

RESEARCH SUMMARY

The Local Economic and Welfare Consequences of Hydraulic Fracturing

by Michael Greenstone, Alexander Bartik, Janet Currie and Christopher R. Knittel

KEY TAKEAWAYS

1. The application of hydraulic fracturing to develop oil and natural gas found in shale deposits has led to a sharp increase in U.S. energy production and generated enormous benefits, including abruptly lower energy prices, a reduced trade deficit, stronger energy security and even lower carbon dioxide emissions in the power sector. Moreover, given the relative prominence of shale resources globally, it is plausible that substantial additional resources could be produced. While the least carbon intensive fossil fuel, unlocking the large reserves of natural gas that exist could also potentially have negative climate implications.
2. As drilling activity has increased in recent years, however, a robust debate has begun within communities where development is occurring—and those where it prospectively may occur—regarding the potential pros and cons of development. Advocates point to increased economic activity, including tax revenue and jobs. Opponents, on the other hand, point to potential disadvantages such as increased levels of crime, a higher burden on public infrastructure, and possible health risks.
3. This study examined the benefits and costs of shale development at the community level across nine different U.S. basins, the most comprehensive assessment to date. The data suggests that the economic benefits are significant, with the average household benefitting by roughly \$1,300 to \$1,900 per year. Such benefits include a 7 percent increase in average income, driven by rises in wages and royalty payments, a 10 percent increase in employment, and a 6 percent increase in housing prices. Local government revenues also increased at a faster pace than expenditures.
4. There were also costs. Combining the effects on housing prices and earnings with an economic model, the authors estimate that fracking reduces the typical household's quality of life by about \$1,000 to \$1,600 annually. These factors included an increase in truck traffic, more noise and air pollution from drilling activity, beliefs regarding negative health effects, and higher rates of crime despite a 20 percent increase in public safety expenditures.
5. This data indicates that the average local benefits from hydraulic fracturing outweigh the costs, though this may change as more information about the environmental and health impacts of hydraulic fracturing is revealed. There is a fair amount of heterogeneity across the nine shale basins. North Dakota's Bakken shale and Pennsylvania's Marcellus shale saw the largest benefits, with house price increases of 23 percent and 9 percent, respectively. Average benefits likely also mask considerable variation in the costs and benefits that accrue to individuals within each community.

Introduction

The discovery of hydraulic fracturing is considered by many to be the most important change in the energy sector in at least the last fifty years. As a result of its discovery, U.S. production of oil and natural gas has increased to levels considered unimaginable even five years ago. Both are now at their highest levels in history, and the United States has begun exporting commercial quantities of crude oil and natural gas for the first time in decades.

This surge in energy production has produced a range of economic benefits for the United States. U.S. natural gas prices have averaged \$3.64 per million Btu since 2010, compared to \$7.10 from 2003 to 2008. Meanwhile, after a period of historic highs from 2007 to 2014, oil prices collapsed in 2015, at least partially due to surging U.S. shale supplies. The typical U.S. household spent \$700 less on gasoline in 2015 than it did in 2014 even as travel increased significantly and efficiency plateaued.

Higher levels of domestic energy production have also cut the trade deficit and increased energy security by reducing the amount of fuel purchased abroad. A decade ago, the U.S. imported 60 percent of its net liquid fuel needs. Last year, it imported just 24 percent. Combined with lower prices, this has sharply reduced U.S. expenditure on oil imports, which had averaged more than half of the trade deficit from 2008 to 2013. The net result was a \$304 billion reduction in capital outflows in 2015 compared to 2008.

While the benefits of shale development have already been significant, the size of the resource base suggests that substantial additional supplies could be produced throughout the United States and globally over the coming decades. Commercial shale deposits are known to exist in Latin America, Europe, Russia, China and elsewhere. Although natural gas is the least carbon intensive fossil fuel, it is important to note that unlocking the massive reserves could potentially have negative climate implications. If world economies used all of the remaining fossil fuel resources that can be profitably extracted with current technology and prices, the total temperature impact is projected to be 2.8°F (1.6°C). Were technological progress or price increases to induce the consumption of all additional currently known fossil fuel resources, further warming of 11.7°F (6.5°C) could be expected: 3.1 degrees from oil and gas and 8.6 degrees from coal.

A range of political, economic, and geological factors will ultimately determine the plausibility and pace of shale development. But one

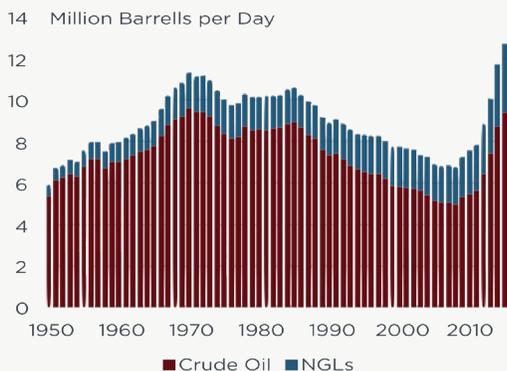
critical issue has rapidly risen to prominence, particularly in the United States and Europe—namely, the willingness of communities to support hydraulic fracturing and shale development.

The geologic nature of shale deposits is such that resources are often dispersed over large geographic areas. Developing the resource, which is trapped in deep, relatively thin layers of dense rock, requires high rates of consistent drilling that can be expansive in nature. It also requires the use of hydraulic fracturing, a drilling technique that generally entails the injection of water, sand and trace levels of chemicals at a high pressure underground. The result is that shale development is relatively intense in nature, involving a steady stream of trucks, materials (water and sand) equipment and labor into and out of areas under development.

In the United States and elsewhere, this form of development has brought the industry into direct contact with local communities, where an increasingly passionate debate has begun over whether shale development—and hydraulic fracturing in particular—is beneficial or detrimental to local populations. Proponents point to increased government revenue, direct and indirect jobs, and a range of economic activity that serves the industry, from restaurants to movie theaters. Opponents argue that industry brings increased crime, a heavy burden on local infrastructure such as roads and schools, and a range of pollution concerns, from noise and air pollution to impacts on the local water supply. On balance, many communities are supportive of the industry and the activity it brings. However, several U.S. cities and states have banned the use of hydraulic fracturing, including New York and Vermont, and several national governments in Europe are either considering bans or have already implemented them.

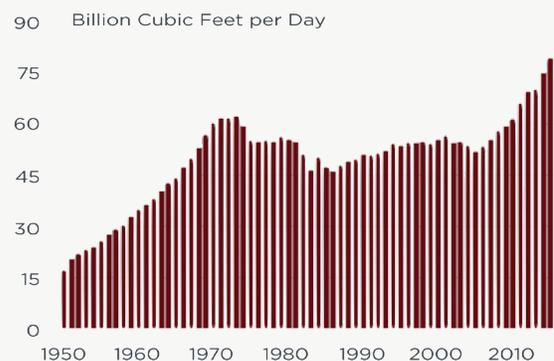
It is increasingly clear that policymakers and stakeholders on all sides of this debate could benefit from evidence-based analysis of the costs and benefits of hydraulic fracturing. The industry is now at least 10 years old in the United States, offering a wealth of data and opportunities to conduct more in-depth analysis.

Figure 1 ·
U.S. Field Production of Crude Oil and Natural Gas Liquids (1950-2015)



Source: DOE, EIA

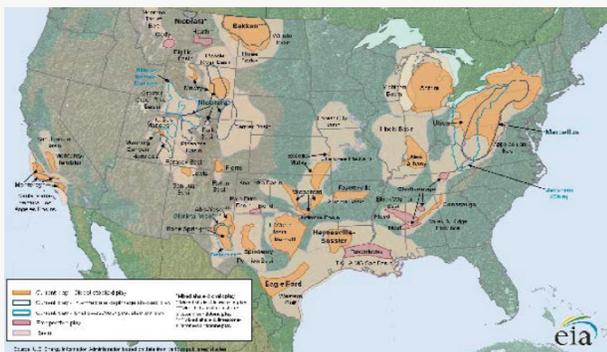
U.S. Marketed Natural Gas Production (1950-2015)



Research Design

This study measures the costs and benefits of hydraulic fracturing on local communities in nine shale basins throughout the United States, making it the most comprehensive assessment of its kind to date. Historically, it has been difficult to measure these impacts because the local economy in communities where shale development has taken root differs so greatly from other parts of the country—making it difficult to identify a community where hydraulic fracturing is occurring that is relatively similar to a different community where development is not occurring. For example, a community with a low level of economic activity would be more likely to allow shale development in order to create jobs. There are a variety of other factors as well: the community's history in exploiting natural resources, the local transportation infrastructure, and the availability of wide-open lands, to name a few

Figure 2 • Lower 48 States Shale Plays



In order to measure the costs and benefits, the researchers focused on identifying opportunities for discrete comparison of communities with and without hydraulic fracturing that would otherwise have experienced similar economic trends. The study exploits two sources of variation:

1. Geologic Variation: Several factors—including thickness, depth and thermal maturity of the shale—determine its commercial viability. Using detailed GIS data from Rystad Energy, this study is able to compare counties within individual shale plays with high potential for development to counties with lower potential for development. This approach essentially controls for other forms of social and economic variability, isolating the effects of shale development.

2. Variation in Timing: The study also compares a range of economic and social indicators before and after the initiation of shale development within individual counties.

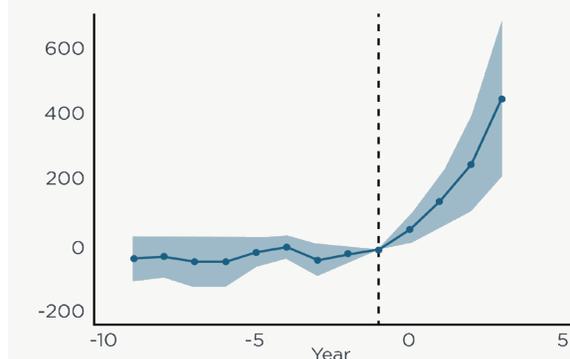
Recognizing that there are clearly a range of costs and benefits to shale development and hydraulic fracturing for individual communities, the researchers combine estimates of the effects of fracing on housing prices and income with an economic model of household decision-making to compute both the overall effect on local welfare, including the benefits from rising income, and changes in local quality of life.

The researchers then use this model to separate the net benefits into the gross benefits households receive from the change in household income and the costs or benefits from the change in local amenities (i.e. features of the local community that determine quality of life, such as crime, pollution, traffic congestion, and local demographics.

Findings

1. Shale development generates significant revenue in communities where drilling takes place. Counties with a high level of hydraulic fracturing activity produce an additional \$400 million worth of oil and natural gas each year. To put this into context, the most productive counties saw a per capita increase in production of about \$19,000.

Figure 3 • Total Production (Millions of Dollars)



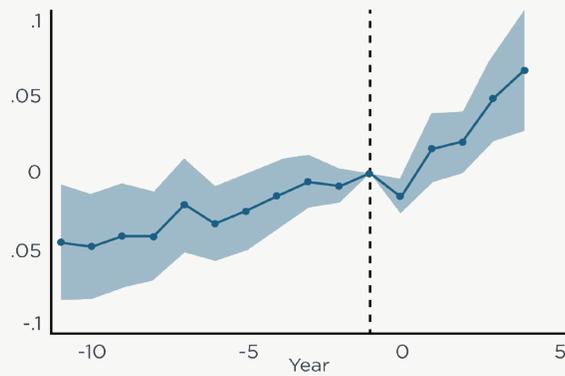
2. Shale development improves the local economy. Counties with a high level of hydraulic fracturing experience marked increases in economic activity. Specifically, the study found up to a 7 percent increase in average income, driven by increases in wages and other factors such as royalty payments from the drilling to local land owners. Employment also increased about 10 percent, with a 40 percent increase alone in natural resources and mining jobs. The construction and transportation industries also saw an increase, while no industries experienced job losses. Additionally, local governments experienced a boost in revenue—though slight because of the need for additional expenses. For example, governments needed to pay more for public safety, infrastructure and utilities, and medical care. (See Figure 4)

“All in all, the current data shows that on average the overall benefits to local communities outweigh the costs.”

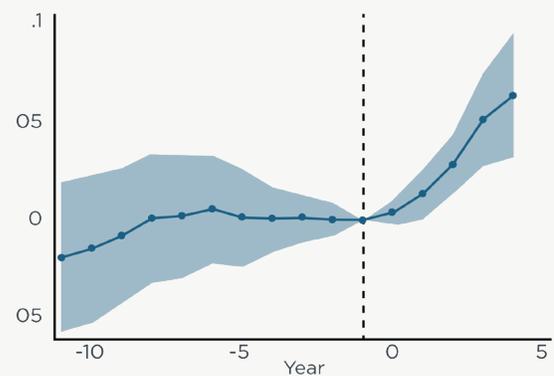
MICHAEL GREENSTONE
DIRECTOR, EPIC

Figure 4 •

Log (Total Income)

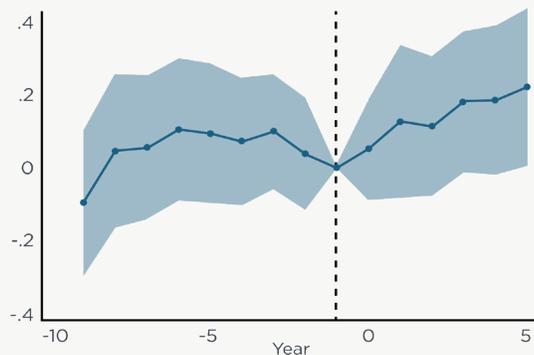


Log (Total Employment)



3. Shale development did impose costs. While communities saw a boost to their local economy with the introduction of hydraulic fracturing, residents experienced decreases in local quality of life. The most directly measurable of these costs was the increase in crime. Despite local governments' efforts to improve public safety—allocating 20 percent more funding—the crime rates still marginally increased.

adds an average welfare gain of about \$1,300 to \$1,900 per household per year—that's as much as \$64 billion in all of the shale drilling areas studied combined. Second, the authors computed how much fracking had changed quality of life, ignoring the benefits from rising incomes. These estimates showed a reduction in the typical household's quality of life by about \$1,000 to \$1,600 annually.

Figure 5 • Log (Violent Crime) (Sample: Consistent)

While the results represent a step forward in our knowledge about the benefits and costs of fracking, the authors caution that these estimates are only as good as the information households have at their disposal about the benefits and costs of fracking. As more information becomes available on, for example, the health impacts, this new knowledge would influence real estate purchasing behavior and prices and general net welfare.

6. Each shale region fares differently, with the Bakken and Marcellus regions seeing the greatest benefits.

These are averages. Not everyone fares equally as positively. Those who are not employed, i.e. students and the elderly, would not see benefits, nor would those who don't own mineral rights for their property. Additionally, there was substantial heterogeneity in estimated effects across the nine shale regions studied. North Dakota's Bakken shale and Pennsylvania's Marcellus shale saw the largest benefits, with house price increases of 23 percent and 9 percent, respectively.

4. Housing prices increased. The study found that housing prices increased on average by about 6 percent after shale development began, indicating the local benefits do outweigh the costs. To put this into context, studies have shown that: dramatic air quality improvements due to regulations have increased housing prices by just 2.5 percent; investments in school facilities have increased housing prices by about 4-8 percent; and the opening of an industrial plant leads to an 11 percent decline in housing prices.

5. Overall local benefits of shale development outweigh the costs on average The authors combined the estimated effects on local housing prices and income with an economic model to compute two important measures of the local consequences of fracking. First, they computed the net impact of fracking on local well-being, which encompasses the gains from increased income and local activity, but also the costs from reduced quality of life because of truck traffic, criminal activity, noise and air pollution from drilling activity, and household beliefs regarding expected health impacts. Their analysis finds that shale development

Policy Implications

There are indeed costs and benefits to hydraulic fracturing. Local communities must weigh these costs and benefits when deciding whether to permit shale development within their jurisdictions. To date, policymakers have often made these decisions without full information on the costs and benefits. The analysis presented here provides these policymakers with this information, showing that on average the benefits outweigh the costs to local communities.

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