Comments and Discussion

COMMENT BY
STEVE CICALA  The development of hydraulic fracturing and horizontal drilling technologies (collectively referred to as fracking) has led to a massive expansion of economically recoverable natural gas reserves in the United States. Gas from the shale and tight oil formations made accessible by this technology has grown in a brief six-year period from obscurity to account for nearly half of U.S. production (Energy Information Administration 2015). These new resources could have profound welfare consequences by reducing the price of energy to consumers and transforming the transportation, electricity, and manufacturing sectors, while also imposing (or reducing) externalities both locally and globally. With so much at stake and so little known, Catherine Hausman and Ryan Kellogg’s comprehensive paper is an important point of departure for subsequent research seeking to measure the implications of the shale gas revolution.

Hausman and Kellogg estimate supply and demand curves for natural gas before and after the widespread adoption of fracking and, importantly, calculate the counterfactual equilibrium that would have prevailed in 2013 in the absence of fracking. This allows them to estimate by how much prices have fallen due to fracking rather than confounding demand factors, such as the Great Recession. They find a net social benefit of $48 billion per year, derived from a $26 billion loss of producer surplus against a tremendous $74 billion annual gain in consumer surplus. The speed of technological innovation in the extraction sector and capital investments necessary to fully take advantage of cheap gas indicate that these short- to medium-run estimates are likely to understate the long-run gross benefits of these new resources, ignoring important considerations such as reduced incentives to invest in renewable energy technology.
To overcome the classic issues of simultaneous equation estimation (Haavelmo 1943, Marschak and Andrews 1944), Hausman and Kellogg draw on the work of Lucas Davis and Erich Muehlegger (2010) and Michael Roberts and Wolfram Schlenker (2013) to derive instruments based on lagged weather in other states, which has the effect of drawing down inventories and increasing prices in a way that is orthogonal to own demand or national supply decisions. For supply, they estimate the price elasticity of wells drilled, which Soren Anderson, Ryan Kellogg, and Stephen Salant (2014) have shown to be the key margin that energy firms can adjust in response to market conditions. In steady state, production is proportional to drilling, yielding the elasticity of supply from drilling data.

My comments focus on estimation issues worth keeping in mind for future studies seeking to quantify the welfare implications of shale gas as these long-run adjustments and innovations are realized. The key issue is that wells typically produce a mix of hydrocarbons of varying lengths, with oil composed of longer carbon chains, natural gas liquids (NGLs, that is, ethane, propane, and butane) composed of shorter chains, and natural gas (methane) molecules formed from a single carbon atom. Buried organic material matures over time, with heat and pressure, to break these carbon chains into shorter and shorter lengths. This process naturally produces a range of hydrocarbons, with the greatest differences occurring across geological formations, so that some are mostly-oil-producing regions (such as the Bakken shale in North Dakota), and some are mostly-gas areas (such as the Marcellus shale in the East).

This joint-production creates what I call a “drumstick” problem for supply curve estimation because NGL and oil are twice and three times as valuable as gas on a per-energy basis, respectively, and fluctuate with world markets. That is, consider measuring the supply curve of chicken drumsticks: If the price of breast meat is sufficiently high to cover the cost of raising a chicken, farmers will continue to flood the market with drumsticks, and are prospectively willing to pay to dispose of them as waste. All else equal, there is an upward-sloping supply curve for drumsticks insofar as they help cover the cost of production, but ignoring the markets for co-produced goods can lead to misleading results.

How important is this issue for estimating the supply curve for natural gas? It depends. Figure 1 overlays oil production from the Bakken shale in North Dakota with the natural gas by-product derived from the oil-rich formation. It is clear that oil production and gas production are tightly linked, but more striking is the fact that about one-third of the gas produced never
makes it to market: insufficient pipeline infrastructure in the area makes it costlier to deliver the gas to market than the price it can fetch there. This unsold third of the natural gas is instead burned off near its source, a practice known as flaring, which is sufficiently widespread so as to be visible from space. Producers often pay royalties and taxes based on the market value of this gas, yielding a negative price for the output that is covered by oil revenues.

Figure 2 shows a more balanced division of output in Texas, the largest oil- and gas-producing state in the union. After peaking in 2009, output from wells producing gas exclusively (including horizontal wells) has only partly rebounded, and it has declined in recent years. Instead, energy companies have focused their efforts on more valuable petroleum products, more than doubling oil production within three years after a long period of virtually unchanged output. In Texas, gas derived from oil-producing wells is referred to as casinghead gas, and the lower panel of figure 2 shows that this increase in oil production has yielded a proportional increase in gas production. Today, roughly one-fourth of natural gas production (and all growth) from Texas is drumstick revenue.
Figure 2. Oil and Gas Production in Texas, 2005–13

Source: Railroad Commission of Texas.
When estimating the elasticity of supply directly, the drumstick problem will have the effect of attenuating or amplifying the estimates, depending on the correlation of co-product prices and revenue shares. Hausman and Kellogg’s estimates are largely buffered from this problem because they estimate the price elasticity of gas well drilling. The steady state that yields equivalent elasticities between supply and drilling also requires that the present discounted value of revenues equals the marginal cost of drilling a new well. With gas wells largely producing gas, omitted revenues play a small role in the drilling decision.

Figure 3 indicates that this concern is not entirely ignorable, however: The most recent growth in production from Pennsylvania’s Marcellus shale (which primarily holds gas) has been accompanied by a 10-fold increase in extraction of more valuable NGL. Thus, as natural gas prices approach break-even prices, it is not inconceivable that this extra revenue could prove pivotal to the drilling decision.

Aside from estimation, the drumstick problem has important implications for interpretation and prediction. The appeal of the drilling-elasticity approach relies on the proportionality of output and new wells. A non-negligible fraction of output coming from outside of the gas-well drilling
decision decouples this relationship for the total market supply curve. It is therefore more difficult to estimate the welfare effects of shale gas if the supply elasticity and drilling elasticity do not line up. Further, even if the elasticities are well estimated, a 10 percent shift in the supply curve from gas derived from oil wells is going to inevitably move the intercept needed to calculate welfare.

Because long-lived investments are needed to fully take advantage of low gas prices, the ability to predict future prices is extremely valuable. Supply and demand elasticities are important for predicting how volatile fuel prices might be, and how they might change due to policy interventions. Based on their estimates, Hausman and Kellogg estimate that the increased supply from shale gas has reduced gas prices by $3.45 per million cubic feet. With U.S. prices far below those around the globe, a natural question is what would happen if the United State began to export substantial quantities to take advantage of these price differentials. Hausman and Kellogg use their estimates to calculate a roughly $0.50 increase in prices from currently approved LNG export projects (9.2 billion cubic feet per day), with another $0.90 increase if one were to allow the additional projects that have been proposed (24.6 billion cubic feet per day).

This same motivation underscores the importance of accounting for oil markets when one wants to predict future gas prices. The recent crash in oil prices has led to substantially reduced oil rig counts, which will eventually translate to reduced associated (casinghead) gas output. The current volume of associated gas is of the same magnitude as LNG exports approved by the Federal Energy Regulatory Commission, as are the welfare consequences of output fluctuations due to swings in world oil markets. Hausman and Kellogg have shown that even in these early days, the term “shale gas revolution” is not hyperbole. Innovations in extraction have defied expectations as drilling has continued in the presence of low prices, leading one to conclude that we have entered a new era of cheap energy. While their estimates may only be the tip of the iceberg, their comprehensive analysis provides an incredibly useful framework for future analysis as events unfold.

REFERENCES FOR THE CICALA COMMENT


COMMENT BY

**DAVID LAGAKOS** If you type the word *fracking* into Google and hit enter, you will find no shortage of gloom and doom. Much of the gloom and doom is deserved, too: Recent evidence shows that fracking can pollute groundwater (Darrah and others 2014), increase seismic activity (Andrews and Holland 2015), or leak methane into the atmosphere. Nor is it surprising that the news media focuses so much on the negative aspects of fracking. If you are the first reporter to interview the farmer whose tap water can be lit on fire, you have yourself a scoop.

Far less exciting is the story of how fracking has lowered the average American’s gas bill by a small but material amount for several years running. In this paper, Catherine Hausman and Ryan Kellogg have written a version of this far less exciting story. I do not mean that as a criticism. A long list of distinguished economists have made their careers pointing to some economic phenomenon or another that leads to modest welfare improvements for the masses and to partially offsetting losses (perhaps of a more obvious nature) for some smaller group. (For other salient examples, see: *Trade, International*.)

Of course, this is not quite fair to Hausman and Kellogg, since their winners and losers are not exactly the winners and losers I have alluded to just now. So let me summarize the story as Hausman and Kellogg would have it. It starts with fracking as a new technology that comes along around 2007, allowing the United States to extract large quantities of natural gas from its massive shale formations that lie, unused, within the ground. The story continues with the United States fracking its way to unprecedented levels of natural gas extraction and to dramatic declines in the price of natural gas.