Stanford University • March 2015

SIEPR policy brief

Stanford Institute for Economic Policy Research

on the web: http://siepr.stanford.edu

The End of Expensive Oil?

By Frank A. Wolak

1. The North American Shale Resource Bonanza

The shale oil and gas revolution in the United States (U.S.) has led to a more than 4 million barrels per day increase in domestic oil production since 2008. Combined with an almost 1 million barrel per day increase from the Alberta tar sands, the surge in North American oil production has significantly reduced the region's demand for imported oil. Increased production of shale gas in North America and the significantly lower dollar per million British thermal unit (BTU) price of natural gas versus oil have caused a number of sectors of the U.S. economy to shift away from consuming oil to natural gas. Consequently, China, rather than the United States, is now the world's largest oil importer, purchasing more than 7 million barrels per day from the global market. Figure 1 shows domestic production of oil in December of 2014 approaching the historical high of slightly more than 10 million barrels per day in November of 1970.

2. The Declining Role of OPEC

The increase in North American oil production and decline in U.S. oil consumption have also significantly reduced the share of global oil demand served by the OPEC countries. Recognizing this fact, Saudi Arabia, the largest OPEC producer, recently decided not to reduce its production in response to prices in the $50 to $40 per barrel range. One can make a strong case that Saudi Arabia concluded that reducing its output would not increase the global price enough to make this unilateral reduction in output profitable. One plausible reason is that Saudi Arabia inferred that other OPEC countries would not follow its lead in reducing output to the extent needed to achieve a jointly profitable (for all OPEC members) global oil price increase.

A number of factors point to stable or even higher output levels from the OPEC countries. Most OPEC countries are currently experiencing massive fiscal shortfalls because of low oil prices. The desire of these countries to avoid

continued on inside...

About The Author

Frank Wolak is the Holbrook Working Professor of Commodity Price Studies in the Economics Department and the Director of the Program on Energy and Sustainable Development. Wolak's recent research focuses on regulation, design, and monitoring of energy and environmental markets. From April 1998 to April 2011, he was Chair of the Market Surveillance Committee (MSC) of the California Independent System Operator. In this capacity, he has testified numerous times at the Federal Energy Regulatory Commission (FERC), and at various Committees of the US Senate and House of Representatives on issues relating to market monitoring and regulatory oversight of energy markets. Until December 2013, Wolak served as a member of the Emissions Market Advisory Committee (EMAC) for California's market for greenhouse gas emissions allowances. This committee advised the California Air Resources Board on the design and monitoring of the state's cap-and-trade market for greenhouse gas emissions allowances.

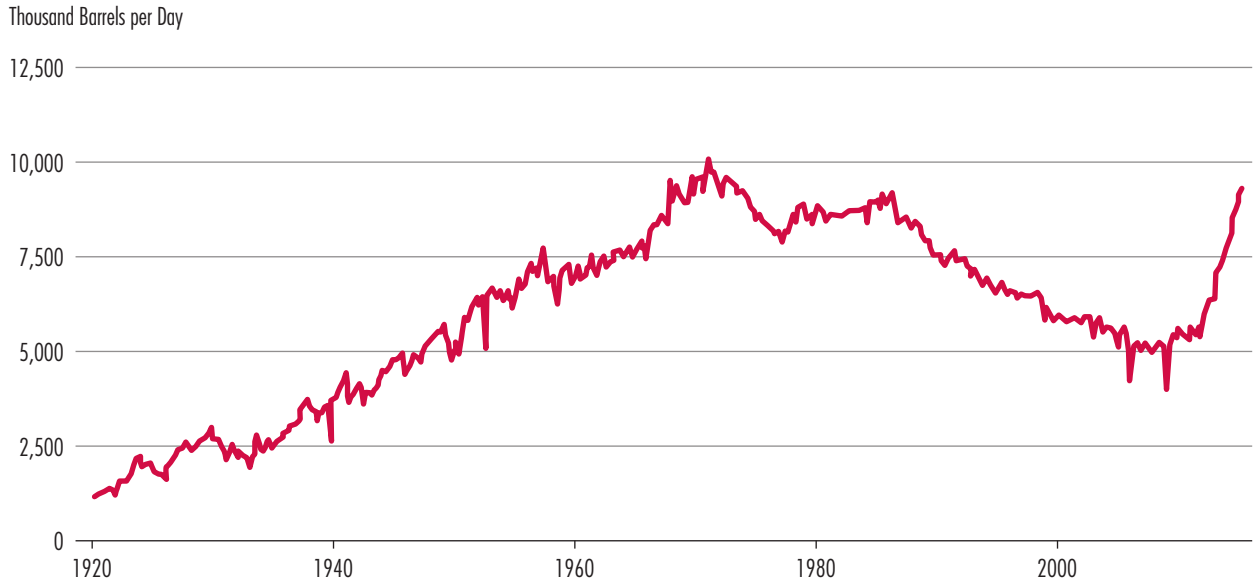
further domestic unrest makes oil output reductions unlikely because this would lead to even larger fiscal shortfalls unless these actions could be successfully coordinated among the OPEC countries to produce a significant increase in the global oil price. Slower demand growth in China and Europe makes unilateral output reductions by Saudi Arabia and other OPEC countries even less likely to increase global oil prices. Finally, over the past year, oil production has increased by almost 1 million barrels per day in Iraq and Libya.

3. Increasing Standardization of Well Drilling

The share of global oil production from the OPEC countries should continue to fall as more countries adopt shale oil and gas production technology. The technology of shale oil and natural gas production is less than 10 years old, so there is still significant scope for cost reductions in exploration, drilling, and production activity, even in the U.S. According to the oilfield services firm Baker/Hughes, more than 37,000 wells were drilled in the U.S. in 2014. This volume of drilling activity has led to increasing standardization of the drilling and production activity. This so-called "factory drilling" process has reduced the time necessary to drill a well to less than 10 days. Historically, approximately 40 percent of the wells drilled are uneconomic in the sense that less oil and gas is recovered than it costs to drill the well. Consequently, there is considerable scope for improvement in well completion efficiency, which should increase the amount of oil or gas that can be recovered from a given well.

Another important trend likely to reduce both drilling and production costs and enhance productive efficiency is the greater integration between oil and gas service companies. Historically, drilling and production activities were undertaken by a range of suppliers. Recently, an increasing number of companies are offering one-stop shopping for all drilling and production activities, which can reduce production costs and increase well efficiency. A prominent example of this trend is the merger between Halliburton and Baker-Hughes, two of the largest oil and gas services companies. This merger is motivated by the desire for a single company that provides fully integrated services for all aspects of oil and natural gas drilling and production.

Figure 1
Monthly U.S. Field Production of Crude Oil



Source: U.S. Energy Information Administration.

4. Natural Gas and Oil Interactions

One key driver of a reduced global demand for oil is the development of technologies that are able to exploit the differential between the dollar per MMBTU cost of oil and the dollar per MMBTU cost of natural gas. Even at $40/barrel, the dollar per MMBTU price of oil is still substantially in excess of the dollar per MMBTU price of natural gas. Assuming the industry standard 5.8 MMBTU per barrel of oil conversion factor implies an $8.60 per MMBTU price of oil. The current dollar per MMBTU price of Henry Hub natural gas is less than half that amount, which implies further switching away from oil is likely to occur in North America, particularly in the heavy-vehicle transportation sector.

The production of associated gas from oil extraction is an additional driver of fuel switching from oil to natural gas. Roughly one-third of the growth in new U.S. natural gas supplies and approximately 10 percent of total domestic natural gas production are derived from the production of oil. Increases in the supply of associated natural gas are driven by the price of oil, but this increased supply of natural gas reduces the price of natural gas. Consequently, the production of associated natural gas increases the difference between the dollar per MMBTU price of oil and dollar per MMBTU price of natural gas, which leads to further switching from oil to natural gas for fossil fuel-based energy services.

5. Technologies that Reduce Oil versus Natural Gas Price Differential

An innovation limiting the amount of natural gas flaring (gas burned at the source without doing any useful work) that takes place in regions with significant shale oil production, such as North Dakota, is the CNG-in-a-Box technology recently developed by General Electric (GE). CNG-in-a-Box is a mobile technology that captures the natural gas that was formerly being flared off and compresses it to produce compressed natural gas (CNG) for use in vehicles serving the region and in drilling equipment, reducing the demand for diesel fuel in the region. This technology makes productive use of natural gas in regions without natural gas pipeline infrastructure.

The pricing of natural gas versus oil-based fuels favors substitution away from oil to natural gas in the transportation sector. At the current price of natural gas in the U.S. in the range of $3/MMBTU, the dollar per gasoline gallon equivalent (GGE) cost of compressed natural gas is approximately $0.50 and the dollar per diesel gallon equivalent (DGE) is $0.60, because of the higher energy content of a gallon of diesel fuel versus a gallon of gasoline. According to the U.S. Energy Information Administration (EIA), at $50 per barrel of oil, the current wholesale price of gasoline is $1.50 per gallon and the wholesale price of diesel is $1.80 per gallon. These price differences between CNG and gasoline and diesel suggest there are still significant opportunities for cost savings from switching from oil to natural gas in the transportation sector and any other sectors that use diesel fuel, even at a price of oil in the range of $50 to $55 per barrel.

6. Exporting Shale Oil and Gas Technology

Although the recent reductions in oil and natural gas prices have caused investments in oil and natural gas exploration and drilling in the U.S. to decline, delivered natural gas prices in the remainder of the world, particularly, Latin America and Asia, remain substantially higher. This fact and a robust global oil demand driven by China and the developing world are sufficient to support continued investments in oil and natural gas exploration outside the U.S. China has embarked on an aggressive program to develop its shale gas resources in an effort to reduce its demand for coal. Major participants in virtually every major shale oil and gas play in the U.S. have a Chinese partner. There are also many joint ventures between U.S. and Chinese companies to explore for shale oil and natural gas in China. International oil and natural gas companies are also continuing to explore for shale oil and natural gas outside of the U.S., albeit at a slower rate, as horizontal drilling and hydraulic fracturing technologies spread outside of the U.S. For the above reasons, the prospects are bright for a stable and growing source of oil and natural gas from unconventional resources outside of the U.S.

7. Flattening of the Supply Curve of Oil

The exploration and development of shale oil and natural gas resources have

an important technological characteristic that is likely to reduce the future volatility of global oil and natural gas prices as these resources are developed. Conventional oil and natural gas resource exploration and discovery typically involved large oil and natural gas finds that were extremely low cost to extract. This led to periods when the global oil market had to swallow large supply surges, which typically led to large price drops followed by price run-ups as demand grew to accommodate this increased supply. There are many historical instances of large oil or natural gas field discoveries yielding this pattern of prices.

The technology of shale oil and natural gas extraction involves significantly higher average variable costs associated with the production of each barrel of oil because of the rapid rate of depletion for each shale oil or gas production rig. A typical well in the Bakken field of North Dakota has a more than 60 percent decline in its rate of production during the first year. Production during the third year declines 30 percent relative to the second-year production. The well produces the remaining economically recoverable resource during the remaining years. Conventional natural gas and oil wells have significantly slower rates of decline. This logic implies that in order to sustain production from a shale oil or gas resource continual drilling of new wells is necessary. This characteristic of shale oil and gas production implies that it is possible to scale up and scale back shale oil and gas production more rapidly in response to demand surges, which should mitigate oil and natural gas price volatility.

Alberta's tar sands have a similar production process. The production of oil from tar sands involves mining tar sands in a manner that is very similar to surface coal mining and then separating the bitumen from the clay, sand, and water that make up tar sands. About two tons of tar sands are required to produce one barrel of oil. The separation process requires adding hot water to the tar sand and agitating the resulting mixture to separate out the bitumen, which floats to the top of the separation vessel. This bitumen also requires upgrading before being converted to synthetic oil that can be refined into gasoline, diesel, and other refinery products. The extraction, separation, and upgrading processes all require the use of fossil fuels, particularly the separation and upgrading steps. Consequently, access to inexpensive natural gas in tar sands producing regions is a major contributor to the favorable economics of this process.

A further argument in favor of global oil prices remaining in the range of $50 to $60 per barrel for at least the next 10 to 20 years is based on the observation that natural gas prices in the range of $6.00 per MMBTU are generally acknowledged to be sufficient for the long-term financial viability of much of the shale gas reserves in the U.S. This implies GGE and DGE prices for CNG in the range of $1.00 and $1.10 per gallon, respectively. Historically, oil has traded at a slight dollar per MMBTU premium relative to natural gas, which suggests that oil prices are not likely to significantly exceed $6/MMBTU over the long terms. Even assuming a $2.00 per MMBTU premium for oil relative to natural gas implies a price of oil in the range of $50 per barrel with the standard conversion factor of roughly 6 MMBTU per barrel of oil.

8. Countervailing Factors

Although all of the factors described above make a medium-term (the next 10 to 20 years) price of $100 per barrel of oil very unlikely, predicting the future is always fraught with uncertainty, so a sustained period of prices in this range cannot be completely ruled out. Factors that would make this outcome more likely include an environmental disaster associated with shale oil and natural gas extraction that causes more regions to prohibit these activities. The experience of the industry in the U.S. suggests it is possible to extract substantial amounts of shale oil and natural gas with limited adverse environmental consequences.

More than 30,000 shale oil and gas wells have been drilled in the U.S. during each of the past five years with only a small number of environmental incidents. During this time significant progress has been made in reducing the fresh water needed to drill shale oil or gas wells and in reducing the amount of produced water that must be disposed of after a well is drilled. There is also a substantial amount of academic and industry research addressing the risk of micro-earthquakes and methane leakage associated with shale oil and gas extraction. If U.S. firms are able to continue to improve their environmental record on shale oil and gas extraction, European countries with significant shale

continued on flap…

and oil and gas resources may decide to end their prohibition on the development of these energy resources.

Another factor that could lead to oil prices in the range of $100 per barrel for a sustained period of time is the inability of the natural gas and oil sector to master the geology of economical production of shale oil and natural gas outside of the U.S. The technical challenges that must be overcome to extract these resources differ according to the underlying geology of the shale. If the oil and natural gas extraction firms are unable to master these challenges outside of the U.S., this could significantly reduce the global supply of oil and natural gas. This outcome seems very unlikely, given the almost 100 years of experience of international oil companies finding and extracting conventional oil and natural gas resources all around the world. The consolidation in the global oil services sector and its growing experience dealing with diverse geologies make it a more likely outcome that these resources will be extracted at average cost per barrel or MMBTU similar to the levels in the U.S.

The U.S. Energy Information Administration (EIA) estimates that there are substantial shale oil and natural gas resources in all of the continents. For example, it estimates that Argentina possesses the world's second-largest shale gas reserves. Several multinational corporations are already in joint ventures with Argentina's state-owned oil company to develop these resources. The results from exploratory drilling operations are very encouraging for the large-scale development of this resource. The major remaining challenge is overcoming the domestic political barriers to the development of this resource by multinational corporations.

A final source of significant uncertainty impacting global oil prices is whether the United Nations international climate policy process will put in place a credible and stable price of carbon. As long as this price of carbon is not so high as to make all fossil fuels uneconomic, this action could further spur the demand for natural gas, as more countries attempt to switch from coal to less greenhouse-emissions-intensive energy sources, such as natural gas. In general, a positive global price of carbon will be a moderating influence on the price of oil because its consumption involves the production of greenhouse-gas emissions, which would require paying for these emissions at the global price of carbon.

9. Concluding Comments

Although there are states of the world that could develop where global oil prices would rise above $100 per barrel, the most likely medium-term outcome is prices in the range of $50 to $70 per barrel. The slowing demand for oil in the industrialized world; the increasing range of technologies that can provide energy services formerly provided by oil using natural gas; ever-advancing technological change in shale oil exploration, drilling, and extraction; and the increasing efficiency of the oil and natural gas services industries all point to a sustained period of significantly lower global oil prices.

SIEPR *policy brief*

Stanford University
366 Galvez Street
Stanford, CA 94305
MC 6015

A publication of the
Stanford Institute for
Economic Policy Research

Non-Profit Org.
U.S. Postage
PAID
Palo Alto, CA
Permit No. 28

SIEPR

About SIEPR

The Stanford Institute for Economic Policy Research (SIEPR) conducts research on important economic policy issues facing the United States and other countries. SIEPR's goal is to inform policymakers and to influence their decisions with long-term policy solutions.

Policy Briefs

SIEPR policy briefs are meant to inform and summarize important research by SIEPR faculty. Selecting a different economic topic each month, SIEPR will bring you up-to-date information and analysis on the issues involved.

SIEPR policy briefs reflect the views of the author. SIEPR is a non-partisan institute and does not take a stand on any issue.

For Additional Copies

Please see SIEPR website at *http://SIEPR.stanford.edu*.