Transatlantic Natural Gas Price Convergence - Is LNG Doing Its Job?

Anne Neumann[1]

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Abstract

International natural gas markets have witnessed substantial institutional and economic changes during the past decade. Liberalization in most parts of the world, restructuring of former vertically integrated supply chains, and falling transportation costs have pushed the emergence of a new "international gas market", replacing the former regionally segmented markets (North America, Europe, Asia). Natural gas traders and analysts alike concur that the "globalization of natural gas markets" has now come about. The dramatic increase in liquefied natural gas (LNG) trade provides the missing link that allows market integration across regions, in particular across the Atlantic Ocean. This paper provides evidence on the integration of international natural gas markets. We test the theoretical proposition that in integrating markets of homogenous products, prices should move in the same direction, price differentials should only represent differences in transportation costs or quality. Our hypothesis is that as markets, in particular transatlantic natural gas markets, are getting more intertwined, price integration is the natural consequence of the integration process. Using daily spot prices for natural gas and oil in North America and Europe we investigate price dynamics covering the period from 1999 until 2006. We deduce the effect that spot prices of oil have on prices for natural gas invalidating the argument of trends in oil prices transmitting on prices for natural gas. Following, we use the Kalman Filter technique to the whole sample of daily prices in order to gain detailed information on trends inherent over time. Results suggest an increasing convergence of spot prices on either side of the Atlantic Basin. This is mainly due to the evolving international, mainly LNG, trade. We expect an increasing intertwining of international prices including the fast growing Asian market.

Keywords: market integration, spot markets, natural gas

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[1] Dresden University of Technology, Dept. of Business and Economics, Chair of Energy Economics and Public Sector Management, D-01069 Dresden, Germany, Phone: +49-351-46339771, Fax: +49-351-46339763, anne.neumann2@mailbox.tu-dresden.de. www.ee2.biz. I thank Christian von Hirschhausen, Georg Zachmann and Claudia Josse Vasquez for valuable input.

1 Introduction

Markets for natural gas have witnessed profound changes in the past decade. Liberalization in most parts of the world, restructuring of former vertically integrated supply chains, and falling transportation costs especially for liquefied natural gas (LNG) have pushed the emergence of a new "international gas market", replacing the former regionally segmented markets (North America, Europe, Asia). In addition, traditional pricing schemes are being reviewed moving from long-term, often oil-price indexed natural gas prices towards prices based on market mechanisms. Natural gas traders and analysts alike concur that the "globalization of natural gas markets", that has often been contemplated, has now come about.

The literature on market integration in commodity and natural gas market has studied a variety of regional integration processes, but global gas markets have not yet been analyzed. The integration of the North American market following FERC Order 436 (1985) has been studied extensively, e.g. by Serletis (1997), Walls (1994), and De Vany and Walls (1995), who use correlation and cointegration analysis. Results of an integrated market were confirmed by studies using other econometric tools such as time-varying coefficients, Johansen test procedure, and impulse response functions, e.g. King and Cuc (1996), Cuddington and Wang (2006), and Serletis and Rangle-Ruiz (2004). Work on the cointegration of European natural gas import prices was first carried out by Asche, Osmundson and Tveteras (2001, 2002). For the UK market, that has been liberalized 15 years earlier than Continental Europe, Panagiotidis and Rutledge (2004) show that the linkage between the natural gas price and the oil price has become more volatile over time which can be interpreted as a sign of decoupling of the natural gas price from the oil price. Neumann et al. (2006) have shown that integration between the UK market and the largest Continental European wholesale market (Zeebrugge) works well, but that price convergence between different Continental European markets is still to come about. Last but not least, Siliverstovs et al. (2005) were the first to address the issue of international market integration for natural gas; they concluded that for the period proceeding liberalization of natural gas markets in Europe, i.e. the 1990s, the hypothesis of integrated transatlantic natural gas prices should be rejected.

This paper provides new evidence on the integration of international natural gas markets. We test the theoretical proposition that in integrating markets of homogenous products, prices should move in the same direction where price differentials should only represent differences in transportation costs or quality. Construction of LNG import and export facilities worldwide facilitates flexibility in global trade of natural gas. Our hypothesis, spurred by evidence and market participants, is that as markets, in particular transatlantic natural gas markets, are getting closer intertwined, price integration is the natural consequence of the integration process.

The remainder of the paper is structured in the following way: the next section describes the recent developments on the international gas markets upon which we base our hypothesis of increasing integration. Section 3 provides the model specification and explains the data on natural gas prices and oil prices. Section 4 presents the estimation results: we find a clear trend towards a higher level of integration between North American and European natural gas prices. Section 5 concludes.

2 Recent Trends in International Natural Gas Markets

International natural gas markets have gone through substantial institutional and economic changes during the past decade. This section describes the major changes on the North American and the European wholesale markets, and points out the critical role of liquefied natural gas (LNG) for the process of integration.

2.1 Development of trading hubs in North America and in Europe

North America pioneered liberalization of natural gas markets as early as the 1970s, with deregulation of wellhead prices (Natural Gas Policy Act, 1978) followed by opening up of access to the trunk line natural gas infrastructure (FERC Order 436, 1985). Subsequently, a trading hub in Louisiana, called the “Henry Hub”, emerged as the market centre since it is closely connected to not less than 16 pipelines, LNG infrastructure and three salt caverns. Since 1988 Henry Hub serves as delivery and reference point for the New York Mercantile Exchange (NYMEX) gas futures contract and is the reference point for all gas export contracts to Mexico. Natural gas futures at NYMEX have a depth of 5 to 6 years and are complemented by options since 1992. It is a highly liquid market that serves as reference for almost all natural gas trade in North America.

The UK followed the US path with a time lag of about a decade. Breaking up the monopoly of British Gas in the UK in 1986 marked the landfall of the first truly competitive gas market in Europe. Already in 1994 the National Balancing Point (NBP), a notional trading point on the National Transport System (NTS), was used as an informal market and developed towards the main place for spot gas trading activities from 1996 onwards. There has been a steady increase in volume traded both physically and financially. A further expansion is expected once the LNG import quantities rise to substantial levels after the opening of import terminals (Isle of Grain, Milford Heaven). Recently, the NBP has served as a reference point for prices in long-term contracts, which has furthermore strengthened its role.

Continental Europe trailed far behind the US and the UK for along time, until the EU Acceleration Directive (2003/55/EC) paved the way to a more stringent market opening. With regard to wholesale markets, the only significant development to date was the opening of the Zeebrugge hub (Belgium),

after the connection with the UK through the Interconnector pipeline. Since its start in 1999, traded volumes have increased steadily.[2] We seem to observe a certain "déjà vu" effect of repeated history trade in Continental Europe is now in its early stages as was Henry Hub 20 years ago.

The restructured industry in Europe and North America features a high proportion of spot trading. Recent gas sales contracts are of a relative short duration comparatively to the traditional long-term contract and contract prices are being keyed to a gas market indicator, since oil-linked pricing is a poor indicator of a gas-to-gas competitive market. Trade press reporting for a reference point such as the Henry Hub in America, the NBP in the UK, or Zeebrugge in Continental Europe provides transparent information about the market. This favors competition, an aspect to which we now turn.

2.2 Increasing role of LNG and emerging transatlantic competition

Given its ease of use and environmental friendliness, natural gas has become a key fossil fuel for the power sector and other industrial and residential demand. Demand for natural gas is increasing in all regions of the world, thus leading to upward pressure on prices and potential competition between the formerly segmented regions. In this context, it is the dramatic increase in LNG-trade that provides the missing link that allows market integration across regions, in particular across the Atlantic Ocean. Although LNG has been around for about four decades now, it is only during the last decade that it has come to play a role as a serious means of interconnecting markets. In fact, one already observes an active arbitrage in the Atlantic Basin, where LNG shipments from Trinidad and Nigeria have been diverted either to the US or Europe depending on spot prices. The impact of these swap and diverting activities have so far only had modest impact on the spot price in countries where cargoes have been sent to.

The three major natural gas consuming regions of the world (North America, Europe, and Asia) differ in the type of importing the good. Whereas LNG so far has only played a minor role in North America representing 2.5% of US gas supplies in 2005 countries like Japan and South Korea are fully dependent on LNG imports. It is only Europe where both pipeline and LNG imports coexist and quantities differ on national levels. However, construction of a number of LNG import facilities in the US and a doubling of European LNG import capacities from currently 76 bcm to 140 bcm by 2008 will lead to significant interaction of these two regions.

According to theory, arbitraging possibilities occur in cases when the price differential of a homogeneous commodity exceeds transportation costs. Thus, convergence of North American and European prices should take place until the difference only reflects transportation costs. The technical

[2] Note that a second hub on the Dutch transmission grid (TTF) was set up in 2003 and has gained more importance since 2005.

prerequisites for LNG to play that role are fulfilled: there is an increasing amount of liquefaction and regasification capacities on either side of the Atlantic. Ship capacities are not critical, first, because there is a large amount of non-dedicated capacities under construction, and second, there are no observable barriers to entry into that market. A favorable regulatory regime is established following the Hackberry Decision in the US and Article 22 of the European Gas Directive 2003/55/EC.

Recent evidence confirms the growing role of LNG: its share in global natural gas trade has risen to about 20% and is expected to reach 30% in the coming years (Cornot-Gandolphe, 2005). A growing share of this LNG-trade is short-term trading, about 11% (~20 bcm) in 2004, and rising (IEA, 2006). Spot trading of LNG has so far mainly occurred during cold winter month, providing an ideal opportunity to meet peak demand, and during times of substantial price differences between North America and Europe. This is possible in times of increased flexibility inherent in long-term contracts. Gas storage deposits could be filled whilst sustainable low prices prevail, thus incurring strategic redirections of tankers to alternative market places performing at higher prices.

3 Data and Model Specification

3.1 Data

We are interested in the relation between natural gas spot prices on either side of the Atlantic Basin. Using daily data covering the time period January 1999 until June 2006 provides a sample with almost 1.900 pairs of observations in the transatlantic basin.

The National Balancing Point (NBP) refers to the European and Henry Hub (HH) to the North American price included in this analysis. Quotations for the NBP are provided by Heren and converted from pence per therm into $/MBtu using daily exchange rates taken from the Federal Reserve Bank. Data on Henry Hub are as reported by the Energy Information Administration. Table 1 provides summary statistics of both prices in levels and log-levels. Note the higher volatility of prices at the NBP which have increased heavily in the second half of the sample.

Table 1: Summary statistics

	NBP	HH
Mean	3.91	4.94
(Log-Levels)	1.18	1.48
Median	3.14	4.89
	1.14	1.59
Maximum	33.75	18.85
	3.52	2.94
Minimum	0.54	1.59
	-0.62	0.46
Std. Dev.	2.99	2.41
	0.57	0.48
Skewness	3.41	1.27
	0.60	-0.05
Kurtosis	20.59	5.74
	3.51	2.37
Observations	1914	1833

3.2 Model Specification

Unsurprisingly, markets for natural gas in North America and Europe are not integrated yet. Recent developments in LNG trade and expectations of developments are going to change this situation. These trends are unlikely to be caught in a framework of cointegration based on long-run relationships. Moreover, before markets or prices can be considered integrated they have to undergo a gradual change from separation towards integration. This is taken into account by introducing a time-variant coefficient into the linear relationship of prices. Considering prices for Henry Hub and NBP we constitute a linear relationship between these two:

$$P_{i,t} = c_{ij} + \beta_t P_{j,t} + \varepsilon_t \tag{1}$$

$$\beta_t = \beta_{t-1} + \mu_t \tag{2}$$

where P is the price in regions i and j, t denotes time and c_{ij} allows for transportation costs. Equation (2) determines values of β_t based on data of the previous observation. If no profitable arbitraging opportunities arise prices are expected to equalize up to the difference in transportation costs, hence are considered to follow the law of one price. It holds for values of β_t equal to one, therefore prices are said to be more integrated the closer β_t is to one. This is valid since the price differential should converge towards transportation costs implying β_t to converge to the value of one. Formally this can

be expressed as $E\{\lim_{t\to\infty}(P_j - P_i)\} = c_{ij}$ with the final state of convergence represented by $E\{\lim_{t\to\infty}\beta_{ij}\} = 1$.[3]

We use the Kalman Filter technique to the whole sample of daily prices in order to gain detailed information on trends inherent over time. The Kalman filter processes the spot prices and provides information on the value of the parameters c_{ij} and β_t for each point in time over which both price series are available by proceeding in two successive steps. First, it estimates β_t by using information up to *t-1*. Following, information at time *t* is realized and the estimates of β_t are updated by incorporating prediction errors from the first step.

Hence, the filter produces linear minimum mean square error estimates of β_t using observed data up through time *t*. These estimates are optimally updated as data beyond *t* becomes available. The filter also ensures that the revisions made in β_t at time $t+k$ follow a (time-varying) moving average process of order *k-1*. If the error terms are assumed to be normally distributed, the parameters can be estimated by using the maximum likelihood method.[4]

An often voiced argument in context of this type of analysis of natural gas prices is the influence of oil prices. Even if it is argued that oil remains the driving force for natural gas prices we believe that prices for natural gas will behave increasingly independent of oil prices. Therefore we extend the analysis by applying the same technique to natural gas price data adjusted for the price of residual fuel oil. Hence, we generate two time series which are by definition uncorrelated to the price of oil but highly correlated with the price of natural gas.

$$P_{i,t}^{NG} = c + P_{i,t}^{Oil} + \varepsilon_{i,t} \qquad i = \{Europe, USA\} \tag{3}$$

$$\tilde{P}_{i,t}^{NG} = \frac{\varepsilon_{i,t}\sigma^2(P_i^{NG})}{\sigma^2(\varepsilon_i)} + \overline{P}_i^{NG} \tag{4}$$

Following equations (3) and (4) results in new series for the Europe and the US which are the residuals of an OLS of the residual fuel oil price[5] on the original natural gas price. Equation (4) generates the final decorrelated time series ($\tilde{P}_{it}^{NG}$) by normalizing the variance of the residual series to the original series variance and adding the mean of the original price ($\overline{P}_{it}^{NG}$) to the generated data.

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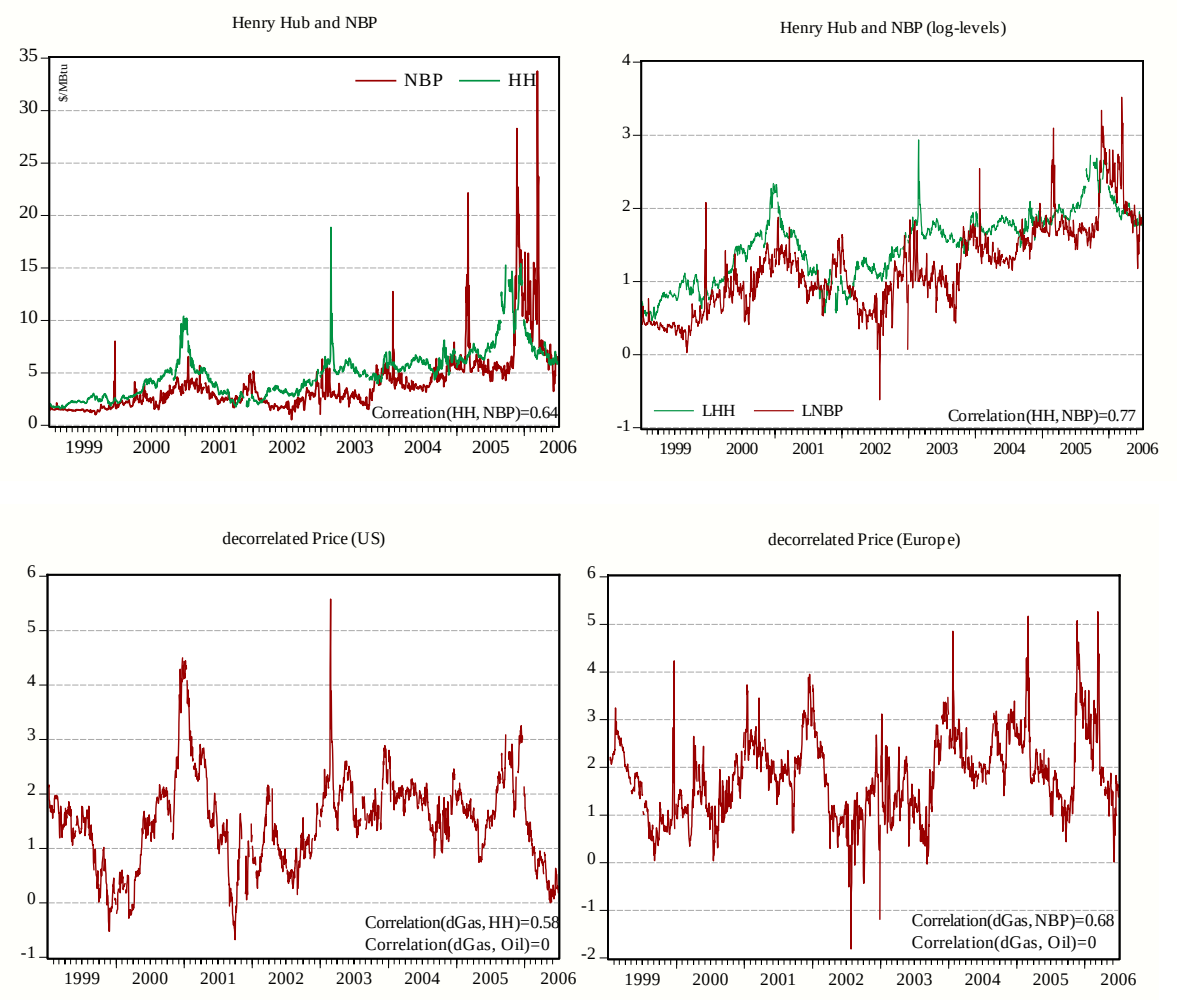
[3] Hall, Robertson, and Wickens (1992) provide a refined interpretation of strong and weak convergence based on these expected values.

[4] See Harvey (1987) and Meinhold and Singpurwalla (1993) for a more detailed and technical description of the Kalman filter.

[5] Rotterdam (ARA) for Europe and Los Angeles, CA for US, both FOB quotes. Data taken from EIA, converted from cent per gallon using a calorific value of 38.157 kwh.

Figure 1 shows the original time series in levels and log-levels, the decorrelated series as well as the correlation coefficients. The upward trend in prices for natural gas since the end of the 1990's is clearly depicted. Prices in North America and Europe are an image of one another until the end of 2002 with Henry Hub consistently prevailing at a higher level. Price spikes reflect exogenous influences such as the events around 09/11, hurricanes Rita and Katrina.[6] Note that prices in the UK jumped to exorbitant levels in the cold winter 2005/2006 but have decreased to a conventional level since; the cold snap in January 2001 is clearly reproduced in Henry Hub prices.

Figure 1: Natural gas prices in levels, log-levels, and generated decorrelated gas prices



The generated decorrelated time series for natural gas in the lower part of Figure 1 exhibit no clear sing of seasonality of prices for natural gas in the US where demand is driven by use in power generation during winter and summer alike. However, the pattern of the generated European price mirrors high demand for natural gas mainly during cold winter months.

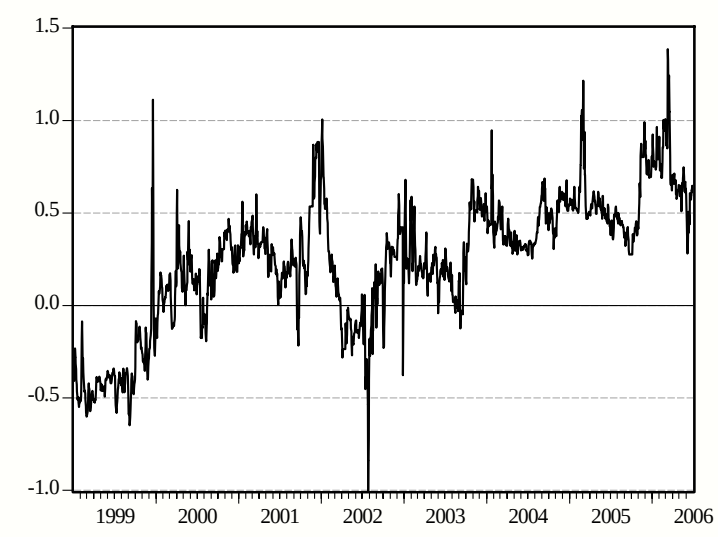
[6] Price at the NBP on July 26, 2002 (3.45p/th) dropped to almost half of the amount of day before (6.65p/th).

4 Results

The analysis investigates the relation between the natural gas prices on either side of the Atlantic, i.e. the Henry Hub and the NBP spot price over time from 1999 to 2006. Applying a time-variant coefficient methodology allows us to determine whether recent trends in international LNG trade have led to a convergence of spot prices in the US and Europe towards the law of one price. An application of the Kalman filter to daily pair of logged spot data results in the estimation of the β_t-coefficient for the time period under consideration. Theory predicts that in a perfectly integrated market beta should be equal to one and c_{ij} would be interpreted to implicit transportation or transaction costs. Due to the non-normalized distribution of the estimated β_t, it is ambitious to test the statistical significance of this β_t -coefficient. Plotting the values of the coefficient over time provides an opportunity to evaluate whether or not convergence occurred. Figure 2 depicts the result for the original natural gas spot prices assuming NBP to depend on prices quoted at the Henry Hub.

There is clear evidence of prices converging towards the law of one price, hence the β-coefficient moving towards the value of one.[7] Interestingly, one could argue that there is some seasonality in the convergence more intensively occurring during winters when the markets are tight. However, there remains scope for potential intertwining of prices across the Atlantic since convergence is far from being achieved. This in return can be observed in the recent spur of oil and gas majors engaging in the LNG business in order to, amongst other reasons, exploit arbitraging possibilities.

Figure 2: Beta coefficient NBP and Henry Hub



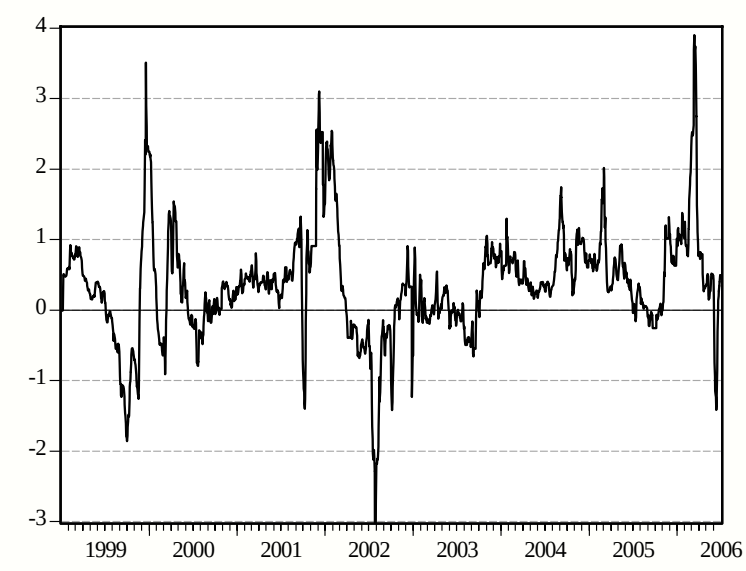
[7] For values of β_t not equal to one the interpretation of the variable accounting for transportation costs is rather ambiguous since there is no strict interpretation of this value in money terms. The filter does require a value of the mean and variance of β_0 to begin the recursions. These values are estimated prior to the adjustment process by using the maximum likelihood method (Harvey, 1987). Hence, the estimated β-coefficients at sample start are somewhat "distorted".

Accounting for the strong relationship of prices for residual fuel oil, mainly in power generation, we generated two time series highly correlated to the values of the respective spot price for natural gas, but independent of oil prices. Applying the methodology of the Kalman filter as described above results in the beta coefficient as depicted in Figure 3.

Whereas there is no clear evidence of convergence towards the law of one price when adjusting for the influence of residual fuel oil, the graph of the estimated coefficients exhibits interesting features. First, for the period until the end of year 2002, prices seemingly do not interact. However, some indications of beginning intertwining of transatlantic developments are suggested for the second half of the sample. This coincides with first spot cargoes delivered to Spain in Europe and signed swap deals.[8] Deliveries to the UK's terminal at Isle of Grain have followed the price difference of North American and UK spot prices since late 2005 (IEA, 2006). Rather surprising is the enormous impact of high prices in the UK during winter 2005/06 on the price relationship.[9]

Given the development of LNG infrastructure on either side of the Atlantic Basin, the sustained exorbitant level of oil prices, and the increasing reliance of countries on LNG imports this movement towards the law of one price is expected to strengthen in the years to come. There are indications of prices for natural gas (adjusted by fuel oil prices) converging towards the law of one price, thus underpinning the development of a global market for natural gas.

Figure 3: Beta coefficient for decorelated series



[8] Nigeria signed a deal with GdF and Enel in November 2005, GdF and Gazprom signed an arrangement allowing Gazprom to deliver a LNG cargo to Cove Point in the US.

[9] The Kalman filter has been applied to the two subsamples as described before with results almost identical to the one presented in Figure 2.

5 Conclusion

This paper places the developments in international LNG trade in perspective to the dawning of the evolution of a global market for natural gas and provides evidence on the integration of international natural gas markets. We have outlined the importance of LNG in the Atlantic Basin and reflected recent progress in the evolution of (regional) spot markets for natural gas. Departing from economic theory, LNG has been identified the key driver for the transmission of regional impacts on prices. Hence, the market for natural gas is currently undergoing substantial change where regionally isolated markets are becoming more integrated. Under such circumstances, economic theory predicts that prices in two regions will converge towards the law of one price until the difference represents transportation or transaction costs only. Using daily data for the Henry Hub in the U.S. and NBP in the UK we apply a time-variant coefficient estimation methodology to test the hypothesis of price convergence for prices covering the period from January 1999 until June 2006.

In a first step we apply the Kalman filter technique to the logged values of spot prices for Henry Hub and NBP. The results show clear evidence of prices converging towards the law of one price. Following, we adjust the original price series for the influence of residual fuel oil prices and natural gas generating two time series which are highly correlated to the price of natural gas but independent of oil. Results obtained from the Kalman filter methodology for the generated series are less evident of a convergence process, but provide support for recent activities in transatlantic LNG trade.

In the light of the ongoing debate on the emergence of a global market for natural gas we have added empirical evidence on the move towards more integration of formerly regionally segmented markets. We have shown that spot prices in the Atlantic Basin are currently moving towards the law of one price. It remains to be seen which impact current infrastructure developments and changes in the institutional framework have on the evolution of a true global gas market.

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