Working paper

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Zhenbo Hou, Dean Granoff, Ilmi Granoff, Jodie Keane, Jane Kennan, Andrew Norton and Dirk Willem te Velde

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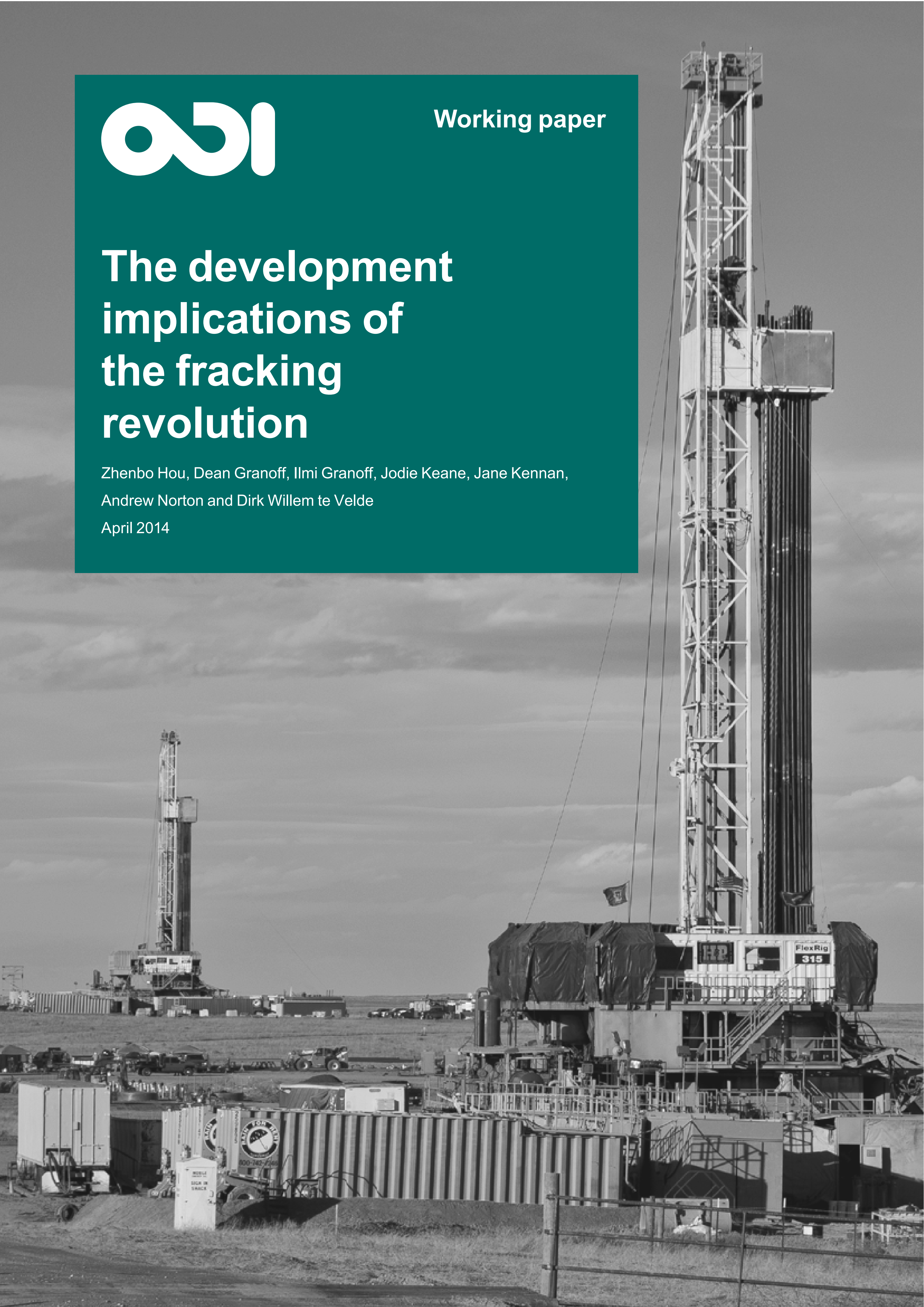

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Shockwatch Bulletin

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Abstract

The primary objective of this report is to examine the economic impacts (actual and potential) on developing countries of current transformations in global energy markets associated with the growth in exploitation of shale gas and tight oil. We have already seen large changes in energy markets; e.g. US oil imports from Africa have dropped significantly and US gas imports have collapsed over the last 5–10 years, as tight oil and shale gas production in the US have increased. We estimate that US imports of oil and gas may have been 50% lower as a result of fracking in 2012. As a result of fracking in the future, Chinese imports of gas could be 30–40% lower in 2020.

In the case of a reduction in US gas imports, our analysis suggests that Trinidad and Tobago would suffer export revenue loss equivalent to more than 3% of GDP, and other countries affected include Yemen, Egypt, Qatar, Equatorial Guinea, Nigeria, Algeria, Peru. In total, developing countries are estimated to have lost US$1.5 billion in annual gas export revenues because of the rise in fracking.

A larger number of countries are exposed to a potential trade shock emerging from a change in US oil imports including Angola, Congo, and Nigeria. An increase in fracking in China with the same size in the trade shock would double the effect. The total estimated effects from a reduction in US oil imports from African countries amount to US$32 billion. The net impacts on exporters will depend on their ability to find other markets, and the conditions under which they do so.

The fracking revolution is also likely to have major geopolitical impacts. The US and China stand to benefit from the prospect of greater energy independence. Europe will be faced with an imperative to reduce its dependence on energy imports from Russia and elsewhere, and will face various options for doing this. Russia, the Middle East and OPEC are expected to lose in political terms. For non-oil exporting developing countries the economic impacts can be expected to be broadly positive, through growth effects and reductions in the cost of importing energy.

Acknowledgements

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Abbreviations

API	American Petroleum Institute
ARI	Advanced Resources International
bcf	Billion cubic feet
bcm	Billion cubic metres
CCA	Causal Chain Analysis
EIA	Energy Information Administration
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HIC	High-Income Country
IEA	International Energy Agency
IMF	International Monetary Fund
LDC	Least Developed Country
LIC	Low-Income Country
LMIC	Lower-Middle-Income Country
LNG	Liquefied Natural Gas
MIT	Massachusetts Institute of Technology
MMbbl	Million barrels
MMBtu	Million British Thermal Units
mtoe	Million tonnes of oil equivalent
OECD	Organisation for Economic Cooperation and Development
OPEC	Organization of the Petroleum Exporting Countries
SITC	Standard International Trade Classification
SVE	Small and Vulnerable Economy
tcf	Trillion cubic feet
UAE	United Arab Emirates
UK	United Kingdom
UMIC	Upper-Middle-Income Country
UNCTAD	United Nations Conference on Trade and Development
US	United States

Executive summary

The primary objective of this Bulletin is to look at the economic impacts (actual and potential) on developing countries of current transformations in global energy markets associated with the rapid growth in exploitation of shale gas and tight oil. We find significant impacts on some developing country gas and oil exporting countries from the changes in the United States (US) energy market – and would expect these to be considerably amplified if, as we expect, the use of fracking technologies expands rapidly in China. We also consider the geopolitical implications of these changes with reference to a range of countries.

The fracking revolution has significant geopolitical and development effects. We have already seen changes in energy markets; e.g. US oil imports from Africa have dropped and US gas imports have collapsed over the last 5–10 years, as tight oil and shale gas production in the US have increased. Fracking is expected to affect a large range of countries. A review of the data suggests that US imports of oil and gas may have been 50% less than would otherwise have been the case in 2013. We can also expect Chinese imports of gas to be some 30–40% lower in 2020 than they would have been if there were no fracking in China. We examine how such changes might affect developing countries.

Fracking also has complex environmental implications that shape its development impacts. Shale gas has already reduced US greenhouse gas (GHG) emissions from electricity generation by replacing domestic coal power, but these gains could be eroded by a ‘rebound’ of coal generation, increased coal exports, and leakage of fracked gas (which is itself a potent GHG). Shale oil provides no potential climate benefits. Fracking also has troubling local environmental risks, particularly for water resources. The complexity and importance of these considerations must be acknowledged in any discussion of fracking and development, but warrant deeper analysis that is largely separate from the trade-related impacts on geopolitics and development that are the topic of this report.

The key findings are:

- US shale gas production increased by US$16 billion over 2007–12. Assuming domestic production of shale gas in the US displaces imports, by 2012 developing countries were exporting 50% less gas than they would otherwise have done to the US market. This implies that developing countries have lost around US$1.5 billion in gas export revenue due to US shale gas production.
- The single developing country most exposed to loss of export market on natural gas to the US is Trinidad and Tobago, which is classified as a small and vulnerable economy (SVE). In the case of the estimated drop in US gas imports associated with rapid development of shale gas, our analysis suggests that Trinidad and Tobago suffers a loss of more than 3% of gross domestic product (GDP). However, the sector has a very small employment footprint and a highly developed social protection system is likely to cushion any possible effects on employment and welfare. Moreover, the sector in Trinidad and Tobago has been able to diversify its markets towards South America and Asia so it is not clear that there has been a significant negative impact.
- US shale oil production increased by approximately 4 million barrels (MMbbl)/day over the period 2007–12. Given that US imports of oil amounted to around 10 MMbbl/day in 2007 and 8 MMbbl/day in 2013, we assume that developing countries export around 50% less oil to the US by 2012 than they would otherwise have done**.** In

the case of suppliers of US oil and related products a much larger number of countries are exposed to a potential trade shock induced by fracking than in the case of gas. This includes Angola, Congo, and Nigeria. The total effects in African countries in terms of lost oil exports to the US are likely to amount to US$32 billion. In support of this analysis data show that actual exports to the US from three of the Organization of the Petroleum Exporting Countries' (OPEC) African members – Nigeria, Algeria and Angola – have fallen to their lowest levels in decades, dropping 41% in 2012 from 2011, largely because of tight oil according to the US Department of Energy.

- Angola's reliance on oil revenues and imports leaves the economy highly exposed to external shocks – which makes the country an important case example. Oil exports currently account for about 46% of Angola's GDP and 96% of its exports; 80% of its public revenue is derived from the oil sector, and annual spending is highly correlated with annual oil revenues. The latest estimates on Angola's elasticity of total employment to total GDP suggest it is around 0.2% (United Nations Conference on Trade and Development (UNCTAD), 2013). Hence any reduction in exports which adversely affects GDP could result in reductions in employment, with concomitant social impacts. The lack of effective social protection measures (compared, for example, to Trinidad and Tobago) means that negative effects are more likely to be transmitted immediately.
- Currently China produces very little shale gas, but production is expected to reach between 60 and 100 billion cubic metres (bcm) by 2020, compared to an estimated 250 bcm imports of gas predicted in 2020 – from which it may be inferred that Chinese gas imports would by then have been around 30–40% higher in the absence of domestic production. China also plans to focus considerable resources on developing tight oil production. Some of the same countries that may already have been adversely effected by fracking in the US, in terms of a reduction in exports and hence GDP, may similarly be affected if production in China also generates a similar magnitude of trade shock. Angola and Congo, for example, are estimated to experience a decline in GDP of considerably more than 1% if fracking in China has an effect on their exports similar to that estimated for the US.
- A reduction in global oil prices of around 25% induced by fracking could lead to an increase in global GDP of around 0.75%. Because low-income countries (LICs) tend to use more oil to achieve the same output, and tend to have more constraints on their current accounts, they are most likely to benefit from a reduction in global oil prices. Oil importing countries such as India, Senegal and Zambia could therefore benefit from oil price reductions induced by fracking. This is assuming that there are no market or policy interventions.
- The fracking revolution is likely to continue to have major geopolitical impacts. The US and China stand to benefit from the prospect of greater energy independence. Europe will be faced with an imperative to reduce its dependence on energy imports from Russia and elsewhere, and will face various options for doing this. Russia, the Middle East and OPEC are expected to lose in political terms. For non-oil exporting developing countries the economic impacts can be expected to be broadly positive. This may contribute to a continuance of the phenomenon of 'convergence' seen since the early 2000s – with many developing countries growing much faster than the Organisation for Economic Cooperation and Development (OECD) average, re-shaping global economic power.

1 Introduction

The discovery and exploitation of shale gas and tight oil is a major innovation with economic and political implications for developing countries. The remarkable growth in the production of shale gas and tight oil by hydraulic fracturing (commonly referred to as fracking) in the US has led to significant changes in US gas prices and US energy imports. This has led some to examine the impact on the US, but also the European Union (EU) (e.g. Beffa and Cromme, 2013; Spencer et al., 2014). While the impact on the US economy can be debated (e.g. Spencer et al. (2014) mention a less than 1% increase in incomes due to the shale revolution) the trade implications are large. To our knowledge there have been very few detailed studies of the impact of fracking on developing countries (Brewer (2014) is one).

This paper examines the scale of the issue with the aim of understanding how developing countries might be affected. We believe that the fracking that has taken place in the US may have had trade effects (consistent with actual US import declines) and we estimate the extent of these (by assuming that US shale gas production has replaced US imports) and then examine the exposure of developing country exporters to fracking in the US and China. There are likely to be other significant effects, such as those related to the environment, but we will not focus on these in this Bulletin.[1]

The structure of the Bulletin is as follows. Chapter 2 discusses fracking in the US and China. In the US there have already been major changes in both oil and gas markets. In China, major changes in the gas market are expected as the technology has now become operational. The chapter concludes with an estimate of the likely magnitude of the shock in terms of changes that may have taken place in the US from 2007 to now and what might happen to Chinese imports by 2020. Chapter 3 discusses the exposure of developing countries to these shocks. Chapter 4 provides an overview of some of the geopolitical implications. Chapter 5 concludes.

[1] For example, there could be a range of environmental implications. In the US, coal's share of electricity production has dropped from almost 50% to 34% over the last three years – significantly lowering US CO_2 emissions from electricity generation – largely due to moving from coal to gas (see, e.g., Cunningham, 2013; Katusa, 2012; Yang, 2012). However, the environmental effects (in the US) are complex and need to take into account, *inter alia:* (i) the GHG implications of methane leakage from well to plant now being studied, which may erode the actual GHG mitigation benefits except under highly specific circumstances; (ii) major water consumption and contamination implications; (iii) the rebound effect of lower coal prices that may erode the benefit of gas fuel-switching in the absence of a national plan that moves infrastructure away from coal; (iv) the trade implications of high coal inventories and lower prices, a situation which could simply export coal, and thus emissions, to other countries; and (v) the further reliance on oil arising from fracking's application to tight oil.

2 The magnitude of fracking

This chapter examines the magnitude of fracking and what has changed in the US. Section 2.1 discusses the basics of shale gas. Section 2.2 discusses the impact of the US shale gas supply on the demand for fossil fuels in the US. Section 2.3 turns to tight oil (or shale oil; we use the terms interchangeably) in the US. Section 2.4 discusses which other countries may produce shale gas, and Section 2.5 discusses China in detail. Section 2.6 summarises by providing an estimate of the likely magnitude of the fracking shock in terms of changes in US and Chinese imports of oil and gas.

2.1 What is shale gas?

Shale gas is natural gas that has been trapped within geological rock formations known as 'shale'.[2] The key factors that differentiate shale gas from conventional gas reservoirs are that the gas does not flow easily out of the shale and there are relatively few spaces for gas to be stored within shale formations (International Energy Agency (IEA), 2012).

Shale gas is extracted using a process known as fracking. This involves pumping a mixture of water, sand and chemical additives into geological formations at high pressure in order to create or enlarge fractures in the geological formation and promote the flow of hydrocarbon resources for extraction.[3] While fracking is often used for extraction of hydrocarbons in shale formations, it can also be used for hydrocarbon extraction in other geological formations.

Box 1: Other unconventional sources

Other unconventional sources of hydrocarbons that are often discussed in the same context as shale gas – largely because they similarly use fracking technologies for extraction – are worth mentioning.

- Tight oil is conventional oil which is found in reservoirs with very low permeability.
- Shale oils are a type of tight oil and are formed from the same geological processes that create shale gas. The two different resources can therefore both exist in the same shale formation.
- Tight gas is similar to conventional gas but is found in formations with low permeability, therefore necessitating technologies like fracking to stimulate the flow of gas.
- Finally, coalbed methane is natural gas contained in coalbeds.

Source: IEA (2012).

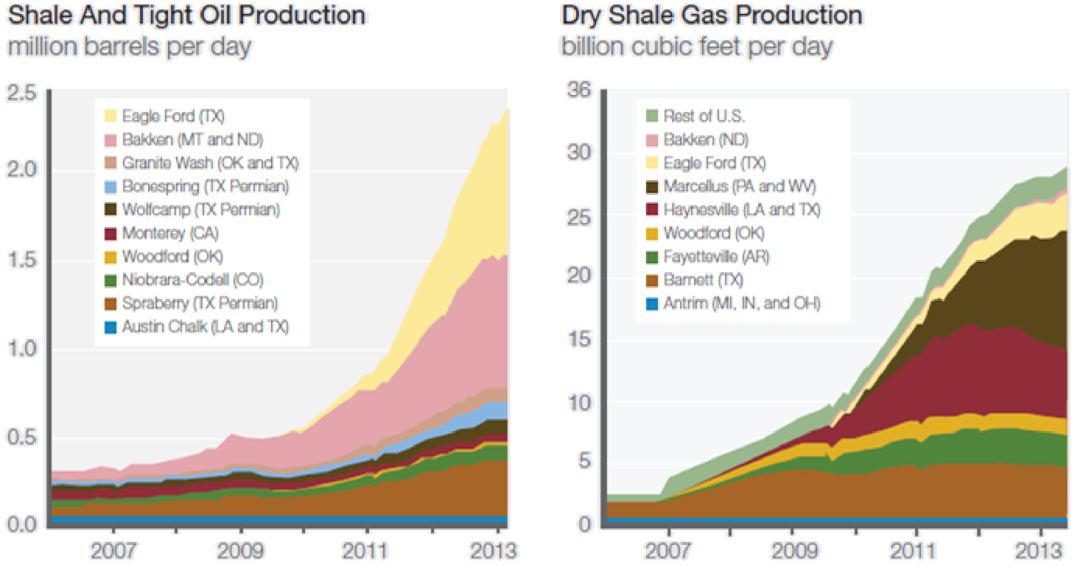
2.2 Impact of US shale gas supply on the demand for other fossil fuels in the US

The extraction of shale gas is not particularly new in the US (it has been happening since 1821), nor is the use of fracking. However, technological advancement in fracking and horizontal drilling has

[2] http://www.eia.gov/energy_in_brief/article/about_shale_gas.cfm.
[3] http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells_hydrowhat.cfm

led to an increase in the quantity of economically accessible and scale-able shale gas production in the last decade (see Figure 1).

Figure 1: The shale revolution in the US (gas and oil)



Source: API (2013).

Gross withdrawals of natural gas from shale increased from 2,000 billion cubic feet (bcf) (56.6 bcm) in 2007 to 10,297 bcf (291.6 bcm) in 2012 (415% change), which represented a shift from 8% to 35% of total natural gas production in the US. Moreover, the importance of shale gas in natural gas production is underlined by the fact that during the same period the total amount of natural gas gross withdrawals in the US grew by 20% although other sources of natural gas fell.[4]

As well as increasing supply, the expansion of shale gas and natural gas production have reduced the price of natural gas. In all sectors the end-use price of natural gas decreased in the 2007–12 period. The largest reduction was the 52% fall in the price of natural gas for electrification over the same period.[5]

The expansion of shale gas production and the subsequent effects on price have eroded the use of coal-powered electrification in the US. By mid-2008 coal's electrical generation advantage over natural gas began to weaken. The costs of natural gas combined-cycle generators and certain segments of coal generation were at parity through 2011. In the spring of 2012 a drop in natural gas prices led to increased competition with even cheaper types of coal-powered generation, which led to natural gas taking an almost equal share of US electric power generation for the first time (US Energy Information Administration (EIA), 2013a: 40). Coal's share of electricity generation fell from 48.5% in 2007 to 37.5% in 2012. Since 2010 50 gigawatts of coal electric capacity have been retired (Trembath et al., 2013).

The exact effect of shale gas on demand for other hydrocarbons is less clear. Gas in the US is predominantly used for power generation, while oil is mostly used for transportation. The expansion of natural gas therefore has little substitution value *vis-à-vis* oil. However, US EIA projections do anticipate a significant penetration of compressed and liquefied natural gas (LNG) for heavy-duty trucks in the future. By 2040, this switch is anticipated to displace 0.5 MMbbl/day of diesel fuel (EIA, 2013a).

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[4] http://www.eia.gov/dnav/ng/ng_sum_lsum_dcu_nus_a.htm.

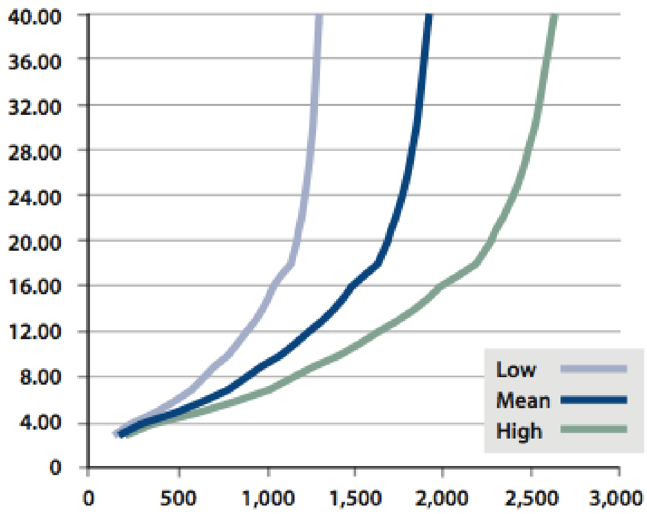
[5] *Ibid.*

The most important relationship between the expansion of the natural gas sector and oil production in the US is that the technological advances that have assisted the gas industry have also been applied to oil. Tight oil production has therefore grown as a result of more effective fracking and horizontal drilling (American Petroleum Institute (API), 2013).

We examine the current forecasts for the timing and scale of continued supply of US shale gas and for its reliability. It is useful to start by looking at estimates of *technically recoverable reserves*, which are defined as 'the total volume of natural gas that could be recovered in the future, using today's technology, ignoring economic constraints' (Massachusetts Institute of Technology (MIT), 2011: 19). A recent estimate by the EIA of technically recoverable shale gas in the US is 665 trillion cubic feet (tcf), or 18,830 bcm.[6] This number is similar to the MIT interdisciplinary study estimate of 650 tcf or 18,413 bcm of technically recoverable reserves (Trembath et al., 2013).[7]

There is inevitably uncertainty with respect to long-term production rates from shale gas formations. With this in mind, projections should be taken with some degree of scepticism. The EIA addresses these concerns to some extent by providing projections in low case, reference case and high case scenarios. The MIT interdisciplinary study estimates that a portion of technical reserves of shale could be economically recovered at a price of between US$4 and US$8 per million British thermal units (MMBtu). The relationship between gas prices and economically recoverable resources can be seen in Figure 2.

Figure 2: Breakeven gas price ($/MMBtu and tcf)



Source: MIT (2011).

The EIA estimates of growth in the US natural gas market through 2040 included continued exploitation of shale gas resources (EIA, 2013a: 79). According to the *EIA 2014 Annual Energy Outlook Preview* there will be a 56% increase in natural gas production from 2012 levels by 2040, to 37.6 tcf or 1,065 bcm. This projection is correlated with shifts in estimated prices of gas which they speculate will remain in the mid-$4.00/MMBtu range until 2020, after which prices will begin to rise steadily as a result of natural gas exports until they will stop at $7.65/MMBtu in 2040. They estimate that the US will become a net natural gas exporter by 2016.

[6] http://www.eia.gov/todayinenergy/detail.cfm?id=14431, 2 January 2014.
[7] However, there is uncertainty surrounding technical reserves. In the 2011 EIA estimate, the technically recoverable reserves for shale gas were as high as 827 tcf or 24,702 bcm, illustrating that current estimates are actually a downgrade of previous ambitious speculations (Trembath et al., 2013). The EIA acknowledges the difficulties in assessing technically recoverable reserves. The uncertainty is illustrated further by differing estimates of technically recoverable reserves. For example, Advanced Resources International (ARI) estimates that US technically recoverable reserves are as high as 1,161 tcf.

2.3 The magnitude of tight oil in the US

Technological breakthroughs in fracking and horizontal drilling have driven an expansion of oil production (API, 2013). US oil production increased from 1.853 billion barrels in 2007 to 2.374 billion barrels in 2012. This growth was driven mostly by increased tight oil production (EIA, 2013a). By 2012 tight oil production accounted for 35% of total US crude oil production (EIA, 2013b).

Between 2005 and 2012 US petroleum imports reduced from 60% to 40% of total liquid fuel consumption. While an increase in oil production has contributed to this change in trade, it is difficult to assess the exact magnitude of the effect of increased production on oil imports. The EIA, which attributes *some* of this import change to the increase in tight oil production, also highlights demand reduction for petroleum resources (EIA, 2013a). Between 2007 and 2013 the US saw a gross 8% drop in oil consumption.[8] The average amount of oil produced from tight oil was 1.9 MMbbl/day in 2012.[9]

Projections for tight oil are highly speculative, but the EIA estimates that there are 58 billion barrels of technically recoverable crude oil from tight oil resources.[10] This number represents 26% of total estimated crude oil resources in the US.[11] In the EIA *2014 Annual Energy Outlook*, tight oil production is projected to increase from 2.3 MMbbl/day in 2012 (35% of total crude oil production) to 4.8 MMbbl/day in 2021 (51% of crude oil production). After 2021 tight oil production is expected to decline as development moves into less abundant zones (EIA, 2013b).

2.4 Shale gas reserves in other countries

The ARI, in conjunction with the EIA, publishes a comprehensive outlook on technically recoverable reserves of shale gas on a global scale. Conventional natural gas resources are particularly abundant in Russia and significant in the Middle East. The recoverable unconventional gas resources are in countries that are net gas importers facing increasing import dependence in the absence of new production.[12]

As unconventional gas production is non-existent in places where potential reserves may be abundant, the problems associated with estimating resources are greater in the global context. ARI estimates apply the assumption that global shale gas formations are generally similar to those found in the US (EIA, 2013c).

It should also be noted that ARI's estimates expanded significantly from 2011 estimates. The estimates for the US are significantly higher than the EIA's. This may indicate that its estimates for the rest of the world overestimate shale gas resources (however, further study would be needed on this point). Thus, ARI's numbers on global technically recoverable reserves may be more useful as a tool for comparison between countries than as an absolute measurement. Table 1 shows the top ten countries with known technically recoverable shale gas reserves.

[8] http://www.nytimes.com/2014/01/25/business/us-oil-production-keeps-rising-beyond-the-forecasts.html.
[9] http://www.eia.gov/analysis/studies/worldshalegas/, Box 2.
[10] http://www.eia.gov/analysis/studies/worldshalegas/
[11] *Ibid.*
[12] http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/weo2012_goldenrulesreport.pdf.

Table 1: Top ten countries with shale gas reserves

Country	Technically recoverable shale gas reserves (tcf)	Estimated natural gas reserves (tcf)
USA	1,161	318
China	1,115	124
Argentina	802	12
Algeria	707	159
Canada	573	68
Mexico	545	17
Australia	437	43
South Africa	390	
Russia	285	1,688
Brazil	245	14

Source: EIA (2013c).

2.5 Shale gas development in China

The supply of energy and the impacts of energy consumption on the environment are potential constraints on China's economic development. Currently China's overall energy consumption is 70% coal based, although this is likely to change as the government seeks to promote cleaner forms of energy.

Shale gas has been identified and listed as a priority in China's 12th Five-Year Plan (2011–15), which sets out to 'promote and accelerate the exploration and utilisation of shale gas and other types of unconventional gas and oil resources'[13] in order to increase natural gas supply, ease the pressure on natural gas supply, improve energy consumption structure and reduce carbon footprint. China has set ambitious targets for developing shale gas into the future.

- By 2015 the Chinese government aims to finalise a country-wide comprehensive survey on the size and location of its shale gas reserves and an evaluation exercise to categorise each according to its suitability for exploitation and production in the short, medium and long term.
- It aims to break the existing technological bottlenecks to enable all of the major exploitation equipment to be produced domestically.
- It aims to establish a series of national standards for shale gas exploitation.
- In particular, within the 12th Five-Year plan (2011–15) the Chinese government has set an ambitious production target of 6.5 bcm of shale gas production by 2015, rising to perhaps 60–100 bcm per year by 2020, and higher thereafter (Figure 3 illustrates the changes). Other sources paint a less optimistic picture.

On 3 December 2011 the Ministry of Land and Resources announced that, like coal and natural gas, shale gas would be an important source of energy to be explored and mined. It selected a few shale gas fields for competitive bidding processes. In late 2012 China issued its new subsidy policy to encourage shale gas exploitation – for every cubic metre of shale gas extracted, the mining company concerned will receive 0.4 Yuan (US$0.07) in government subsidy.[14] According to the National Energy Administration in China, as of late 2013 over one hundred shale gas wells had been drilled – more than forty of which had been successful in yielding shale gas. In late 2013 major technological break-throughs were made in Sinopec's Chongqing-Peiling national shale gas pilot/demonstration zone.[15]

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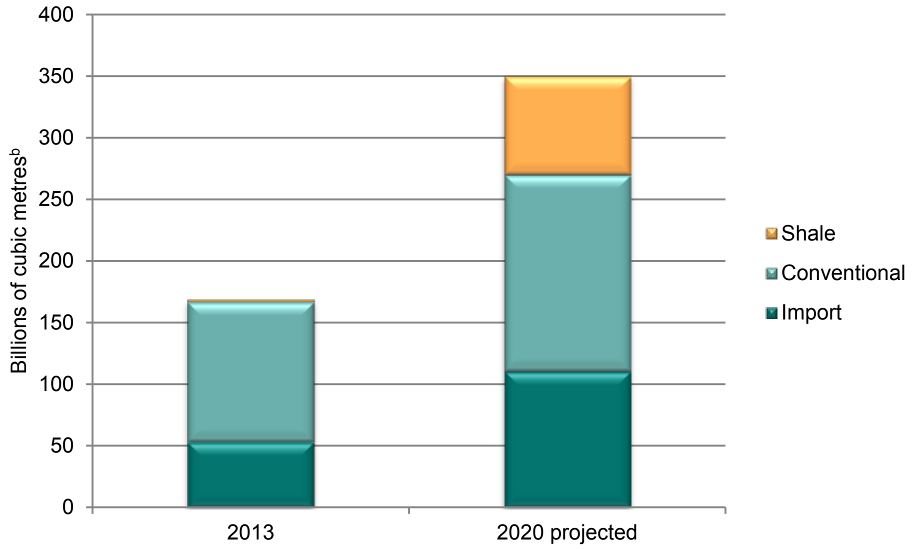
[13] Shale gas development guidance (2011–15), Chinese government: page 1 (available in Chinese at http://www.coalchina.org.cn/page/zt/130130/125gh/15.pdf).
[14] A speech by Mr Yuqing Zhang, Deputy Director General of the National Energy Administration, at the 13th China–US oil and gas industrial forum on 25 September 2013 (http://www.nea.gov.cn/2013-10/11/c_132788961.htm).
[15] http://www.nea.gov.cn/2013-12/04/c_132940713.htm

Figure 3: Current and projected Chinese natural gas consumption[a]



Notes:
(a) Including imports, conventional natural gas and shale gas.
(b) Assuming natural gas import ratio remains at the 2013 level of 31.6%.
Source: 'Strategic analysis of future Chinese energy development', People's Daily, *12 February 2014; China's shale gas development guidance (2011-15).*

Table 2 shows the current share of imports in Chinese oil and gas consumption.

Table 2: China's imports of oil and gas as a percentage of total consumption

	2012	2013
Oil	56%	58.1%
Natural gas	27%	31.6%

Source: CNPC (2014); speech by Mr Yuqing Zhang, Deputy Director General of the National Energy Administration, at the 13th China-US oil and gas industrial forum on 25 September 2013.

There is a range of challenges to developing shale gas in China:

- a country-wide comprehensive survey and evaluation of shale gas stocks in China has yet to be undertaken;
- key technologies such as fracking have not yet been mastered by domestic engineers or firms;
- there is a need to develop viable mechanisms for entry requirements and regulation for companies exploiting shale gas;
- most of China's shale gas reserves are located in the south-western part of the country, which is mountainous and has many rivers – posing a significant challenge for large-scale pipeline and infrastructure activities.
- in order to scale up production there is a need to develop incentive mechanisms (such as subsidies and tax breaks for companies) to accelerate shale gas production in China.

In 2009 the Chinese government signed a 'Memorandum of understanding on collaboration on shale gas exploration' with its US counterpart, aiming to learn the best practices in fracking technology, evaluation methods and policy support. It was followed by an inflow of foreign multinationals investing in and exploring China's shale gas potential. So far Shell, ExxonMobil and Chevrolet have entered the market. Informal discussions suggested that a significant obstacle to foreign multinationals operating in China is the high fees they charge due to China's inability to benefit from economies of scale. The interviewee believed that the cost of drilling a well in China is three to four times more than in the US. The competitive bidding process is open to state-owned enterprises as well as foreign and domestic private companies. Establishing joint ventures with foreign multinationals is intended to leverage the technology required, as well as to meet human capacity needs in some of the smaller, private Chinese firms.

If China can establish shale gas production successfully, as well as relieving pressure on other energy sources it will reduce dependence on imported energy (particularly as some of China's fuel imports come from politically unstable and unreliable sources of supply – e.g. Sudan, Venezuela, Iran, and pass through the Strait of Malacca). It may also reduce tension with Japan over the Diaoyu/Senkaku Island dispute, which according to *The Economist* magazine is due to the unexplored gas underneath these islands.[16]

2.6 Impact of US and Chinese shale gas production on trade with developing countries

This concluding section reviews the estimates and translates them into shocks in terms of imports from developing countries. In many cases the links between domestic shale gas and oil production and energy imports are complex. We are not claiming to have exact estimates of the effects, however we produce some initial estimates with the aim of using these in Chapter 3 to examine which countries are vulnerable to such changes.

Building on the analysis in this chapter, we will assume and then estimate the effects of a halving of US imports of oil and gas and a halving of Chinese imports of gas. These are very rough modelling scenarios but they bear some relation to what has actually occurred in the US or is likely to happen in China.

1. **US gas imports shock.** We have observed an approximately US$16 billion increase in the value of US shale gas production over 2007–12 (taken as the estimated changes in volume times the gas price). The change is approximately half of the total US imports of gas in 2007 (US$33.5 billion). Similar numbers apply to data in volumes. Assuming domestic production displaces imports of gas, we will assume that developing countries will export 50% less than they would otherwise have done to the US market (this assumes that developed and developing countries are reacting the same).
2. **US oil imports shock**. We have observed an increase in the amount of shale oil **production** of approximately 4 MMbbl/day. Given that US imports of oil amounted to around 10 MMbbl/day in 2007 and 8 MMbbl/day in 2013, we assume that developing countries export around 50% less oil to the US than they would otherwise have done.
3. **China gas imports shock.** Currently China produces very little shale gas, but production is expected to reach between 60 and 100 bcm by 2020, compared to an estimated 250 bcm imports of gas predicted in 2020 – from which it may be inferred that Chinese gas imports would by then have been around 30-40% higher in the absence of domestic production.

Thus the scenarios cover assumptions on three changes; both the simulations and the baseline theoretically account for other factors influencing energy imports (economic cycle, energy efficiency, etc.). We will use these scenarios to examine the vulnerability of developing countries to energy technology shocks by providing country-level detail on exposure and ability to cope (resilience). The changes considered in this Bulletin are likely to be underestimates, e.g. if: (i) increased US exports of gas to Asia reduce gas imports by Japan and India; (ii) Europe lifts its bans on fracking; and (iii) global energy prices (e.g. oil) are affected. We will describe in particular the last point (the extent to which global oil prices change with different knock-on effects for oil importers and exporters) in further detail in the next chapter.

[16] http://www.economist.com/blogs/economist-explains/2013/12/economist-explains-1

3 The impact of fracking on developing economies

The objective of this chapter is to identify and explore the actual and potential effects of transformations in energy markets associated with shale gas and tight oil on energy exporters to the US and China.

It does this by first analysing the pattern of US and Chinese imports of energy products that are substitutes for domestically produced shale gas and oil. It then identifies the major exporters of these products. In order to explore the potential effects of fracking on LICs, we employ the sustainability impact assessment framework which embeds causal chain analysis (CCA). We introduce this framework in Section 3.1 before tracing through the observed and potential effects of fracking on LICs.

3.1 Impact assessment methodology

There is no one standard, universally applicable methodology to assess impacts. There are four main steps involved in an impact assessment: (i) screening and scoping of the issues; (ii) detailed assessment of proposed measures; (iii) assessment of mitigating and enhancing measures; and (iv) monitoring/post-evaluation (Kirkpatrick and Lee, 2002).

In Chapter 2 we screened and scoped the main trade-related shocks; this section provides details on how we undertake an impact assessment of these shocks. This assessment links each proposed change to its eventual impact, positive or negative, and expected time-frame. The purpose of a CCA is to identify the significant cause–effect links between a trade shock and eventual impacts. We focus in particular on the economic impacts. We do acknowledge that there are complex economic-social-environmental relationships which need further examination in the case of fracking and trade in energy.

Analysis of the effect of a trade shock on these pathways is typically the first step. The approach draws attention to how a new structure of incentives and market opportunities can result from an external trade-related shock. The trade shock can be a change in volumes and prices (or a combination of the two) and this will induce changes in the economic behaviour of producers, consumers and intermediaries. These changes will in turn affect the production system.

As discussed by UNCTAD (2013), fracking is expected to influence developments in international commodity prices in the future. North America is forecast to become self-sufficient in energy production by the end of the decade (Citigroup, 2013). Although UNCTAD (2013) discusses the role of new techniques in increasing the supply of oil in the US, as well as that of natural gas, it notes that these developments – related to the US energy self-sufficiency drive – will have a significant impact on fuel-exporting least developed countries (LDCs). In this chapter we set out to assess the extent to which this may be the case. We do this by examining how exporters to the US, including LDCs, are affected (Section 3.4) through:

1. **direct effects:** direct changes in US/Chinese imports from developing countries (where net exporters to the US/China are expected to lose when there are fewer US/Chinese imports); and

2. **indirect effects:** price effects and other supply responses (where net exporters are expected to lose, and net importers to gain).

Hence, the first step in terms of assessing the potential effect of fracking on the US and China's trade partners is to examine changes in energy import patterns, and the potential relationship of these to the production of shale gas through fracking (which we began to do in Chapter 2 and continue in greater detail in Section 3.3). Given this, we focus first on providing an overview of patterns of energy production in the US .

Section 3.5 discusses two case studies in more detail.

3.2 Energy production in the US

Production of natural gas in the US increased by 10.7% over the period 2009–11. As shown in Table 3, this is considerably more than other sources such as coal, crude oil and nuclear, but not as much as (renewable) sources of energy such as hydro, geothermal, biofuels and waste.

Table 3: Percentage changes in US natural gas production

	Coal and peat	Crude oil	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste
2009	100	100	100	100	100	100	100
2010	100.32	103.34	103.14	101.05	95.16	113.50	107.44
2011	101.18	107.53	110.70	98.94	116.74	129.52	111.43
% change 2009–11	1.2%	7.5%	10.7%	-1.1%	16.7%	29.5%	11.4%

Source: Calculated from data obtained from the IEA country balance report.

The increase in production of natural gas has resulted in declines in prices.[17] There has been a dramatic decline in the prices of natural gas for all types presented in Table 4 except LNG.

Table 4: Natural gas energy prices (2005–13)

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Natural gas LNG, $/MMBtu, nominal$	6.0	7.1	7.7	12.5	8.9	10.8	14.7	16.6	16.0
Natural gas LNG, $/MMBtu, real 2010$	6.8	7.9	8.1	12.2	9.3	10.8	13.5	15.4	15.1
Natural gas, 2010=100, real 2010$	162.4	140.8	136.9	174.8	98.9	100.0	99.6	92.2	105.7
Natural gas, Europe, $/MMBtu, nominal$	6.3	8.5	8.6	13.4	8.7	8.3	10.5	11.5	11.8
Natural gas, Europe, $/MMBtu, real 2010$	7.2	9.4	9.0	13.0	9.0	8.3	9.7	10.7	11.1
Natural gas, US, $/MMBtu, nominal$	8.9	6.7	7.0	8.9	4.0	4.4	4.0	2.8	3.7
Natural gas, US, $/MMBtu, real 2010$	10.2	7.5	7.3	8.6	4.1	4.4	3.7	2.6	3.5

Source: World Bank, Global Economic Monitor Commodities.

3.3 US energy import patterns

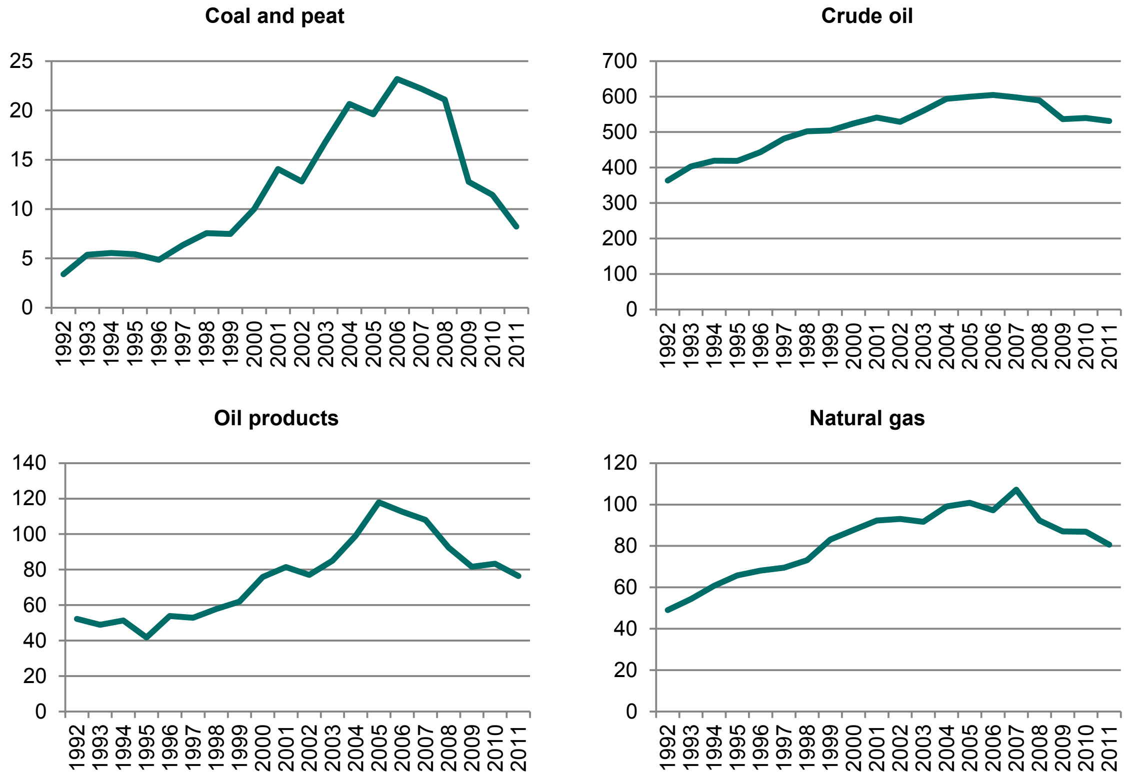
We analyse US imports of:

- coal, coke and briquettes (Standard International Trade Classification (SITC) 32);
- petroleum and products/ related materials (SITC 33);
- gas, natural and manufactured (SITC 34); and
- electric current (SITC 35).

We do this both for volume and value. Figure 4 shows in that the case of import volumes there has been a decline across all types – coal and peat, crude oil, oil products, and natural gas – since 2009. The decline in import values since 2009, shown in Figure 5, coincides with the beginning of production of shale gas through fracking. However, the decline is far less pronounced for imports of

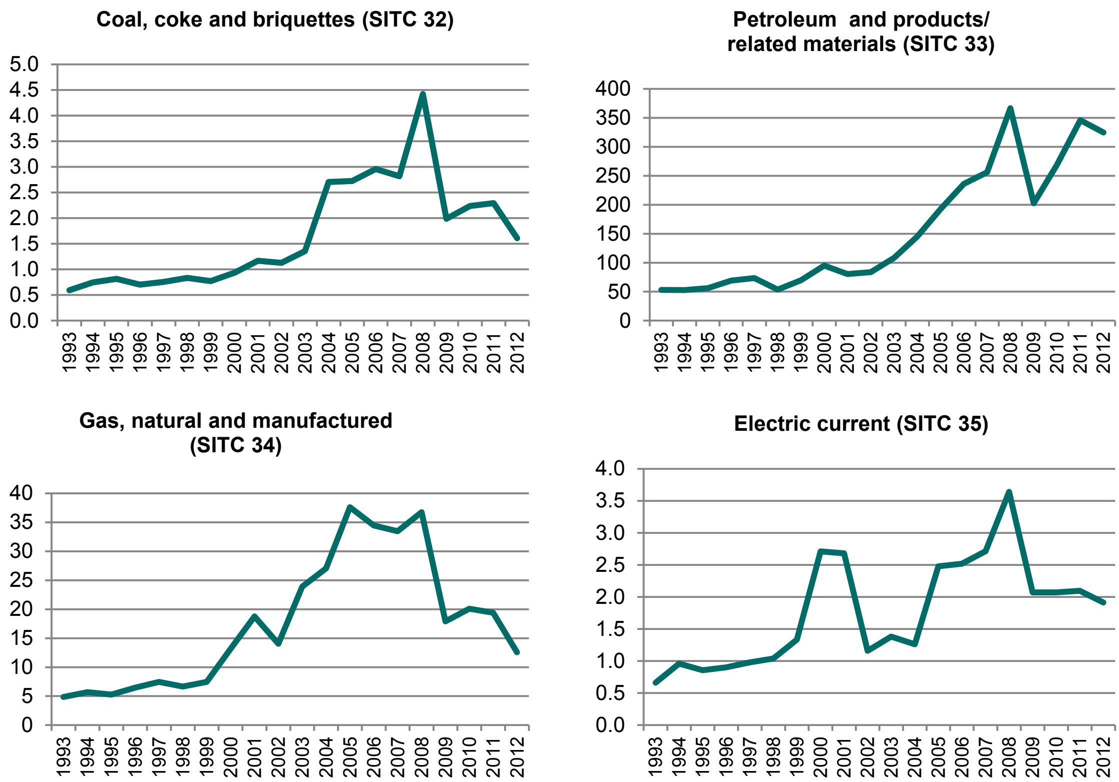
[17] http://www.ft.com/cms/s/0/45d75ad0-fe7f-11e2-97dc-00144feabdc0.html#axzz2x017Ge4K.

Figure 4: US fuel imports, 1992–2011 (mtoe[a])



Note: (a) Million tonnes of oil equivalent on a net calorific value basis.
Source: IEA country balance sheets.

Figure 5: US fuel imports, 1993–2012 (US$ billion)



Source: UN COMTRADE database. (Values in 'UN special codes' within the SITC Rev. 3 headings indicated omitted.)

petroleum and products/related materials. Distinguishing between the effects of the global financial crisis is one of the challenges in linking the effect of fracking to declines in imports.

3.3.1 Suppliers to the US

As can be seen from Table 5, Canada is the major supplier of petroleum and products/related materials (SITC 33) and gas, natural and manufactured (SITC 34), and is the second-largest supplier (after Colombia) of coal, coke and briquettes (SITC 32). It is the sole supplier to the US of electric current. While sources of gas and coal have become more diversified over time, those of petroleum have become more concentrated. None of the major US suppliers of the energy products included in Table 5 is a LIC. However, sub-Saharan African producers such as Nigeria and Angola feature as major suppliers of petroleum and products/related materials. Trinidad and Tobago features as a major supplier of gas, and is classified as an SVE.[18]

Table 5: Major suppliers of US fuel imports, 1993 and 2012

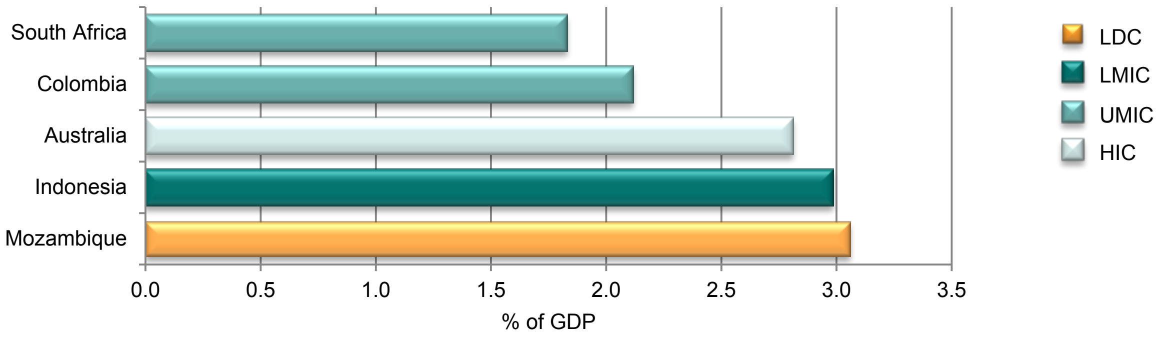
1993		2012		1993		2012	
Supplier	*Share (%)*	*Supplier*	*Share (%)*	*Supplier*	*Share (%)*	*Supplier*	*Share (%)*
Coal, coke and briquettes				**Petroleum & products/related materials**			
Canada	32.2	Colombia	39.6	Saudi Arabia	15.1	Canada	23.2
Japan	25.5	Canada	39.0	Venezuela	14.1	Saudi Arabia	17.2
Colombia	22.7	UK	10.4	Canada	13.5	Mexico	11.6
Venezuela	8.0	Ukraine	3.2	Nigeria	10.4	Venezuela	10.7
Indonesia	5.6	Venezuela	2.0	Mexico	9.4	Iraq	6.0
Australia	4.7	Indonesia	1.9	UK	4.8	Nigeria	5.6
South Africa	0.9	Japan	1.2	Angola	4.2	Colombia	4.9
China	0.2	China	0.9	Kuwait	3.6	Kuwait	4.0
Finland	0.1	Brazil	0.8	Algeria	2.7	Angola	2.9
New Zealand	0.1	Latvia	0.4	Colombia	2.4	Brazil	2.4
All others	*0.1*	*All others*	*0.5*	*All others*	*19.8*	*All others*	*11.5*
Gas, natural and manufactured				**Electric current**			
Canada	86.8	Canada	82.7	Canada	100.0	Canada	100.0
Algeria	5.7	Trinidad/Tobago	7.5				
Saudi Arabia	3.3	Algeria	1.3				
Mexico	1.5	Brazil	1.2				
UK	0.5	Netherlands	0.9				
Korea, Rep.	0.4	Qatar	0.9				
Kuwait	0.3	Yemen	0.8				
Turkey	0.3	Norway	0.7				
Venezuela	0.2	Mexico	0.7				
France	0.2	Belgium	0.7				
All others	*1.1*	*All others*	*2.7*				

Source: Derived from data obtained from UN COMTRADE database.

The effects of a change in demand for the products exported by LDCs, other LICs and SVEs could have subsequent repercussions on their economies because of the high dependence on such fuel exports to markets such as the US. As shown by Figures 6–8, if we look specifically at the value of fuel exports as a share of GDP, we can see that the value of coke/coal/briquettes accounts for over 3% of GDP for LDCs and LICs such as Mozambique. Natural gas and petroleum account for a considerable share of GDP in SVEs such as Trinidad and Tobago and Belize. This means it is important to examine more closely the knock-on effects of fracking on trading partners, and following a CCA, potential effects on GDP.

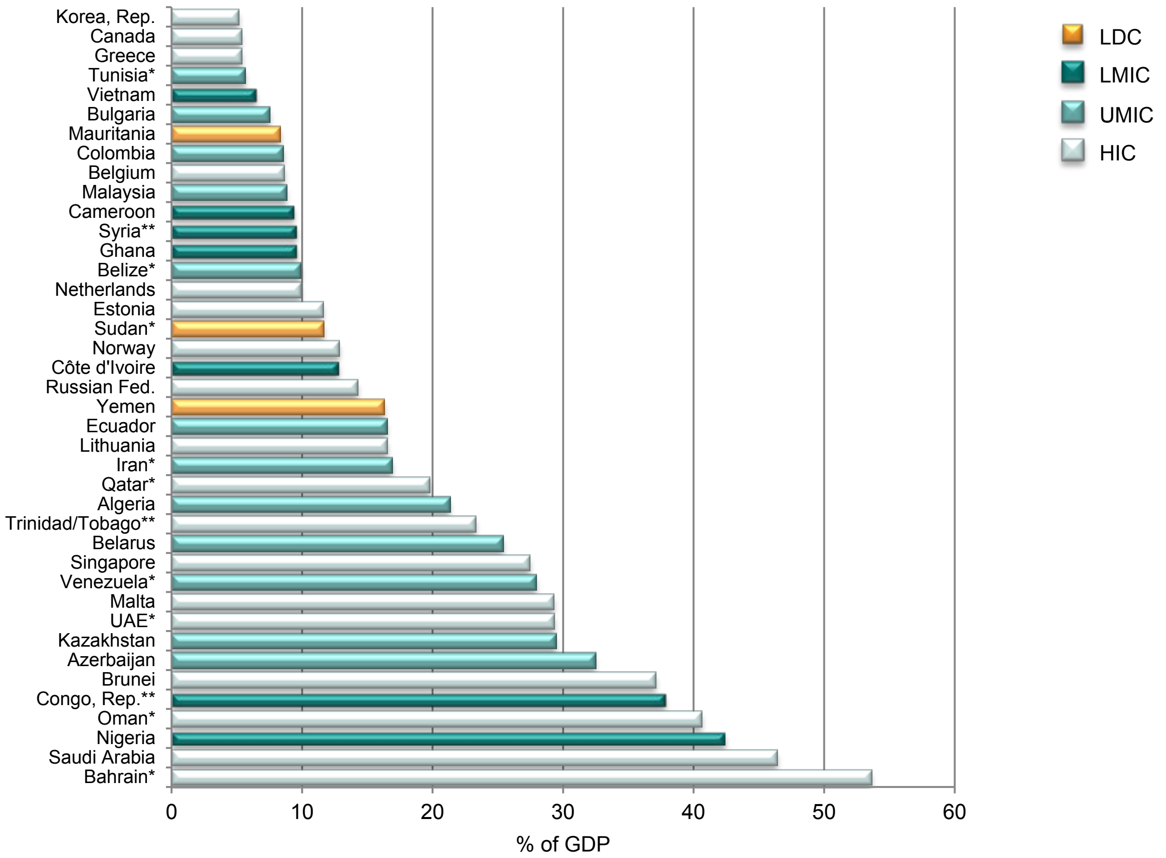
[18] This is precisely because countries such as Trinidad and Tobago can have relatively high levels of GDP *per capita* but nevertheless still be more economically vulnerable than other groups of countries because of an economic dependence on a narrow range of exports and an inability to influence international prices, as well as other characteristics related to limited economies of scale.

Figure 6: Value of coke/coal/briquette exports as % of GDP



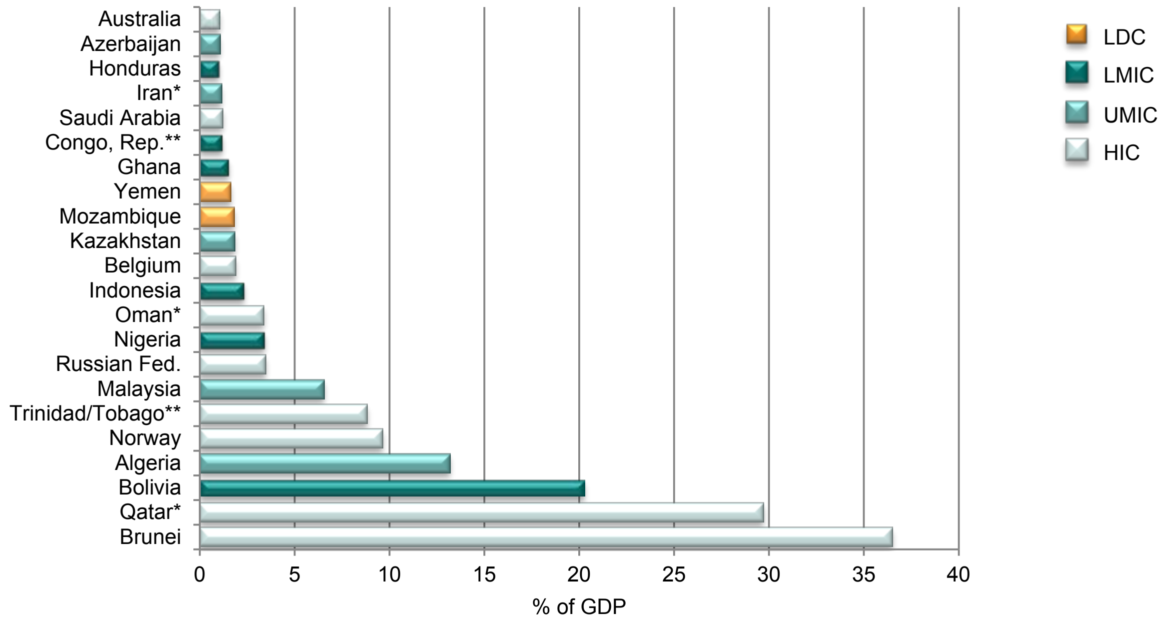
Note: All countries for which value of coke/coal/briquettes exports (SITC 32) accounted for 1% or more of GDP in 2012. LDC = least developed country; LMIC = lower-middle-income country; UMIC = upper-middle-income country; HIC = high-income country.
Source: World Bank, World Development Indicators database (GDP) and UN COMTRADE database (export values).

Figure 7: Value of petroleum and products exports as % of GDP



Note: All countries for which value of petroleum and products exports (SITC 33) accounted for 5% or more of GDP in 2012 (or 2011 or 2010**).*
LDC = least developed country; LMIC = lower-middle-income country; UMIC = upper-middle-income country; HIC = high-income country.
Source: World Bank, World Development Indicators database (GDP) and UN COMTRADE database (export values).

Figure 8: Value of natural/manufactured gas exports as % of GDP



Note: All countries for which value of natural and manufactured gas exports (SITC 34) accounted for 1% or more of GDP in 2012 (or 2011 or 2010**).*
LDC = least developed country; LMIC = lower-middle-income country; UMIC = upper-middle-income country; HIC = high-income country.
Source: World Bank, World Development Indicators database (GDP) and UN COMTRADE database (export values).

3.4 Estimating the effect of trade shocks on exporters

Here we explore the effects on exporters of the scenarios described in Section 2.6. This includes the economic effects of a 50% reduction in the volume of US gas and oil imports over the period 2007–12, and the potential effects on exporters to China. We also explore the potential effects of a global oil price shock induced by fracking.

3.4.1 Effect of trade shock on exporters to the US

We calculated the average value of exports of natural gas (SITC 3431 plus 3432) over the period 2007–12 for all suppliers to the US, and the potential effect of a 50% trade value shock expressed as a share of GDP. We did the same for all suppliers of oil and related products (SITC 33). We then examined those countries where the potential trade shock has an effect equivalent to 0.5% or more of GDP for either one of these products. Table 6 presents the results.

Table 6: Exporters to US: trade shock equivalent to 0.5% or more of GDP

Supplier	Average US import value 2007–12 (US$ 000)	Value of 50% shock (US$ 000)	Trade shock as % of GDP (average 2007–12)
Natural gas (SITC 3431 (natural gas, liquefied) and 3432 (natural gas, in the gaseous state)			
Trinidad and Tobago	1,767,235	883,618	3.87
Canada	15,977,106	7,988,553	0.51
Other countries (0.01%–0.5%):			
Yemen	*105,853*	*52,927*	*0.18*
Egypt	*426,504*	*213,252*	*0.11*
Qatar	*199,077*	*99,539*	*0.08*
Equatorial Guinea	*19,336*	*9,668*	*0.07*
Nigeria	*188,685*	*94,343*	*0.04*
Algeria	*95,702*	*47,851*	*0.03*
Peru	*43,073*	*21,537*	*0.01*
Total developing countries (including those not listed)		**1,498,764**	

Supplier	Average US import value 2007–12 (US$ 000)	Value of 50% shock (US$ 000)	Trade shock as % of GDP (average 2007–12)
Oil and related products (SITC 33)			
Chad	2,449,103	1,224,552	13.97
Congo, Rep.	2,957,406	1,478,703	12.68
Gabon	2,337,200	1,168,600	7.67
Angola	12,573,520	6,286,760	7.24
Equatorial Guinea	1,965,575	982,788	7.11
Nigeria	27,941,833	13,970,917	6.57
Iraq	15,533,198	7,766,599	5.43
Venezuela	34,220,222	17,110,111	5.22
Ecuador	5,982,583	2,991,291	4.45
Saudi Arabia	41,230,803	20,615,401	3.78
Algeria	10,824,683	5,412,341	3.21
Belize	76,092	38,046	2.78
Kuwait	6,798,243	3,399,122	2.62
Trinidad and Tobago	1,109,231	554,616	2.43
Azerbaijan	2,299,087	1,149,544	2.20
Canada	56,923,131	28,461,566	1.81
Colombia	9,159,430	4,579,715	1.64
Mexico	33,131,504	16,565,752	1.56
Congo, Dem. Rep.	242,866	121,433	0.92
Oman	814,658	407,329	0.73
Total African countries (including those not listed)		**32,028,774**	

Note: There are insufficient GDP data to enable a trade shock percentage of GDP to be calculated for Libya and Taiwan, both of which are suppliers of oil and related products.
Source: UN COMTRADE; World Bank, World Development Indicators.

The data presented in Table 6 assume no shift of supplies across exporters. We take a static rather than dynamic approach towards estimating the trade shock. Essentially this is a first-round accounting effect. Actual effects will depend on supply responses and multiplier effects within countries. This approach shows that Trinidad and Tobago is the only country where the trade shock estimated because of fracking in the US on natural gas exporters has a potential effect of over 1% of GDP. Canada may experience a reduction of 0.5% of GDP. Because of the effect of fracking on oil and related products imported to the US, there is a range of other countries that we also estimate to experience a decline in GDP of up to 0.5%. These include Yemen, Egypt, Qatar, Equatorial Guinea, Nigeria, Algeria and Peru. As has already been discussed, Trinidad and Tobago is an SVE, and hence we undertake further analysis on potential within-country effects using CCA in the following sub-section. In total, developing countries may have lost US$1.5 billion in gas export revenue due to US shale gas production.[19]

In the case of suppliers of US oil and related products (SITC 33), a much larger number of countries seem particularly exposed to a potential trade shock induced by fracking. This includes Angola, Congo, and Nigeria. The total effects in African countries amount to US$32 billion.[20]

3.4.2 Effect of trade shock on exporters to China

Some of the same countries that may already have been adversely effected by fracking in the US, in terms of a reduction in exports and hence GDP, may similarly be affected if production in China also generates a similar magnitude of trade shock. We assume the effects are evenly distributed across current suppliers, similar to the case in the US. As shown in Table 7, this includes countries such as Angola and Congo. Both of these countries are estimated to experience a decline in GDP of considerably more than 1% if fracking in China has an effect on their exports similar to that estimated for the US.

[19] The actual decline in US gas imports from these countries over 2007–12 amounted to US$4.3 billion and this could be for many reasons.
[20] We have already observed a decline in African oil exports to the US of US$23 billion between 2011 and 2012 (or US$27 billion 2007–12) but this could be because of many factors (including the recession), of which tight oil is only one.

Table 7: Exporters to China: trade shock equivalent to 0.5% or more of GDP

Supplier	Average Chinese import value 2007–12 (US$ 000)	Value of 50% shock (US$ 000)	Trade shock as % of GDP (average 2007–12)
Natural gas (SITC 3431 (natural gas, liquefied) and 3432 (Natural gas, in the gaseous state)			
Turkmenistan	2,359,462	1,179,731	5.19
Qatar	1,323,471	661,736	0.56
Oil and related products (SITC 33)			
Congo, Rep.	3,050,424	1,525,212	13.08
Angola	21,795,123	10,897,561	12.55
Oman	10,266,037	5,133,019	9.23
Equatorial Guinea	1,388,287	694,144	5.02
Sudan	5,426,652	2,713,326	4.80
Yemen	2,352,534	1,176,267	4.10
Mauritania	225,434	112,717	3.03
Saudi Arabia	27,780,377	13,890,189	2.55
Iraq	5,776,217	2,888,109	2.02
Kuwait	5,014,022	2,507,011	1.93
Iran	14,655,021	7,327,511	1.89
Kazakhstan	5,467,492	2,733,746	1.85
Mongolia	179,718	89,859	1.36
Brunei	351,926	175,963	1.27
Chad	185,674	92,837	1.06
Gabon	315,505	157,752	1.04
Venezuela	4,722,920	2,361,460	0.72
United Arab Emirates	3,945,128	1,972,564	0.67
Congo, Dem. Rep.	171,217	85,609	0.65
Cameroon	274,127	137,064	0.59

Note: There are insufficient GDP data to enable a trade shock percentage of GDP to be calculated for Cuba, Libya, Myanmar and Taiwan, all of which are suppliers of oil and related products.
Source: UN COMTRADE; World Bank, World Development Indicators.

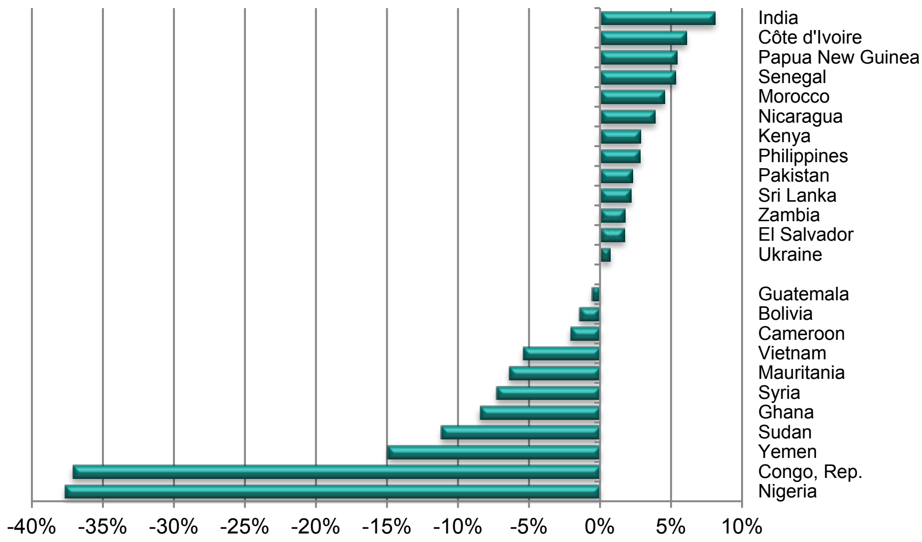
3.4.3 Effect on oil importers through lower global oil prices

There will also be effects globally on importers and exporters of oil (even when they are not exporting to the US) because of changes in oil prices. Global oil consumption is around 80 MMbbl/ day, while US production of tight oil has already increased by 4 MMbbl which could easily have led to a change in global oil prices of 5%. Some suggest that the exploitation of shale oil has kept prices low, with the potential to reduce oil prices by 25% compared to what they otherwise would have been[21] with projections of a reduction in global oil prices ranging from 25 to 40%.[22] The likely impact of a one-third increase in oil prices as discussed by te Velde (2011) could be a 1% reduction in global GDP. A reduction in global oil prices of around 25% induced by fracking could therefore lead to an increase in global GDP of around 0.75%.

Because LICs tend to use more oil to achieve the same output, and tend to have more constraints on their current accounts, they are most likely to benefit from a reduction in global oil prices. Figure 9 presents net oil imports as a % of GDP. The countries shown are all LICs/LMICs for which net imports (or net exports) are equivalent to >0.5% of GDP.[23] These data suggest that countries such as India, Senegal and Zambia could benefit from oil price reductions induced by fracking. This is assuming that there are no market or policy interventions.

[21] See http://www.thetimes.co.uk/tto/business/industries/naturalresources/article3687534.ece).
[22] *Ibid.*
[23] In whichever of 2010, 2011 or 2012 there were complete data for (the year varies from country to country).

Figure 9: Net oil imports (% GDP)



Note: Trade code SITC 333 (petroleum/bituminous oil, crude).
Source: UN COMTRADE database; World Bank, World Development Indicators.

3.5 Case studies

In order to look more closely at the economic dependence of countries that export energy products which are substitutable with shale oil and shale gas, we select the following countries for further analysis:

- Trinidad and Tobago;
- Angola.

We selected Trinidad and Tobago because it is clearly the country that could lose most from the direct effects of fracking on the volume/value of natural gas that it exports to the US. We focus on Angola because it is expected to experience the second-largest decline in GDP after the Congo, as a result of oil export reduction induced by fracking (first-round effects)[24] We focus on identifying potential economic and social impacts from a trade shock. We also investigate potential effects on foreign direct investment and whether there is any evidence to suggest reductions in flows to export-oriented energy sectors to date.

3.5.1 Trinidad and Tobago

Trinidad and Tobago's fiscal revenues are strongly dependent on oil and natural gas resources; it has been producing oil commercially since 1908, and so is one of the oldest oil-producing countries in the world.[25] The energy sector accounts directly for over 40% of GDP and generates 60% of government revenue and up to 90% of merchandise export value, but accounts for less than 4% of direct employment (Watson and Mohan, 2012). In the case of the estimated drop in US gas imports associated with rapid development of shale gas over the period 2007–12, our analysis suggests that Trinidad and Tobago suffers a loss of more than 3% of GDP.

A simple econometric analysis gives an estimated elasticity of employment to GDP of around 0.3 (International Monetary Fund (IMF), 2013). This means that with every percentage point increase

[24] And there is simply more literature available than in the case of the Congo.
[25] See: http://fuelfix.com/blog/2013/11/03/trinidad-energy-minister-touts-worlds-first-natural-gas-economy/

in GDP, employment increases by approximately 0.30%. Hence, a decline in GDP could in theory mean subsequent reductions in employment.

In practice, however, as discussed in quite some detail by the IMF (2013), despite low recorded unemployment rates, there is evidence of significant underemployment in Trinidad and Tobago; the government has introduced various employment support and training programmes under the Social Sector Investment Programme to reduce high unemployment, which are funded predominantly from revenues from the energy sector. Participants in employment programmes are classified as employed under International Labour Organization standards, and are counted as part of the community, social, and personal services sector; the share of this sector in total employment increased from 31% to 34% from 1995 to 2012. This means that the effect of a reduction in GDP on employment could be rather dampened, at least in the short term.

According to most recent reports, exports to the US of natural gas from Trinidad and Tobago have declined, but this is not perceived as necessarily bad news.[26] This is because the sector in Trinidad and Tobago has been able to diversify its markets towards South America and Asia (where prices are higher). Moreover, contrary to expectations, the news that the US will soon begin to export natural gas is viewed positively since this will help to better harmonise the US gas market with the world gas market (although what this means in practice is not clear).

3.5.2 Angola

As discussed in World Bank (2013), and clearly evident in Table 6, Angola's reliance on oil revenues and imports leaves the economy highly exposed to external shocks. Oil exports currently account for about 46% of Angola's GDP and 96% of its exports; 80% of its public revenue is derived from the oil sector, and annual spending is highly correlated with annual oil revenues.

According to Faucon et al. (2013), exports to the US from three of OPEC's African members – Nigeria, Algeria and Angola – have fallen to their lowest levels in decades, dropping 41% in 2012 from 2011, largely because of shale oil according to the US Department of Energy. African OPEC members such as Algeria and Nigeria – which produce oil of a similar grade to shale oil – are suffering the worst effects from the North American oil boom.[27] For example, Nigerian Oil Minister Diezani Alison-Madueke has deemed US shale oil a 'grave concern'.[28]

The latest estimates on Angola's elasticity of total employment to total GDP suggest it is around 0.2% (UNCTAD, 2013). Hence any reduction in exports which adversely affects GDP could result in reductions in employment, with concomitant social impacts. The lack of effective social protection measures (compared, for example, to Trinidad and Tobago) means that negative effects are more likely to be transmitted immediately.

[26] *Ibid*.
[27] http://online.wsj.com/news/articles/SB10001424127887323855804578508871186460986
[28] *Ibid*.

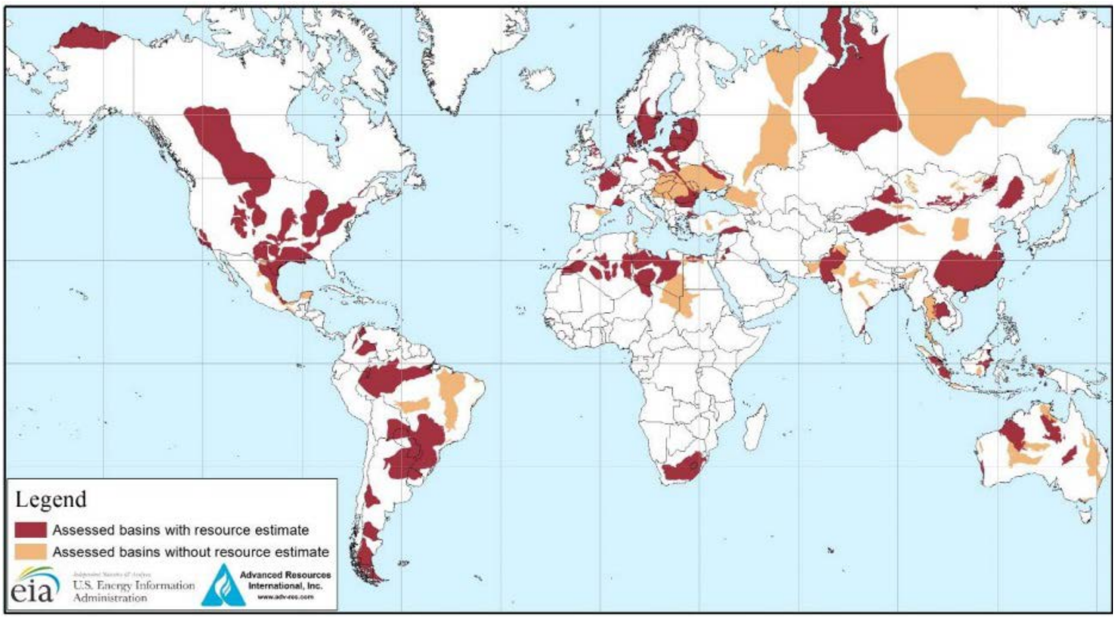
4 Geopolitical implications of the fracking revolution

The growing production of new supplies of unconventional oil and gas has the potential to shift global power – enhancing the power of some states and undermining that of others.

The major geopolitical implications of shale gas and tight oil are commonly seen as including the following: strengthening the US position, particularly in the short-term; reducing China's energy dependence over the medium term; generating a significant global economic stimulus; decreasing Russia's influence in the short term (offset in the long term by Russia's own resources); possibly destabilising major Gulf states and reducing US interest in that area.[29]

Figure 10 shows the location of assessed shale gas basins. Assuming that shale gas and other associated unconventional gas can be successfully exploited in the next decade or so, this chapter briefly sketches the winners and losers in geopolitical terms. The emergence of shale gas and tight oil demonstrates how technological innovation can change the global economic and geopolitical balance.

Figure 10: Where are shale gas reserves located?



Note: As of May 2013. US basins from US EIA and US Geological Survey; other basins from ARI based on data from various published studies.
Source: EIA (2013c).

[29] See for example New York Times Op-Ed, Alan Riley (December 2012) *The Shale Revolution's Shifting Geopolitics* (http://www.nytimes.com/2012/12/26/opinion/global/the-shale-revolutions-shifting-geopolitics.html?_r=0).

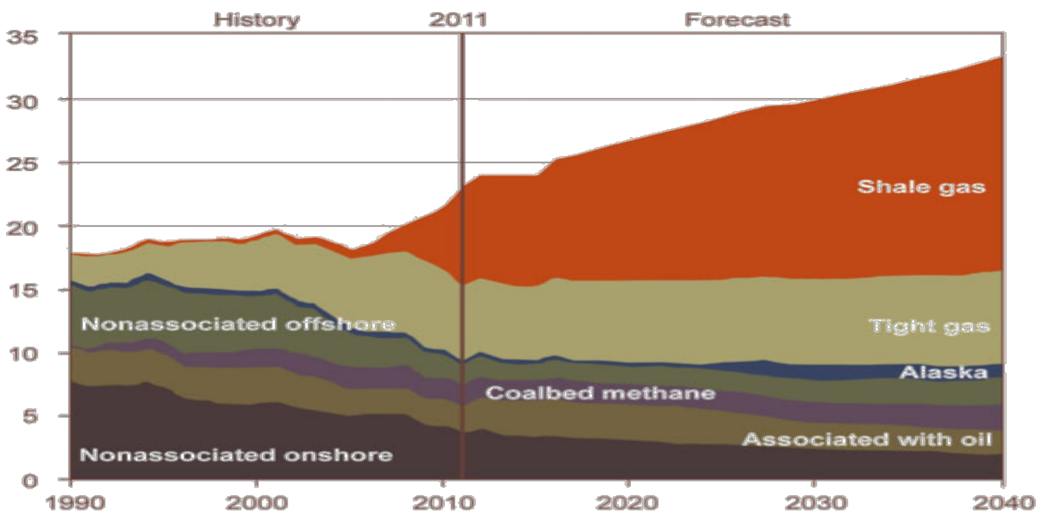
4.1 Winners

4.1.1 The United States

The US stands to be the biggest beneficiary from shale gas. It has already received an economic boost from shale gas and the combined impact of technological innovation and creativity, open energy markets and widespread development in transport technology will all play a positive role in increasing US energy leverage on other states (Figures 11 and 12).

More importantly, as the US imports less and less oil and gas from abroad (Figure 13), the relative power in the natural gas market of traditional energy exporting countries is bound to decline due to the increase in US natural gas production. Estimates in the early 2000s were that the US would become a large importer of LNG from countries such as Qatar. In reality, however, the US has moved in the opposite direction and is due to become an exporter of LNG by as early as 2015.[30] This has led some to argue that America's entry into the global natural gas market could potentially reduce Russia's political dominance over its European markets in the future. Meanwhile, such prospects have already given consuming nations more leverage in negotiating supply contracts – as is demonstrated, for example, by Gazprom's willingness to lower gas contract prices, to US$370–380 per 1,000 cubic metres in 2013 compared to $402 in 2012.[31]

Figure 11: Increased contribution of shale gas to total US supply, 1990–2040 (tcf/year)



Source: EIA (2013a).

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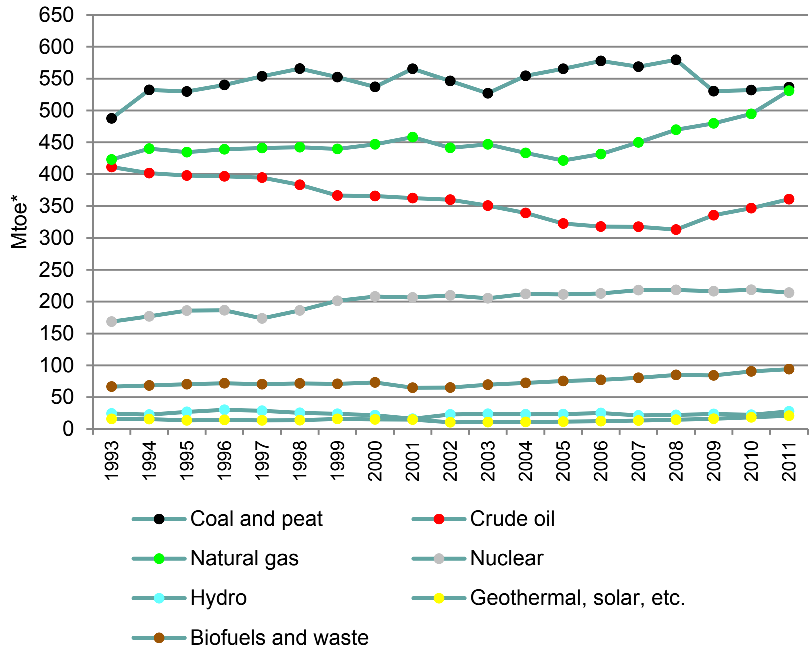
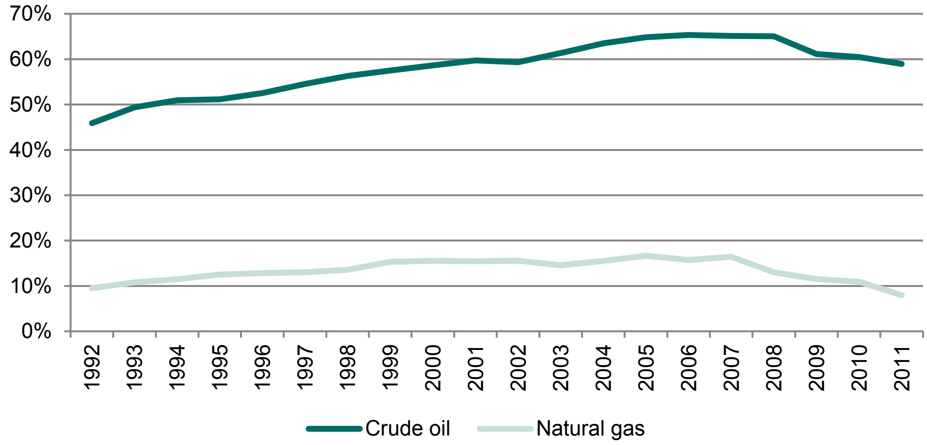
[30] http://www.theguardian.com/environment/2014/mar/25/us-expands-gas-exports-in-bid-to-punish-putin-for-crimea.
[31] http://www.bloomberg.com/news/2013-06-04/gazprom-cuts-2013-gas-export-price-forecast-amid-contract-talks.html

Figure 12: US energy production, 1993–11



*Note: * Million tonnes of oil equivalent on a net calorific value basis.*
Source: IEA country balance report.

Figure 13: US dependency ratio on oil and natural gas imports



Source: IEA country balance report.

The US also appears to have dramatically reduced its GHG emissions due to the shale gas boom. US emissions of carbon dioxide, which peaked in 2007, had fallen by 12% as of 2012 and were back at 1995 levels. This may in large part be due to fracked gas.[32] However the environmental effects in the US are complex and need to take into account, *inter alia:* (i) the GHG implications of methane leakage from well to plant, which may erode the actual GHG mitigation benefits except under highly specific circumstances; (ii) major water consumption and contamination implications; (iii) the rebound effect of lower coal prices that may erode the benefit of gas fuel-switching in the absence of a national plan that moves infrastructure away from coal; (iv) the trade implications of high coal inventories and lower prices, a situation which could simply export coal, and thus

[32] Frankel argues (http://www.project-syndicate.org/commentary/overcoming-objections-to-shale-gas-by-jeffrey-frankel) that this reduction in emissions is not because of the economic recession. As the recession ended in June 2009 and GDP growth since then, though inadequate, has been substantially higher than in Europe. Yet US emission have continued to fall, while EU emissions began to rise again after 2009.

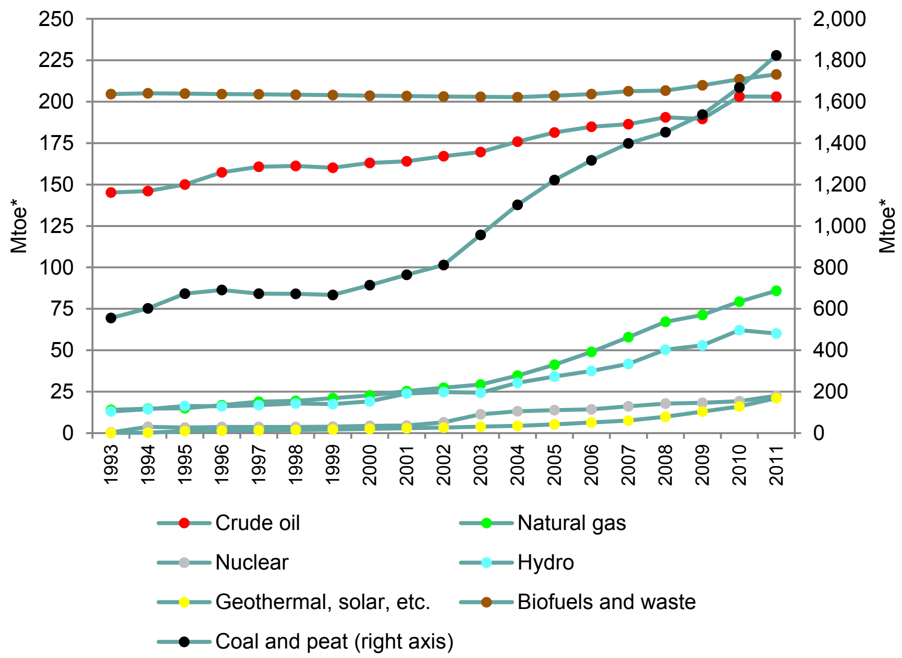
emissions, to other countries; and (v) the further reliance on oil arising from fracking's application to tight oil.

The other important implication for the US economy of the increased exploitation of shale gas is the possibility that some manufacturing businesses will re-shore to the US as cheaper fuel could increase their product competitiveness. This could lead to significant job creation. Lastly, abundant supply of US shale oil could further strengthen the US's ties with the rest of North America and Latin America. Canada imports 464,000 barrels of crude oil daily from the US – 18% of its daily consumption. Mexico, Brazil, Chile and many other parts of Latin America and the Caribbean also depend on the US.[33]

4.1.2 China

The composition of China's energy production has changed dramatically over the last twenty years. As shown in Figure 14, while production from nuclear, biofuels and geothermal has remained steady, energy supplies from natural gas, crude oil and hydropower have grown more rapidly. The most significant increase however, came from coal, which more than doubled its output between 2000 and 2011.

Figure 14: China's energy production, 1993–2011

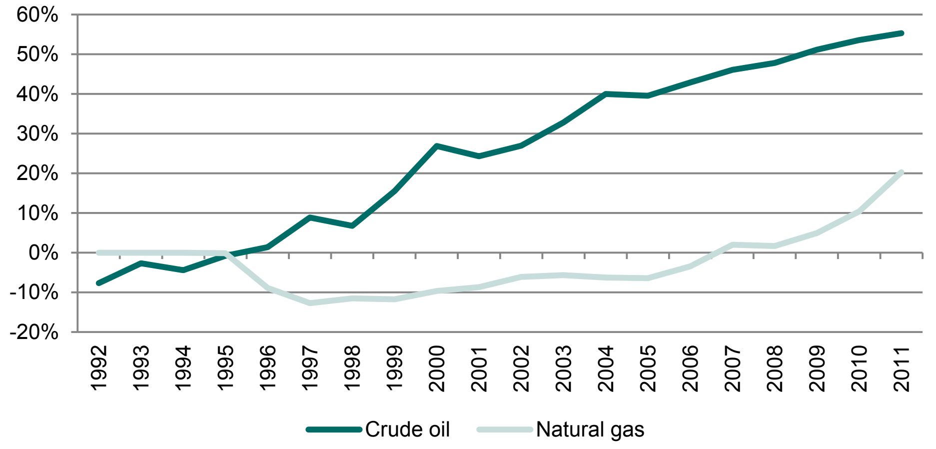


*Note: * Million tonnes of oil equivalent on a net calorific value basis.*
Source: IEA country balance report.

The economic implications for China are likely to be predominantly positive (Riley, 2012). As a country that relies heavily on foreign energy supply, as shown in Figure 15, domestically produced shale gas could significantly increase China's energy security by reducing this reliance. China's main suppliers of natural gas and oil/related products in 2012 are shown in Figures 16 and 17. A range of countries might be negatively affected by reduced exports to China – including African, Middle Eastern and Central Asian producers of oil and natural gas.

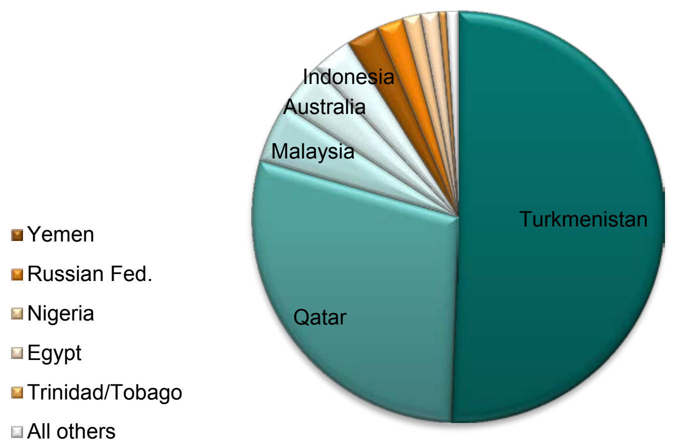
[33] http://www.nea.gov.cn/2014-01/10/c_133033475.htm.

Figure 15: China's dependency ratio on oil and natural gas imports



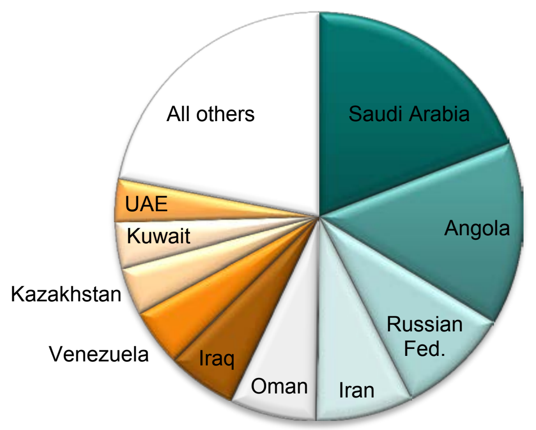
Source: IEA country balance report.

Figure 16: China's top ten natural gas suppliers by value, 2012



Note: Value of imports in SITC 3431 (natural gas, liquefied) plus SITC 3432 (natural gas, in the gaseous state).
Source: Derived from data obtained from UN COMTRADE database.

Figure 17: China's top ten oil and related products suppliers by value, 2012



Note: Value of imports in SITC 33 (petroleum and products/related materials).
Source: Derived from data obtained from UN COMTRADE database.

There are also national security concerns for China in importing oil and gas from politically volatile regions in Africa and the Middle East, via strategic locations such as the Strait of Hormuz and the Strait of Malacca, where the US navy maintains the ability to blockade the sea routes. Following on from that, it is also possible that the military tension between China and Japan over the South China Sea may be reduced if the supply of energy is likely to increase, as the underlying reason for this dispute between the two Asian powers is the oil and gas resources underneath the Senkaku/Diaoyu Island.

Lastly, shale gas could potentially, under certain circumstances, reduce China's GHG emissions and air pollution issues in many urban areas. As with the US, however, the environmental implications of fracking are complex for China. In addition to the issues raised previously for the US, China faces: (i) higher energy intensity to recover its reserves, which increase emissions per unit of recovered gas; (ii) the risk that high levels of trucking associated with the transport of fracking water exacerbate local air pollution problems; and (iii) more severe water contamination and consumption risks.

4.2 Neutral

4.2.1 The European Union

The European Union will also face consequences as a result of the fracking revolution. Europe could benefit from lower natural gas prices due to more abundant supply and reduce its reliance on Russian gas. Nevertheless, if the EU continues to import energy from the Middle East it would become increasingly dependent on the US for supply security at a time when the US itself was no longer dependent on Middle Eastern oil. If this were the case one might expect the US to have less incentive to deploy its military assets, such as the Fifth Fleet, to patrol the Gulf.

Europe may also be expected to start its own shale gas programmes in the future to offset such risks, although currently bans are in place. As shown in Figure 10 at the beginning of this chapter, technically recoverable reserves of shale gas have been found in countries including France, Sweden, Poland, and the United Kingdom (UK). Effective exploitation of these assets could significantly increase Europe's energy security by reducing its dependence on energy from non-European sources. The events in Ukraine in early 2014 have led some among the European business community to call for shale gas exploration in order to reduce Europe's energy dependence on Russia.[34]

EU member states hold different opinions over the potential environmental implications of shale gas exploration. Leading nations in the EU are still debating the costs and benefits of the potential shale gas industry. One of the leading pro-shale gas countries is the UK, where Prime Minister David Cameron and his Chancellor George Osborne have argued that fracking is safe and have played down the local environmental risks and talked up the benefits – arguing that it could provide enough energy for the UK for the next 40–50 years while significantly reducing household energy bills.[35] The UK's pro-fracking position could also be explained by its rising imports of oil and gas, shown in Figure 18. France, however, opposes shale gas exploitation in Europe and has banned fracking domestically. The European Commission has been drawing up proposals for a new framework directive, which could take years to negotiate, in order to regulate the pollution risks of 'unconventional' fuels, including shale gas, which could threaten the UK's efforts in shale gas exploration.

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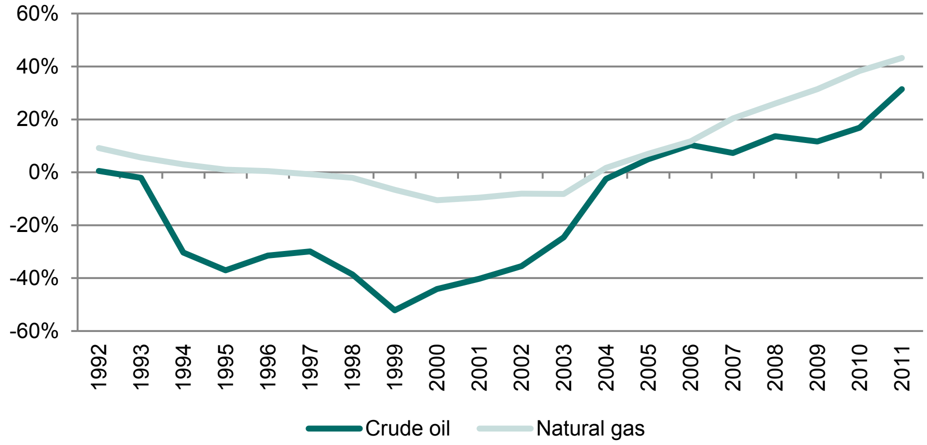
[34] See for example EurActiv 13 March 2014 – *Beyrer: End the EU's Energy Dependence on Russia through Shale Gas* (http://www.euractiv.com/energy/business-europe-calls-eu-explore-interview-534107).
[35] http://www.bbc.co.uk/news/uk-politics-25868997;

Figure 18: UK's dependency ratio on oil and natural gas imports



Source: IEA country balance report.

4.3 Losers

4.3.1 OPEC

Fracking can have a negative impact on the oil cartel that was formed in 1960. OPEC, which produces 40% of the world's oil, predicts that demand for OPEC's crude oil will fall by 1.1 MMbbl/day to 29.2 MMbbl/day between 2013 and 2018; whereas shale oil production in the US and Canada will climb to 4.9 MMbbl/day in 2018, compared with an estimate of 1.7 MMbbl/day in its 2012 report (OPEC, 2013). This represents a significant rise in estimation of the significance of North America's energy boom, OPEC also predicts a fall in its market share to 39% at the end of the decade, from 41% in 2013.[36] (Such a fall would possibly trigger OPEC to start losing its grip on global oil price and therefore reduce its bargaining power in the world economy.)

4.3.2 The Middle East

First, if the US gradually moves towards energy independence in the next two to three decades this could spark a shift of Middle East and North African exports to Asia. This possibility is already leading to anxiety in some of the Arab capitals. Further, while the US will continue to import energy in the future, more of it will come from Canada. Iran controls the Strait of Hormuz, which is the only outlet from the Persian Gulf to the open ocean and one of the most strategic military choke points. Increasing US shale oil supply could decrease the strategic importance of the Strait of Hormuz and therefore the bargaining power of Iran.

But even before the growth of unconventional oil the Persian Gulf provided only 10% of total US supply,[37] which means that the Middle East has not featured very prominently in the overall US petroleum picture for some time. Despite that, the Middle East is likely to remain geopolitically important, as its oil still accounts for about 40% of global oil consumption, which implies it will remain a strategically important region for the US.

Some even argue that the fact that Iran is now serious about nuclear negotiations might well not have happened[38] were it not for tight oil. Previously, when strict sanctions were imposed on Iranian oil exports many feared that world oil prices would spike and that the sanctions would ultimately fail owing to insufficient alternative supply. But according to Daniel Yergin,[39] the vice president of

[36] http://www.bloomberg.com/news/print/2013-11-07/opec-sees-less-demand-for-its-oil-to-2018-amid-shale-boom.html.
[37] http://www.project-syndicate.org/print/daniel-yergin-traces-the-effects-of-america-s-shale-energy-revolution-on-the-balance-of-global-economic-and-political-power
[38] *Ibid.*
[39] *Ibid.*

IHS, a global information company, the increase in US oil production over the last two years has more than made up for the missing Iranian output, enabling the sanctions (bolstered by parallel financial measures) to have more of an effect.

4.3.3 Russia

Russia is likely to suffer some of the largest negative consequences of shale gas exploration. As 40% of its fiscal revenue comes from oil and gas exports, any price reductions would lead to serious concerns about government revenue and economic policy at a time when oil production in Russia has begun to plateau. The Russian share of the European market is predicted to fall from 27% in 2009 to 13% in 2040 (Medlock et al., 2011). Russia has also, famously, been prepared to use its strong position in terms of control of energy markets to reinforce its sub-regional political position.

Recent Russo-Ukrainian relations, in particular, have been strongly affected by the politicisation of energy exports and their use as a means of exerting Russian regional influence. In 2006, 2009 and again in 2013/14, simmering tensions pertaining to the supply and price of natural gas (alongside accusations of Ukrainian siphoning) have destabilised the region and threatened supplies to much of Europe. At present Ukraine is anticipating a steep rise in the prices charged for accessing gas imports from Russia, with the possibility of further disruptions to supply.[40] Europe's reliance on Russian gas supplies, coupled with the centrality of the gas industry to the Ukrainian economy, have led to Russia using energy supply as a means to exert its influence over former Soviet countries, as well as on wider European politics. These repeated crises have led to calls for increased energy diversity in Europe as a means of insulating countries from the impact of protracted regional gas disputes and of dependence on Russian supplies. In the short-to-medium term, contractual obligations preclude any such diversification, with Russia's European customers tied into long-term legal agreement for gas deliveries (with many stretching beyond 2025–30).

Unlike Saudi Arabia, which has large reserves and a relatively small population, Russia has a population of 140 million and proportionately far smaller capacity to build reserves to survive a sustained fall in energy prices. With existing socio-economic challenges, the Russian government needs a high energy price to balance its economy and maintain its political influence among its neighbours. The obvious risk is that the sense of impending vulnerability which the prospect of reduced revenue and political influence might bring could influence Russia to seek to achieve geopolitical goals in the shorter term. In the longer term, however, Russia may benefit from the development of its own shale gas reserves.

[40] http://www.reuters.com/article/2014/03/28/ukraine-crisis-economy-idUSL5N0MP1VL20140328.

5 Conclusions

This Shockwatch Bulletin has examined how the technical changes permitting new forms of oil and gas production are changing world energy markets, and trade with developing countries. We estimate that US shale gas production may have led to a decline in US imports of gas of around 50% since 2007. The effect on oil imports is also estimated to be around 50% (around 4 MMbbl/day), but the value for oil is much larger than for gas. Chinese imports of gas in the future may also be reduced by 50%.

These changes in two major importers will affect other countries, the world energy market, and geopolitical relations. Our assumptions suggest that certain developing country exporters will lose. Trinidad and Tobago is the only natural gas exporter for which the trade shock estimated because of fracking in the US has a potential effect of over 1% on GDP, but other countries affected include Yemen, Egypt, Qatar, Equatorial Guinea, Nigeria, Algeria, and Peru. In total, developing countries may have lost an estimated US$1.5 billion in annual gas export revenue due to US shale gas.

In the case of suppliers of US oil, a much larger number of countries seem exposed to a potential trade shock induced by fracking. This includes Angola, Congo, and Nigeria. Should an increase in fracking in China generate a similar trade shock this will double the effect. The total effects in African countries amount to US$32 billion (of which US$14 billion in Nigeria, US$6 billion in Angola and US$5 billion in Algeria); we have already observed a decline in African oil exports to the US of US$23 billion between 2011 and 2012 (or US$27 billion 2007–12). The net economic loss to those countries would of course depend on their ability to sell the oil not sold to the US in other markets.

The fracking revolution is also likely to have major geopolitical impacts. The US and China stand to benefit from the prospect of greater energy independence. Europe will be faced with an imperative to reduce its dependence on energy imports from Russia and elsewhere, and will face various options for doing this. Russia, the Middle East and OPEC are expected to lose in political terms. For non-oil exporting developing countries the economic impacts can be expected to be broadly positive. This may contribute to a continuance of the phenomenon of ‘convergence’ seen since the early 2000s – with many developing countries growing much faster than the OECD average.

We conclude that fracking has been an important technological shock with potentially large consequences for developing countries, certainly in terms of trade. Several energy exporters lose out from lost export revenues, but other developing countries might gain from lower oil prices and faster world growth. Some of this may have already happened, but some may still happen into the future. It is important that developing countries account for this in their future economic projections.

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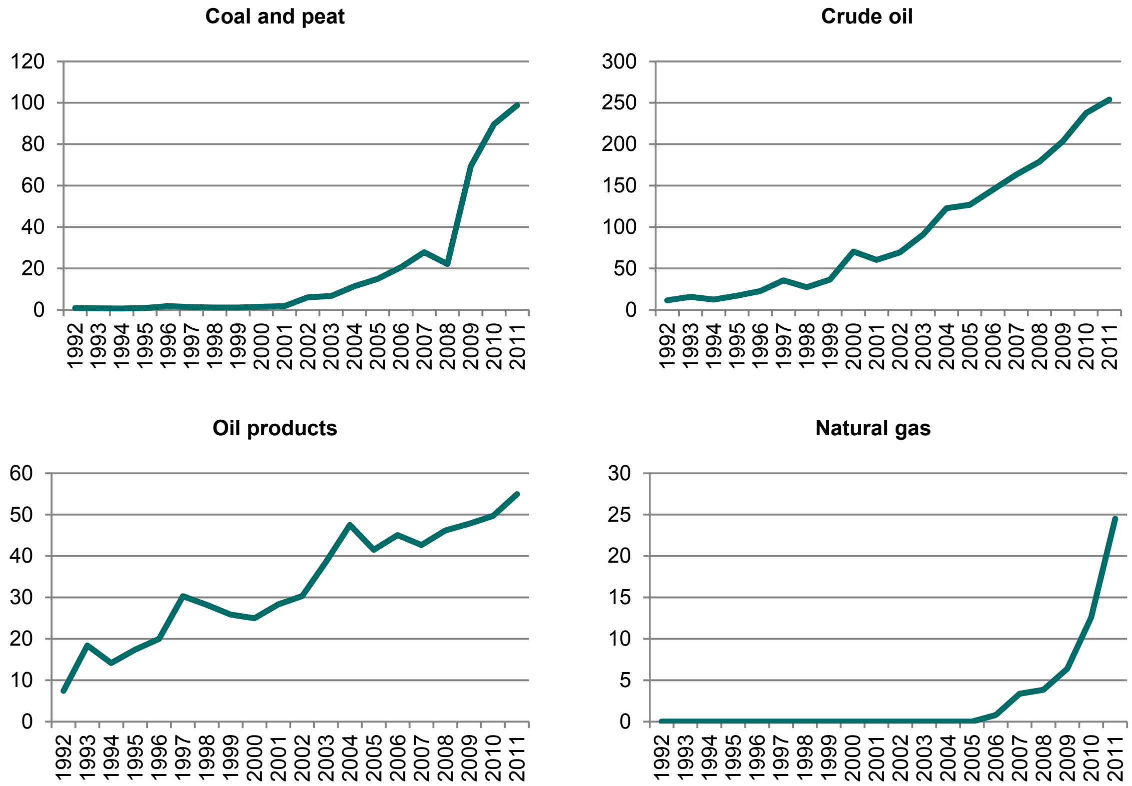
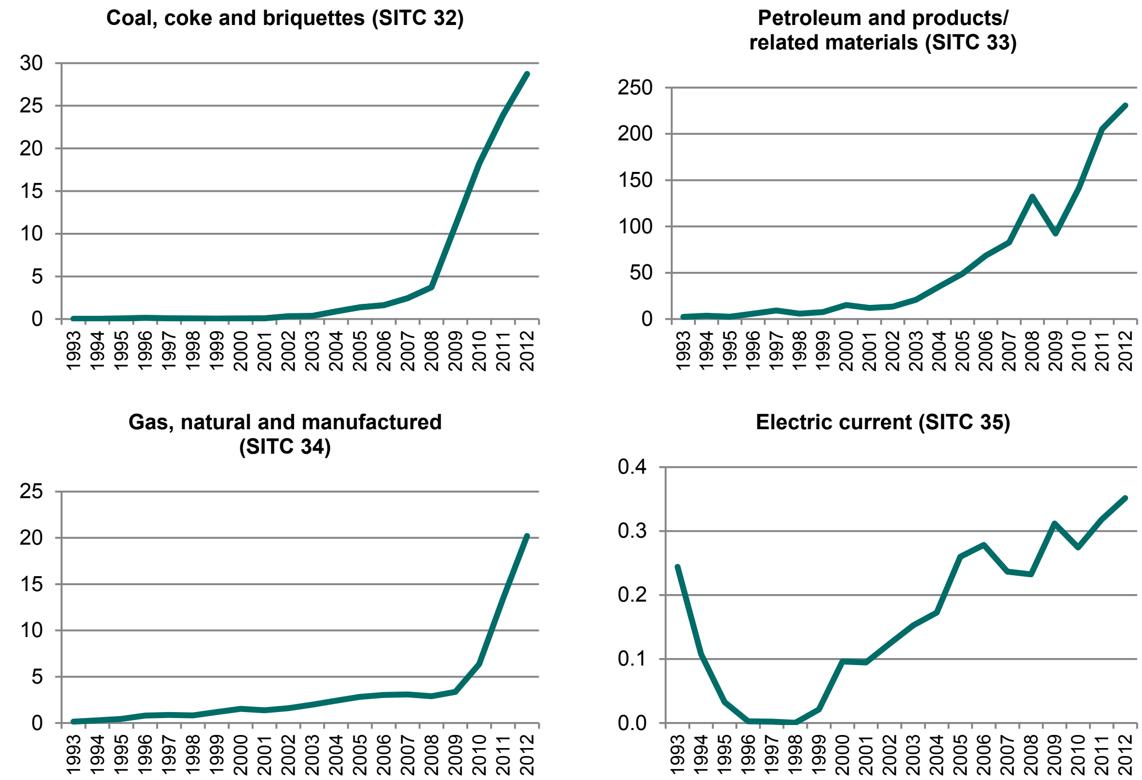
Appendix

Figure A1: Chinese fuel imports, 1992–2011 (mtoe[a])



Note: (a) Million tonnes of oil equivalent on a net calorific value basis.
Source: IEA country balance sheets.

Figure A2: Chinese fuel imports, 1993–2012 (US$ billion)



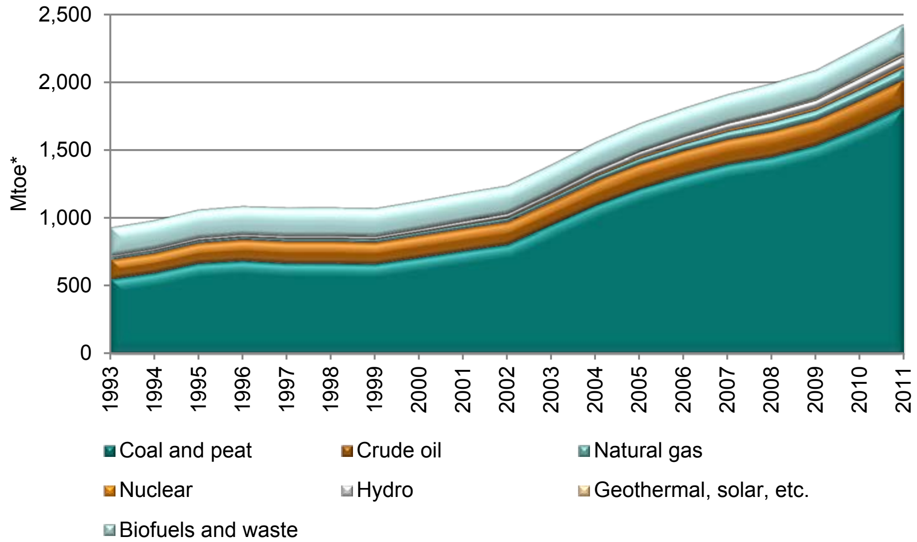
Source: UN COMTRADE database. (Values in 'UN special codes' within the SITC Rev. 3 headings indicated omitted.)

Table A1: Major suppliers of Chinese fuel imports, 1993 and 2012

1993		2012		1993		2012	
Supplier	*Share (%)*	*Supplier*	*Share (%)*	*Supplier*	*Share (%)*	*Supplier*	*Share (%)*
Coal, coke and briquettes				**Petroleum & products/related materials**			
Australia	52.4	Indonesia	32.6	Indonesia	24.9	Saudi Arabia	19.1
New Zealand	18.2	Australia	26.9	Oman	23.3	Angola	14.5
Vietnam	16.4	Russian Fed.	8.4	Yemen	10.6	Russian Fed.	8.9
Korea PDR	7.7	Mongolia	6.0	Angola	7.5	Iran	7.7
South Africa	3.7	South Africa	5.5	Papua N. Guinea	5.1	Oman	6.9
Japan	1.1	Canada	5.1	Libya	4.5	Iraq	5.5
Russian Fed.	0.2	Vietnam	4.6	Utd Arab Emirates	3.9	Venezuela	4.5
Myanmar	0.2	USA	4.2	Singapore	3.7	Kazakhstan	3.8
Korea, Rep.	0.01	Korea PDR	4.2	Malaysia	3.4	Kuwait	3.6
Taiwan	0.01	Colombia	1.0	Australia	2.8	Utd Arab Emirates	3.4
All others	*0.02*	*All others*	*1.5*	*All others*	*10.2*	*All others*	*22.0*
Gas, natural and manufactured				**Electric current**			
Philippines	32.3	Turkmenistan	42.1	Hong Kong	99.6	Hong Kong	45.6
Singapore	24.7	Qatar	26.7	Russian Fed.	0.4	Russian Fed.	35.0
Korea, Rep.	11.6	Australia	4.3			Myanmar	17.9
Hong Kong	7.5	Malaysia	4.2			Korea PDR	1.5
Saudi Arabia	6.9	Utd Arab Emirates	3.8			Kyrgyz Rep.	0.01
Japan	5.4	Indonesia	2.7				
Indonesia	3.0	Saudi Arabia	2.7				
Thailand	2.7	Kuwait	2.2				
USA	1.7	Yemen	2.1				
Qatar	1.4	Russian Fed.	1.7				
All others	*2.8*	*All others*	*7.4*				

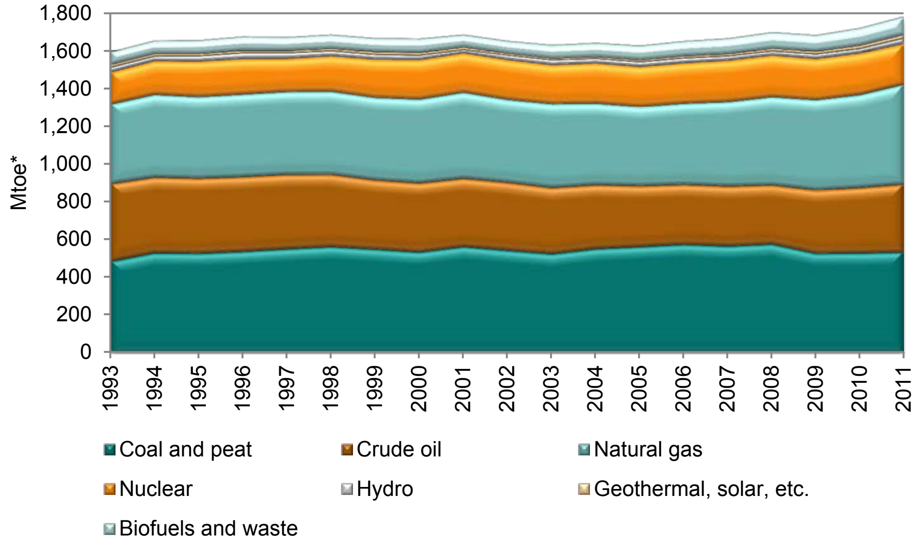
Source: Derived from data obtained from UN COMTRADE database.

Figure A3: Energy production: China



*Note: * Million tonnes of oil equivalent on a net calorific value basis.*
Source: IEA country balance report.

Figure A4: Energy production: US



*Note: * Million tonnes of oil equivalent on a net calorific value basis.*
Source: IEA country balance report.

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