

# **Gas versus oil prices**

## **The impact of shale gas<sup>1</sup>**

Frank Asche, Atle Oglend and Petter Osmundsen

University of Stavanger

### **Abstract**

What significance will developments in shale gas production have for European gas prices? Some commentators paint a gloomy picture of the future gas markets. But most forecasts for the oil market are positive. Consequently, a view appears to prevail that price trends will differ sharply between oil and gas markets. This article looks at developments in US shale gas production and discusses their impact on the movement of European gas prices. The relationship between oil and gas prices over time is also analysed.

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## 1. Introduction

Improvements in the cost efficiency of production technology for shale gas have made it profitable to recover such resources in the USA.<sup>2</sup> This could have a negative effect on gas price developments in Europe because it means a substantial expansion in global gas output. There are signs that European gas prices have now become more decoupled from oil prices than before, and a number of market players believe increased gas-to-gas competition will result in a pricing where the most expensive gas projects set the standard – including costly Russian developments. Cera (2010) expresses a belief that marginal projects will be price leaders when it asks whether prevailing European gas prices will be high enough over time to ensure the execution of the new projects required to meet demand. Uncertainty also prevails about the continued development of new energy because the financial crisis has created budget problems in many countries.<sup>3</sup> However, a number of refinements can reasonably be introduced in this context, not least a distinction between short- and long-term effects.

Considerable price differentials arise at times between oil and gas as a result of various market shocks. To the extent that oil and gas are substitutable, market forces will also exist which encourage price differences to iron out, but various forms of inertia mean that this will take time. If gas is substantially cheaper than oil, for instance, with a bigger price difference than usual, investments will be attracted to oil projects at the expense of gas developments upstream – and vice versa downstream. However, gas projects do not come a halt at short notice, since many fields are typically already under development, and new oil projects have substantial lead times. Similarly, energy customers typically take a considerable time to shift their demand from one energy bearer to another. A large price difference of this kind prevailed at the beginning of 2011. Increased production of liquefied natural gas (LNG) and

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<sup>2</sup> Technological progress has been made with horizontal multilateral wells and shale stimulation/fracturing.

<sup>3</sup> “UK Treasury Set to Kill Off Green Investment Bank”, *Mail on Sunday*, 6 February 2011, <http://www.dailymail.co.uk/money/article-1354090/Treasury-obstructs-Coalitions-green-bank-investment-wind-farms-nuclear-power-stations.html>

coal bed methane (CBM), new shale gas output in the USA and reduced demand because of the financial crises drove gas prices down relative to those for oil. However, it is not given that this represents a permanent shift, since lead times mean substitution is a lengthy process in this market. Official oil company statements express faith in European gas prices. Statoil CEO Helge Lund, for instance, has commented: “We believe we can secure higher gas prices in the future. This means we’re holding back some of the gas for a few years”.<sup>4</sup>

Generally speaking, it is sensible not only to listen to what oil companies say, but also to look at what they are actually doing. Companies on the Norwegian continental shelf (NCS) do not appear to have panicked and cut all new investment in gas projects. Eni, for instance, has submitted a plan for development and operation (PDO) of Marulk,<sup>5</sup> a gas and condensate field on the NCS, with an estimated investment cost of NOK 4 billion.<sup>6</sup> Similarly, Exxon recently sanctioned a gas development in Papua New Guinea costing USD 15 billion.<sup>7</sup> But examples can also be found of projects put on hold, in part with reference to lower gas prices. Russia’s Shtokman development is a case in point. That could help to stabilise gas prices.

The various views on how gas prices will develop build on differing assumptions about the way these prices are set. Traditionally, gas prices in continental Europe were determined by long-term contracts using formulae embracing oil prices and the cost of primarily oil-based products. That yielded a gas price which was strongly covariant with those for oil (Asche et al 2002). Two hypotheses exist about how gas prices are set in deregulated markets. One emphasises gas-to-gas competition, and implies that prices are primarily determined by supply and demand for gas. The other argues that most consumers are seeking energy, and that a substantial degree of substitution exists between various energy bearers, so

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<sup>4</sup> *Stavanger Aftenblad*, 12 February 2010.

<sup>5</sup> See the press release of 19 April 2010 from the Ministry of Petroleum and Energy:  
<http://www.regjeringen.no/nb/dep/oed/pressesenter/pressemeldinger/2010/Klart-for-ny-milliardinvestering-pa-norsk-sokkel.html?id=601019>

<sup>6</sup> See the press release of 19 April 2010 from Eni Norge:  
<http://www.eninorge.no/EniNo.nsf/ne/77882614C149BE7BC125770A0044EAF3?OpenDocument&Lang=english>

<sup>7</sup> <http://www.france24.com/en/20100313-exxon-png-gas-project-clears-final-hurdles>

that prices will follow paths which coincide over time. An interesting point here is that long lead times mean the first hypothesis could be valid in the short term, while the other holds true in the longer term.

A number of articles which empirically investigate competition in the gas market have appeared in recent years. Asche et al (2006) and Panagiotidis and Rutledge (2007) find that gas, oil and electricity compete in the same market in the UK. The US gas market is regional (De Vany and Wallis 1993, Doane and Spulber 1994). Gas competes with oil on the east coast (Serletis and Herbert 1999), and with electricity but not oil on the west coast (Emery and Lui 2002). The European market seems well integrated, regardless of whether the gas is priced spot or under long-term contracts (Asche et al 2002, Silverstovs et al 2005). This article builds on considerably longer data series than earlier European studies. These series thereby pick up more cycles in the relationship between oil and gas and thereby provide a clearer indication of whether this connection is stable in the long term.

We start by describing the relative development of oil and gas prices in section 2, before looking at US progress with shale gas production in section 3 and discussing how far a similar process can be expected in Europe. Section 4 discusses the competitiveness of European pipeline gas. Data and methodology for analysing the relationship between oil and gas markets are analysed with the aid of a cointegration analysis in section 5, with the empirical results reported in section 6 and our conclusions in section 7.

## **2. Relative price developments for oil and gas**

Gas prices have fallen since 2008 for both immediate and future delivery. However, they have recently recovered somewhat. The spot price is shown in figure 1 together with the oil price.

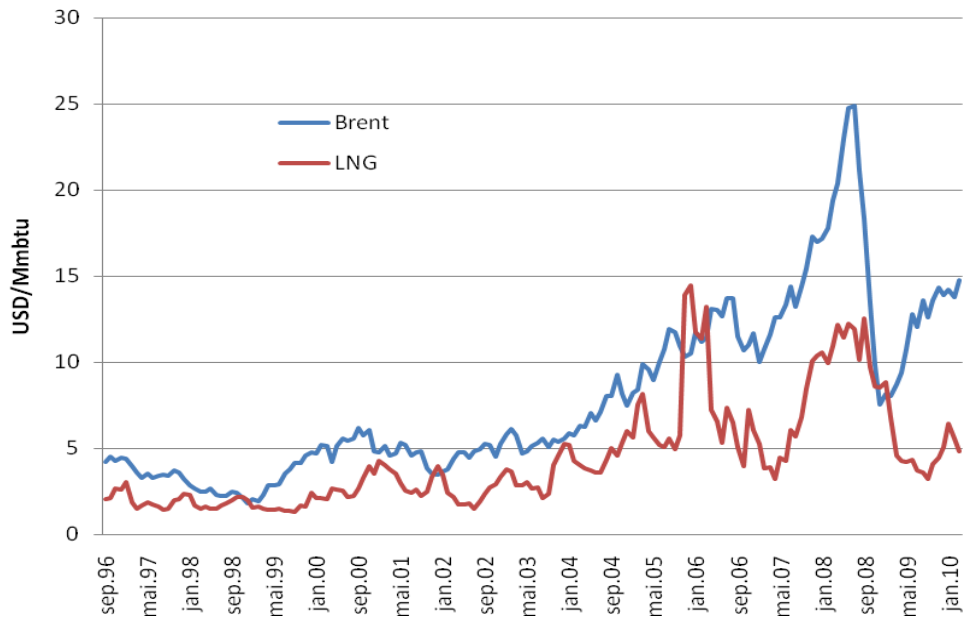


Figure 1. Spot price for gas (NBP) and oil (Brent) in the UK, measured in millions of British thermal units (Mmbtu).

The immediate impression given by figure 1 is that the *absolute* difference between oil and gas prices appears to be increasing over time – the gap between them is widening. But this coincides with a general rise in energy prices. Where competition between gas and oil is concerned, however, the important consideration is the *relative* price differential – and it is not certain that this has increased correspondingly. Figure 1 clearly shows that large percentage variations have existed between oil and gas prices in earlier periods. The relative sizes emerge more clearly in Figure 2, where we have illustrated the relative price by dividing the oil price with the gas price.

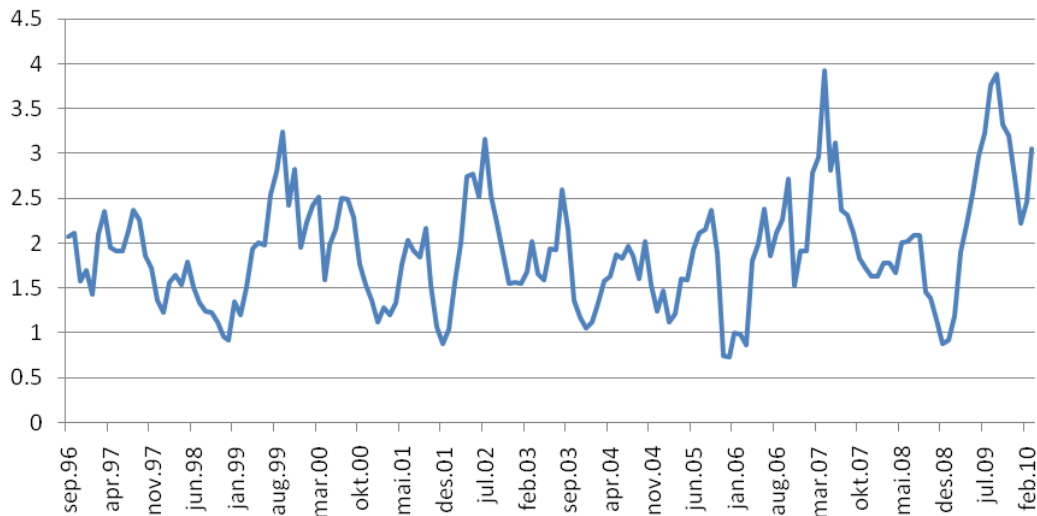


Figure 2. Relative spot price for oil (Brent) and gas (NBP) in the UK.

It is no longer so easy to detect a clear trend in the relationship between oil and gas prices.

Figure 2 shows that oil is priced higher on average than gas, measured per unit of energy. The average relative price in our data set is 1.95, or very close to the 2 used by gas analysts from time to time as a rule of thumb. This is partly because oil has more areas of application and is easier to transport, and because market players assume that oil is scarcer than gas. The relative price is also characterised by short-term fluctuations, with peaks of 3.9 and troughs of 0.7.

However, big swings in one direction or another are corrected over time, and the figure shows a movement back to a mean level. From that perspective, it is timely to note that the highest relative price in our data set was in October 1996 and that it has reached similar levels on only two other occasions.

### 3. Shale gas

The recent drop in spot gas prices can be attributed in part to an increase in unconventional supplies, including shale gas. Accounting for only one per cent of US gas output in 2000, the

latter now represents 20 per cent and a potential of 50 per cent by 2035 is forecast.<sup>8</sup> The expected growth in US demand for LNG has accordingly failed to materialise.

However, the decline in gas prices also reflects reduced demand as a result of slower economic growth. Prices for oil and other types of energy have also fallen, and gas pricing follows alternative energy forms in most markets. Many market players say they believe in positive price progress for gas in the rather longer term, when energy demand recovers at the end of the present recession. Unanswered questions also exist over the environmental impact of shale gas production. Shale gas is controversial in the USA, in part because of fears that drinking water will be contaminated.<sup>9</sup> Relevant issues are whether the water and chemicals used in production can migrate to drinking water, and whether produced water can be handled acceptably to avoid pollution. Whether adequate geological separation exists between subsurface fracture zones and adjacent drinking water reservoirs is another question.

The challenges facing shale gas in relation to public opinion seem to be even greater in Europe. Higher population density could be an explanatory factor. Companies looking for shale gas in France recently agreed to postpone further activity until the government has conducted studies of the economic, social and environmental impact of drilling and hydraulic fracturing. Proposals in the UK call for the authorities to postpone shale gas exploration for at least two years to identify the environmental consequences.<sup>10</sup> Developing shale gas resources is also controversial in many other EU countries. Germany's *Der Spiegel* uses the formulation "massive doubts" and points to the risk of pollution and explosions.<sup>11</sup> The resource potential for shale gas in Europe has not been thoroughly investigated so far. A very important driver for shale gas developments in the USA has been access to substantial and inexpensive drilling

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<sup>8</sup> Cera (2010).

<sup>9</sup> Cera (2010).

<sup>10</sup> *Petroleum Intelligence Weekly*, 21 February 2011.

<sup>11</sup> "Shale Gas Dispute Shakes EU Energy Summit", Spiegel Online, 4 February 2011, <http://www.spiegel.de/wirtschaft/soziales/0,1518,743535,00.html>; and "UK Parliamentary committee to hold first evidence session of shale gas inquiry", <http://www.parliament.uk/business/committees/committees-a-z/commons-select/energy-and-climate-change-committee/news/sg1/>

capacity as conventional gas production on land declines sharply. No such drilling capacity is available in Europe. In a report on shale gas potential outside the USA, Cera (2009) cites a number of challenges – recruiting suitable technical personnel as well as lack of access to suppliers, special equipment and infrastructure. It believes shale gas will never be profitable in areas without an extensive gas pipeline network. However, it notes that production companies may be able to negotiate good terms in areas where security of supply is critical.

In the short term, the supply of shale gas and other resources has offset the decline in the USA's conventional gas production. At the same time, LNG capacity has been built up in many more countries to meet the expected growth in demand. Some of that gas is now being sent to Europe, pushing down the price of pipeline gas. However, LNG can only be received at terminals with regasification (or possibly evaporation) facilities, and restrictions in the European transport network dampen the price effect in a number of areas. High growth rates in Asia have also attracted substantial volumes of LNG to these regions.

Markets normally manage to dampen the impact of technological shifts of the kind now being observed. Capacity restrictions mean that production costs for shale gas could rise if many companies pursue developments simultaneously, as we have seen with Canada's oil sand projects in Alberta. The decline in US shale gas costs partly reflects reduced drilling costs as a result of spare capacity because fewer conventional gas wells are being drilled. That could change if everyone jumps on the bandwagon. As with other non-renewable energy sources, production costs and environmental standards for shale gas vary from field to field and, in the absence of regulation, the cheapest fields will be developed first.

#### **4. Competitive position of natural gas**

Caution must be exercised when analysing the gas market in isolation. This is perhaps the biggest objection to analyses which indicate a long-term negative effect for European gas



prices. Customers do not demand gas as such, but *energy*. This has been confirmed by a number of studies, but with data for substantially shorter periods than those we use here.<sup>12</sup> In many contexts, gas competes with coal, oil and other energy sources, and increased output of shale gas could just as well be at their expense as at that of conventional European gas production. That applies especially in the longer term, when customers can make adjustments and adapt to changes in relative prices. This is the opposite of what was seen when oil and gas prices rose. Among other effects, it was demand for coal which increased. At the same time, prices for various energy bearers could become uncoupled for periods because of the substantial time lags involved in initiating new projects. This means that the literature contains a number of studies which indicate separate markets for the various energy bearers (Serletis and Herbert 1999, Bachmeier and Griffiths 2006).

Doomsday prophecies for the gas market appear to build on a view that gas – which is very utilisable in such areas as heating, electricity generation and to some extent transport – will be much cheaper in the long term than competing energy bearers, and that gas-to-gas competition will eliminate substitution opportunities between gas and oil. This conflicts with a fundamental economic principle – people will normally choose the cheapest energy source. That reasoning is subject to certain modifications. If a move to gas incurs conversion costs, it will not be made until the price change is seen to be lasting. In other words, temporary price differentials can arise, but the displacement of demand over time will encourage prices for various energy bearers to equalise. Declining prices, security of supply and increased climate awareness suggest that demand for natural gas to generate power in the USA could rise from 19 to 35 billion cubic feet (Bcf) per day by 2030.<sup>13</sup> Confidence in long-term gas supplies has increased. In addition, higher shale gas output, greater LNG import capacity, and more

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<sup>12</sup> See Asche et al (2006) and Panagiotidis and Rutledge (2007).

<sup>13</sup> Cera (2010).

storage capacity represent substantial shock absorbers which could reduce disruptions and market imbalances.

One aspect which could argue against price equalisation between oil and gas is that the transport sector accounts for more than half the world's oil consumption. This proportion will probably increase in the future. Although cars exist which can run on gas, oil and gas are by no means close substitutes in the transport sector. However, renewed interest is being shown in the use of gas and other energy sources for transport purposes, both directly and via electric vehicles. Should substantial price differences prove to persist over time, strong incentives exist to study opportunities for gas in the transport sector (GtL, CNG, ethanol, methanol, etc).

On the other hand, the use of oil in the electricity sector – where the greatest substitution opportunities are to be found – has declined substantially in recent decades (at least in the OECD countries). Gas competes as least as much with coal in today's energy market. That could argue for an decoupling of oil and gas prices if coal has a different price path. However, Bachmeier and Griffin (2006) indicate that a relationship also exists between oil, gas and coal prices in the long term. Carbon emissions from gas-fired power stations are only half the level of their coal-fired counterparts, and other types of unwanted emissions are also much lower. Extensive building of gas-fired power stations in the 1990s was the primary reason why the UK was the only country to reach its Kyoto target.<sup>14</sup> Gas-fired power is also required as swing capacity for increased development of wind energy. Increased output of nuclear power is being planned, but the first target here must be to replace capacity due to be phased out. In the EU, gas-fired power must fill the gap between phased-out nuclear facilities up to 2020 and their still unclarified replacements, which are unlikely to be seen in any numbers before 2025.<sup>15</sup> The nuclear accident in Japan may have weakened opportunities for

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<sup>14</sup> Heren (2011).

<sup>15</sup> Heren (2011).

new development of this energy source and brought forward the shutdown of old capacity in many countries. That has already had a positive impact on gas prices.

At the societal level, the price factor is supplemented by national security of supply. One of Europe's concerns here is declining domestic gas production and growing dependence on Russian imports. With increased gas reserves from the improved recoverability of shale gas, and supplies from several sources through LNG and Russian export pipelines which avoid Ukraine, European security of gas supply has been substantially strengthened,<sup>16</sup> which could weaken the development of competing and more expensive energy sources such as nuclear and wind. Climate measures are a joker in the pack at the societal level. If greenhouse taxes are set accurately over time – so that they reflect volumes of carbon and other emissions – gas could gain a competitive advantage which will boost producer prices relative to oil and particularly coal. However, concerns about self-sufficiency in European countries with domestic coal production could be an obstacle here.

The big headlines on cuts in shale-gas production costs give the impression that this is something unique. Not so. Improving production techniques are an integral part of the oil and gas industry, which have always been experienced without especially dramatic consequences. The difference between conventional and unconventional reserves is that the first are commercially recoverable with prevailing prices and technology. A reclassification occurs over time, with certain unconventional reserves becoming conventional through changes in production methods or price. Shale gas is now becoming conventional, in the same way as oil sands. To put this in a historical context, it should be sufficient to recall that oil and gas in medium to deep water were earlier classified as unconventional reserves.

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<sup>16</sup> An exception here is Poland, which sees shale gas as a key means of reducing dependence on Russian gas imports. See “Shale Gas Dispute Shakes EU Energy Summit”, Spiegel Online, 4 February 2011, <http://www.spiegel.de/wirtschaft/soziales/0,1518,743535,00.html>

## 5. Data and methodology

Our empirical analysis is based on the European gas market and utilises monthly observations of oil prices represented by Brent blend and gas prices at the national balancing point (NBP) in the UK from September 1996 to March 2010.<sup>17</sup> Let  $p_{1t}$  be the price of one commodity and  $p_{2t}$  the price of another. The basic relationship then considered when testing for market integration is thereby as follows:<sup>18</sup>

$$\ln p_{1t} = a + b \ln p_{2t} \quad (1)$$

where  $a$  is an intercept which species the difference in level between prices and  $b$  specifies the relationship between prices . If  $b = 0$  no relationship exists between the prices, while if  $b = 1$  the prices are proportional and the relative price is constant. This relationship is known as the *unit price law*. If  $b$  is greater than zero but less than one, a relationship will exist between the prices but they will not be perfect substitutes. Equation (1) describes the position when prices are adjusted immediately. Normally, however, frictions will exist. So a dynamic model is adopted through the introduction of lagged prices. The long-term relationship will then nevertheless have the same form as equation (1).

It is known from the literature on energy markets that oil and gas prices are non-stationary and first-order integrated (Asche et al 2002, Silverstovs et al 2005, Asche et al 2006, Bachmeier and Griffin 2006, Panagiotidis and Rutledge 2007). ADF tests provide clear indications that this is also the case for our data series. Cointegration analysis is then the most appropriate econometric approach, and we will make use here of Johansen's (1988)

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<sup>17</sup> September 1996 is the first available observation for the NBP.

<sup>18</sup> Asche, Osmundsen and Sandmark (2006) provide a more detailed discussion of this relationship in an energy context.

multivariate test, since this also permits hypothesis testing for parameters in the possible cointegration vector as well as exogeneity tests (Johansen and Juselius 1990).

The Johansen test is based on a vector autoregressive error correction model (VECM). With the aid of a vector,  $P_t$ , which contains the  $N$  prices we are interested in, the system can be written as:

$$\Delta P_t = \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \Pi P_{t-k} + \mu + e_t \quad (2)$$

The  $\Pi$  matrix contains the parameters in the long-term context when  $\Pi$  does not have full rank.  $\Pi; -\Pi = \alpha\beta'$  can then be factorised, where  $\alpha$  and  $\beta$  are  $(N \times r)$  matrices, and  $\beta$  contains the cointegration vectors and  $\alpha$  the adjustment parameters.

On our case, there will be two price series in the  $P_t$  vector. If the prices are cointegrated, the rank of  $-\Pi = \alpha\beta'$  will be 1 and  $\alpha$  and  $\beta$  will be  $2 \times 1$  vectors. Assuming only one lag or that the short-term dynamic is excluded, the system being estimated will be given as:

$$\begin{bmatrix} \Delta \ln p_{1t} \\ \Delta \ln p_{2t} \end{bmatrix} = \begin{bmatrix} A_1 \\ A_2 \end{bmatrix} + \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} \begin{bmatrix} 1 & b \end{bmatrix} \begin{bmatrix} \ln p_{1t-1} \\ \ln p_{2t-1} \end{bmatrix} \quad (3)$$

The intercept in equation (1) is incorporated here in parameters  $A_1$  and  $A_2$ , depending on which variable is used on the left-hand side of equation 1.

A test of the  $\beta' = (1, -1)'$  restriction will then provide a test of whether the long-term relative price is constant or whether  $b=1$ . Vector  $\alpha$  provides information on (weak) exogeneity in the system. When both elements in the  $\alpha$  vector are different from zero,

causality will exist in both directions. If one of the elements is zero, the associated price will be exogenous and will then determine the other price in the system.

## 6. Empirical results

A system with four lags is sufficient to eliminate indications for dynamic error specifications, since an LM test for autocorrelation in the system cannot then reject the null hypothesis that no dynamic error specifications exist (the test statistic is  $F(48,240)=1.0879$  with a  $p$ -value of 0.339). Results from the cointegration tests are presented in table 1, the eigenvalues, the unrestricted cointegration vectors and the adjustment speeds coefficients (factor loadings) are reported in table 2. It can be seen that the hypothesis of no cointegration vectors can be rejected, but not the hypothesis that a single cointegration vector exists. Oil and gas prices thereby have a long-term relationship. The third column in table 2 shows that the unrestricted estimate for  $b$  is 0.924. A test of whether this is significantly different from 1 is reported in the LOP column of table 1. This hypothesis cannot be rejected, and the conclusion can be drawn that we are unable to reject the hypothesis that the long-term relative price is constant. The final column in the table reports the exogeneity test. This shows that we cannot reject the null hypothesis that oil prices are exogenous, while we can clearly reject the hypothesis that gas prices are exogenous. Our results thereby accord well with those reported from other studies with shorter data sets – they indicate that oil and gas in Europe compete in the same market and that gas prices are determined by oil prices in the long term.

**TABLE 1.** Cointegration tests

	$H_0: \text{rank} = r$	Trace test <sup>a</sup>	LOP <sup>b</sup>	Exogeneity <sup>b</sup>
Brent	$r=0$	28.45**	1.064 (0.301)	0.949 (0.329)
NBP	$r \leq 1$	1.28		24.802 (0.000)**

<sup>a</sup>Critical value from Johansen and Juselius (1990)

<sup>b</sup> *p* values in brackets

**TABLE 2.** Unrestricted cointegration vectors and adjustment speeds

	Eigenvalues	Cointegration vectors		Adjustment coefficients	
		NBP	Brent	NBP	Brent
NBP	0.159	1.000	-0.024	-0.303	-0.005
Brent	0.008	-0.924	1.000	0.032	-0.014

Given the relatively long time series, and the many shocks experienced by the energy market in the period – with per-barrel oil prices both below USD 10 and above USD 150 – it is reasonable to check the stability of the relationship. Since we have no *a priori* view on the timing of a possible structural shift, we have used a recursive Chow test which will also identify the possible date of such a shift. Testing for a structural shift in the data set is conducted by “rolling” the structural shift through the data set. The test statistics are reported in figure 3, where the blue horizontal line indicates the critical value at a five per cent level of significance. As can be seen, the test statistics are far below the critical value at every point in time. Consequently, no sign can be found that the null hypothesis of a stable relationship must be rejected. The test thereby confirms the impression provided in figure 2 of a relative price which varies a good deal around a constant average.

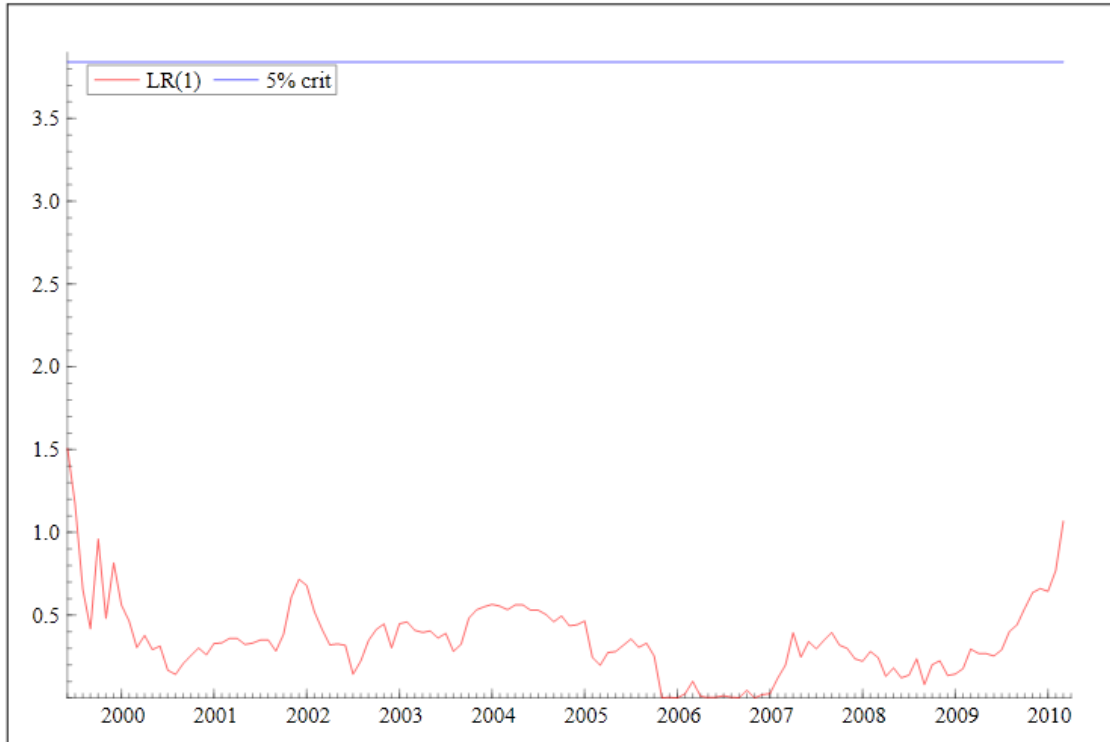


Figure 3. Recursive Chow test

## 7. Conclusion

The gas industry is subject at regular intervals to supply shocks. A substantial rise in US shale gas production provides a good example. The existence of these resources has long been known, but new technology and access to cheap drilling capacity following a substantial decline in conventional gas production mean that US shale gas is moving from unconventional to conventional reserves. However, this is not a unique development since large supply shocks occur at regular intervals in the gas market. The considerable progress made with deepwater production, for example, has had a similar effect.

Experience from earlier supply shocks indicates that the gas market does not collapse, but that a number of adaptations occur in different markets. The downward pressure on gas prices leads to many adjustments. The most expensive gas developments are postponed. Increased gas reserves and supplies from stable countries enhance security of gas supply.



Cheaper and more secure supplies shift energy consumption towards gas at the expense of other energy sources. Furthermore, a sharp increase in shale gas activity will drive up costs. Producing shale gas also raises a number of environmental concerns.

In our view, market adjustments will mean that European pipeline gas – which is cost-effective and lies close to important markets – remains competitive. An important explanatory factor in the reduction of gas prices has been the financial crisis. Rising demand for gas, not least in Asia, has already yielded some recovery in the price. Our econometric analysis of the relationship between oil and gas prices over time shows that substantial differences can arise between the two prices in the short term, but that these are eliminated and the price relationship brought back to a long-term equilibrium level in a process which is disrupted by constant shocks. The relative price varies around a constant average. When all is said and done, the customer is not seeking gas or oil as such but energy – and oil and gas are strong substitutes in a longer time frame.

An interesting issue not analysed in the article is the development in the relationship between prices for gas and for other energy bearers such as coal. This is relevant since gas often competes with coal as a power station fuel. However, price regulation for coal over long periods presents analytical challenges in this area in Europe, while price relationships are known to exist in the USA (Bachmeier and Griffin 2006).

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