COUNCIL *on* FOREIGN RELATIONS

ENERGY BRIEF

The Shale Gas and Tight Oil Boom: U.S. States' Economic Gains and Vulnerabilities

Stephen P.A. Brown and Mine K. Yücel

October 2013

This brief is made possible through the generous support of the Alfred P. Sloan Foundation.

The Council on Foreign Relations (CFR) is an independent, nonpartisan membership organization, think tank, and publisher dedicated to being a resource for its members, government officials, business executives, journalists, educators and students, civic and religious leaders, and other interested citizens in order to help them better understand the world and the foreign policy choices facing the United States and other countries. Founded in 1921, CFR carries out its mission by maintaining a diverse membership, with special programs to promote interest and develop expertise in the next generation of foreign policy leaders; convening meetings at its headquarters in New York and in Washington, DC, and other cities where senior government officials, members of Congress, global leaders, and prominent thinkers come together with CFR members to discuss and debate major international issues; supporting a Studies Program that fosters independent research, enabling CFR scholars to produce articles, reports, and books and hold roundtables that analyze foreign policy issues and make concrete policy recommendations; publishing *Foreign Affairs*, the preeminent journal on international affairs and U.S. foreign policy; sponsoring Independent Task Forces that produce reports with both findings and policy prescriptions on the most important foreign policy topics; and providing up-to-date information and analysis about world events and American foreign policy on its website, CFR.org.

The Council on Foreign Relations takes no institutional positions on policy issues and has no affiliation with the U.S. government. All views expressed in its publications and on its website are the sole responsibility of the author or authors.

For further information about CFR or this paper, please write to the Council on Foreign Relations, 58 East 68th Street, New York, NY 10065, or call Communications at 212.434.9888. Visit CFR's website, www.cfr.org.

INTRODUCTION

U.S. policymakers have been concerned about the country's dependence on imported energy since World War II. Those concerns were highlighted in the 1970s when episodes of sharply rising oil prices led to recessions, economic stagnation, and high inflation. However, recent gains in U.S. oil and natural gas production are changing the dialogue about U.S. energy strengths and vulnerabilities.

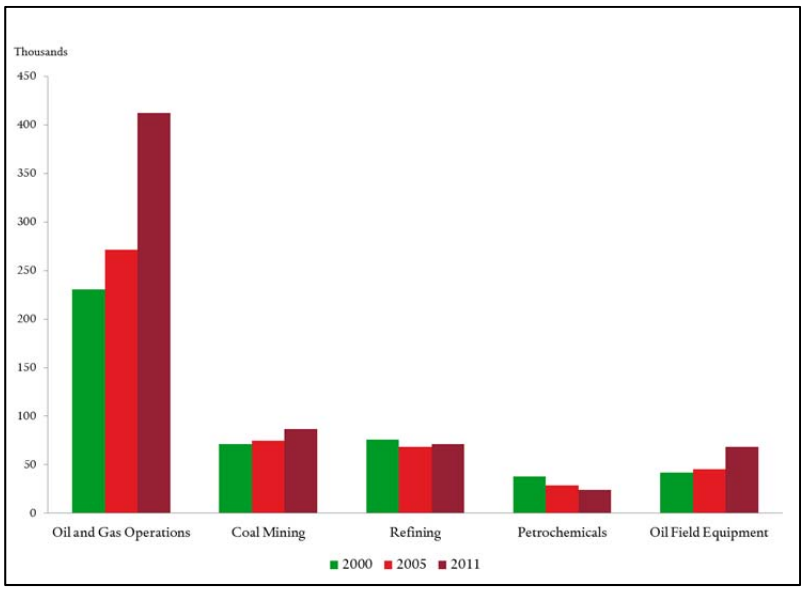
The "shale revolution" has stimulated tremendous production of oil and natural gas in the United States. The revolution is the product of advances in oil and natural gas production technology—notably, a new combination of horizontal drilling and hydraulic fracturing. These technological advances combined with high oil and gas prices have enabled increased production of the abundant oil and natural gas resources in the United States.

Greater availability of domestic energy resources benefits the United States by reducing dependence on imported energy and diversifying the economy.[1] But the boom also brings new vulnerabilities. Examining how changes in U.S. oil and natural gas production may affect individual state economies shows that some of the states providing new energy resources are becoming less economically diversified and more economically vulnerable to energy price declines.

OIL PRICES AND EMPLOYMENT IN THE U.S. FOSSIL FUEL INDUSTRY

Until recently, the U.S. oil and natural gas industry mostly followed the ups and downs of world oil prices, but with a long-term decline that reflected the decreasing availability of U.S. oil and natural gas resources. At the height of the early 1980s oil boom, the five industries most sensitive to oil prices—coal mining, oil and gas extraction, oil field machinery, petroleum refining, and petrochemicals—accounted for 1.6 million jobs, 1.8 percent of total U.S. nonagricultural employment.[2] By 2000, the share of these five industries had dwindled to 0.4 percent of total U.S. nonagricultural employment, only 457,000 jobs. With oil and natural gas prices rising beginning in the early 2000s, employment in the oil and natural gas sector began growing too. The boom in production of oil and natural gas from shale formations became a significant factor after 2008. Figure 1 shows that rising energy prices and the shale boom led to strong growth of U.S. oil and gas employment from 2005 to 2011.

Figure 1. U.S. Fossil Fuel–Related Employment



Sources: U.S. Bureau of Labor Statistics; author calculations.

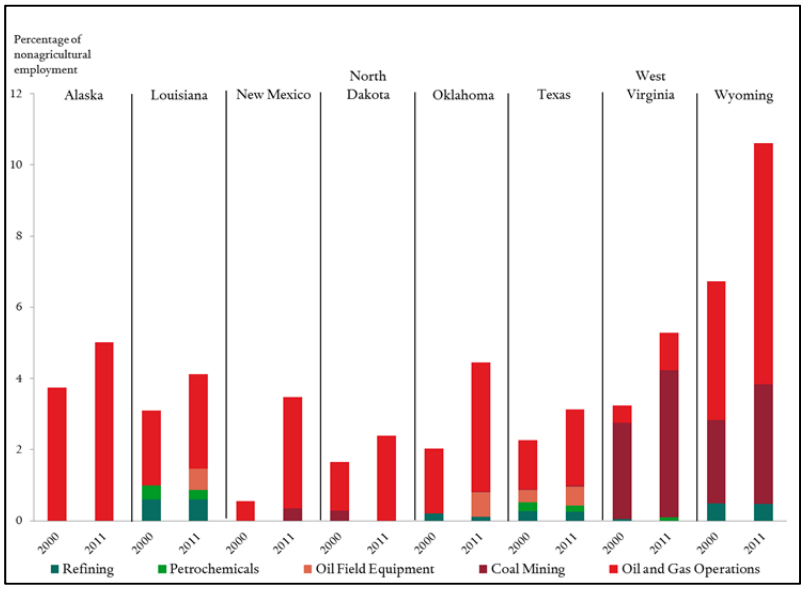
Despite recent gains, however, the fossil fuel industry has a smaller share of U.S. employment than it did in the early 1980s, and the industry's share of national economic activity is relatively small. After the end of the recession, between 2010 and the end of 2012, the industry added 169,000 jobs nationwide, growing at a rate about ten times that of overall U.S. employment. The industry's output shares follow a similar path. The share of oil and gas extraction was 4.3 percent of U.S. gross domestic product (GDP) at its height in 1981, but declined to 0.6 percent by 1999. The share of oil and gas rose to 1.6 percent of GDP in 2011 as a result of the shale boom.[3]

FOSSIL FUEL INDUSTRIES AND STATE EMPLOYMENT

As energy prices and U.S. oil and natural gas production fell from the mid-1980s to the early 2000s, most U.S. energy-producing states diversified away from energy production and energy-intensive industries. In 1982, the states with the greatest concentration of energy-related industries were West Virginia, Wyoming, Delaware, Oklahoma, Louisiana, and Texas.[4] Oil and natural gas accounted for much of the activity except in Delaware, which had a high concentration of the petrochemical industry, and in West Virginia, the heart of coal country. Shares of energy-related employment ranged from 7.3 percent in Texas to 13.7 percent in West Virginia. By 2000, these shares had declined to a range from 2.5 percent to 7.4 percent.

Rising oil and gas prices since the early 2000s prompted a resurgence of energy employment. Increased use of horizontal drilling and hydraulic fracturing led to further gains in oil and gas hiring. As of 2011, the states with the highest shares of energy employment were Alaska, Louisiana, New Mexico, North Dakota, Oklahoma, Texas, West Virginia, and Wyoming. As shown in Figure 2, energy employment shares increased in all eight of these states from 2000 to 2011.[5] Although there is little oil and gas activity in West Virginia, its coal production grew because coal prices followed the upward trend in oil prices in the 2000s. Despite these gains, however, almost every one of these states depends less on the five main energy-related industries than they did in 1982.

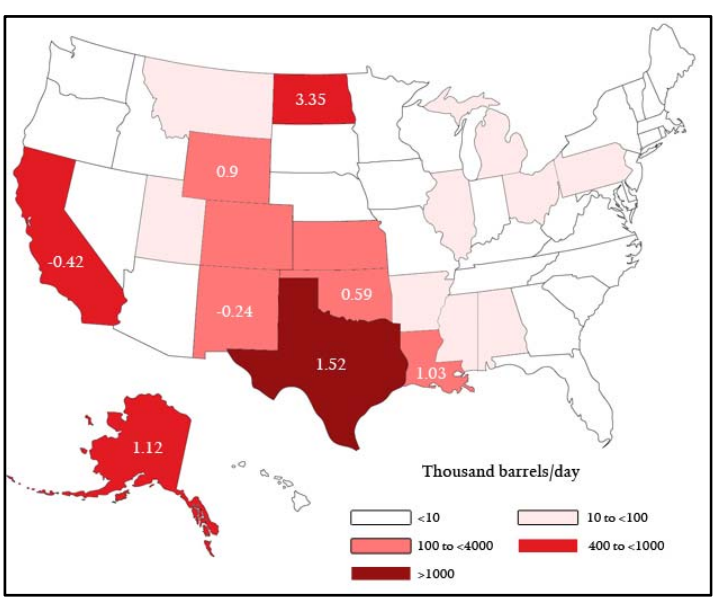
Figure 2. State Employment Shares



Sources: Author calculations with data from the U.S. Bureau of Labor Statistics.

Fossil fuel production has been important to these states' recent economic performance. Since the early days of the shale boom in 2006, the four states with the highest rates of employment growth are the states with the highest shares of oil and gas employment (Figure 3). The greatest growth has been in Texas and North Dakota, states with production from shale and the largest production increases. As seen in Figure 3, between 2006 and 2012, U.S. employment declined 0.05 percent per year on average, while employment in North Dakota and Texas grew by 3.4 and 1.5 percent, respectively, the fastest growth in the country.

Figure 3. Shale Oil and Employment Growth



Note: 2006–2012 yearly employment growth rates; U.S. average annual employment growth of -0.05.
Sources: Author calculations; data from U.S. Bureau of Labor Statistics; U.S. Energy Information Administration.

Because the United States is an oil importer, its economy has been hurt by previous episodes of sharply rising oil prices that resulted from oil supply shocks.[6] Given the oil production increase in the past couple of years, has the response of the U.S. economy to oil price shocks changed? The economic composition of individual states affects their responses to oil price shocks. We find that the economies of forty-two states and the District of Columbia would suffer if oil prices rise. In contrast, the economies of eight states—Alaska, Louisiana, New Mexico, North Dakota, Oklahoma, Texas, West Virginia, and Wyoming—would benefit from such increases.

To assess the effects of oil price shocks on states' economies, we first estimate the responses of individual industries to changes in oil prices using methods we used in a 1995 paper.[7] As shown in Table 1, the estimated price elasticity of total U.S. employment, based on data for 2000–2011, is -0.02, which means that a 10 percent increase in oil prices reduces U.S. employment by 0.2 percent.[8] Employment in the fossil fuel industries is considerably more responsive to oil price movements than employment in the overall economy is, but the responsiveness is less than we estimated eighteen years ago.[9] These differences are the result of changing relationships between the industries, such as the reduced sensitivity of coal and natural gas prices to oil prices, the closure of some U.S. refineries, and how relative changes in oil and natural gas prices affect the U.S. petrochemicals industry.

Table 1. Elasticities of Employment With Respect to Oil Prices[10]

	Elasticity
Total U.S. Employment	-0.02
Coal Mining	0.24
Oil and Natural Gas Extraction	0.40
Oil Field Machinery	0.29
Refining	-0.03
Petrochemicals	0.36

Sources: Author calculations.

To calculate the employment response of each state to an oil price shock, we combine these elasticities with the input-output analysis framework we previously developed and published in 1995 (updated with new multipliers).[11] The framework takes into account the composition of each state's economy, quantitative differences in multiplier effects across states, and the response of individual fossil fuel industries to changes in oil prices. Differences across the states in concentrations of energy-producing and energy-consuming industries account for most of the variation in the response of employment to oil price changes across the states. Differences in multiplier effects also account for some of the variation between states.[12]

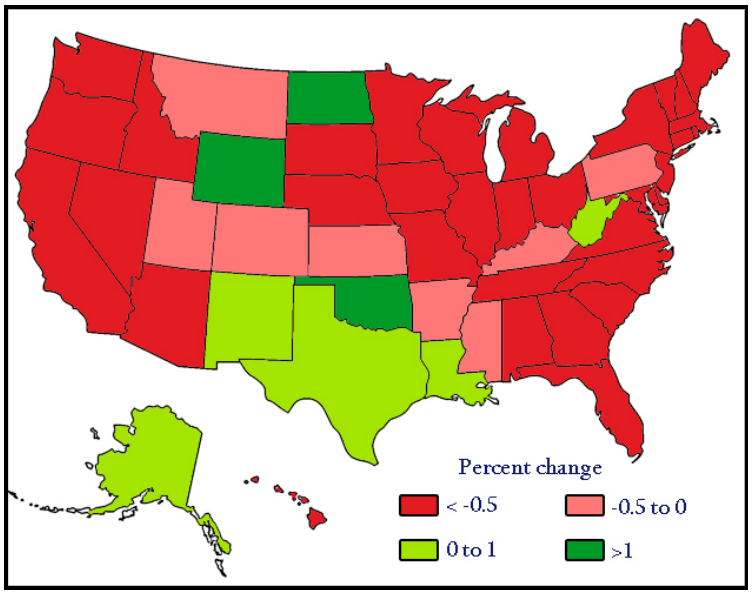
The results show that a 25 percent increase in oil prices (for example from $100 to $125) would result in a loss of more than 550,000 jobs nationwide.[13] None of the states stand out as being hurt by rising oil prices by much more than the country as whole (Table 2). Several states without much of an oil and gas industry would see somewhat stronger negative effects from rising oil prices than the country as a whole.

Table 2. Estimated Employment Response to a 25 Percent Increase in Crude Oil Prices, 2012

	Percent		Percent
United States	-0.43		
Wisconsin	-0.74	Ohio	-0.61
Minnesota	-0.73	Missouri	-0.60
Tennessee	-0.72	Illinois	-0.59
Rhode Island	-0.71	Massachusetts	-0.59
Florida	-0.71	Delaware	-0.58
New Hampshire	-0.70	South Dakota	-0.57
Idaho	-0.69	New York	-0.57
Nevada	-0.69	California	-0.56
Arizona	-0.68	Alabama	-0.56
Indiana	-0.68	District of Columbia	-0.50
Nebraska	-0.67	Kentucky	-0.48
Vermont	-0.66	Pennsylvania	-0.47
Iowa	-0.66	Utah	-0.38
New Jersey	-0.65	Kansas	-0.35
Washington	-0.64	Mississippi	-0.35
Maryland	-0.64	Arkansas	-0.34
Georgia	-0.64	Montana	-0.31
Michigan	-0.64	Colorado	-0.15
Virginia	-0.64	New Mexico	0.36
South Carolina	-0.64	West Virginia	0.36
Oregon	-0.64	Texas	0.60
Connecticut	-0.63	Louisiana	0.78
Maine	-0.62	Alaska	0.87
North Carolina	-0.62	North Dakota	1.01
Hawaii	-0.61	Oklahoma	1.16
		Wyoming	2.14

Sources: Author calculations; data from U.S. Bureau of Labor Statistics and the *Wall Street Journal*.

Figure 4. Estimated Employment Response to a 25 Percent Increase in Crude Oil Prices, 2012



Sources: Author calculations; data from U.S. Bureau of Labor Statistics and the *Wall Street Journal*.

Several states with larger fossil fuel industries see positive effects or a smaller negative effect than the country as a whole. Alaska, Louisiana, New Mexico, North Dakota, Oklahoma, Texas, West Virginia, and Wyoming would benefit from rising oil prices. Combined, these eight states would add around a hundred thousand jobs in response to a 25 percent rise in oil prices.

Wyoming would benefit most from an oil price spike because it has a small population and a large share of oil and gas extraction employment. Alaska's economy has traditionally depended on the oil extraction industry, has the second highest share of extraction employment among all states, and remains a beneficiary of higher oil prices. North Dakota's fossil fuel industry has grown rapidly since the onset of the shale boom and extraction is now 4 percent of state employment. West Virginia, with a strong coal industry, benefits from higher oil prices, but by less than what we previously estimated in 1995 for 1982 and 1992.[14] Coal prices moved together more tightly with oil prices until the global recession. Although coal prices have slowly trended higher during the recovery, the relationship with oil has weakened. As long as coal prices move with those for oil, the West Virginia economy will benefit from higher oil prices, albeit in a more muted manner than in the past.

The Louisiana and Texas economies are helped by rising oil prices, but employment response is less than in some energy states. These two states are home to 40 percent of U.S. refining capacity, and refining is hurt by rising oil prices. In addition, Texas has a large and diverse economy: the share of oil and gas extraction is about 2 percent of state employment, much less than in other energy-producing states.

Louisiana and Texas are also home to a substantial portion of U.S. petrochemical production. Rising oil prices help the U.S. petrochemicals industry as long as natural gas prices remain low. If enough domestic natural gas were exported such that U.S. natural gas prices again moved with oil prices, the U.S. petrochemicals industry would no longer benefit from rising oil prices.[15]

These employment responses differ substantially from those we previously estimated for 1982, a year at the height of the last U.S. oil and gas boom.[16] For that year, economies of thirteen states would have benefitted from rising oil prices. In addition to the eight states mentioned above, rising oil prices would have aided Colorado, Kansas, Montana, Mississippi, and Utah. Over the past thirty years, the economies in these five states have diversified away from crude oil production, and they no longer respond favorably to rising crude oil prices. Nonetheless, the presence of sizable oil and natural gas industries in these five states mutes their negative response to rising oil prices.

Increased energy prices and technological improvements were catalysts for the U.S. fossil fuel industry's turnaround. Would declining prices reverse those gains? A brief look at history is telling.

From 1972 to 1982, when oil prices increased more than tenfold, Texas economic output and employment averaged annual growth rates of 7.5 percent and 5.5 percent, respectively. When oil prices collapsed to about eleven dollars per barrel in 1986, the Texas economy went into a deep recession for two years. Economic output contracted 5.6 percent and employment fell 1.1 percent.

Even though oil and gas extraction accounted for 19 percent of the Texas economy in 1981, that share was the second smallest among the eight oil-sensitive states (West Virginia was smallest). As a percentage of state GDP, the oil and gas sector accounted for 49 percent in Alaska, 37 percent in Wyoming, 35 percent in Louisiana, and 20 percent in North Dakota. The 1986 oil price crash also caused a recession in most of these states, with employment declines largest in Wyoming (-5.9 percent) and Alaska (-4.5 percent)—states with the largest oil and gas output shares. The economies of these oil-sensitive states rebounded after 1987, but their growth rates were weaker than that of Texas.

Table 3 shows how the fossil fuel industry's output shares contracted after the oil industry peak in 1981 and later expanded with the shale boom, especially in North Dakota, Oklahoma, and Wyoming. The 2012 shares of state GDP from oil and gas extraction should prove even higher, given that oil production has been increasing in these states.[17] If oil prices were to collapse, these states with the highest concentrations in oil and gas extraction would be the hardest hit.

Table 3. Share of Oil and Gas Extraction in State GDP

	Percent		
	1981	**2000**	**2010**
Alaska	49.5	15.1	19.1
Louisiana	35.5	11.1	9.7
New Mexico	26.1	5.2	5.1
North Dakota	20.3	0.9	4.3
Oklahoma	21.6	4.8	9.1
Texas	19.1	5.8	7.8
West Virginia	2.4	1.0	1.5
Wyoming	37.1	9.8	18.5

Source: Author calculations; data from U.S. Bureau of Economic Analysis.

This finding is consistent with the results reported in Table 2. Applying our model in the same way for a price decline as for a price increase shows that falling oil prices would cause overall employment losses in Wyoming, Oklahoma, North Dakota, Alaska, Louisiana, Texas, West Virginia, and New Mexico, with the greatest percentage losses in the first three.[18]

States like Texas and Louisiana that have downstream oil and gas industries that benefit from falling energy prices such as refining and petrochemicals would be less affected. In addition, states in which natural gas is more prominent than oil are likely to see less harm from falling oil prices. With the recent weakening in the relationship between oil and natural gas prices, a decline in oil prices does not necessarily imply as big a change in natural gas prices as it once did, lessening the effect of an oil price decline.

While many states have diversified away from either a heavy reliance on energy consumption or energy production, others have seen and will continue seeing an increasing dependence on energy pro-

duction as a result of the shale revolution. Economic activity in these states is vulnerable to energy price declines. The smaller and less diversified the state, the larger the vulnerability. This vulnerability will increase with growing oil and natural gas production.

Yet most states that currently benefit from falling oil and gas prices will still gain from such developments even if their oil and gas production rises significantly in the coming years. For example, California, Colorado, and Pennsylvania produce a considerable amount of oil and natural gas, but these states would still gain from falling oil prices—even if their oil and gas sectors grew substantially. The California oil and gas sector, for example, would need to be more than 9.5 times larger than it is today for an oil price fall to hurt the California economy. Similarly, the sector would need to be more than 3.9 times larger in Pennsylvania and more than 1.3 times larger in Colorado for oil price declines to hurt the relevant state economies.

CONCLUSION

Given that oil is priced on an international market, increased domestic oil production will not do much to lower prices for U.S. consumers, as any gains in U.S. production will be spread across the international market. Greater reliance on domestic oil resources in substitution for imports will reduce the vulnerability of the economy to oil supply disruptions, although not by much.

Reduced energy use has lessened the vulnerability of the U.S. economy to oil price shocks. A similar phenomenon is seen at the state level, with many state economies having diversified away from energy-using industries. At the same time, the growing prominence of energy production can make states with small, undiversified economies more susceptible to an economic downturn during an energy price decline.

About the Authors

Stephen P.A. Brown is a professor of economics and the director of the Center for Business and Economic Research at the University of Nevada, Las Vegas. An internationally recognized scholar for his work in energy economics, Brown has conducted economic research and analysis on regional economic growth, aggregate economic activity, economic indicators, business conditions, public finance, energy, environment, climate policy, and economic impacts.

Mine K. Yücel is senior vice president and director of research at the Federal Reserve Bank of Dallas, where she has worked since 1989. Yücel analyzes the regional economy and energy markets on an ongoing basis and has published numerous articles on energy economics and regional growth. She has been the president of both the International and U.S. Association of Energy Economics and has served on the boards of numerous professional organizations.

The views expressed are those of the authors and should not be attributed to the Federal Reserve Bank of Dallas or the Federal Reserve System.

Endnotes

1. See Stephen P.A. Brown and Hillard G. Huntington, "Assessing the U.S. Oil Security Premium," *Energy Economics* vol. 38 no. C, July 2013, pp. 118–127; and Stephen P.A. Brown and Ryan T. Kennelly, "Consequences of U.S. Dependence on Foreign Oil," Center for Business and Economic Research, University of Nevada, Las Vegas, 2013.
2. U.S. Bureau of Labor Statistics.
3. U.S. sectoral GDP data come out with a lag. The latest data are from 2011.
4. See Stephen P.A. Brown and Mine K. Yücel, "Energy Prices and State Economic Performance," *Economic Review*, Federal Reserve Bank of Dallas, Second Quarter, 1995.
5. Latest detailed state sectoral data are from 2011, as of this writing.
6. Lutz Kilian provides evidence that rising oil prices that result from demand shocks do not adversely affect U.S. economic activity. See Lutz Kilian, "Not All Oil Price Shocks Are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market," *American Economic Review* vol. 9 no. 4, June 2009, pp. 1053–1069.
7. Stephen P.A. Brown and Mine K. Yücel, "Energy Prices and State Economic Performance," *Economic Review*, Federal Reserve Bank of Dallas, second quarter, 1995.
8. This estimate of the overall U.S. employment response is in the range of estimated GDP responses to oil price movements.
9. We previously estimated the oil-price elasticities of employment in coal mining, oil and natural gas extraction, oil field machinery, refining, and petrochemicals at 0.45, 1.01, 1.23, -0.56, and -0.32. See Stephen P.A. Brown and Mine K. Yücel, "Energy Prices and State Economic Performance," *Economic Review*, Federal Reserve Bank of Dallas, second quarter, 1995.
10. The industry elasticities are obtained from regressions of sectoral employment on WTI crude oil prices, using monthly data for the time period 2000–2011. The total U.S. employment elasticity is taken from empirical work in the economics literature. See Stephen P.A. Brown and Mine K. Yücel, "Energy Prices and State Economic Performance," *Economic Review*, Federal Reserve Bank of Dallas, second quarter, 1995.
11. Stephen P.A. Brown and Mine K. Yücel, "Energy Prices and State Economic Performance," *Economic Review*, Federal Reserve Bank of Dallas, second quarter, 1995. We used the RIMS II multipliers for 2010 from the U.S. Bureau of Economic Analysis to update the analysis.
12. See Stephen P.A. Brown and Mine K. Yücel, "Energy Prices and State Economic Performance," *Economic Review*, Federal Reserve Bank of Dallas, second quarter, 1995, for an exposition of the model.
13. Previous research on the response of U.S. economic activity to oil price shocks, such as James Hamilton's 2003 paper, finds the U.S. economy responds more strongly to oil price increases than oil price decreases. See James D. Hamilton, "What Is an Oil Shock?," *Journal of Econometrics* vol. 113 no. 2, April 2003, pp. 363–98.
14. Stephen P.A. Brown and Mine K. Yücel, "Energy Prices and State Economic Performance," *Economic Review*, Federal Reserve Bank of Dallas, second quarter, 1995.
15. We showed in 2009 that there is coordinated movement in natural gas prices across the Atlantic, which can be accomplished through LNG shipments. But their results strongly suggest that the coordination of natural gas prices across the Atlantic is facilitated through oil prices, especially given that natural gas contracts in Europe are linked to oil prices. See Stephen P.A. Brown and Mine K. Yücel, "Market Arbitrage: European and North American Natural Gas Prices," *Energy Journal* vol. 30, special issue, 2009, pp. 167–185.
16. Stephen P.A. Brown and Mine K. Yücel, "Energy Prices and State Economic Performance," *Economic Review*, Federal Reserve Bank of Dallas, second quarter, 1995.
17. At the time of this writing, the most recent detailed GDP data for the states were from 2010.
18. Because the results for the energy-producing states are dominated by shifts within the fossil fuel industry, applying our model to oil price decreases creates only a slight upward bias to our estimates. That bias increases as we shift our attention toward energy-importing states.