

THE ECONOMIC EFFECTS OF HYDROFRACTURING ON LOCAL ECONOMIES: A Comparison of New York and Pennsylvania

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EXECUTIVE SUMMARY

In 2013, New York's state government will decide whether to permit extraction of natural gas by hydraulic fracturing or, instead, turn its current moratorium into a permanent ban on this technology. In weighing their choice, New York officials have an abundance of useful data from neighboring Pennsylvania. There, nearly 5,000 wells have been hydrofractured since 2002. If New York lifts its moratorium, companies will be drilling the same type of wells to exploit the same subterranean source of gas—the Marcellus Shale. Pennsylvania's experience is a good guide to what would happen in New York.

In this paper, we analyze the effect of hydrofracturing—at modest, moderate, and high levels—on jobs and income growth in Pennsylvania counties. We then use these data to project the benefits that New York counties stand to gain if the state again permits hydrofracturing.

We find that:

- Pennsylvania counties with hydrofractured gas wells have performed better across economic indicators than those that have no wells.
- The more wells a county contains, the better it performed.
- Between 2007 and 2011, per-capita income rose by 19 percent in Pennsylvania counties with more than 200 wells, by 14 percent in counties with between 20 and 200 wells, and by 12 percent in counties with fewer than 20 wells.
- In counties without any hydrofractured wells, income went up by only 8 percent.
- Counties with the lowest per-capita incomes experienced the most rapid growth.
- Counties with more than 200 wells added jobs at a 7 percent annual rate over the same time period.
- Where there was no drilling, or only a few wells, the number of county jobs shrank by 3 percent.
- Using the Pennsylvania data to project hydrofracking's effect on New York counties, we find that the income of residents in the 28 New York counties above the Marcellus Shale has the potential to expand by 15 percent or more over the next four years—if the state's moratorium is lifted.
- Our data also suggest that had New York allowed its counties to fully exploit the Marcellus Shale, those counties would have seen income-growth rates of up to 15 percent for a given four-year period, or as much as 6 percent more than they are experiencing.

ABOUT THE AUTHORS

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Furchtgott-Roth is the author of *Regulating to Disaster: How Green Jobs Policies are Damaging America's Economy* (Encounter Books, 2012) and *Women's Figures: An Illustrated Guide to the Economic Progress of Women in America* (AEI Press, 2012). She is the editor of *Overcoming Barriers to Entrepreneurship in the United States* (Rowman and Littlefield, 2008). Her articles have been published in *The New York Times*, the *Washington Post*, the *Financial Times*, *The Wall Street Journal*, *Investor's Business Daily*, the *Los Angeles Times*, and *Le Figaro*, among others. She is a frequent guest on FOX Business News and has appeared on numerous other TV and radio shows, including CNBC's *Larry Kudlow Show*, C-SPAN's *Washington Journal*, and PBS's *The NewsHour with Jim Lehrer*. Furchtgott-Roth's areas of expertise include employment, taxation, education, pensions, unionization, and immigration. She was assistant to the president and resident fellow at the American Enterprise Institute from 1993 to 2001. From 1987 to 1991 she was an economist at the American Petroleum Institute, where she authored papers on energy and taxation.

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THE ECONOMIC EFFECTS OF HYDROFRACTURING ON LOCAL ECONOMIES: A COMPARISON OF NEW YORK AND PENNSYLVANIA

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INTRODUCTION

Large parts of Pennsylvania and western New York are located above the Marcellus Shale, a vast subterranean expanse of rock that is estimated to contain up to 489 trillion cubic feet of natural gas.¹ Pennsylvania has allowed companies to extract natural gas with the technique known as hydraulic fracturing, hydrofracturing, or, as its vociferous opponents like to call it, “fracking.” Usually, this method is combined with horizontal drilling (in which the drill turns off the vertical to extend horizontally through the rock formation, allowing more of it to be tapped). Today, many Pennsylvania counties are bustling with this “unconventional drilling.”

In neighboring New York, all is quiet. Although New York once allowed hydraulic fracturing and horizontal drilling,² the state placed a moratorium on the technique in 2010. This year, the state government will either end that moratorium or make it permanent. While New York ponders, drilling companies hold their pre-2010 leases on land, uncertain whether they will ever be able to use the resources beneath.

Any reasonable decision about hydrofracturing will weigh its costs against benefits. One of these benefits is economic growth in the areas where modern drilling techniques are used. A broad analysis of hydraulic fracturing by the Yale Graduates in Energy Study Group compared the cost of repairing potential environmental damage with a projection of likely benefit to consumers as well as producers.³ The study concluded that benefits exceeded costs by a factor of up to 400.

This paper aims to inform the New York debate by assessing the economic benefits of hydrofracturing on counties in neighboring Pennsylvania. We find that:

- Those counties in Pennsylvania that contain hydrofractured gas wells have performed better across economic indicators than those that do not.
- Economic performance correlates with a county's number of such wells and therefore is best among the counties most prolific in hydrofracturing.
- Pennsylvania's counties are narrowing the economic growth-rate gap that existed between them and New York's counties, and this is most pronounced in counties where many hydrofractured wells have been drilled.
- Income of residents in the 28 New York counties above the Marcellus Shale has the potential to expand by 15 percent or more over the next four years if the state's moratorium is lifted.

Between 2007 and 2011, per-capita income rose by 19 percent in Pennsylvania counties with more than 200 wells, by 14 percent in counties with between 20 and 200 wells, and by 12 percent in counties with fewer than 20 wells. In counties without any hydrofracking wells, income went up by only 8 percent. It is important to note, too, that counties with the lowest per-capita incomes experienced the most rapid growth. Moreover, counties with more than 200 wells added jobs at a 7 percent annual rate over the same time period. Where there was no drilling, or only a few wells, the number of county jobs shrank by 3 percent.

Similar benefits could also be realized by residents of New York State, and they would not have long to wait: shale gas drilling start-up expenditures make the first hydraulically fractured wells especially lucrative for a local economy. We calculate that a New York county that permits the drilling of a mere 20 wells could, in a four-year period, see per-capita income rise 3 percent more than it would have if no wells had been drilled. If all New York counties above the Marcellus Shale were to pursue this course, our estimate is that they would collectively have \$4.2 billion more in income just in the last year of that four-year period. On the other hand, drilling 400 wells in a county, which some Pennsylvania counties have done in a similar

time frame, could raise incomes by over 6 percent, with commensurate increases in statewide gains. Tax revenues would increase with incomes.

BACKGROUND AND METHOD

University of Wyoming professor Timothy Considine and Penn State professor Robert Watson have completed multiple studies specifically concerning the economic effects of the Marcellus Shale. They estimate that, in 2009, more than 44,000 Pennsylvania jobs were created because of the local shale gas drilling industry, through direct employment and the indirect and induced effects of the industry's equipment purchases and land royalties. Their input-output models also show that \$3.87 billion in total value was added to the Pennsylvania economy because of the Marcellus drillers' activities.⁴

Modeling the New York economy in a similar fashion, Considine and Watson project that a reopening of that state's shale formation to hydrofracturing could result in \$11.4 billion in economic output and create 15,000 to 18,000 jobs in southwestern counties (Allegany, Steuben, Chemung, Tioga, and Broome) alone.⁵

The New York State Department of Environmental Conservation (NYSDEC) commissioned a study of potential hydrofracturing-spurred growth in the state in 2009, finally addressing the full results in a 2011 release. The authors estimated that with an average projection for growth, hydraulic fracturing would directly create nearly 25,000 jobs in well construction and operation, as well as 29,000 jobs in indirectly influenced industries such as transportation.⁶ These 54,000 jobs would, in 2010, have represented approximately 0.7 percent of the labor force. This is a significant number at any time; but in 2010, it would have been especially high, with New York's unemployment rate then exceeding 8 percent.

Our inquiry focuses on job and income growth—the direct benefits from expanded drilling operations. Thanks to the contrasting policies of Pennsylvania and New York, there is no need for hypothetical projections to examine what exploration of the Marcellus Shale might do for New York's economy. Moreover, counties within Pennsylvania differ widely in the

extent of their exploitation of natural gas resources. These circumstances provide a rich vein of comparative information with which to estimate the potential benefits of hydrofracturing in New York.

Using data from the Pennsylvania Department of Environmental Protection, the Bureau of Labor Statistics, and the Bureau of Economic Analysis, we have found a correlation between the presence and scale of hydraulic fracturing operations in a particular county, on the one hand, and improvement in economic indicators, on the other.

First, we compare average measures of economic growth among counties that are at different levels of Marcellus Shale development. This allows us to esti-

mate whether the existence of shale energy reserves, along with the use of hydraulic fracturing to access those reserves, has offered an economic benefit to residents of individual counties.

Second, we perform a regression analysis, which suggests what specific economic effects might be predicted for Marcellus Shale counties in New York if the drilling moratorium ended. These analyses make clear the economic benefits of hydraulic fracturing.

Economic effects are just one part of a decision on the societal usefulness of hydraulic fracturing. But well-paying jobs and more tax revenue are important to consider in such an evaluation. Therefore, measuring the effects of hydrofracturing on local economies is

Table I. Unconventional Wells Drilled in Pennsylvania by County and Year

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | County Total |
|------------|------|------|------|------|------|------|------|------|------|------|--------------|
| Adams | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Allegheny | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 5 | 9 |
| Armstrong | 0 | 0 | 0 | 0 | 3 | 2 | 7 | 19 | 37 | 34 | 102 |
| Beaver | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 6 | 8 |
| Bedford | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Berks | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Blair | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 6 |
| Bradford | 0 | 0 | 0 | 1 | 2 | 2 | 24 | 160 | 378 | 399 | 966 |
| Bucks | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Butler | 0 | 0 | 0 | 0 | 3 | 12 | 11 | 10 | 35 | 34 | 105 |
| Cambria | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 3 | 6 |
| Cameron | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 3 | 7 | 15 |
| Carbon | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Centre | 0 | 0 | 0 | 0 | 1 | 1 | 4 | 7 | 41 | 8 | 62 |
| Chester | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Clarion | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 3 | 3 | 10 | 20 |
| Clearfield | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 24 | 39 | 58 | 128 |
| Clinton | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 9 | 35 | 39 | 87 |
| Columbia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 |
| Crawford | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cumberland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dauphin | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Delaware | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Elk | 0 | 0 | 0 | 1 | 1 | 6 | 8 | 6 | 16 | 22 | 60 |
| Erie | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fayette | 0 | 0 | 0 | 0 | 2 | 6 | 20 | 57 | 44 | 54 | 183 |

| | | | | | | | | | | | |
|-----------------|----------|----------|----------|----------|-----------|-----------|------------|------------|------------|--------------|--------------|
| Forest | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 6 |
| Franklin | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fulton | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Greene | 0 | 0 | 0 | 0 | 2 | 14 | 67 | 101 | 103 | 122 | 409 |
| Huntingdon | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Indiana | 0 | 1 | 0 | 0 | 0 | 0 | 5 | 6 | 7 | 21 | 40 |
| Jefferson | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 8 | 15 | 29 |
| Juniata | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lackawanna | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 |
| Lancaster | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lawrence | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| Lebanon | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lehigh | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Luzerne | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| Lycoming | 0 | 0 | 0 | 0 | 0 | 5 | 12 | 23 | 119 | 300 | 459 |
| McKean | 0 | 0 | 0 | 0 | 2 | 1 | 5 | 7 | 22 | 19 | 56 |
| Mercer | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mifflin | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Monroe | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Montgomery | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Montour | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Northampton | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Northumberland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Perry | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Philadelphia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pike | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Potter | 0 | 0 | 0 | 0 | 0 | 8 | 6 | 8 | 36 | 12 | 70 |
| Schuylkill | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Snyder | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Somerset | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 7 | 4 | 7 | 20 |
| Sullivan | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 22 | 19 | 42 |
| Susquehanna | 0 | 0 | 0 | 0 | 1 | 2 | 33 | 88 | 125 | 205 | 454 |
| Tioga | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 124 | 276 | 274 | 689 |
| Union | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Venango | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| Warren | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 3 |
| Washington | 1 | 1 | 0 | 5 | 19 | 45 | 66 | 101 | 166 | 156 | 560 |
| Wayne | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 0 | 5 |
| Westmoreland | 0 | 2 | 1 | 1 | 0 | 4 | 33 | 39 | 49 | 59 | 188 |
| Wyoming | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 24 | 71 | 97 |
| York | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PA TOTAL | 1 | 3 | 2 | 6 | 22 | 69 | 171 | 399 | 849 | 1,127 | 4,897 |

Source: Pennsylvania Department of Environmental Protection, Wells Drilled by County Report Viewer, http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Oil_Gas/Wells_Drilled_By_County

an important step toward a fair and useful assessment of this approach to energy extraction.

THE DATA

The number of horizontal, hydraulically fractured wells drilled in each of the 67 Pennsylvania counties from 2002 to 2011 is available in tables at the Pennsylvania Department of Environmental Protection website.⁷ The “unconventional” category encompasses the relevant sets of hydrofractured wells. Numbers of such wells were low until 2007, when unconventional well-drilling began in earnest in Pennsylvania. (See Table 1 for annual and total unconventional-well counts for 2002–11.)

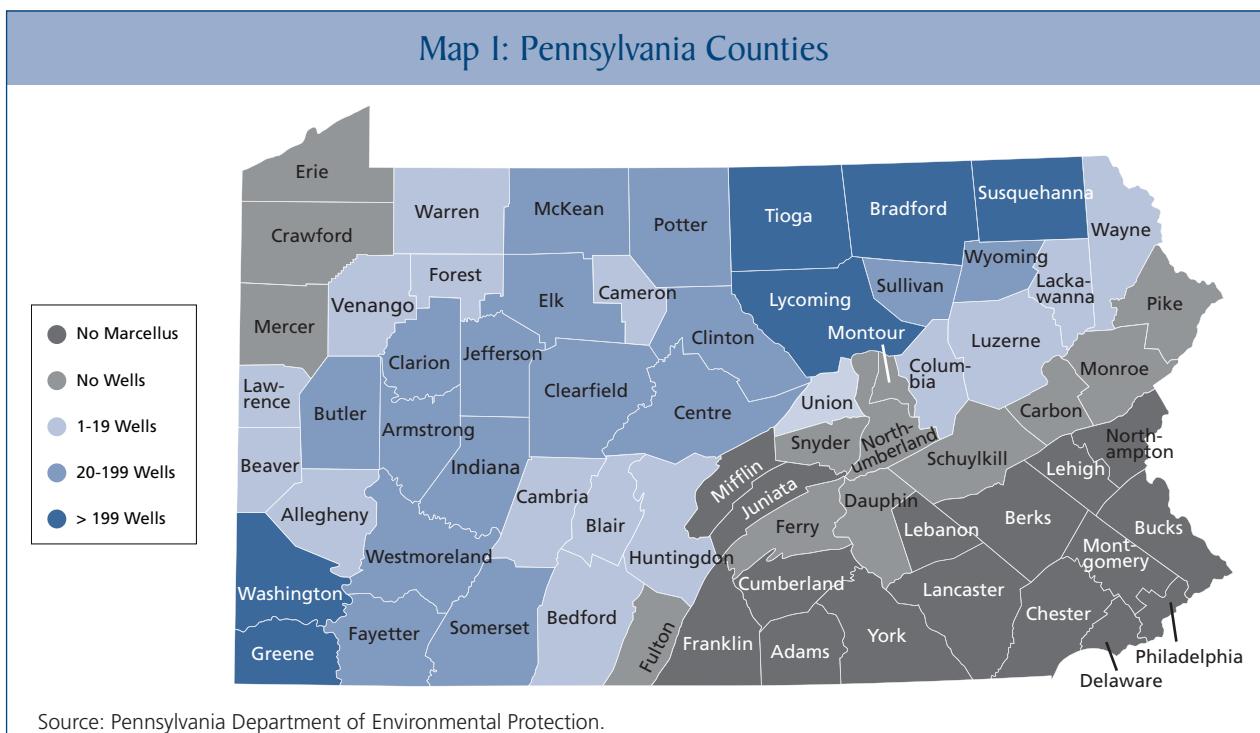
Based on the total number of unconventional wells drilled between 2002 and 2011, we divided counties into four groups: those counties that did no drilling of this type at all (30 counties); those that participated marginally in unconventional drilling, with fewer than 20 wells (15); those that drilled between 20 and 200 wells (16); and those that drilled more than 200 (6). All six counties in the last category contained at least 409 unconventionally drilled wells by 2011.

Map 1 displays these distinctions in a color-coded visual format.

Data were collected and analyzed for a variety of county-by-county metrics, including income and jobs totals, population levels, per-capita income levels, and unemployment rates, all on an annual basis.⁸ County-level economic data are available only through 2011, so that is the last year considered in this study. All periodic economic assessments were made for 2007–11, during which time significant amounts of well-drilling were done in Pennsylvania counties.

We measure changes in economic growth in 2007–11 through the use of three variables: the total number of jobs; the rate of unemployment; and per-capita personal income in each county. Per-capita income values are not adjusted for inflation, but comparisons of percentage change across counties and states will not be influenced by changes in this common variable.

In the analysis, we had to determine how much, if any, of each county sits on the Marcellus Shale. Most of the state's counties are either on the Marcellus entirely or not on it at all. In the few cases in which



county borders encompassed some land on the Marcellus Shale and some not, we made a visual judgment about its status. We then designated a county as having access to the Marcellus Shale if one-third or more of its land sits on the formation. These assignments were made based on maps provided by the Pennsylvania Department of Environmental Protection.⁹ For our comparative analysis of New York counties, we used a similar map provided by the New York State Department of Environmental Conservation.¹⁰

RESULTS BY COUNTY GROUP

As we have mentioned, in order to assess potential effects of natural gas drilling on economic performance in New York counties, it is useful to examine various experiences in Pennsylvania. To that end, economic indicator averages were calculated for our four groupings, based on the amount of drilling, of Pennsylvania counties. Between 2007 and 2011, per-capita personal income levels rose about 8 percent in those counties with no unconventional wells drilled; and 12 percent where fewer than 20 wells were drilled. In contrast, income levels rose 14 percent in counties with more than 20, but fewer than 200, wells; and 19 percent in the counties with the most hydrofracturing wells.

Some counties drilled no wells because they have no known resources. However, the effect—more wells correlating with more prosperity—holds when we examine only counties that have access to the Marcellus Shale. For those counties, the ones in which no wells were drilled saw 9 percent per-capita income growth. That is not much different from the overall average for the no-wells group and far below the average for counties with many wells.

Among counties with no wells, the one that experienced the most growth was Philadelphia County, at over 15 percent. This is unsurprising; a heavily populated urban county should be an outlier in the generally more rural and more sparsely populated state of Pennsylvania. Philadelphia's economic performance is likely the least relevant when we seek to compare those counties that could benefit from oil and gas drilling. Of the remaining 29 Pennsylvania counties

without unconventional wells, only two—Union and Northumberland—exceeded 14 percent income growth, the average rate experienced by counties in the 20–200 well group.

Meanwhile, employment growth in Pennsylvania counties, measured as the percentage change in jobs from 2007 to 2011, tells a somewhat similar story, though the effect becomes pronounced only in the more prolific unconventional-well-drilling counties. Where there was no such drilling, the number of jobs *shrank* in each county by an average of 3.27 percent. Counties with fewer than 20 unconventional wells improved only marginally on this number, losing 3.23 percent of jobs on average.

However, those counties with between 20 and 200 wells lost, on average, less than 1 percent of their jobs. Finally, the most striking value is the growth of employment in the heavy-drilling group. These counties *added* jobs at an average rate of 7.67 percent. None of the six counties with more than 200 unconventional wells failed to add jobs in 2007–11, despite the economic turmoil that gripped the rest of the state—and the nation—during this period.

In fact, each of these six counties had a higher rate of job creation than any of the other 61 Pennsylvania counties save two: Butler, in which 105 unconventional wells were drilled; and Montour, which had a 12 percent increase in job creation (though it has no wells).¹¹

Unemployment rates display the same trend. They increased, on average, by only 2.2 percentage points in the heavy-drilling counties but by 3.7 points in counties with no unconventional drilling. The shale-land counties with no wells fared worst, averaging an increase in their unemployment rate of over 3.8 percentage points.

EXTRAPOLATING RESULTS TO NEW YORK STATE

Pennsylvania counties where hydraulic fracturing takes place have performed better economically on average than those with little or no such drilling. If New York State lifts its moratorium, the same driv-

ers of growth will be in place, and their effect can be estimated.

We analyzed regressions of an economic indicator on variables associated with hydraulic fracturing. This allowed us to specify the influence of drilling on growth. Our per-capita income-growth variable was regressed on natural logarithms of the values of possible causal factors, including the number of hydraulic fracturing wells drilled. To be sure that the calculated effects of drilling do not encompass the actual influence of other variables, income growth was also regressed on the natural logarithms of population and base-year (2007) income in each Pennsylvania county, as well as the square of base-year income. Population levels were found to have a negligible effect, independent of other tested variables. However, 2007 income showed a negative correlation with growth rates. This negative correlation diminished somewhat at higher base-year income levels.

In the 2007–11 period, those Pennsylvania counties with the *lowest* per-capita incomes experienced the *most* rapid growth. This will bear some connection with the correlation between growth and hydraulic fracturing levels, which were somewhat higher in poorer areas. This connection is not enough to suggest that natural gas drilling by itself was the prominent factor in economic performance in these burgeoning areas. It merely shows that, for the relevant period, county incomes converged.

Details of the statistical analysis are provided in the Appendix. The results of the analysis indicate that the increase in income growth provided by the drilling of one well is proportional to the percent increase in the number of wells represented by the one new well, at a rate of 0.01006. For the sake of discussion, we can approximate this with 0.01.

For instance, if a county has five hydrofractured wells, the drilling of one more such well represents a 20 percent increase in the total. Twenty times 0.01 yields 0.2, so the model predicts that this county will experience 0.2 percent greater income growth over a four-year period. In a county starting with 40 wells, one new well would represent a

2.5 percent increase, and 2.5 times 0.01 is 0.025. A county with 40 wells can therefore expect to see a 0.025 percent increase in four-year per-capita income growth in conjunction with one new well, based on our model.

While these rate increases appear small on a per-well basis, they are cumulatively very important. For a given county with a given base income level, we project that permitting 50 hydraulically fractured wells throughout a four-year period will cause incomes to grow 3.95 percent more in that period than they would have with no wells. At 400 wells—a number that was exceeded by the six most active hydrofracturing counties in Pennsylvania from 2007 to 2011—the expected income growth is over 6 percent.

These increases represent an average of thousands of dollars more in the pocket of each earner within the county's economy, and up to \$8.3 billion in personal income for the Pennsylvania counties above the Marcellus Shale.

As one would expect, the model predicts a diminishing per-well effect. In order to drill initial unconventional wells, the natural gas industry would need to inject more resources into the local economy by leasing land, purchasing equipment, hiring workers, and making other start-up outlays. Later wells will not require such a level of investment. However, in a logarithmic model such as that presented, the influence of a particular variable never diminishes to zero. Even adding one well to 400 will have some positive effect on income.

In addition, the expansion of hydraulic fracturing in Pennsylvania was only a few years old as of 2011, where the data for this study end. It is reasonable to hypothesize that once most of the start-up benefits have been reaped, a linear relationship between drilling and growth will emerge, and per-well benefits will persist rather than decline.

Importantly, our model, though quite simple in projecting income growth based solely on current income levels and the number of hydraulically fractured wells to be drilled, nonetheless

accounts for half of the total variation in growth rates among counties. There is little to suggest a relevant inherent difference between the economy in Pennsylvania and economies in other states that face hydrofracturing decisions. Therefore, it is not unreasonable to think that the results of our regressions indicate the benefits that would accrue to areas outside Pennsylvania, should they allow the process to be used to recover natural gas. With

this in mind, we examine the potential economic benefits to New York State of lifting the hydrofracturing moratorium.

POTENTIAL EFFECTS OF HYDROFRACTURING ON NEW YORK STATE

Twenty-eight counties in New York lie above the Marcellus Shale. These range from Onondaga in the

Table 2. Projections for New York per-Capita Income Growth by County and Wells (dollars)

| County | Actual 2011 per-Capita Income | Projected Four-Year Increase in per-Capita and County Income, by Number of Wells | | | | |
|---|----------------------------------|---|---------------------|---------------------|---------------------|---------------------|
| | | 0 | 20 | 52 | 200 | 400 |
| Albany | 48,283.61 | 50,767.65 | 52,246.30 | 52,698.66 | 53,343.33 | 53,678.76 |
| Allegany | 28,205.89 | 31,380.57 | 32,244.35 | 32,508.61 | 32,885.20 | 33,081.15 |
| Broome | 35,962.60 | 38,541.63 | 39,642.95 | 39,979.88 | 40,460.04 | 40,709.88 |
| Cattaraugus | 34,695.65 | 37,345.39 | 38,407.91 | 38,732.97 | 39,196.22 | 39,437.25 |
| Cayuga | 34,060.75 | 36,749.99 | 37,793.08 | 38,112.19 | 38,566.96 | 38,803.58 |
| Chautauqua | 31,664.50 | 34,526.67 | 35,496.37 | 35,793.03 | 36,215.80 | 36,435.78 |
| Chemung | 35,516.92 | 38,119.58 | 39,207.25 | 39,540.01 | 40,014.22 | 40,260.96 |
| Chenango | 33,837.84 | 36,541.59 | 37,577.85 | 37,894.87 | 38,346.66 | 38,581.74 |
| Cortland | 31,972.29 | 34,810.18 | 35,789.31 | 36,088.85 | 36,515.73 | 36,737.85 |
| Delaware | 32,372.95 | 35,180.14 | 36,171.53 | 36,474.83 | 36,907.06 | 37,131.96 |
| Erie | 41,244.58 | 43,649.04 | 44,912.12 | 45,298.54 | 45,849.22 | 46,135.75 |
| Genesee | 33,826.08 | 36,530.61 | 37,566.50 | 37,883.41 | 38,335.05 | 38,570.04 |
| Greene | 36,848.04 | 39,384.16 | 40,512.60 | 40,857.82 | 41,349.81 | 41,605.80 |
| Livingston | 32,361.01 | 35,169.10 | 36,160.13 | 36,463.32 | 36,895.39 | 37,120.21 |
| Madison | 33,663.42 | 36,378.75 | 37,409.67 | 37,725.06 | 38,174.52 | 38,408.39 |
| Onondaga | 41,388.80 | 43,791.27 | 45,058.77 | 45,446.53 | 45,999.14 | 46,286.68 |
| Ontario | 41,834.10 | 44,231.39 | 45,512.53 | 45,904.46 | 46,463.02 | 46,753.65 |
| Otsego | 33,414.44 | 36,146.65 | 37,169.94 | 37,483.00 | 37,929.14 | 38,161.27 |
| Schoharie | 35,529.93 | 38,131.88 | 39,219.95 | 39,552.83 | 40,027.21 | 40,274.04 |
| Schuyler | 35,317.25 | 37,930.93 | 39,012.49 | 39,343.38 | 39,814.92 | 40,060.28 |
| Seneca | 33,783.14 | 36,490.50 | 37,525.08 | 37,841.59 | 38,292.66 | 38,527.35 |
| Steuben | 37,278.49 | 39,795.71 | 40,937.33 | 41,286.59 | 41,784.32 | 42,043.30 |
| Sullivan | 37,457.01 | 39,966.76 | 41,113.85 | 41,464.78 | 41,964.90 | 42,225.12 |
| Tioga | 36,096.92 | 38,669.09 | 39,774.52 | 40,112.71 | 40,594.67 | 40,845.44 |
| Tompkins | 36,263.49 | 38,827.33 | 39,937.87 | 40,277.62 | 40,761.79 | 41,013.72 |
| Ulster | 39,589.14 | 42,027.08 | 43,239.47 | 43,610.37 | 44,138.96 | 44,413.99 |
| Wyoming | 31,358.74 | 34,245.62 | 35,205.96 | 35,499.75 | 35,918.45 | 36,136.30 |
| Yates | 32,110.20 | 34,937.41 | 35,920.76 | 36,221.59 | 36,650.32 | 36,873.39 |
| Additional total personal income from hydrofracturing in above counties | | | | | | |
| TOTALS | 0 | 0 | \$4.21 bill. | \$5.50 bill. | \$7.34 bill. | \$8.29 bill. |

Source: Actual 2011 Incomes from the Bureau of Economic Analysis, Regional Data Tables. Local Areas Personal Income and Employment by County, updated 26 Nov 2012. Interactive tables are available at <http://www.bea.gov/itable/itable.cfm?ReqID=70&step=1>.

north to Sullivan in the south, and from Greene in the east to Chautauqua in the west. Our model can estimate their added income-growth potential due to the presence of shale gas.

Table 2 shows the projected effects on various counties for different levels of hydrofracturing. The latest income data are for 2011. If hydrofracturing had been permitted in New York just as it was in Pennsylvania, we would expect to see significant effects by 2015 in New York. In the 50 Pennsylvania counties lying above the Marcellus, an average of 52.3 wells per county were hydraulically fractured from 2007 to 2011, so this figure provides a guide to what could have happened in New York.

Consider the example of Chemung County, which in 2011 had a per-capita income of under \$36,000, about average for the New York Marcellus counties. Under the hydrofracturing moratorium, our model projects that Chemung will see a per-capita income of over \$38,000 in 2015, a 7 percent increase. Total annual income would have increased by \$231 million.

However, if hydrofracturing were permitted in Chemung, natural gas extraction start-up and the drilling of just 20 unconventional wells through the period would have brought per-capita income up to an estimated \$39,207, an increase of over 10 percent. Well-drilling at the average Pennsylvania rate of 52.3 wells in 2011–15 would bring another full percent of income growth, to \$39,540.

This average level of hydraulic fracturing would represent, for Chemung as well as for the other New York counties, an increase in income-growth rates of 4 percentage points. The county would have seen an increase in annual income of \$357 million, or \$126 million more than the case of no hydrofracturing.

The five most prolific counties in Pennsylvania had more than 400 natural gas wells hydraulically fractured in a similar period. At that high rate of production, Chemung would be expected to see average income easily surpass the \$40,000 mark by 2015.

Table 2 also displays the effect that certain per-county levels of unconventional drilling could have on total

personal income per year in the counties concerned. Income is projected to grow by \$4.2 billion more if counties have an average of 20 wells. This figure increases to \$5.5 billion at the average level of well-drilling found in Pennsylvania: 52 wells per county. At 400 wells per county, New York would gain another \$8.3 billion in revenue by lifting the moratorium. These personal income gains would increase tax revenues and do not take into account potential residual activity and benefits for nearby counties that do not sit on the Marcellus Shale.

Of course, each county will choose its own quantity of wells. But even at levels of development far below the maximum, our analysis estimates that billions of dollars could accrue to local economies if hydrofracturing is permitted in New York State.

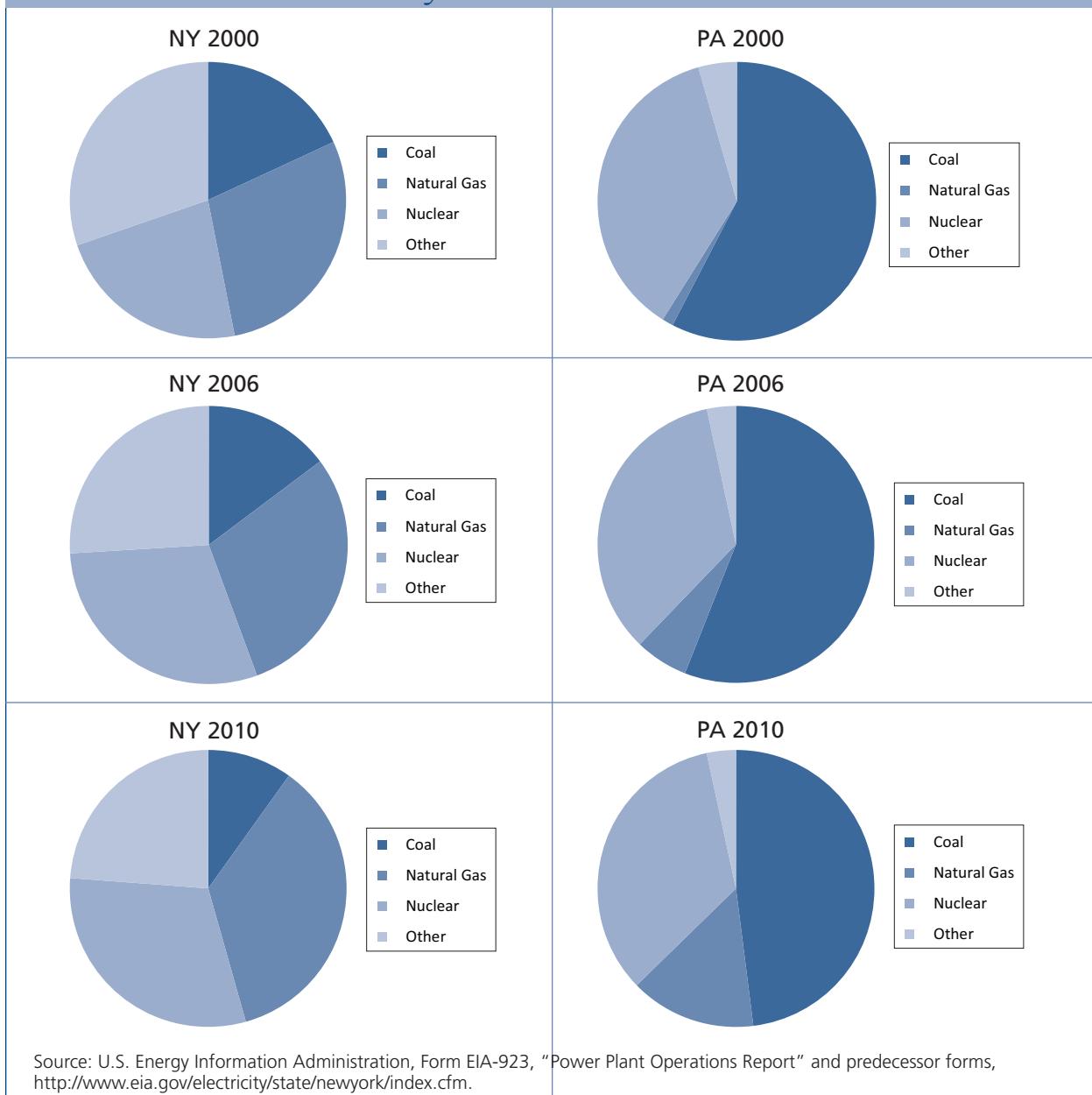
CONCLUSION

We have shown that Pennsylvania counties with hydraulic fracturing had higher economic growth rates than those without. The results also reveal that a greater number of wells correlated with a higher rate of economic growth. These results could equally well be applied to counties in New York and other states, from California to West Virginia, that have the potential to drill for oil and natural gas. They suggest that over the past decade, had New York State counties on the Marcellus Shale been allowed to use these resources, economic growth would have been substantially higher—at up to 15 percent for a given four-year period, or 6 percent greater than would otherwise be expected. This corresponds to a potential \$8 billion in extra income in upstate New York.

The various benefits discussed here are within relatively easy reach for the state of New York. Figures 1–6 show the proportion of electrical power generated from various energy sources by Pennsylvania and New York in 2000, 2006, and 2010. Much can be gleaned from these figures.

New York already generates a fair amount of its power using natural gas. This means that it has the infrastructure available to take advantage of this resource once obtained. But it also means that New York's

Figures I–6. Electricity Generation by Source: New York and Pennsylvania, 2000/2006/2010



power must either be limited by its moratorium on its own Marcellus resources or dependent on imports from other areas for expansion. New natural gas production spurred by hydraulic fracturing would constitute an in-state energy supply, attracting more manufacturing back to the state.

As we have noted, decisions about the societal value of hydraulic fracturing must reckon with many

considerations. But in balancing the costs and risks against the benefits, it is important to be precise about those benefits. Counting, as the physicist Lewis Fry Richardson used to say, is an antiseptic against prejudice. By our count, there are immediate and concrete benefits in hydrofracturing wells: more money in the pockets of the people, more tax revenue for the state. These data deserve close attention and consideration as New York State confronts its decision.

APPENDIX

In the analysis of Pennsylvania counties, a dummy variable was established for whether each county sits on the Marcellus Shale. This variable serves to allow consideration of those counties to which the questions of hydraulic fracturing are most immediately pertinent. Counties that sit atop the shale were assigned a 1 for this variable, while those that do not were assigned a 0. In the few cases in which only parts of a county sat on the Marcellus Shale, a visual judgment was made as to the dummy-variable designation. If approximately one-third or more of a county's land sits on the Marcellus Shale, it was categorized as having access to the shale and assigned a 1. Dummy-variable assignments were made based on maps provided by the Pennsylvania Department of Environmental Protection.¹² A similar map for the Empire State is provided by the New York State Department of Environmental Conservation.¹³ In the final regression analysis of Pennsylvania counties, this equation is specified:

$$y = .01006(\ln(\text{wells} + 1)) - 3.99905(\ln(y_{07})) + .18474(\ln(y_{07}))^2 + 22.69351$$

"y" is the ratio of per-capita income in 2011 to that in 2007. " $\ln(\text{wells} + 1)$ " represents the natural log of one more than the number of hydrofractured wells drilled in the given county through 2011. 1 is added to the number of wells to permit logarithmic calculations for counties with zero such wells. " $\ln(y_{07})$ " represents the natural log of per-capita income in 2007, the base year for this exercise. All coefficients are statistically significant (see Table A-1 below for t-test values).

This model projects an increased per-capita income growth, over a four-year period, of at least 3 percent for a county permitting 20 unconventional wells and over 5 percentage points for a county permitting 200 such wells, given current income levels. For example, the lowest-earning New York county, Allegany, shows an increase of 3.0 percentage points with 20 wells and 5.3 percent with 200 wells. The highest-earning county with shale land, Albany, would gain 3.1 percent with 20 wells and 5.4 percent with 200.

Thus, while the coefficient for wells appears small, it is both statistically significant and qualitatively meaningful. Natural logarithms of per-capita income levels, which are all of the same order of magnitude, are similar, and variation in well-drilling is estimated to have an important effect.

As we have noted, this model explains approximately half of the variation in income growth since 2002 among the Pennsylvania counties sampled, as evidenced by the adjusted R-squared value appearing below in Table A-1. So while there is a fair amount of variation in income-growth projections in this model, a good deal of that variation is captured by counts of hydrofractured wells.

Table A-1. T-Test Values for Regressions

| | ln(wells+1) | ln(y07) | (ln(y07))2 | Constant |
|------------------|--------------------|----------------|-------------------|-----------------|
| Est. Coefficient | 0.0100588 | -3.9990533 | 0.1847353 | 22.6935116 |
| Lower Bound* | 0.0141400 | -0.9401473 | 0.3311413 | 38.6715578 |
| Upper Bound* | 0.0059775 | -7.0579592 | 0.0383295 | 6.7154653 |
| Std. Error | 0.0020823 | 1.5606663 | 0.0746969 | 8.1520644 |
| T Value | 2.812 | 2.592 | -4.680 | 8.222 |

*Lower and upper bounds calculated for a 95 percent confidence interval

Adjusted R-squared: 0.49977

F Statistic: 20.98162, degrees of freedom 57

ENDNOTES

¹ New York State Department of Environmental Conservation (NYSDEC), "Marcellus Shale," <http://www.dec.ny.gov/energy/46288.html>.

² Idem, "What Are Horizontal Drilling and Hydraulic Fracturing?," <http://www.dec.ny.gov/energy/46288.html#horizontal>.

³ Robert M. Ames et al., "The Arithmetic of Shale Gas," Yale Graduates in Energy Study Group, June 15, 2012, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2085027.

⁴ Timothy J. Considine, Robert Watson, and Seth Blumsack, "The Economic Impacts of the Pennsylvania Marcellus Shale Natural Gas Play: An Update," May 24, 2010, <http://energy.wilkes.edu/PDFFiles/Library/The%20economic%20impacts%20of%20the%20PA%20marcellus%20shale%20natural.pdf>.

⁵ Timothy J. Considine, Robert W. Watson, and Nicholas B. Considine, "The Economic Opportunities of Shale Energy Development," Manhattan Institute, *Energy Policy & the Environment Report*, no. 9 (June 2011), http://www.manhattan-institute.org/html/eper_09.htm.

⁶ NYSDEC, "Fact Sheet: Economic Impacts of High-Volume Hydraulic Fracturing in New York State," September 2011, http://www.dec.ny.gov/docs/materials_minerals_pdf/econimpact092011.pdf.

⁷ Wells Drilled by County Report Viewer, http://www.dereportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Oil_Gas/Wells_Drilled_By_County.

⁸ All economic data were retrieved from the Interactive Data tables on the Bureau of Economic Analysis website (<http://www.bea.gov/ITable/ITable.cfm?ReqID=70&step=1>), with the exception of unemployment rates, which were obtained from the Bureau of Labor Statistics (Local Area Unemployment Statistics, <http://bls.gov/lau>).

⁹ Pennsylvania map: <http://www.dep.state.pa.us/dep/deputate/minres/oilgas/BOGM%20Website%20Pictures/2010/Marcellus%20Shale%20Formation.jpg>.

¹⁰ New York map: <http://www.dec.ny.gov/energy/46381.html>.

¹¹ Montour's large-percentage job growth is linked to two facts: its small population (just over 18,000); and the existence of a single, large, expanding employer, the Geisinger Medical System, in Danville, Pennsylvania (the Montour County seat). That system, which employs more than 14,000 Pennsylvanians and more than 8,000 in Danville alone, constructed a new Hospital for Advanced Medicine in the relevant time period, opening it in early 2010. Geisinger also expanded women's and children's services in 2011. The jobs provided by these expansions are likely a large reason for Montour's success in creating jobs between 2007 and 2011, and this situation is unique to this particular county.

¹² Pennsylvania map: <http://www.dep.state.pa.us/dep/deputate/minres/oilgas/BOGM%20Website%20Pictures/2010/Marcellus%20Shale%20Formation.jpg>.

¹³ New York map: <http://www.dec.ny.gov/energy/46381.html>.

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