Asian customers such as PetroChina and KOGAS, progress towards physical exports may be slower than the industry in Canada might have hoped.

In conclusion, then, the recent price differentials between North American gas prices and those in Europe and Asia have encouraged a broad energy industry initiative to create export opportunities for US and Canadian gas. Although only one US and one Canadian project currently have full export and construction approval, many others have applied for licences or been proposed, with a potential overall impact that could swamp the current global LNG market. Politicians in the USA are very concerned about the impact that any exports could have on their domestic gas price and as a result on the US economy, with the consequence that an extensive review process is now underway which is unlikely to reach any definitive conclusion until later in 2013.

However, international trade theory suggests that the politicians should not be overly concerned, as the interaction between gas markets is likely to find an equilibrium price that will not be far removed from the price that would be needed in any case to sustain US gas production. In fact, at the $5–6/mmBtu price that most commentators believe will be needed to make US gas producers profitable, gas exports to Europe immediately become less interesting. Indeed the most obvious influence of potential US exports based on this level of Henry Hub prices could be to provide a benchmark price of $9.5–10.5/mmBtu for Europe's higher cost suppliers such as Russia, who would have a clear signal as to the price below which they would likely exclude a new rival source of supply or above which they would encourage its arrival in Europe. On the other hand physical exports to Asia look much more likely, as North American gas exports would remain competitive with the oil-linked LNG contract price even if Henry Hub prices jumped to $8/mmBtu.

The implication, therefore, of North American gas exports to Asia is that higher cost sources of imports will be pushed down the supply chain, reducing the marginal cost of gas in the region. The situation could be complicated by a number of other factors, such as increased demand if prices stay low or the introduction of new indigenous production such as shale gas in China, which could certainly reduce the volumes of North American gas arriving in the Asian market. However, even if actual volumes are small, the impact of North American gas, and in particular that produced or purchased directly by consumers in Asia, may be as much psychological as physical. The introduction of gas at prices set by supply, demand and the cost of production, rather than based on a link to an alternative fuel, is likely to increase the focus on cost-of-supply-related rather than oil-related pricing. While it would probably be wrong to suggest that the oil link will disappear completely, given that oil is a competing fuel in some markets and has been used as the basis of contract negotiations for decades, nevertheless it would seem to be likely that, while the introduction of North American gas exports may not have as dramatic an impact on global gas prices as expected it could significantly change the way in which prices are negotiated. ■

OIL AND NATURAL GAS

Benefits of Hydraulic Fracking

KEVIN HASSETT and APAMA MATHUR

If an average American heard the word 'fracking' ten years ago, chances are he or she would have worried about the manners of the speaker. Today, however, opinions about fracking are solidifying, and battle lines are being drawn, even if understanding remains sketchy. For many on the American left, fracking connotes something dangerous, unhealthy – even, as in a recent Hollywood production, potentially nefarious. For those on the right, fracking is often regarded as the best hope for a struggling economy.

While the outcome of the policy struggle is impossible to predict, the economic stakes could hardly be higher.

Hydraulic fracturing, or fracking as it is more commonly called, is a process that's been used to extract oil and natural gas since it was first introduced by Standard Oil in the 1940s. Over the past decade, as other technologies have combined with the use of fracking to make the tapping of shale profitable, it has contributed to a resurgence of oil production in the USA and a dramatic increase in natural gas production. Proponents of fracking have hailed it as a major development in the energy industry, one that has allowed for tapping of reserves of gas and oil that were previously prohibitively difficult to reach. In some parts of the country, most notably in North Dakota, this has lead to massive expansions of energy production, and gold rush level increases in economic activity.

As enthusiastic as are its supporters, fracking faces equally determined opponents who view its environmental consequences as excessively negative, and there is significant variation across the United States in policy. The most notable focal point of opposition to fracking is New York state, which placed a moratorium on it in 2008, but other states have been as aggressive. Vermont has formally banned the practice, and New Jersey has enacted a moratorium as well. Many other states seem likely to follow.

To date, much attention in the debate has focused on the potential negative local impacts. There is ongoing investigation into the costs of fracking to the environment, infrastructure, and health of workers and citizens near drill sites. Less attention has been paid to discussion of the likely scale of the benefits, and a rational assessment of proper policy, of course, requires inspection of both costs and benefits.

Our focus, therefore, is on the benefit side of the equation, which hopefully can be used to better weigh costs when they are debated in the future.

Fracking in the United States

The process of hydraulic fracturing involves the injection of a mixture of water, a proppant such as sand, and chemicals into an oil or gas well. The fluid creates fractures in a pre-drilled well, allowing greater permeability of the stone surrounding it. The proppant fills the small cracks created by the water to keep them open after the water flows back out. The chemicals, such as gelling agents, are used for a variety of purposes, most importantly to gel the water on its entry so that the proppant remains suspended in the mixture and does not sink to the bottom of the solution. Other chemicals (which can even be unidentified and a trade secret) enhance the solution's fracturing abilities. It is these chemicals that form the basis of concern for fracking opponents, who worry about possible contamination of water sources from the fracking fluid, not all of which eventually makes its way to the top of wells to be captured by drillers.

Although the first version of hydraulic fracturing was patented in the USA in 1949, it has come into greater use over the last decade in combination with other advances in drilling technology (such as horizontal drilling), which have made many reserves of oil and natural gas economically viable that were previously considered prohibitively difficult to exploit. These reserves are in many cases contained within shale, a formation low in permeability and porousness, which previously made tapping the gas and oil held within the formations very difficult. Fracking, along with horizontal drilling, has made many of these previously known formations commercially viable, and has facilitated the discovery of new reserves as companies seek gas and oil in new locations.

A few numbers illustrate how fracking has contributed to a turnaround in US energy production over the past decade. In 1990, the USA produced in total 70.706 quadrillion Btu of energy, a number which remained fairly steady through 2006, when total production was 69.443 quadrillion Btu. After that year, however, as fracking, in combination with horizontal drilling and other new technologies in energy production became more widely spread, total production of the energy sector eventually reached 74.812 quadrillion Btu in 2010, accelerating even faster to 78.091 in 2011. A large part of that was an increase in domestic production of natural gas and crude oil. Natural gas, after previous steady production of around 19 quadrillion Btu per year, experienced an increase beginning in 2007, with production reaching 23.608 quadrillion Btu in 2011 and the industry on track to exceed that in 2012. This made the USA the second largest natural gas producer in 2011 – just behind Russia, according to the World Factbook. The third highest producer, the European Union, produced only about a quarter of the natural gas produced in the United States.

Oil, on the other hand, gradually declined in production from 1980 onward, and only recently has experienced annual increases, largely attributable to fracking and new drilling techniques. In 1980, the USA produced 18.249 quadrillion Btu of oil, which decreased to 12.358 in 2000 and 10.615 in 2008. Since then, however, it has risen to 11.598 quadrillion Btu in 2010 and 11.955 in 2011, and, like natural gas, the industry was on pace to exceed that figure in 2012.

This significant increase in production of oil and gas energy has direct economic effects that are relatively easy to quantify and potentially broad reaching indirect effects as well. However, direct and indirect effects are often misrepresented in public discussions. Below, we describe what is known of fracking's potential impact and a guide to an economically rational discussion of the total benefits.

Direct Economic Impact

The direct benefit of increasing oil and gas production includes the value of increased production attributable to the technology. In 2011, the USA produced 8,500,983 million cubic feet of natural gas from shale gas wells. Taking an average price of $4.24 per thousand cubic feet, that's a value of about $36 billion, due to shale gas alone.

This increase in value produced can also increase the number of people employed directly in production and delivery activities. These numbers will often be pointed to in political debates. In an economy with full employment, such an increase would not be considered a 'benefit' per se, but a state such as New York with a high unemployment rate of 8.2 might wish to weigh the potential employment effects when evaluating the merits of a moratorium. At its peak in 1980, the oil and gas extraction sector supported 267,000 employees, according to data from the Federal Reserve Bank of St. Louis. As more easily tapped oil reserves grew scarcer and domestic oil production gradually declined over the following two decades, so did employment, with the number of employees in oil and gas extraction shrinking by over 50 percent to 118,400 in 2003. Since 2003, however, there has been a steady upward climb in employment, slowing only slightly during 2009 and reaching 198,400 by December 2012 – over a 67 percent increase. As other industries have sputtered in the aftermath of the 2008 recession, oil and gas has been a remarkably bright spot in the US economy, with employment at the end of 2012 at its highest since 1987.

"… opinions about fracking are solidifying, and battle lines are being drawn …"

There is also a direct effect of this production on the trade balance. The increase in oil and natural gas extraction has directly impacted the energy trade balance between the USA and other countries. Natural gas imports decreased by 25 percent between 2007 and 2011, while petroleum imports dropped from a high of 29.248 quadrillion Btu in 2005 to 24.740 in 2011. By 2020, the Energy Information Administration predicts that the USA will become a net exporter of natural gas, and as more natural gas reserves are discovered and tapped, that date may yet be pushed earlier. Trade balance, of course, is not a measure of welfare, and, while interesting, should not be considered a direct benefit, but often will be.

Indirect Economic Impact

Along with its direct effects within the extraction industry, fracking has had a traceable effect on other industries as well. The first notable area is electricity generation. As natural gas production has increased over the past five years, so has its consumption within the USA – moving from a historical centre at about 23 quadrillion Btu per year to 24.256 in 2010 and 24.757 in 2011, according to data from the EIA. Much of this increase is attributable to electricity generation, where plants have switched some input from coal to natural gas as natural gas prices have dropped in the wake of its increased supply. While natural gas use in electricity generation gradually increased from 5.3 quadrillion Btu in 2000 to 6.38 in 2006 and 7.7 in 2011, coal experienced a small increase from 19.6 in 2000 to 20.5 in 2006 before dropping off quickly to 18.04 in 2011.

According to the Environmental Protection Agency, natural gas-fired electricity generates half the carbon dioxide of coal-fired production. An estimate of the indirect benefit of fracking should include an estimate of the potential social gains from this reduction. Historically, CO2 emissions grew alongside GDP, reaching a peak of just over 6 billion metric tons in 2007, according to data from the EIA. Since then, however, emissions have fallen off, and were expected to total less than 5.3 billion tons in 2012, a full 10 percent decrease over five years. Although some of this drop was related to a faltering economy in 2008, emissions have remained lowered even while GDP has recovered its previous size and then some. The EIA even projects that CO2 emissions will remain below their 2005 level (just under 6 billion metric tons) through 2040 – in some part because of increased reliance on renewables but in large part because of substitution of natural gas for coal.

The drop in natural gas prices worldwide would normally lead to a reduction in electricity prices in the United States. To the extent that geographic complementarities produce inframarginal benefits over and above the reductions in electricity prices that would normally follow from a reduction in price, these also should be included in net benefit calculations. If, for example, local electricity generation is a much higher value use than exporting the gas, then the inframarginal gains from that use would be included in any cost benefit calculus. The same would be true for other industries as well, such as the chemicals industry, fertiliser producers, and the steel and aluminum industries. To the extent that employment increases in these sectors, one would apply the same caution about interpreting this as a net benefit that applied to the direct employment effects.

Two additional indirect effects should also be mentioned, and considered by policymakers as they assess the benefits of regulatory interventions. First, a surge in production could well have Keynesian multiplier effects on a local economy. Second, land prices will surge throughout a state if fracking is suddenly allowed, and the higher prices will affect all relevant landowners' wealth and thus their consumption. This would have near-term economic effects on local economies (North Dakota luxury car dealers are presumably doing quite well) that may well be larger than the direct impact of production.

Several reports have attempted to quantify the impact of the expansion in fracking on the US economy but it is an extremely nascent literature. A 2010 study by Considine, Watson, and Blumsack of Pennsylvania State University used an input-output model to estimate that investment into natural gas extraction in the Marcellus shale region contributed 44,000 jobs to the economy. A 2012 study by IHS Global Insight made an attempt to model both the direct and indirect effects, employing a macroeconomic model. The study, which was funded by America's Natural Gas Alliance, is the most exhaustive study available to date. It concluded that the shale gas industry supported 600,000 jobs in 2010, a number which would increase to 870,000 by 2015. The study also found that three indirect jobs are created for each energy sector job, suggesting that the employment effects could be enormous. Looking at GDP growth, the IHS study found that, 'The shale gas contribution to GDP was $76.9 billion in 2010, will increase to $118 billion by 2015, and will nearly triple to $231 billion in 2035,' all in 2010 dollars. Alternatively, a study by economist J.G. Weber published in Energy Economics in 2012 estimates that 2.35 local jobs are created for every million dollars in gas production. If one assumes that total production increases by the approximately $68 billion from 2010 to 2035 assumed by the IHS study, then this would suggest a net increase of employment of only 159,859. Whether either of these jobs numbers reflects an increase in aggregate employment, of course, is another question, but the scale of the possible GDP gain is very large indeed, and sets a very high bar for opponents of fracking. If the debate over fracking is to be dominated by reason rather than emotion, researchers must refine our thinking of the economic benefits of rapid expansion of energy production, and improve our estimates of the potential environmental costs as well. ■

CLEAN ENERGY, ELECTRICITY AND CLIMATE CHANGE

The Case for a US Carbon Tax

JOSEPH E. ALDY

Every aspect of economic activity affects greenhouse gas emissions and, hence, the global climate. Since individuals and businesses bear virtually no cost for emitting greenhouse gases in the absence of public policy, and thus have no incentive to reduce these emissions, the government has a strong case for climate change policy. US policymakers may choose among three general approaches to drive more climate-friendly economic activity: (1) subsidise businesses and individuals to invest in and use lower-emitting goods and services; (2) mandate businesses and individuals to change their behaviour regarding technology choice and emissions; or (3) price the greenhouse gas externality, so that decisions take account of this external cost. Let's consider these options in turn.

In the United States, state and federal subsidies have supported the deployment of clean energy technologies for decades. The 2009 economic stimulus, the American Recovery and Reinvestment Act, represented the largest energy bill in US history by providing about $90 billion for investments in efficiency, renewable power, mass transit, smart meters,