizing plants

The cost of for new processing plants was estimated to be $400,000 per million cubic feet of natural gas per day (MMCFD). This requires an investment of $80 million for a one-skid processing plant with throughput capacity of 200 MMCFD. The estimated throughput in 2014 should be roughly 1.5 BCFD, requiring 7.5 skids.[71] Because processing plants are modular the Study Team assumed that the total investment amount of $600 million would be spread evenly over three years of construction, ending in 2014.

Building a fractionation plant with a capacity of 36,000 barrels a day is projected to cost about $100.8 million. To satisfy the capacity required for the projected production in 2014, 2 plants will need to be built in Ohio. It typically takes two years to build a plant. It is assumed that the construction of these 2 plants concludes by the end of 2014.

The storage facilities necessary to accommodate the liquids generated by a one BCFD throughput is expected to cost about $80 million. Accordingly, storage capacity for the 1.5 BCFD throughput projected for 2014 requires an estimated $120 million. The rail loading terminals for

[71] It is by no means a foregone conclusion that the processing plants will be built in Ohio. It is possible to transport the gas into Pennsylvania or West Virginia, and process it there. But given that the liquid rich areas are likely to be more toward the western side of the Utica play, it is probably a safe to assume that at least one or two processing plants will be built in Ohio.

the liquid product will require an additional investment of $40 million per each BCFD a year of throughput, or $60 million for liquids generated by 1.5 BCFD.

Data from interviews allowed for the allocation of costs between Ohio and non-Ohio-based providers for the midstream infrastructure. As was true for road construction expenses for materials and equipment are expected to range from 40 to 60 percent of the total expenditure for construction, rights-of-way around 10 percent, and labor costs accounted for the remainder. Twenty percent of the materials used in constructing the processing and fractionation plants are expected to be sourced intrastate. Ohio is expected to supply half of the labor used to construct the midstream infrastructure and all of the labor employed in operations and maintenance.

Figure 9. Natural gas processing plant (courtesy of M3 Midstream, LLC).

Maintaining producing wells and midstream infrastructure

The costs of maintaining producing wells and midstream infrastructure are also included in the model. The maintenance of a single well costs approximately $60,000 a year; 80% of this cost is labor. (The number of wells included in the model has been discussed earlier in this report.) To develop the estimates for maintaining the midstream infrastructure some “rules of thumb” provided through interviews and the literature were used. Each segment of the midstream infrastructure (pipelines, compressors, storage facilities, loading terminals) requires operations and maintenance and the work created will directly benefit Ohioans because they will create permanent jobs. Salaries for this work are projected to be around $60,000 a year. The maintenance of gathering lines requires about one employee for every 20 miles of pipe. Operating and maintaining processing and fractionation plants, with their associated storage facilities, is estimated to require around $5.7 million per year for labor, with annual salaries of around $60,000 per person.

Lease Bonuses and Royalties

The final set of assumptions required for the impact modeling relates to the estimate of lease bonuses and royalties from production paid to landowners. Estimates of the additional income received by landowners were derived by combining data on land leases reported by major producing companies developing the Utica with information from previous studies that estimated spending patterns of these sorts of "windfall" payments. Additional information was collected from the landowner groups[72] in six counties in Ohio.

To date producing companies have leased at least 3.8 million acres in Ohio's Utica Shale formation.[73] It is likely that these operations began in 2009 and the data is current through 2011, therefore it is reasonable to assume that roughly 1.3 million acres (30% of total reported leases) was leased in 2011, and that this lease rate will continue in 2012, and begin to decline thereafter.[74] The Study Team estimates 800,000 acres will be leased in 2013 and 400,000 in 2014. For 2011 on an average lease rate of $2,500 per acre was assumed.[75] Royalty payments in the model are based upon throughput, with an assumed average royalty rate of 15% for the entire period of the study.

[72] F&M #2 - Northeastern OH - Oil and Gas Leasing - Marcellus - Utica – Ohio, representing Trumbull, Ashtabula, Portage, Lake and Geauga Counties (http://www.washingtonpalawyer.com/F_M__2_-_Northeastern_OH.html); Oil and Gas Leasing Group of Athens County (http://www.acrealtyinc.com/oag-groups); Ohio Valley Landowners Group.

[73] This does not include the many acres of mineral rights that have been subleased. Traditionally, leases have been granted in Ohio for all subsurface minerals beneath the property, regardless of depth, and those old leases have been held by production. The companies that owned the lease could sublease the deeper Utica Shale rights to another producer, and indeed many acres of mineral rights have been subleased in this fashion. The Study Team did not attempt to include sublease bonus or royalty payments (called overriding royalties, or sometimes a "carried interest") into the model. However the model did include a slight reduction in the average landowner royalty rate to account for the old leases, which typically have a smaller royalty percentage.

[74] *Marcellus Drilling News*, January 12, 2012, http://marcellusdrilling.com/2012/01/correction-exxon-buys-25k-acres-of-utica-shale-leases-in-oh/; Reuters, December 2, 2011, http://www.reuters.com/article/2012/01/03/us-total-chesapeake-idUSTRE80208320120103; *Seeking Alpha*, October, 28, 2011, http://seekingalpha.com/article/303338-best-bets-to-get-in-on-the-utica-shale; Seeking Alpha, October 20, 2011, http://seekingalpha.com/article/300790-ev-energy-partners-an-emerging-powerhouse-with-its-utica-shale-play; *Seeking Alpha*, October 5, 2011, http://seekingalpha.com/article/297867-5-more-companies-operating-in-utica-shale; *Reuters*, September 30, 2011, http://www.reuters.com/article/2011/09/30/idUS103177+30-Sep-2011+MW20110930.

[75] According to the Harrison County Ohio Landowners Group's, "current lease offers from individual landmen in parts of Harrison County have reached the $5,000 per acre and 19% royalty range. *See* website of the Harrison County Ohio Landowners Group (http://hcolg.org/), and Columbus Dispatch's special report on November 10, 2011 (http://www.dispatch.com/content/stories/local/2011/09/26/drillers-snapping-up-rights-leases-in-ohio.html).

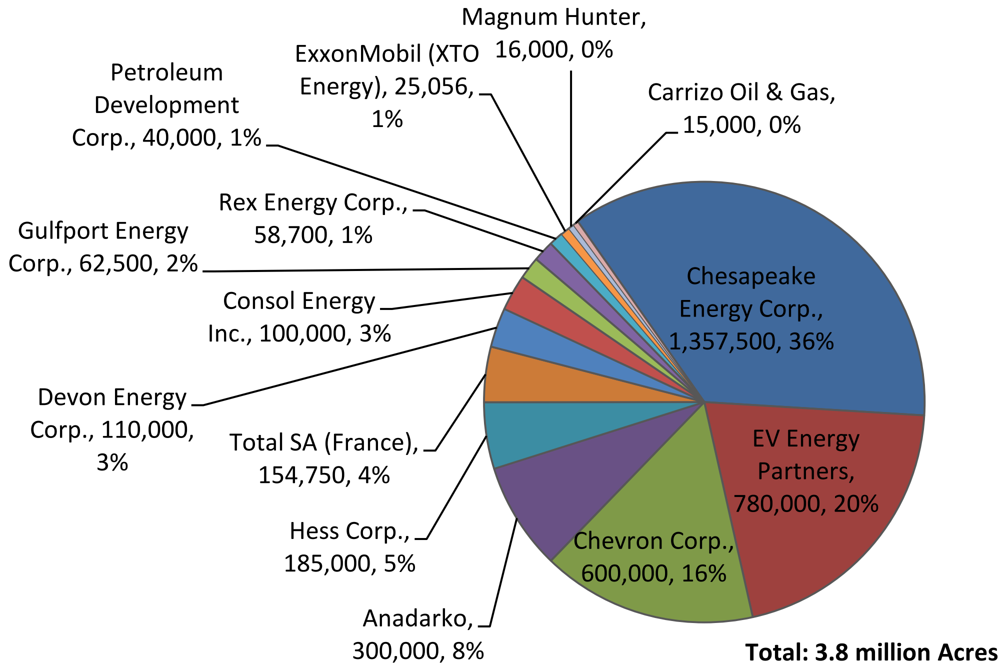

Figure 10: Leaseholds by Company (Net Acres)

Other studies reported on leasing practices and royalty payments as well as on the propensity for spending the windfall payments that are received each year.[76] The specifications of this model in regards to who receives these payments were particularly informed by Kelsey, et. al. (2011). However, the Study Team used more conservative estimates about the proportion of leases that are held by out-of-state entities. We assumed that 15% of the mineral rights are owned by out-of-state entities instead of the 10% assumed by Kelsey. We assumed that 4% of the lease bonuses are spent in the first year after they are received and none are spent after that. The same assumption is made in regard to royalty payments, that is: 4% of royalties are spent annually. We also assumed that another 20% of the leases are owned by government or corporate lessors, and that none of the bonuses or royalties attributable to those leases have been, or will be, recycled directly into Ohio's economy. We assumed that any such funds received by the state will replace other tax sources that would have been collected statewide and that impact will accordingly be dissipated across the state. Similarly, we assumed that the corporate stockholders are dispersed outside of Ohio.[77] To calculate the amount of royalties received by private non-corporate owners, the total throughput of production was given a value of $65 per barrel for liquids and $3.60 per MCF for natural gas.[78]

[76] Kleinhenz and Associates (2011); Kelsey, et al. (2011); Considine, et al. (2011); Center for Community and Business Research (2011); Scott, et al. (2010); Pennsylvania Economy League (2008), etc.

[77] Kelsey et al. (2011) used a less conservative 7.7% of leases owned by out-of-state residents. Kelsey also assumed that 66% of all the royalty dollars were invested and not spent immediately. It should be noted here that the out of state residence is only a factor for the calculation of spending in the Ohio economy; for purposes of taxes, out of state residents are required to pay income tax and commercial activity taxes on royalty and bonus income.

[78] These prices are low and high, respectively, for oil and gas sales at the wellhead in Ohio, in early 2012. The low price for liquids was chosen as an average of

Manufacturing Example: Ariel Corporation

Founded in 1966 by James Buchwald and led since 2001 by his daughter, Karen Wright, Ariel Corporation is the world's leading supplier of reciprocating compressors. Paired up with engines or electric motors capable of delivering 100 to 10,000 horsepower, these compressors are used in virtually every part of the gas industry: at the wellhead for both extraction and reinjection, in pipeline systems, for storage (e.g., in salt dome formations), in petrochemical processing, etc. More than 38,000 Ariel compressors are in operation throughout the world – just about any place where hydrocarbons are extracted and processed. Deliveries and sales revenues are in line with trends in oil and gas markets, which are subject to fluctuation. However, revenue-growth since 2001 has averaged 10 percent per annum.

This growth has caused Ariel to increase its workforce by 170 percent during the same period, from about 500 employees in 2001 to 1,350 today. Most of these individuals work at four factories located in Mount Vernon, Ohio, where the firm is headquartered, and the rest in Akron. Machinists and other skilled laborers comprise a large segment of the workforce and new machinists earn about $18 an hour, supplemented by retirement and other benefits.

In the short term, Ms. Wright expects some volatility in the market for Ariel's products. This is due to the current oversupply of gas, which has driven the price below break-even levels for some customers. However, the overall rig count remains strong and, because the price of oil is still elevated, there has been a repositioning of rigs from gas to oil – after more than 35 years when gas drilling has dominated domestic exploration and production. Among other things, compressor sales remain robust for the handling of associated gas from oil production. In addition, pipelines and other infrastructure are less fully developed outside the United States and Canada, so the potential is enormous for long-term growth of all kinds of hydrocarbon production and utilization world-wide.

Under these circumstances, Ariel will continue investing approximately 20 percent of net income in capital improvements. A major reason for U.S. demand for natural gas to grow is the switch by public utilities to gas-fired generators. Other potential markets in this country hold considerable promise, yet would require a sizable investment. This is true, for example, of the conversion of fleet vehicles to run on compressed natural gas.

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all liquids pricing, including natural gas liquids. The high gas price was used because it is unlikely prices will remain significantly lower than this rate through 2014.

E. The Model Results and Interpretation

The input-output model used to estimate the impacts of investments in Ohio's Utica Shale formation as a source for oil, natural gas, and associated liquids produces *annual* estimates of the number of jobs, labor income, the total value of output, and Value Added—which is an analog to Gross Domestic Product, that are associated with the development.[79] Many of these jobs will be new, but others will be existing positions that will shift into servicing this emerging source of labor demand. The expected investments involved in developing Ohio's Utica Shale energy resources from 2011 to 2014, along with predicted revenues from payments to local landowners from leases and royalty payments, are given in Table 5.

Table 5 lists increases in final demand for Ohio-made products and services expected due to the development of the Utica play. These expenditures come from four sources: payments to land holders in the form of lease bonuses, royalty payments, and right-of-way payments; road and bridge construction; well pad construction, drilling, and associated infrastructure; and the construction of midstream oil and gas infrastructure. The total amounts invested into the state of Ohio's economy from these new sources of final demand increase from $229.6 million in 2011 to $6.4 billion in 2014.[80] By 2014 ninety percent of these expenditures will be for the development of the oil and gas field in terms of wells and midstream infrastructure.

As noted in the previous section of this report these estimated spending impacts only account for goods and services that are expected to be purchased in the state of Ohio, for wages and salaries paid to Ohio residents, and for the additional income that will be received and spent in Ohio through lease bonuses and royalties. These amounts exclude spending that will take place outside of the state for materials, imported or transient labor, or for lease bonuses and royalty payments that go to out-of-state landowners.

The pattern of spending displayed in Table 5 shows the expected pace of development. The first year is dominated by lease bonus payments. As the production is brought online lease payments drop while royalty income climbs and as the industry becomes more fully developed in 2012 and 2013 drilling expenses climb rapidly, reaching $4.7 billion in 2014.

The investments in midstream infrastructure increase significantly over the last three years of this time period, growing from $50.7 million spent in Ohio in 2011 to $411.3 million spent in the state in 2012, with $905.7 million in 2013 and $1.1 billion in 2014. Although the amounts invested by the midstream industries grow steadily throughout, they are closely connected to drilling activity. The same holds true for road and bridge construction that is related to the pace of drilling.

[79] The model was developed with Version 3.0 of IMPLAN's software, which uses 2009 data to form its technical coefficients. User reviews of a recently updated version of the model indicate that multipliers related to oil and gas development are likely to increase. We suspect that this is due to the incorporation of hydro-fracturing technologies that are reflected in the 2010 data and are not in the 2009 data. The implication is that the results presented in this report are likely to be conservative. The IMPLAN users' guide can be found at: http://implan.com/V4/index.php?option=com_multicategories&view=categories&layout=blog&cid=222:referencemanualusersguidetoimplanversion30software&Itemid=14
An accessible discussion of the IMPLAN Model was developed at the University of Florida and is available at: http://edis.ifas.ufl.edu/fe168.

[80] All expenditures and monetary impacts are expressed in terms of 2012 real, or inflation adjusted, dollars.

Table 5. Inputs to the IMPLAN Model:
Increase of Final Demand Due to Utica Shale Development in 2012 Dollars

	2011	2012	2013	2014
Lease Bonuses (4%)	$93,177,568	$72,728,362	$63,164,827	$34,992,551
Royalties (4%)	$86,074	$5,286,628	$21,367,377	$45,278,948
Road & Bridge Construction	$22,861,159	$102,315,789	$322,668,932	$426,915,817
Drilling	$62,851,483	$570,443,645	$2,604,315,389	$4,722,240,422
Midstream Infrastructure	$50,669,010	$411,301,793	$905,701,838	$1,138,004,105
Total	**$229,645,295**	**$1,162,076,217**	**$3,917,218,363**	**$6,367,431,844**

All figures are expressed in 2012 dollars

This spending translates into substantial added annual economic impact on the state of Ohio as evidenced by the estimates that the model provides. (Table 6) Value Added can be thought of as a close analog to Gross Domestic Product and includes wages, business income, other income, and indirect business taxes. Labor income includes wages and benefits of employees as well as the income of the owner, which IMPLAN refers to as proprietor income. Output is the total value of output, which is value added plus the cost of intermediate goods and services purchased. Average labor income is labor income divided by employment.

Table 6. Returns from Increased Demand in Ohio Due to Utica Shale Development In 2012 Dollars

	2011	2012	2013	2014
Value Added	$162,030,036	$878,982,133	$2,980,378,198	$4,857,632,095
Employment	2,275	12,150	40,606	65,680
Labor Income	$99,758,497	$571,543,463	$1,994,216,405	$3,298,757,195
Output	$291,574,770	$1,667,574,417	$5,823,268,396	$9,642,544,988
Total State and Local Taxes	$16,522,865	$73,422,148	$271,539,607	$433,528,922
Average Labor Income	$43,850	$47,041	$49,111	$50,225

The $229.6 million investment in oil and gas development in the Utica play in 2011 (Table 5) had an immediate impact on Ohio's economy, resulting in the state's Gross Product, as measured by Value Added, increasing by $162 million in that year (Table 6). This translated into 2,275 jobs, most will be new and some existing jobs will be supported by this new source of demand, and nearly $100 million in increased labor income. As the industry grows and matures the impacts also grow. In 2014 the incremental economic activity in the state of Ohio from that year's expected expenditure of $6.4 billion in Utica Shale development is expected to result in 65,680 jobs and $3.3 billion in labor income, or an average income of $50,225 per job. The model shows average labor income rising over time as the work shifts from leasing and road construction to drilling and infrastructure maintenance. The other notable source of return for the state is $433.5 million dollars in taxes that will be paid to state and local governments.

These estimates are conservatively constructed. They do not assume that a major oil or ethane processing facility will be built in the tri-state area, as news reporting indicates is likely to happen. They do not account for direct and indirect employment impacts that could be derived from investments in new manufacturing plant and equipment by chemical companies and plastics-using industries that want to be near a supply of natural gas and natural gas liquids. The next section documents the expected employment impacts from shale development by showing the industries that will be affected by this increase in economic activity.

1. Employment and Income Impacts

Three large general areas of job growth will be triggered by the development of the Utica Shale deposits: oil and gas development activities and its supply chain, professional service provision, and personal services to the newly employed and the transitory workforce (Tables 7 and 8). Expected average earnings are highest in the professional services sector, at nearly $70,000 per position, followed by an average of nearly $60,000 among those directly involved in developing the resource, while the lowest average earnings are among those industries that provide personal services, with an average of $36,000. [81] The expected average earnings across all four of these broad sectors in 2014 is $50,225, which is contrasted with Ohio's most recently reported median household income of $47,358.[82]

Oil and Gas Field Development and Its Supply Chain

Nearly 17 percent of the increase in the number of jobs triggered by the development of Ohio's Utica Shale deposits will come from oil and gas field service companies, with employment doubling between 2013 and 2014. The average labor income for this group is $69,000. The largest growth in employment will be in construction-related trades as wells are being drilled and midstream facilities are constructed. Nearly 11,000 local construction jobs will be created as new manufacturing facilities and other nonresidential structures are built, which includes midstream infrastructure, as well as pipelines and roads and bridges. These jobs will pay an average of $48,000 per position. The large increase in construction employment is expected to occur in 2013.

The oil and gas patch has a supply chain, which will make its way into Ohio. The model predicts significant employment growth among wholesale companies and trucking services due to the volume of equipment that will arrive from out-of-state and the large geographic extent of the play. These two sectors will see nearly 4,000 new positions by 2014. Wholesale companies will experience a pick up in their business between 2012 and 2013, while trucking services will jump in the next year.

Truck drivers will be in great demand as servicing companies, wholesalers, delivery services, and construction companies ramp up their employment to meet demand. Expected average labor income in this industry is nearly $53,000. The model also predicts a minor increase in employment in the water-borne transportation industry. The full list of employment impacts directly associated with developing the production fields is given in the upper portions of Table

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[81] Average labor income in each industry is the same in each year in Table 8 because the income data are cross-sectional and the IMPLAN model assumes that there are no labor supply constraints, as is true with all input-output models. The average labor income reported in each of the four major sections on Table 8 changes annually because the composition of industries involved in the development of the field changes annually. This results in changes in the mix of jobs and, therefore, results in changes in the average wage that is reported in each major section of the table.

[82] The estimate is an average from 2006 to 2010 from the American Community Survey of the U.S. Census Bureau. http://quickfacts.census.gov/qfd/states/39000.html

7 and 8. The jobs listed in these tables account for 85 percent of the estimated employment increase that is associated with the development of Ohio's Utica play.

Professional Services

Investing billions of dollars in new facilities and executing complicated leasing agreements and investigating property records means that white-collar workers will work in the Utica along with those wearing blue-collars and hard hats. The model estimates that by 2014 over 1,500 jobs for engineers and architects will be established, as well as 1,000 environmental compliance and monitoring technicians. There will be demand for more than 1,800 office workers (managers, accountants and bookkeepers, and people in business support services), along with nearly 500 technical consultants. Finally, all of the leasing and contracting work will help turn around a soft market for attorneys, with nearly 841 positions expected to open for legal services. The highest paid in this sector are the managers, with average labor income of $109,000, followed by those who provide consulting services at $75,000.

Mixed Sources of Demand for Labor

There are industries that will service both the demands of the development of the Utica play and meet the demands of the workforce and landowners. Since we cannot disentangle the sources of demand for their services, they are listed as a separate category. The largest source of employment in this group will be from the engagement of "landmen," a career unique to the oil and gas and mining industries. Development in Ohio's Utica will demand the services of more than 2,100 people in the real estate industry, with average incomes of nearly $70,000; accompanied by 1,900 in banking and securities (investing) and nearly 900 in insurance, when insurance agencies are included. The temporary staffing industry will fill an expected 1,100 positions associated with the development of the field in 2014. These are lower paying positions with average labor income of $28,000.

Personal Services

The local service sector will add a bit more than 16,000 jobs in 2014, which will be a huge addition to the economy in a part of Ohio that has lagged since the mid-1980s. These are jobs required to service the demands of new local employees as well as meeting the demands of out-of-state workers who need to be fed and housed. Retail employment is expected to support more than 5,800 positions, along with nearly 4,000 restaurant workers. Health care practitioners will experience increased demand for their services as well, with 1,520 positions in offices of physicians; another 1,900 positions in hospitals, labs, and outpatient care facilities, and 1,000 in nursing homes and residential care facilities. Other local servicing jobs will open as well. Average labor income is given in the bottom section of Table 8.

The next section presents data on the economic value that are expected to be created through the development of Ohio's Utica Shale formation. Value Added is the increase in value that takes place through the production process. In accounting terms think of Value Added as the final sales price less the cost of purchased inputs. Value Added is, therefore, the same as Gross Domestic Product, while the value of Total Output is the total value of the finished product, good, or service. Value Added is then used to pay labor and taxes, and once those bills are paid there may be something left over for profit.

Table 7. Employment Impacts Due to Ohio Utica Shale Development

	Industry	2011	2012	2013	2014
Field Development & Supply Chain	**Subtotal**	**575**	**4,369**	**16,646**	**28,153**
	Support activities for oil and gas operations	59	1,058	5,450	10,843
	Construction of new nonresidential manufacturing structures	169	1,232	4,746	7,670
	Construction of other new nonresidential structures	173	994	2,552	3,213
	Wholesale trade businesses	66	398	1,374	2,228
	Transport by truck	49	253	965	1,591
	Transport by water	3	37	148	243
	Lessors of nonfinancial intangible assets	1	7	30	51
	Cement manufacturing	3	28	114	187
	Valve and fittings other than plumbing manufacturing	2	45	186	313
	Commercial and industrial machinery and equipment rental and leasing	7	39	155	262
	Electric power generation, transmission, and distribution	6	26	81	127
	Fabricated pipe and pipe fitting manufacturing	1	32	133	223
	Natural gas distribution	1	6	23	38
	Maintenance and repair construction of nonresidential structures	8	72	232	427
	Services to buildings and dwellings	28	141	459	736
Mixed Sources of Demand	**Subtotal**	**270**	**1,257**	**3,958**	**6,279**
	Real estate establishments	105	452	1,367	2,123
	Insurance carriers	28	125	373	572
	Monetary authorities and depository credit intermediation activities	28	135	430	689
	Nondepository credit intermediation and related activities	14	67	204	318
	Telecommunications	11	55	178	284
	Employment services	39	206	699	1,140
	Securities, commodity contracts, investments, and related activities	29	148	501	836
	Insurance agencies, brokerages, and related activities	15	69	206	318
Professional Services	**Subtotal**	**138**	**872**	**3,299**	**5,712**
	Architectural, engineering, and related services	30	232	877	1,502
	Management of companies and enterprises	15	103	405	721
	Legal services	32	151	522	841
	Environmental and other technical consulting services	15	122	553	1,019
	Management, scientific, and technical consulting services	10	56	246	482
	Accounting, tax preparation, bookkeeping, and payroll services	16	93	325	543
	Business support services	13	73	259	433
	Office administrative services	6	43	111	172
Personal Services	**Subtotal**	**858**	**3,676**	**10,627**	**16,066**
	Imputed rental activity for owner-occupied dwellings	NA	NA	NA	NA
	Retail Stores	289	1,318	3,853	5,840
	Food services and drinking places	190	856	2,527	3,865
	Private hospitals	95	367	1,014	1,498
	Offices of physicians, dentists, and other health practitioners	88	361	1,019	1,520
	Nursing and residential care facilities	77	266	730	1,083
	Medical and diagnostic labs and outpatient and other ambulatory care	25	94	264	395
	Civic, social, professional, and similar organizations	40	180	547	850
	Automotive repair and maintenance, except car washes	21	100	302	460
	Individual and family services	35	133	372	554
	Total	**2,275**	**12,150**	**40,606**	**65,680**

Note: Industries are sorted by 2014 output impact within sectors
NA: Not applicable

Table 8. Expected Average Annual Income, by Industry, Associated with the Development of the Utica Shale Formation by Year

	Industry	2011	2014
Field Development & Supply Chain	**Subtotal**	**$54,100**	**$59,451**
	Support activities for oil and gas operations	$69,319	$69,319
	Construction of new nonresidential manufacturing structures	$48,383	$48,383
	Construction of other new nonresidential structures	$48,213	$48,213
	Wholesale trade businesses	$73,415	$73,415
	Transport by truck	$52,589	$52,589
	Transport by water	$64,461	$64,461
	Lessors of nonfinancial intangible assets	$38,761	$38,761
	Cement manufacturing	$77,404	$77,404
	Valve and fittings other than plumbing manufacturing	$76,376	$76,376
	Commercial and industrial machinery and equipment rental and leasing	$81,131	$81,131
	Electric power generation, transmission, and distribution	$128,229	$128,229
	Fabricated pipe and pipe fitting manufacturing	$61,252	$61,252
	Natural gas distribution	$103,908	$103,908
	Maintenance and repair construction of nonresidential structures	$46,369	$46,369
	Services to buildings and dwellings	$24,240	$24,240
Mixed Sources of Demand	**Subtotal**	**$37,846**	**$38,414**
	Real estate establishments	$11,573	$11,573
	Insurance carriers	$78,223	$78,223
	Monetary authorities and depository credit intermediation activities	$69,627	$69,627
	Nondepository credit intermediation and related activities	$69,777	$69,777
	Telecommunications	$72,108	$72,108
	Employment services	$28,106	$28,106
	Securities, commodity contracts, investments, and related activities	$35,380	$35,380
	Insurance agencies, brokerages, and related activities	$61,820	$61,820
Professional Services	**Subtotal**	**$67,071**	**$69,177**
	Architectural, engineering, and related services	$67,382	$67,382
	Management of companies and enterprises	$109,280	$109,280
	Legal services	$63,828	$63,828
	Environmental and other technical consulting services	$68,263	$68,263
	Management, scientific, and technical consulting services	$75,313	$75,313
	Accounting, tax preparation, bookkeeping, and payroll services	$53,458	$53,458
	Business support services	$34,735	$34,735
	Office administrative services	$67,454	$67,454
Personal Services	**Subtotal**	**$37,287**	**$36,018**
	Imputed rental activity for owner-occupied dwellings	NA	NA
	Retail Stores	$29,804	$29,815
	Food services and drinking places	$19,401	$19,401
	Private hospitals	$63,498	$63,498
	Offices of physicians, dentists, and other health practitioners	$78,727	$78,727
	Nursing and residential care facilities	$33,767	$33,767
	Medical and diagnostic labs and outpatient and other ambulatory care	$52,822	$52,822
	Civic, social, professional, and similar organizations	$29,620	$29,620
	Automotive repair and maintenance, except car washes	$39,329	$39,329
	Individual and family services	$25,371	$25,371
	Total	**$43,843**	**$50,225**

Note: Industries are sorted by 2014 output impact within sectors, NA: Not applicable

Table 9. Expected Value Added from the Industries Associated with the Development of Ohio's Utica Shale Formations by the Oil and Gas Industry

	Industry	2011	2012	2013	2014
Field Development & Supply Chain	**Subtotal**	**$43,683,726**	**$328,090,637**	**$1,267,381,332**	**$2,162,344,758**
	Support activities for oil and gas operations	$4,361,218	$77,926,699	$401,229,819	$798,318,392
	Construction of new nonresidential manufacturing structures	$9,114,897	$66,605,779	$256,712,219	$414,839,538
	Construction of other new nonresidential structures	$9,468,612	$54,443,801	$139,826,297	$176,054,657
	Wholesale trade businesses	$8,281,333	$50,260,758	$173,303,150	$281,065,467
	Transport by truck	$3,280,417	$17,114,177	$65,180,832	$107,501,848
	Transport by water	$394,411	$4,567,645	$18,309,636	$30,016,761
	Lessors of nonfinancial intangible assets	$2,323,773	$11,660,942	$47,433,032	$80,042,589
	Cement manufacturing	$497,102	$5,184,059	$20,970,318	$34,561,346
	Valve and fittings other than plumbing manufacturing	$285,069	$7,200,954	$29,695,663	$49,983,538
	Commercial and industrial machinery and equipment rental and leasing	$1,019,453	$5,966,681	$23,779,964	$40,375,827
	Electric power generation, transmission, and distribution	$2,573,482	$11,480,222	$35,664,822	$55,845,402
	Fabricated pipe and pipe fitting manufacturing	$169,232	$4,187,479	$17,224,576	$28,927,602
	Natural gas distribution	$543,671	$2,874,257	$10,078,693	$16,933,426
	Maintenance and repair construction of nonresidential structures	$423,255	$3,932,436	$12,708,263	$23,396,792
	Services to buildings and dwellings	$947,801	$4,684,748	$15,264,047	$24,481,574
Mixed Sources of Demand	**Subtotal**	**$27,676,957**	**$126,989,235**	**$393,514,646**	**$618,558,980**
	Real estate establishments	$9,043,961	$38,865,199	$117,414,545	$182,406,196
	Insurance carriers	$5,788,364	$26,029,181	$77,812,999	$119,257,229
	Monetary authorities and depository credit intermediation activities	$4,054,656	$19,561,792	$62,340,652	$99,941,419
	Nondepository credit intermediation and related activities	$2,396,569	$11,142,761	$34,074,251	$53,175,994
	Telecommunications	$2,602,455	$12,595,115	$40,422,948	$64,517,748
	Employment services	$1,322,123	$6,888,299	$23,409,134	$38,149,305
	Securities, commodity contracts, investments, and related activities	$1,138,177	$5,857,861	$19,834,244	$33,052,235
	Insurance agencies, brokerages, and related activities	$1,330,652	$6,049,027	$18,205,873	$28,058,854

Table 9. (Continued) Expected Value Added from the Industries Associated with the Development of Ohio's Utica Shale Formations by the Oil and Gas Industry

	Industry	2011	2012	2013	2014
Professional Services	**Subtotal**	**$11,754,071**	**$72,796,544**	**$275,564,241**	**$477,097,039**
	Architectural, engineering, and related services	$2,139,107	$16,503,404	$62,413,724	$106,884,665
	Management of companies and enterprises	$1,992,183	$13,648,361	$53,889,111	$95,931,774
	Legal services	$3,658,002	$17,217,910	$59,386,887	$95,729,014
	Environmental and other technical consulting services	$1,092,038	$8,666,243	$39,407,258	$72,561,172
	Management, scientific, and technical consulting services	$855,284	$4,753,390	$20,886,043	$40,866,375
	Accounting, tax preparation, bookkeeping, and payroll services	$1,118,644	$6,369,399	$22,354,567	$37,293,670
	Business support services	$478,148	$2,699,549	$9,541,287	$15,972,909
	Office administrative services	$420,665	$2,938,288	$7,685,365	$11,857,461
Personal Services	**Subtotal**	**$56,085,027**	**$240,230,095**	**$690,048,412**	**$1,038,710,662**
	Imputed rental activity for owner-occupied dwellings	$15,508,302	$67,839,509	$194,439,651	$291,895,470
	Retail Stores	$13,987,226	$63,827,129	$186,527,126	$282,671,336
	Food services and drinking places	$5,265,569	$23,781,701	$70,173,408	$107,339,081
	Private hospitals	$6,411,229	$24,892,798	$68,734,319	$101,528,950
	Offices of physicians, dentists, and other health practitioners	$7,378,708	$30,325,702	$85,539,038	$127,610,762
	Nursing and residential care facilities	$2,795,421	$9,695,445	$26,605,827	$39,491,664
	Medical and diagnostic labs and outpatient and other ambulatory care	$1,664,340	$6,365,655	$17,914,419	$26,823,062
	Civic, social, professional, and similar organizations	$1,181,478	$5,385,639	$16,339,492	$25,414,382
	Automotive repair and maintenance, except car washes	$998,710	$4,732,411	$14,321,845	$21,837,518
	Individual and family services	$894,042	$3,384,107	$9,453,287	$14,098,436
	Total	**$162,030,036**	**$878,982,133**	**$2,980,378,198**	**$4,857,632,095**

Note: Industries are sorted by 2014 output impact within sectors.

Table 10. Expected Total Output from the Industries Associated with the Development of Ohio's Utica Shale Formations by the Oil and Gas Industry

	Industry	2011	2012	2013	2014
Field Development & Supply Chain	**Subtotal**	**$89,084,839**	**$723,520,587**	**$2,881,283,680**	**$5,007,112,029**
	Support activities for oil and gas operations	$12,727,524	$227,416,764	$1,170,925,835	$2,329,766,094
	Construction of new nonresidential manufacturing structures	$18,805,674	$137,419,717	$529,643,537	$855,888,691
	Construction of other new nonresidential structures	$22,066,061	$126,878,169	$325,857,199	$410,285,338
	Wholesale trade businesses	$11,342,917	$68,842,010	$237,372,801	$384,974,528
	Transport by truck	$7,150,534	$37,304,865	$142,078,829	$234,328,648
	Transport by water	$1,466,020	$16,977,872	$68,056,652	$111,571,867
	Lessors of nonfinancial intangible assets	$3,027,946	$15,194,555	$61,806,658	$104,297,882
	Cement manufacturing	$1,424,292	$14,853,316	$60,083,961	$99,024,847
	Valve and fittings other than plumbing manufacturing	$561,422	$14,181,740	$58,483,390	$98,438,836
	Commercial and industrial machinery and equipment rental and leasing	$2,003,355	$11,725,284	$46,730,640	$79,343,614
	Electric power generation, transmission, and distribution	$3,479,246	$15,520,805	$48,217,423	$75,500,765
	Fabricated pipe and pipe fitting manufacturing	$400,969	$9,921,585	$40,810,976	$68,539,489
	Natural gas distribution	$1,927,943	$10,192,566	$35,740,622	$60,048,577
	Maintenance and repair construction of nonresidential structures	$860,421	$7,994,125	$25,834,224	$47,562,596
	Services to buildings and dwellings	$1,840,515	$9,097,215	$29,640,934	$47,540,256
Mixed Sources of Demand	**Subtotal**	**$45,244,377**	**$208,136,572**	**$644,564,376**	**$1,012,819,238**
	Real estate establishments	$12,482,773	$53,643,031	$162,059,430	$251,763,051
	Insurance carriers	$9,766,393	$43,917,624	$131,289,652	$201,216,253
	Monetary authorities and depository credit intermediation activities	$7,772,879	$37,500,453	$119,508,613	$191,590,239
	Nondepository credit intermediation and related activities	$5,690,652	$26,458,479	$80,909,286	$126,266,363
	Telecommunications	$4,558,656	$22,062,551	$70,807,880	$113,014,147
	Employment services	$1,636,881	$8,528,201	$28,982,162	$47,231,535
	Securities, commodity contracts, investments, and related activities	$1,432,138	$7,370,792	$24,956,908	$41,588,759
	Insurance agencies, brokerages, and related activities	$1,904,006	$8,655,440	$26,050,446	$40,148,892

Table 10. (Continued) Expected Total Output from the Industries Associated with the Development of Ohio's Utica Shale Formations by the Oil and Gas Industry

	Industry	2011	2012	2013	2014
Professional Services	**Subtotal**	**$18,190,923**	**$114,848,949**	**$435,934,448**	**$756,428,787**
	Architectural, engineering, and related services	$3,792,561	$29,259,956	$110,657,341	$189,502,760
	Management of companies and enterprises	$3,289,879	$22,538,827	$88,992,178	$158,421,198
	Legal services	$4,782,829	$22,512,375	$77,648,211	$125,165,455
	Environmental and other technical consulting services	$1,703,520	$13,518,868	$61,473,183	$113,191,490
	Management, scientific, and technical consulting services	$1,363,484	$7,577,801	$33,296,295	$65,148,713
	Accounting, tax preparation, bookkeeping, and payroll services	$1,733,135	$9,868,225	$34,634,331	$57,779,752
	Business support services	$808,511	$4,564,730	$16,133,584	$27,008,962
	Office administrative services	$717,003	$5,008,166	$13,099,325	$20,210,457
Personal Services	**Subtotal**	**$86,170,735**	**$365,578,440**	**$1,048,033,769**	**$1,576,757,665**
	Imputed rental activity for owner-occupied dwellings	$20,378,725	$89,144,681	$255,503,922	$383,565,991
	Retail Stores	$16,003,108	$73,025,733	$213,408,544	$323,408,349
	Food services and drinking places	$10,717,106	$48,403,314	$142,825,173	$218,469,122
	Private hospitals	$13,512,056	$52,463,086	$144,861,754	$213,978,433
	Offices of physicians, dentists, and other health practitioners	$12,266,009	$50,411,984	$142,195,972	$212,133,978
	Nursing and residential care facilities	$4,871,395	$16,895,607	$46,364,207	$68,819,500
	Medical and diagnostic labs and outpatient and other ambulatory care	$3,271,335	$12,511,978	$35,211,589	$52,721,922
	Civic, social, professional, and similar organizations	$2,274,066	$10,366,088	$31,449,677	$48,916,706
	Automotive repair and maintenance, except car washes	$1,538,010	$7,287,899	$22,055,598	$33,629,712
	Individual and family services	$1,338,927	$5,068,071	$14,157,333	$21,113,953
	Total	**$291,574,770**	**$1,667,574,417**	**$5,823,268,396**	**$9,642,544,988**

Note: Industries are sorted by 2014 output impact within sectors.

2. Value Added or Gross State Product

Gross State (or Domestic) Product is expected to increase by $4.9 billion in 2014 due to the development of the Utica formation as an energy resource (Table 9). This is equal to a 1 percent increase in the real value of Ohio's Gross State Product. Another way of thinking of this number is that the increase in the state's GSP from the development of the Utica is equal to nearly half of the state's annual economic growth rate in a good year.[83] This is a very conservative estimate, because it does not factor in the expected downstream utilization of the liquids, oil, and natural gas as the basis for additional business development activities throughout the state, which will come later in the development process.

The IMPLAN model projects that in 2014 a bit less than half of the increase in Value Added will come from developing and maintaining the field itself ($2.1 billion), another billion dollars will flow into the general economy of the state through spending on personal services, and a half billion dollars through the purchase of professional services.

Value Added from the development of the Utica formation will grow from $162 million in 2011 to $4.9 billion in 2014. The biggest contributors to Value Added in 2011 were lease bonus and right-of-way payments. This shifts to drilling and well maintenance as the industry becomes established and as support activities for oil and gas operations become the largest generator of Value Added. *Construction of new nonresidential manufacturing structures* and *Wholesale trade businesses* are two other industries that will benefit from the development of the Utica formation.

The development of the Utica formation will also result in increased land and property values throughout the region, which are outcomes that cannot be captured in any input-output economic model. This will not only be due to the direct economic activity triggered by drilling and building out supporting infrastructure, but will also be due to the increased value of housing and general commercial structures throughout the eastern half of the state as employment increases and wages and incomes rise.

While much of the media focus has been on the boost to the economy of some of the poorer counties in Appalachian Ohio, the importance of the development of shale to Northeast Ohio, east of the I-71 corridor, should not be understated. Continuing the revitalization of all of Eastern Ohio from prolonged deindustrialization that began in earnest in the early 1980s rests on developing this resource and on both the upstream and downstream economic activities that should follow.

Table 10 lists the total value of output that is expected from the development of the Utica Shale field. The differences between Tables 9 and 10 are due to the difference between a net figure, Value Added (Table 9), and a gross figure, Total Output (Table 10), for the economic activity that is generated by the development of this energy field. Table 9 presents the net figure; which is defined in the previous section. Table 10 is the total value of output; that is, the sales price of the good or service, including work-in-process inventory and goods and services that are purchased outside of the region as part of the production process.

Comparing Tables 9 and 10 paints a fairly complete picture of the economic impact

[83] From 1997 to 2010 Ohio's annual real growth rate in real Gross State Product ranged from 3.3% from 1997 to 1998 to -4.2% from 2007 to 2008, with an average real annual growth rate over this 13-year period of 0.6%. The state has had year-to-year growth rates that exceed 2.0% only three times over this time period.

from the development of the Utica as an energy source as well as identifying possible areas of industrial recruitment. A close examination of the differences between Tables 9 and 10 identify gaps between the economic value that is retained in Ohio compared to the total economic impact of the development of the Utica Shale formation on the national economy. Identifying where these gaps are large, and then comparing them to the capabilities of firms located in Ohio, can provide insights for business development opportunities And workforce development efforts.

The group of industries labeled *field development and supply chain* in these two tables yields the highest economic returns. This industry will generate $3.8 billion in Value Added, or Gross State Product, from 2011 to 2014, which is compared to $8.7 billion in the value of Total Output over that time period. This means that there is nearly $5 billion dollars in leakage to out-of-state sources of supply and the associated supply chains within those industries. This includes workers.

For example, the models show that the development of the Utica play will result in $68.5 million in total output of fabricated pipe in 2014 (Table 10), with $28.9 million in Value Added (Table 9). A great deal of the difference lies in the value of the raw materials needed to make pipe—taconite, scrap and coke mostly come from outside of the state and not all of the electricity required in the manufacturing process will be generated in the state. Ironically, the natural gas required to operate blast furnaces will initially come from the Gulf of Mexico, but should be locally sourced once natural gas wells in the Utica play are producing. The same observation is made with cement manufacturing: demand for cement will generate $35.6 million in Value Added (Table 9) and it is nearly three times higher in terms of Total Output ($99.0 million).

3. What are the Multipliers?

Multipliers are part of any input-output analysis of an economy and frequently enter public policy discussions about the impact of a specific economic activity on an economy. In fact, the entire economic impact analysis of the development of Ohio's Utica Shale rests on these multipliers. The challenge is that many different types of multipliers enter the analysis and the differences among them quickly become both technical and arcane. In this section two tables of multipliers (Tables 11 and 12) are presented and discussed so that readers can have an understanding of how investments in the Ohio's Utica play become multiplied both throughout the state but also in the national economy. Some of these concepts were presented in the previous section of the report and are repeated here for the reader's convenience.

Multipliers occur because money circulates within an economy. These rounds of spending get smaller as goods and services are imported into the economy (these are often referred to as "leakages" from the economy) or when money is placed into savings. Three types of spending are accounted for in an input-output model. The easiest to observe is *direct* spending, which occurs through the direct purchase of a final good or service.

The direct purchase sets off a series of orders that spiral down the supply chain of the original vendor (in the automobile industry this is the Original Equipment Manufacturer—think Honda), and of that vendor's supply chain (this would be a company that provides an important subassembly such as the seat manufacturer), in the third round tier 2 suppliers get in the act (the company that supplies the seat adjustment assemblies), ending up with tier 3 suppliers (they provide components such as the steel and electronics used in the seat adjustment assembly). The orders that flow down the supply chain are known as *indirect demand* because demand for the item is indirectly caused by the sale of the final product—back to the automobile.

The third round of multiplied spending occurs when the workers in all of these companies get their paychecks and go forth and spend. This is called *induced* spending, because while it is associated with the purchase of the final good or service, the spending takes place with a lag. Here the raft of consumer spending from home mortgages, health care, to food services takes place. For example, the purchase of a CR-V by an oil and gas service company worker gets routed to Honda's central Ohio complex and the cycle begin anew, with the engine coming from Anna, the transmission from Rusell's Point and final assembly in East Liberty).

As mentioned above, there are two sources of leakage from the economy. The first takes place when indirect or induced demand is satisfied with an imported good or service. In the case of a study of the economic impact on the state of Ohio, if the good or service comes from outside of the state's borders it is an import. Said differently, if the check used to pay for something crosses the state line, it is an import. The second source of leakage is savings because the money goes out of circulation and stops that particular round of spending. It will reenter the economy later as a loan or an investment, but that would be considered to be part of a new round of spending.

Two types of Output multipliers are displayed for Ohio in Table 11. The first is the combination of direct and indirect spending; think of this as the economic activity that is triggered directly by an order placed for the final product by a consumer along with the economic activity that is associated with the orders for parts and services that flow down the supply chain. The second type of multiplier listed in the table includes direct, indirect, and induced spending. Consumer spending by the workforce of the entire supply chain is included. Goods and services that are provided by out-of-state suppliers and out-of-state workers are included in Table 11 because it lists Total Output. The multipliers for the industries most closely associated with the development of the Utica Shale formation are in bold. These are: *drilling for oil and gas wells*, *support activities for oil and gas operations*, and *construction of other new nonresidential structures*.

The drilling industry and support activities for drilling have the highest direct and indirect multipliers listed in Table 11. The multiplier coefficient for drilling shows that each dollar spent directly in drilling activities results in another 49 cents being spent for intermediate goods and services in its supply chain. A major supplier of the drilling industry is the industry that supplies it with support services—this is where a lot of that multiplied 49 cents ends up. Every dollar spent on support activities for oil and gas operations turns around and generates another 48 cents of activity down its supply chain. The multiplier for nonresidential construction is 0.42, or 42 cents for each dollar of final demand.

These multipliers are among the largest of those listed in Table 11 because the manufacturing sector of the economy is collapsed into one line. If the industries within manufacturing were broken out many would have higher multipliers than those associated with oil. Nevertheless, oil and gas development has large multiplier effects.

It is important to observe what occurs when the induced multiplier effect is included in the analysis. The direct, indirect, and induced multiplier for drilling is 1.69, the multiplier for support activities for oil and gas operations is 1.94, and construction of nonresidential buildings is 1.91. When induced multiplier effects, or consumer spending, are included, drilling drops to the bottom third of the listed multipliers. The other two multipliers that we are interested in remain at the top of the list. How can this difference occur? It is because drilling is a "capital intensive" industry. This means that a great deal of machinery and supplies, yet a relatively small number of people, are deployed for oil and gas drilling. Even the supply chains for drilling operations are capital intensive, with two prominent exceptions: support activities and construction of nonresidential building.

The true impact of oil and gas development becomes clearer when the data in Table 12 are examined. The direct, indirect, and induced multipliers for Value Added are listed. Value Added is a much narrower construct than is Total Output. Value Added includes wages, business income, other income, and indirect business taxes of the Ohio-based operation. In other words, anything that is imported, or is purchased from another vendor and incorporated into the product or service, is not counted. That is why the multipliers are so much lower in this table than in the previous table. The last column in Table 12 is labeled Total; this is the sum of the direct, indirect, and induced effects and is conceptually equal to the last column of Table 11, except that Table 12 is for total output, while Table 11 reproduces value added.

The direct and indirect effects for value added for the oil and gas drilling industry is 0.52, meaning for every dollar's worth of contracts going into an oil and drilling operation in Ohio only 52 cents remains in the form of wages to workers from Ohio. This is the value that is added directly by the business, and indirect business taxes paid. The rest goes to other suppliers—remember the miles of pipe, and tons of sand and cement that are used and the specialized out-of-state labor that goes from oil and gas play to oil and gas play. Approximately the same results exist for the industry that will get a large volume of the contracts from the drilling companies, *support activities for oil and gas companies*. The direct and indirect multiplier for value added for this industry is 0.62. This industry is probably a bit more labor intensive and uses more local labor, but its value rests in the contracted drilling rigs and the skilled roustabouts that know how to use the rigs. As the Utica play is developed this number can increase dramatically as more rigs are localized and more local labor becomes skilled in the use and maintenance of the equipment.

Table 11. Output Multipliers for Ohio

Description	Output Multipliers	
	Direct & Indirect	Direct, Indirect, & Induced
Ag, Forestry, Fish & Hunting	1.3419	1.5797
Mining	1.2923	1.5758
Drilling oil and gas wells	**1.4901**	**1.6944**
Support activities for oil and gas operations	**1.4809**	**1.9402**
Utilities	1.2403	1.4457
Construction	1.359	1.7961
Construction of other new nonresidential structures	**1.4172**	**1.9144**
Manufacturing	1.4031	1.6411
Wholesale Trade	1.3284	1.7546
Retail trade	1.1501	1.6292
Transportation & Warehousing	1.3861	1.8126
Information	1.4172	1.7394
Finance & insurance	1.4885	1.8467
Real estate & rental	1.3091	1.4355
Professional scientific & tech services	1.3082	1.8673
Management of companies	1.3435	1.8839
Administrative & waste services	1.3156	1.8408
Educational services	1.3773	1.9244
Health & social services	1.3907	1.9364
Arts- entertainment & recreation	1.4019	1.887
Accommodation & food services	1.4038	1.8072
Other services	1.3866	1.9367
Government & non NAICs	1.0723	1.7555

4. Following the Money: How was the money spent to develop the play?

The total economic activity generated by the development of Ohio's Utica play from 2011 to 2014 is impressive: $17.4 billion. This accounts for the rounds of direct, indirect, and induced spending associated with the five categories of final demand presented at the beginning of this section: Lease bonuses and right-of-way payments; royalties; improvements to public infrastructure—roads and bridges; drilling, completion and ancillary site improvements; and the construction of midstream infrastructure. Of this amount, $8.9 billion will remain in Ohio as Value Added or Gross State Product. (Table 13) Drilling and related activities alone will generate $6.7 billion in local Value Added over this four-year time period. The development of midstream facilities should contribute another $1.9 billion in Value Added to the state of Ohio's economy.

It is important to remember that when expenditure figures are used, they should be interpreted as spending that is *associated* with a specific activity because they include direct spending on the activity itself, indirect spending through the supply chain, and spending that is induced by the wage payments made to workers in the industry and its supply chain. Some of the labor and other resources used in developing the Utica play will be new, while others will be bid into the drilling supply chain and away from other uses.

Lease bonuses, right-of-way payments and royalty payments are expected to contribute between $85 million to $88 million to Value Added each year beginning in 2012. And the total amount of money spent to upgrade public roads and bridges is expected to generate $777 million in economic activity over this four-year time period. Nearly half of all spending is either for goods and services that come from outside of Ohio or are materials that are purchased from local vendors that are outside of the oil and gas development industry (This is listed in Table 14 in the third box titled Imports and Local Intermediate Goods). Spending that is associated with imports or locally sourced intermediate goods associated with drilling account for 49.0 percent of all expenditures over the four-year period examined.

Local labor expenditures follow a similar pattern. A bit more than a third of all direct local spending is for labor, most going to drilling (24.8 percent of the total expenditures). This is followed by labor expenditures associated with midstream infrastructure development (5.9 percent), and then public road and bridge capital improvements, 2.8 percent. While these percentages may look small, the amount of spending destined for the wallets of Ohio's workers is significant. The model indicates that the four-year expenditure for Ohio-sourced workers is $6.0 billion after accounting for all of the multiplier effects. These include $119.5 million associated with the lease bonus and royalty payments targeted for Ohioans; $490 million from spending for workers associated with the public works improvements; $4.3 billion to work associated with drilling, and $1.0 billion for midstream development. It is important to note that these numbers capture payments made to the Ohioans directly employed in these activities and it also includes those Ohioans who benefit through the spending of these workers—from teachers and medical professionals to restaurant workers.

These estimates are undercounts. This is because the study team could not estimate the in-state consumer spending of the substantial number of out-of-state workers who will be brought in to work in the development of the Utica play with the data available.

The pattern that the development of the Utica Shale formation will take is evident when looking across the columns of Table 14 and examining the changes in the percent distribution of expenditures in the top box and then taking the actual dollar figure from Table 13. The first year's expenditures are dominated by spending associated with acquiring drilling rights and the early stages of infrastructure development needed to support the drilling and the distribution of the product. Over one-third of the value of Total Output in 2011 is associated with acquiring leases and rights-of-way and a bit less than one-third of the value of total output is associated with drilling activity. Leasing as a share of Total Output drops significantly in the last two years when drilling and midstream infrastructure development take center stage.

A subtle change appears in the third portion of Table 14: the share of Total Output that remains in the state increases over time. Local Spending accounts 52.7% of Total Output at the start of the development process. It then appears to stabilize at 55 percent to 56 percent in the later years.

In 2012 the distribution of activity, as measured by the share of Total Output, is expected to change dramatically, with both a jump in drilling activity, accounting for 54.8 percent of the value of Total Output, and a decline in mineral rights acquisition. Ninety-nine million dollars was given to Ohioans as bonuses associated with leasing activity in 2011. This is expected to drop by more than half in 2014, while royalty payments move in the opposite direction as wells start to come online. Drilling takes over in the second year both in terms of dollar volume and as a share of the total expenditure, reaching more than three-quarters of total expenditures in 2014. While spending for local public infrastructure, such as roads and bridges, declines as a share of total spending, the dollar volume of work explodes in 2013 and 2014.

Large sums are poised to be invested in energy resource development in Eastern Ohio. The impact of the Utica Shale development will ripple through the state's economy. In 2011 the early stages of development led to $291.6 million in increased output, $161 million in total value added, and $99.8 million in labor income. If the development path of the Utica play follows the track laid out in the model then intrastate economic activity will grow to $4.9 billion and 65,680 jobs will be supported and an additional $3.3 billion in labor income will be created for Ohioans.

Table 12. Total Value Added Multipliers for Ohio

Description	Direct Effects	Indirect Effects	Induced Effects	Total
11 Ag, Forestry, Fish & Hunting	0.3751	0.1791	0.1441	0.6984
21 Mining	0.5126	0.1692	0.1718	0.8535
Drilling oil and gas wells	**0.3006**	**0.2525**	**0.1216**	**0.6747**
Support activities for oil & gas operations	**0.3633**	**0.255**	**0.2734**	**0.8917**
22 Utilities	0.5581	0.1329	0.1243	0.8153
23 Construction	0.4529	0.2022	0.2647	0.9198
Construction of other new nonresidential structures	**0.4583**	**0.2273**	**0.296**	**0.9816**
31-33 Manufacturing	0.2712	0.2077	0.144	0.6229
42 Wholesale Trade	0.6552	0.1977	0.258	1.1109
44-45 Retail trade	0.8435	0.0915	0.29	1.225
48-49 Transportation & Warehousing	0.509	0.2144	0.2582	0.9816
51 Information	0.5072	0.2401	0.195	0.9423
52 Finance & insurance	0.5553	0.2833	0.2168	1.0554
53 Real estate & rental	0.6979	0.1843	0.0766	0.9588
54 Professional- scientific & tech services	0.6717	0.1848	0.3385	1.1951
55 Management of companies	0.6321	0.21	0.3271	1.1691
56 Administrative & waste services	0.6365	0.1841	0.318	1.1385
61 Educational services	0.5754	0.2304	0.3311	1.1369
62 Health & social services	0.5641	0.2342	0.3303	1.1286
71 Arts- entertainment & recreation	0.5714	0.2433	0.2936	1.1083
72 Accommodation & food services	0.4981	0.2374	0.2442	0.9798
81 Other services	0.5721	0.2273	0.3332	1.1325
92 Government & non NAICs	0.8996	0.041	0.4134	1.354

Table 13. Economic Activity Generated at the Different Stages of Utica Shale Development: Leases and Royalties, Roads and Bridges, Drilling, and Midstream Infrastructure in 2012 dollars

	2011	2012	2013	2014	Total
Total Output					
Total	**$291,581,483**	**$1,668,109,590**	**$5,825,883,115**	**$9,648,887,930**	**$17,434,462,118**
Leases & Rights of way	$98,793,226	$77,195,293	$64,330,730	$34,928,687	$275,247,936
Royalty Payments	$97,975	$6,146,503	$24,842,792	$51,539,247	$82,626,517
Roads & Bridges	$37,197,958	$167,367,248	$508,643,594	$662,478,878	$1,375,687,678
Drilling & related	$94,747,875	$914,363,416	$4,133,638,504	$7,527,815,002	$12,670,564,797
Midstream	$60,744,449	$503,037,130	$1,094,427,495	$1,372,126,116	$3,030,335,190
Value Added					
Total	**$162,033,963**	**$879,295,230**	**$2,981,907,909**	**$4,861,342,962**	**$8,884,580,064**
Leases & Rights of way	$57,797,854	$45,162,229	$37,635,962	$20,434,631	$161,030,676
Royalty Payments	$57,319	$3,595,942	$14,533,993	$30,152,451	$48,339,705
Roads & Bridges	$19,265,483	$86,746,439	$263,826,683	$343,878,255	$713,716,860
Drilling & related	$49,985,824	$456,276,484	$2,038,451,994	$3,679,876,878	$6,224,591,180
Midstream	$34,927,483	$287,514,136	$627,459,277	$787,000,747	$1,736,901,643
Imports and Local Intermediate Goods (Total Output - Value Added)					
Total	**$129,547,520**	**$788,814,360**	**$2,843,975,206**	**$4,787,544,968**	**$8,549,882,054**
Leases & Rights of way	$40,995,372	$32,033,064	$26,694,768	$14,494,056	$114,217,260
Royalty Payments	$40,656	$2,550,561	$10,308,799	$21,386,796	$34,286,812
Roads & Bridges	$17,932,475	$80,620,809	$244,816,911	$318,600,623	$661,970,818
Drilling & related	$44,762,051	$458,086,932	$2,095,186,510	$3,847,938,124	$6,445,973,617
Midstream	$25,816,966	$215,522,994	$466,968,218	$585,125,369	$1,293,433,547
Local Spending from All Sources					
Total	**$153,638,612**	**$985,198,077**	**$3,260,496,884**	**$5,326,765,064**	**$9,726,098,637**
Value Added Less Labor	$62,273,232	$349,139,944	$1,009,923,273	$1,550,756,964	$3,029,833,948
Labor Income	$99,760,731	$571,721,573	$1,995,086,605	$3,300,868,178	$5,967,437,087
State & Local Taxes	$16,523,312	$83,807,565	$271,713,176	$483,950,001	$855,994,054

Table 13. (Continued) Economic Activity Generated at the Different Stages of Utica Shale Development: Leases and Royalties, Roads and Bridges, Drilling, and Midstream Infrastructure in 2012 dollars

	2011	2012	2013	2014	Total
Lease Bonuses and Right-of-way Payments (4% spending)					
Total Local Direct Spending	**$39,437,639**	**$30,815,881**	**$25,680,427**	**$63,943,314**	**$159,877,261**
Value added Less Labor	$24,918,663	$19,471,005	$16,226,170	$8,810,079	$69,425,917
Labor Income	$32,879,191	$25,691,224	$21,409,792	$11,624,552	$91,604,759
State & Local Taxes	$6,558,448	$5,124,657	$4,270,635	$52,318,762	$68,272,502
Royalty Payments (4% spending)					
Total Local Direct Spending	**$63,823**	**$45,570,269**	**$39,285,166**	**$23,856,095**	**$108,775,353**
Value Added Less Labor	$24,712	$43,116,622	$29,368,078	$3,281,949	$133,531,896
Labor Income	$32,607	$2,045,607	$8,267,884	$17,152,682	$27,498,780
State & Local Taxes	$6,504	$408,040	$1,649,204	$3,421,464	$5,485,212
Capital Improvements to Public Roads and Bridges					
Total Local Direct Spending	**$20,963,789**	**$94,408,780**	**$287,177,918**	**$374,377,173**	**$776,927,660**
Value Added Less Labor	$5,996,867	$27,067,285	$82,521,794	$107,825,097	$223,411,043
Labor Income	$13,268,616	$59,679,154	$181,304,889	$236,053,158	$490,305,817
State & Local Taxes	$1,698,306	$7,662,341	$23,351,235	$30,498,918	$63,210,800
Construction of Drill Pads, Wells, and Related Infrastructure					
Total Local Direct Spending	**$54,338,156**	**$495,316,966**	**$2,211,438,367**	**$3,990,516,122**	**$6,751,609,611**
Value Added Less Labor	$16,949,440	$143,616,443	$626,507,938	$1,110,744,289	$1,897,818,110
Labor Income	$33,036,384	$312,660,041	$1,411,944,056	$2,569,132,589	$4,326,773,070
State & Local Taxes	$4,352,332	$39,040,482	$172,986,373	$310,639,244	$527,018,431
Midstream Infrastructure					
Total Local Direct Spending	**$38,835,205**	**$319,086,181**	**$696,915,006**	**$874,072,360**	**$1,928,908,752**
Value Added Less Labor	$14,383,550	$115,868,589	$255,299,293	$320,095,550	$705,646,982
Labor Income	$20,543,933	$171,645,547	$372,159,984	$466,905,197	$1,031,254,661
State & Local Taxes	$3,907,722	$31,572,045	$69,455,729	$87,071,613	$192,007,109

Table 14. Percent Distribution of the Economic Activity Generated at the Different Stages of Utica Development

	2011	2012	2013	2014	Total
Total Output					
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Leases & Rights of way	33.9%	4.6%	1.1%	0.4%	1.6%
Royalty Payments	0.0%	0.4%	0.4%	0.5%	0.5%
Roads & Bridges	12.8%	10.0%	8.7%	6.9%	7.9%
Drilling & related	32.5%	54.8%	71.0%	78.0%	72.7%
Midstream	20.8%	30.2%	18.8%	14.2%	17.4%
Value Added					
Total	55.6%	52.7%	51.2%	50.4%	51.0%
Leases & Rights of way	19.8%	2.7%	0.6%	0.2%	0.9%
Royalty Payments	0.0%	0.2%	0.2%	0.3%	0.3%
Roads & Bridges	6.6%	5.2%	4.5%	3.6%	4.1%
Drilling & related	17.1%	27.4%	35.0%	38.1%	35.7%
Midstream	12.0%	17.2%	10.8%	8.2%	10.0%
Imports and Local Intermediate Goods (Total Output - Value Added)					
Total	44.4%	47.3%	48.8%	49.6%	49.0%
Leases & Rights of way	14.1%	1.9%	0.5%	0.2%	0.7%
Royalty Payments	0.0%	0.2%	0.2%	0.2%	0.2%
Roads & Bridges	6.2%	4.8%	4.2%	3.3%	3.8%
Drilling & related	15.4%	27.5%	36.0%	39.9%	37.0%
Midstream	8.9%	12.9%	8.0%	6.1%	7.4%
Local Spending from All Sources					
Total	52.7%	59.1%	56.0%	55.2%	55.8%
Value Added Less Labor	21.4%	20.9%	17.3%	16.1%	17.4%
Labor Income	34.2%	34.3%	34.2%	34.2%	34.2%
State & Local Taxes	5.7%	5.0%	4.7%	5.0%	4.9%

Table 14. Percent Distribution of the Economic Activity Generated at the Different Stages of Utica Development

Lease Bonuses and Right-of-way Payments (4% spending)					
Total Local Direct Spending	13.5%	1.8%	0.4%	0.7%	0.9%
Value added Less Labor	8.5%	1.2%	0.3%	0.1%	0.4%
Labor Income	11.3%	1.5%	0.4%	0.1%	0.5%
State & Local Taxes	2.2%	0.3%	0.1%	0.5%	0.4%
Royalty Payments (4% spending)					
Total Local Direct Spending	0.0%	2.7%	0.7%	0.2%	0.6%
Value Added Less Labor	0.0%	2.6%	0.5%	0.0%	0.8%
Labor Income	0.0%	0.1%	0.1%	0.2%	0.2%
State & Local Taxes	0.0%	0.0%	0.0%	0.0%	0.0%
Capital Improvements to Public Roads and Bridges					
Total Local Direct Spending	7.2%	5.7%	4.9%	3.9%	4.5%
Value Added Less Labor	2.1%	1.6%	1.4%	1.1%	1.3%
Labor Income	4.6%	3.6%	3.1%	2.4%	2.8%
State & Local Taxes	0.6%	0.5%	0.4%	0.3%	0.4%
Construction of Drill Pads, Wells, and Related Infrastructure					
Total Local Direct Spending	18.6%	29.7%	38.0%	41.4%	38.7%
Value Added Less Labor	5.8%	8.6%	10.8%	11.5%	10.9%
Labor Income	11.3%	18.7%	24.2%	26.6%	24.8%
State & Local Taxes	1.5%	2.3%	3.0%	3.2%	3.0%
Midstream Infrastructure					
Total Local Direct Spending	13.3%	19.1%	12.0%	9.1%	11.1%
Value Added Less Labor	4.9%	6.9%	4.4%	3.3%	4.0%
Labor Income	7.0%	10.3%	6.4%	4.8%	5.9%
State & Local Taxes	1.3%	1.9%	1.2%	0.9%	1.1%

F. Tax Assumptions Made and Estimations of Taxes

IMPLAN calculates federal, state and local taxes generated by the economic activity and jobs supported by the expenditures modeled. However certain areas of tax revenue will be directly implicated by shale activity. Those areas are modeled separately herein as a result of their particular circumstances. They are, however, not additive to the tax revenue projected to IMPLAN. There may be some overlap in the tax models. While it is likely that IMPLAN may underestimate taxes specific to the oil and gas industry, there is no way to know if it will affect the overall likely tax revenue projected without changing the model parameters, which is beyond the scope of this Study.

Two forms of taxes are directly impacted by shale development activity. These are (1) severance taxes and (2) ad valorem (property) taxes.[84] These each require some discussion herein to understand what assumptions have been made in order to calculate impacts and why, and how these assumptions affect the calculations made.

1. Severance Taxes

Severance taxes are imposed by the State of Ohio on natural gas and oil production.[85] The tax is imposed on the volume of production at the well-head (i.e. the point at which the hydrocarbons are "severed" from the earth). Natural gas is taxed at a rate of $0.025/MCF. Oil is taxed at a rate of $0.10/bbl. Historically, in Ohio, production has been in the form of either oil or natural gas because natural gas production has not been rich enough in liquids to process the gas. Currently in Ohio natural gas liquids are not taxed separately.[86] Instead, production at the well in liquid form is taxed as oil, and in gaseous form, as natural gas. Liquids held in suspension within the natural gas are included as part of the natural gas, and make of a portion of the volume taxed at that rate.

Beginning on July 1, 2010, an oil and gas regulatory cost recovery assessment was imposed on production.[87] An owner of the production must pay the assessment in the same manner as is required for filing a return under the severance tax law. The tax is assessed at a rate of $0.10/bbl of oil and $0.005/MCF of natural gas, thereby making the total tax $0.20/bbl and $0.03/MCF.

While it is speculative at this early date in the development of shale in Ohio to estimate what portions of hydrocarbons will be produced as liquids in the field, and what portions will be produced as natural gas, the Study Team used those figures set forth in Table 2 in Section II, *supra*., to calculate severance taxes. The calculations are set forth below.

2. Ad Valorem Taxes

[84] There are other taxes that may be directly impacted by the shale development, but those impacts are either small, or the impact too uncertain to be modeled separately for analysis. Those include, among others, conveyance taxes ("fee simple" transfer of mineral rights are rare), natural gas distribution taxes, public utility taxes, other property taxes besides oil and gas reservoirs, and sales taxes. It is noteworthy that sales of oil and gas exploration and production equipment falls under the direct extraction exemption; *see* ORC 5739.02 (B) (42) (a); and the same is true for plant processing equipment; see Ohio Administrative Code Rule 5703-9-21). Purchases to support temporary roads or haulways built for site preparation also appears to be exempt from sales taxes pursuant to Ohio Administrative Code Rule 5703-9-22(C). However purchases of gravel and other materials in support of public road improvements are apparently exempt from sales taxes. One tax is likely to see a significant increase will be the Commercial Activity Tax. The determination of the disposition of hydrocarbons as having been sold inside or outside of Ohio is likely to have a significant affect on the CAT revenues in Ohio as a result of shale development.

[85] Ninety percent of the severance taxes are earmarked for the State Oil and Gas Well Fund, which deals with environmental issues such as orphaned wells. Ten percent of the tax is earmarked to support the Ohio Geological Mapping Survey. Ohio Department of Taxation, http://tax.ohio.gov/divisions/excise/severance/index.stm.

[86] With the advent of natural gas liquids becoming a significant part of production in Ohio, the State may review how severance taxes are paid on natural gas liquids. *See* "Kasich seeks taxes on oil, gas drilling," *The Columbus Dispatch*, January 18, 2012, http://www.dispatch.com/content/stories/business/2012/01/18/kasich-to-propose-fee-tax-on-oil-gas-industry.html. Producing companies meter oil and gas separately, and severance taxes are paid based upon these amounts. However the heavier natural gas liquids may physically separate from the gas stream in the field after being subjected to atmospheric pressures and temperatures, and may not get metered, depending upon how and where the producer does its gas metering. If they are not metered, those liquids may avoid taxation. Some states have resolved this problem by requiring a separate metering for such liquids under the category of "condensate."

[87] Ohio Revised Code 1509.50(A).

Ad valorem (meaning "based on value") taxes are property taxes that assess a tax based upon the value of hydrocarbon reserves in the ground. Primary responsibility in assessing ad valorem taxes rests with the auditors of the 88 counties in Ohio.[88] The tax revenue is paid to the county taxing district political subdivision within which the oil and gas properties reside. Accordingly, this tax will inure principally to benefit of eastern Ohio, where the shale development activity is greatest.

Value is not created until drilling and initial production first proves up the existence of the reserves, and value diminishes each year thereafter as reserves are depleted from the reservoir. Projecting the value of the reserves in the ground can be tricky, insofar as it requires speculation not only as to future pricing of hydrocarbons, but also future production from the reservoir. Accordingly, the value of reserves in the ground is based upon a formula the State of Ohio has negotiated with the oil and gas industry designed to reflect both projected pricing and anticipated production decline curves. That formula to determine the reservoir value is as follows:

Formula for calculating reservoir value for ad valorem taxes

Natural Gas:

[First year Average Daily Production] x 0.575 x $450/MCF = reservoir value

[Second year Average Daily Production] x 0.500 x $450/MCF = reservoir value

[Same formula for ensuing years]

Oil:

[First year Average Daily Production] x 0.575 x $4640/bbl = reservoir value

[Second year Average Daily Production] x 0.500 x $46400/bbl = reservoir value

[Same formula for ensuing years]

"Average Daily Production" is determined by measuring the production generated in the previous year and dividing that number by the total number of production days for that year. As a result of using measurements from the prior year's production (which is only reported once a year), ad valorem taxes are delayed one to two years from the date of production.

The reservoir value is then multiplied by the taxing district's local "effective tax rate" to determine the tax due.[89] The effective tax rate varies from tax district to tax district both within and between counties, and range from as low as 35.5 mills (3.55%) in Lawrence County to as high as 84.05 mills (8.41%) in Montgomery Count.[90] Statewide, the average effective tax rate is 67.5 mills (6.75%). However the counties involved in the shale development tend to be more rural and located in Eastern Ohio, which both tend to have lower effective rates. Accordingly, for purposes of this study, a more conservative average of 50 mills (5.00%) was used. This rate is similar to that used by other studies.[91]

For purposes of estimating ad valorem taxes, the Study Team assumed a reservoir value based upon the liquids and natural gas volumes per well at the well as set forth in Table 2, since this would more accurately

[88] Ohio Department of Taxation, http://tax.ohio.gov/divisions/real_property/index.stm.

[89] The ad valorem tax is shared by the county and local subdivisions contained therein. Those local subdivisions may cause additional variation in the effective rates than set forth herein.

[90] Mineral properties are considered "Class II" real property. Class I real property is agricultural and residential property; Class II is everything else. A listing of the net tax rates by county can be found at http://tax.ohio.gov/divisions/tax_analysis/tax_data_series/tangible_personal_property/pd23/documents/PD23CY10.pdf .

[91] Kleinhenz assumed a rate of 5.1% to calculate ad valorem taxes (Kleinhenz and Associates, 2011).

represent reporting of production by the producing companies, times the number of wells drilled each year. Tax revenue was estimated by the following formula:

Reservoir Value x Number of Wells Drilled x Average Effective Rate

3. Summary of Taxes

A summary of the tax revenue anticipated as a result of Utica Shale development in Ohio through 2014 is set forth in Table 15 below. A one-year delay in payment is assumed for both the ad valorem and the severance taxes, based upon the reporting requirements for each. Of the taxes collected in 2012, state and local governments will receive $93,717 as ad valorem taxes and $46,500 as severance taxes. By 2014, these numbers will increase to $17.5 million in ad valorem taxes and $8.9 in severance taxes and will account for 6.3% and 3.7% of the total taxes generated through development of the Utica Shale, respectively.

Table 15. Total State and Local Tax Impact, 2011 - 2014, in 2012 dollars

	2011	2012	2013	2014	2015
Total State and Local Taxes	$16,522,865	$73,422,148	$271,539,607	$433,528,922	N/A
Ad Valorem Taxes	$0	$146,460	$5,946,389	$27,388,701	$56,471,821
Severance Taxes	$0	$84,600	$3,442,500	$16,133,220	$34,109,640

Note: The total state and local taxes were calculated by IMPLAN. Ad Valorem and Severance Taxes were calculated based on the projected production volumes and the current state taxation rates. Ad Valorem and severance tax collections are delayed by one to two years from the date of production. For these calculations, it was assumed both would be delayed one year, and revenue is calculated to 2015.

VII. Impacts of Shale Development on Downstream Industries

Ohio´s portion of the Utica Shale formation will supply an array of hydrocarbons, not just the methane used to heat homes, generate electricity, and so forth. Oil is expected to be extracted in significant quantities.[92] In addition, the Utica play will be an important source of ethane and other natural gas liquids (NGLs), which comprise the feedstock for the chemical and polymers sector.[93] All else remaining the same, increased local supplies of fossil fuels ought to reduce what Ohio industry pays for energy and other inputs – mainly because some of the expense of bringing in fossil fuels from other places can be avoided (see section IV, supra).

[92] "Producers, Refiners Sniff Opportunity in Rust Belt Oil Shale," *Wall Street Journal*, August 16, 2011, http://online.wsj.com/article/0,,SB100014240531119033929045765126713608993 38,00.html.

[93] American Chemistry Council, "Shale Gas and New Petrochemicals Investment in Ohio," July 2011.

Manufacturing Example: Gorman Rupp

A public corporation founded in 1933, Gorman Rupp is headquartered in Mansfield, Ohio and manufactures pumps and related equipment for a wide variety of markets: wastewater treatment, industrial, construction, petroleum, etc. Where shale formations deep underground are being exploited, the company's products are used in various ways:

- pumping water from streams, wells, and other sources to sites where hydraulic fracturing takes place;
- mixing fracturing fluid, which is made up mainly of fresh water but also contains proppants (usually sand) as well as chemicals in small concentrations; and
- pumping flowback and produced water from wells to settling ponds and storage tanks.

Approximately 500 individuals work at the Mansfield Division, where hourly wages for new employees range from $12 to $13 for unskilled positions to $20 to $21 for machinists.

Approximately two years ago, Gorman Rupp expanded its manufacturing facility at its Mansfield Division to 850,000 square feet, which has increased the Division's productive capacity by 30 to 50 percent. Expectations of new business related to shale development did not necessarily drive this investment. Nevertheless, utilization of productive capacity has been sustained at high levels since the expansion was completed, thanks largely to gas and oil drilling in the region. At present, the Mansfield Division is adding manufacturing equipment in order to supply its customers.

Demand for pumps, which are powered mainly by diesel engines, is expected to remain strong as drilling into the Marcellus formation of Pennsylvania and neighboring states continues and as exploitation of the Utica deposit ramps up in eastern Ohio. The U.S. Environmental Protection Agency recently promulgated new rules for diesel emissions. This has slowed the delivery of engines from John Deere and other providers, which in turn has constrained pump production.

Cheaper hydrocarbons are an obvious benefit for industries that use a lot of energy. However, the impacts of extracting oil and gas from the Utica formation on industrial output, investment, and employment are not as straightforward as what one might expect. This is because energy consumers outside the state might value Ohio's resources more highly than anyone else does, including Ohio manufacturers, in which case they would bid away those resources. This possibility is reflected in the comments that follow about oil refining, the fertilizer industry, and chemical and polymer sector.

A. Oil Refining

There are four refineries in Ohio that convert crude petroleum into gasoline and other derivatives. Two are in Toledo: one owned by BP-Husky, which employs 700 to 800 workers full-time and 400 to 600 part-time, as well as the Toledo Refining Company, which is of similar size and was formerly owned by Sunoco. BP-Husky also has a facility in Lima that has 300 to 400 full-time employees and a part-time labor force of 200 or so. The fourth refinery, in Canton, is of comparable size and is owned by Marathon. Marathon also has a large plant on the Ohio River in Cattlesburg, Kentucky, which supplies Columbus and the surrounding region with gasoline via the Cardinal Pipeline.[94]

According to price-data provided by the Energy Information Agency (EIA), crude oil is relatively cheap in Ohio. Moreover, hydrocarbon production from the Utica and other formations in the state ought to help keep local prices below prices in coastal regions (section IV). But if Ohio's refiners are to be supplied entirely with crude petroleum extracted inside the state's borders, new pipelines will have to be constructed. For example, there is no conduit at present connecting southeastern Ohio, where a large share of shale development is now taking place, with the aforementioned facilities in Toledo and Lima. Additional pipeline capacity would be needed if existing refineries are expanded or if new refineries are constructed in Ohio, in response to substantial increases in crude oil output from the Utica and other formations. However, expansion along these lines will depend on various factors, not just the availability of crude petroleum. One of these is the regulatory environment, which is not always accommodating to refinery construction. Another factor is inter-regional competition over the state's hydrocarbons.

The intensity of this competition was put in sharp relief by an August 2011 article in the *Wall Street Journal* about the benefits that petroleum refineries in the northeastern United States anticipate from fossil fuel extraction from the Utica. One such benefit has to do with helping refineries in New Jersey and neighboring states overcome a pricing disadvantage they currently face in the national market. As emphasized in the article, increased production in the so-called mid-continent area – which includes a pair of oil-rich shale formations (the Bakken in North Dakota and the Eagle Ford in southern Texas) – has driven down prices at the center for gathering and storage located at Cushing, Oklahoma. Refineries along the Gulf Coast and other parts of the country within reach of Cushing use up all the crude petroleum passing through the hub. As a result, other facilities, including those in northeastern states, must rely on imports that are valued on the basis of the Brent international reference price. As a rule, this price exceeds the value at which crude oil changes hands in Cushing – by as much as $24/barrel in 2011.[95]

Quoting an industry analyst, the authors of the article go on to point out that northeastern refineries would be willing to pay more than the Cushing price (plus charges for transportation) for petroleum extracted from the Utica for the sake of diminishing their dependence on imports valued according to the Brent price. Access to Utica oil might even prevent other companies from following the lead of Valero, which has ended its refining operations in the region.[96]

There are no guarantees that refineries in the northeastern United States will outbid all other competitors for crude oil extracted in Ohio. Industry sources from inside the state are confident that the state's fossil fuels will be processed nearer by, in large refineries alongside the Ohio River for example. But likewise, it cannot be taken for granted that those same fossil fuels will be refined inside the state, thereby adding to economic activity and creating jobs here. As explained above, specific outcomes will hinge on pricing differentials, the expense of building pipelines (and perhaps adding to refining capacity), as well as the regulatory environment.

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[94] Terry Fleming, Ohio Petroleum Council, personal communication, 21 November 2011.

[95] *Wall Street Journal*, August 16, 2011.

[96] *Wall Street Journal*, August 16, 2011.

B. Nitrogen Fertilizer Production

Just as increased extraction of hydrocarbons in Ohio would reduce the expense of delivering crude oil to refineries in Toledo, Lima, and Canton, industries that use natural gas intensively stand to benefit. A case in point is a plant in Lima where PotashCorp produces nitrogen fertilizer (i.e., ammonia) with a workforce made up of 140 of the company's own employees plus 90 individuals hired as contractors.[97]

Manufacturing nitrogen fertilizer is capital intensive and requires methane both as a source of energy and as a feedstock. Currently, expenditures on natural gas comprise 70 to 85 percent of ammonia production costs. Moreover, the U.S. nitrogen fertilizer industry is internationally competitive largely due to the prices for natural gas that now prevail in this country (Section IV). This represents a stark contrast from the situation no more than ten years ago, when high U.S. prices for gas drove ammonia production costs here above prevailing prices in global markets for nitrogen fertilizer.

When gas prices rise in this country and remain at elevated levels, the U.S. nitrogen fertilizer industry undergoes considerable stress. For example, approximately 20 ammonia plants were shuttered during the early 2000s, when natural gas was more expensive than it is today. In contrast, maintaining reliable access to competitively-priced gas from domestic sources, including shale formations, causes production facilities to fall into the category of "core assets." Such facilities are internationally competitive and, unlike marginal plants, are not apt to be shuttered in response to fluctuations in the marketplace. In addition, investment in new core assets could well happen in the United States if the current relationship between ammonia and natural gas prices is sustained.

With respect to any individual plant, access to competitively price methane depends in part of pipelines and related infrastructure, needed to deliver gas to the specific plant. A plant's viability depends on taxes, fees, and the regulatory environment as well.

C. The Chemical and Polymer Sector

Since liquid hydrocarbons will be extracted in large volumes from the Utica play, downward pressure will be exerted on NGL prices in and around Ohio (section IV). This is expected to benefit the chemical industry, which among other things converts ethane into the ethylene used to make polyethylene for packaging, polyvinyl chlorides (PVCs) contained in siding, pipes, and other products, and many other goods. Also receiving a boost will be polymer firms, which make use of large organic molecules with repeating chemical structure that have a wide range of properties. The output of these firms includes plastics of various sorts, such as liquid crystals and sealants, as well as compounds used in paint and PVCs. Polymer products tend to be light and inexpensive. As a result, they have replaced goods made from other materials in a number of industrial applications, such as the manufacture of car windows. This is an important reason why the industry is expanding around the world at about double the rate of overall economic growth.

Ohio is a leading manufacturer of polymer products, not just in the United States but for the world as a whole. As of March 2011, there were approximately 2,440 firms in the industry, serving automobile companies, health-care providers, and many other customers. Of these firms, 2,160 were small, with fewer than 100 employees each. There were also 273 businesses with a workforce of 100 to 999 individuals as well as nine with at least 1,000 employs. The total number of Ohioans working in the

[97] Audrea Hill, PotashCorp, personal communication, January 12, 2012.

industry is estimated to be 130,000 and median wages are above state and national averages.[98]

The competitive edge of Ohio's polymer firms rests largely on a full "pipeline" of new products and improved processes. This pipeline is kept full by research and development, undertaken by private companies as well as Case Western Reserve University, the University of Akron, Ohio State University, and other educational institutions. Polymer-related research also has been supported by the state government – through the Third Frontier Program, for example.[99]

One positive impact of shale development for the chemical and polymer sector relates to feedstock costs. For 25 percent of all polymer firms, expenditures on chemical inputs (e.g., resins) represent more than 44 percent of sales revenues. The same category of expenditures accounts for less than 27 percent of revenues for another 25 percent of the industry's firms, which means that feedstock costs comprise 27 percent to 44 percent of revenues for the middle two quartiles of the distribution.[100] Obviously, lower prices for ethane and its derivatives enhance the profitability of any enterprise engaged in polymer production.

Another benefit has to do with the cost of electricity and other energy inputs. At present, spending on these inputs represents 3.8 percent to 4.6 percent of total value added (equal to sales revenues minus expenditures on materials and purchased components and other outside direct costs) for the middle two quartiles of all polymer firms.[101] This category of expenditures will decline significantly if shale development accelerates the switch to gas-fired generators, which are a highly efficient source of electricity. The impact on profits would be sizable for manufacturers of molded polymer products, which use energy intensively.

A report issued in March 2011 by the American Chemistry Council highlights a pair of reasons why the extraction of ethane and other NGLs from the Utica and other shale deposits will favor the chemical and polymer sector in this country over foreign competitors. First, transoceanic shipment costs are sufficiently high to preempt NGL exports. Second, the decoupling of oil and natural gas markets (section IV) has lowered costs of production in the United States, where ethane is the main feedstock, relative to costs in Europe and other places where naptha (a petroleum derivative) is the primary feedstock for the chemical industry.[102]

As explained in section IV, the gap between gas prices in the United States and prices in other parts of the world – a gap that is sizable at present, as highlighted in the ACC report – could narrow in the future, particularly if this country becomes an exporter of LNG. However, costs of liquefaction and transportation are high enough to insure the chemical industry's competitiveness in LNG-exporting nations.

A large share of the U.S. chemical industry's capacity is concentrated along the Gulf Coast, which has sizable gas reserves, water resources, and major port facilities. Due to these same advantages, chemical production is expected to increase in the Gulf Coast because of shale development.

[98] Barber, Farooq, and the Battelle Technology Partnership (2011), *2011 Update: Ohio's Polymer Strategic Opportunity Roadmap*.

[99] Barber, Farooq, and the Battelle Technology Partnership (2011).

[100] Jeff Mengel, Plante Moran, personal communication, January 24, 2012.

[101] Jeff Mengel, Plante Moran, personal communication, January 24, 2012.

[102] Swift, Moore, and Sanchez (2011), *Shale Gas and New Petrochemicals Investment: Benefits for the Economy, Jobs, and U.S. Manufacturing*, p. 12.

Manufacturing Example: Pioneer Pipe

Part of the Pioneer Group of companies, Pioneer Pipe, Inc. is headquartered in Marietta and is one of the Midwest's leading firms undertaking construction, maintenance, and fabrication projects of all sizes. The company, which has been in business for more than 30 years, performs more than $85 million of work annually. It employs more than 500 people at three fabrication shops (with a combined area of over 150,000 square feet of space under roof) in Marietta and at industrial and commercial job-sites throughout the region.

Pioneer specializes in various kinds of projects of direct relevance to the oil and gas industry, including general, mechanical, and electrical construction, pipe fabrication and installation, steel fabrication and erection, as well as modular fabrication and assembly. Examples of work done for the industry are the fabrication and assembly of all types of piping, structural steel, pipe supports/hangers, pressure vessels, pig launchers/receivers, compressor station pipe skids, well head covers, equipment units, and miscellaneous steel items.

Up until two years ago, projects for the oil and gas industry were the source of little more than 5 percent of Pioneer's business. However, this share has gone up substantially, mainly due to exploitation of the Marcellus formation in western Pennsylvania, northern West Virginia, and adjacent areas. Work in the oil and gas sector, which currently accounts for approximately one-fifth of the company's business, could double during the next four to five years, as Marcellus and Utica deposits are developed in Ohio.

Recent increases in oil- and gas-related work have led Pioneer to create 40 additional jobs. If the company's business in the oil and gas sector is double its current size five years from now, as many as 80 to 100 more employees could be hired. Their earnings would be appreciably above average rates of compensation in southeastern Ohio.

Some of the feedstock required for this expansion will probably come from the Marcellus and Utica. This is indicated by the recent announcement by Enterprise Products of its plans to construct an ethane-pipeline 1,230 miles from Pennsylvania, across Ohio, Indiana, and Illinois, and finally to Cape Girardeau, Missouri, where a connection will be made to an existing network serving refineries and other facilities along the Gulf Coast.[103]

However, no one expects all the NGLs extracted from Ohio and neighboring states to be shipped to other parts of the United States. Ohio is centrally located vis-à-vis major markets in the Midwest and the northeastern United States. Hydrologic resources in Ohio are more than sufficient to satisfy the chemical industry's needs for process-water. In addition, major markets in the Midwest and the northeastern United States are within easy reach, via navigable waterways as well as other modes of transportation. Moreover, the "double-stacked" rail line that Norfolk Southern has completed between Rickenbacker Air Field, in Columbus, and the seaport in Portsmouth, Virginia has created export opportunities. In particular, goods produced in Ohio, including chemicals, are now about one day closer to European

[103] "Enterprise Products Proposes Ohio Pipeline to Move Shale Ethane," *Business First*, November 4, 2011, http://www.bizjournals.com/columbus/blog/2011/11/enterprise-products-proposes-ohio.html.

customers than goods originating along the Gulf Coast.[104]

The excellent chances that at least some of the NGLs extracted from the Utica and Marcellus will be processed and converted into finished products in and around Ohio are indicated by internal discussions within midstream companies to build infrastructure to support the storage and transportation of liquids. Another indicator of the beneficial consequences of shale development for the chemical and polymer sector is the active discussion of new cracking plants – large facilities where heat, catalysts, and solvents are applied to break complex organic molecules – in the region.[105]

VIII. Future Considerations: Challenges for the Natural Gas Industry

Needless to say, cheap natural gas is hardly the best of news for oil and gas producing companies, which ironically enough are responsible for low prices by virtue of having invented and applied better techniques for exploration and extraction. Adding to their challenges is the sizable investment required to develop unconventional resources, especially shale. Whereas one million dollars or so must be spent to install a vertical well in Ohio, the up-front cost of a horizontal-drilling operation can be as high as $10 million.[106] Running expenses after a well is completed (i.e., ready for production) are also considerable.

Squeezed between low prices and up-front expenses, the natural gas industry also faces greater scrutiny from environmental regulators and organizations, not to mention the general public, as it taps into shale formations. To date there has been little evidence that hydraulic fracturing thousands of feet underground can damage fresh water aquifers within a few hundred feet of the land surface. As a federal panel observed: "The risk of fracturing fluid leakage into drinking water sources through fractures made in deep shale reservoirs is remote."[107] However, hydrologic resources are adversely affected by surface spills of produced water, which comprises a mixture of fracking fluid[108] and the brine that comes out of shale along with gas and oil. Also, the concrete that encases wells is occasionally flawed, which creates the possibility of a direct release of produced water or hydrocarbons into aquifers. The odds of casing-failure may be small – smaller than the chances of a surface spill, for instance – yet the resulting costs can be much larger, in terms of obtaining water from other sources if aquifers have been polluted.

Facing a combination of low prices and sizable costs, including the expense of complying with regulations meant to contain environmental risks, natural gas producers are keen to expand into new markets. One option is to produce more electricity in gas-fired generators, as can be done with great efficiency.[109] Another is to run more fleet vehicles – for example, buses and mail trucks, which can return regularly to central facilities for refueling – on natural gas.

[104] Arthur Arnold, Ohio Railroad Association, personal communication, January 24, 2012.
[105] American Chemistry Council, "Shale Gas and New Petrochemicals Investment in Ohio," July 2011.
[106] Kleinhenz and Associates (2011).
[107] Secretary of Energy's Advisory Board (2011), *Ninety-Day Report*.
[108] Primarily aqueous, fracking fluid also contains "propants" such as sand, needed to keep open the small cracks created by fracturing and through which gas and oil flow out, as well as chemicals in modest concentrations, many of which are not toxic but some of which are.
[109] Ridley (2011), *The shale gas shock*.

Other market opportunities exist beyond the U.S. border. Except for coal, this country has not been a net exporter of hydrocarbons for years. Yet foreign sales could outpace imports in the not-too-distant future if the shale gas industry continues to expand rapidly and if investments needed for the production of liquefied natural gas (LNG) are made.

For companies that are highly specialized in the production of natural gas, however, the most promising adaptation to low prices is the diversification of output. The drive for diversification explains their presence in the Eagle Ford play of southern Texas. This formation yields ethane and other natural gas liquids (NGLs), which the chemical industry uses as a feed-stock, and crude petroleum in addition to "dry" gas (i.e., methane), which is suitable for heating homes and powering generators. Likewise, the interest of energy companies is substantial in the Bakken formation of western North Dakota, which is an important source of oil, as well as the portion of the Utica formation that lies under the eastern third of Ohio, which is expected to yield dry gas, NGLs, and petroleum.

Manufacturing Example: V&M STAR, a subsidiary of Vallourec

The oil and gas industry uses large quantities of steel – for pipelines, in the construction of drilling rigs, etc. The demand for seamless tubular products is especially strong where horizontal drilling is required for the exploitation of shale formations, as is the case with the Marcellus play of Pennsylvania and neighboring states as well as the Utica play of eastern Ohio.

In addition to enhancing the demand for seamless pipes and other steel products, shale development has lowered production costs. This is because that development has driven down U.S. prices of natural gas, which is the main source of energy for foundries and other plants where steel is forged and fabricated.

Due to demand growth and cheaper natural gas, productive capacity in the steel industry is being expanded and upgraded in and around Ohio. Examples of this investment include the $95 million going into U.S. Steel's tubular plant in Lorain, Ohio and the $50 million that Timken is spending on facilities located in Canton. But the largest investment is being made by Vallourec, which is a global company specializing in premium tubular solutions primarily for customers in the energy sector. In 2002, that firm acquired a plant in Youngstown, which was built in the early 1900s. The plant, which includes a pipe mill that was installed during the 1980s, produces approximately 500,000 per annum of seamless pipes. Currently rising alongside V&M STAR, as the plant has been called since it was purchased, is an entirely new pipe mill.

Once completed, at a cost of $650 million, this facility will employ approximately 350 workers. Their wages are industry-competitive and tend to be above prevailing levels of compensation in Youngstown, which for decades has suffered from mill closures and losses of population and employment. Much of the new facility's output, which will be approximately 350,000 tons per annum, will be sold to gas and oil drillers in Ohio, Pennsylvania, and neighboring states.

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