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Price discovery in European natural gas markets☆

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HIGHLIGHTS

- We use intraday data to gauge price discovery in European natural gas markets.
- We explore short and long-term dynamics in physical and financial market layers.
- Results show ICE's UK natural gas futures are the main venue for price discovery.

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ABSTRACT

We provide the first high-frequency investigation of price discovery within the physical and financial layers of Europe's natural gas markets. Testing not only looks at short-term return dynamics, but also considers each security's contribution to price equilibrium in the longer-term. Results show that UK natural gas futures traded on the Intercontinental Exchange display greater price discovery than physical trading at various hubs throughout Europe.

1. Introduction

Natural gas markets are in a state of flux. Advances in extraction technologies have the United States poised to become a gas exporter, massive projects off Australia's North West Shelf will soon help meet Asian energy demand and, more generally, growing international trade in liquefied natural gas[2] seems likely to not only equilibrate regional prices[3] but support the growing dominance of market pricing as the basis for long-term supply contracts. In Europe, while natural gas sourced from the East is mostly secured under long-term, take-or-pay contracts, market pricing at key hubs has steadily moved from the United Kingdom (UK), where it originated in the mid-1990s, into North West Europe through an increasing number of interconnected pipelines. As customers have generally paid less for natural gas under market pricing systems in recent years, it has increasingly become the dominant basis for new long-term contracts. Understanding where within the interconnected network of natural gas pricing hubs and derivative securities these market prices are determined, or the location of price discovery, is crucial for all market participants[4].

Notwithstanding this, studies of European natural gas prices typically focus on their interactions with natural gas prices in other regions of the world (see, for example, Mazighi, 2005; Siliverstovs et al., 2005; and, Kao and Wan, 2009) or with crude oil prices (see, for example, Asche et al., 2006, 2012; Panagiotidis and Rutledge, 2007). Further, while Neumann et al. (2006) study convergence in day-ahead natural gas prices from two key regional hubs, they do not directly investigate price discovery. We make an important contribution in this respect by employing two distinct methodologies to better understand both short-run and longer-term aspects of the price formation process in European natural gas markets. With respect to the former, we employ regression analysis to assess the contemporaneity of returns in securities representing ownership of the same underlying asset, thus providing evidence on the relative speed of information absorption in both the physical and financial markets. Thereafter, we calculate Hasbrouck's (1995) information shares in order to

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[2] Infrastructure fundamental to the global trade of LNG, which includes liquefaction facilities, storage tanks, carriers and regasification terminals, is rapidly expanding to keep up with increased natural gas demand.

[3] Neumann (2009) provides evidence of converging spot prices as an indication of the role played by LNG trade in integrating natural gas markets globally.

[4] Price discovery is the process by which information becomes impounded in security prices and is related to liquidity and market frictions that impede the price formation process.

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quantify the permanent impact of each security's innovations on the equilibrium natural gas price in the longer-term.

Regression analysis reveals that, despite the web of interconnecting gas pipelines across Europe, the short-term return linkages between different markets are somewhat weak. In fact, there is some evidence that return interactions are stronger at similar points on the forward curve than interactions between returns at specific hubs, with short-dated gas prices displaying similar demand inelasticity to electricity prices. The information share results clearly demonstrate that UK natural gas futures traded on the Intercontinental Exchange (ICE) make the greatest contribution to price equilibrium in the longer-term and are consistent with findings documented in other contexts concerning the important role played by futures contracts as a venue for price discovery (see, for example, Fleming et al., 1996 for equity markets; and, Schultz and Swieringa, 2012 for crude oil markets).

The remainder of this paper is organised as follows: Section 2 briefly overviews the structure of Europe's natural gas markets; Section 3 outlines the regression and information share methodologies employed to assess price discovery in natural gas securities; Section 4 describes the data employed in testing; Section 5 presents our key findings; and, Section 6 concludes.

2. Market structure

In Europe, natural gas is predominantly priced through one of two distinct systems. Specifically, in markets including Germany, natural gas is mainly priced under long-term, oil-indexed contracts[5]. These agreements are complicated, but typically run for 10 to 30 years and include price renegotiation clauses together with a limited amount of volume flexibility at the discretion of the gas purchaser. The most transparent price in this system is the German Border Price, which is a volume-weighted average price, published monthly[6].

In contrast, market pricing is used in markets including the UK, where pricing has occurred at a virtual trading location known as the National Balancing Point (NBP) since deregulation in the mid-1990s. Market pricing of gas contracts has since spread and become increasingly important in continental Europe, particularly since bi-directional pipelines connecting the UK's NBP to Belgium's Zeebrugge hub and to the Dutch Title Transfer Facility (TTF) became operational in 1998 and 2006, respectively. Significant periods in which North West European market prices were lower than the oil-indexed prices charged by Gazprom and others under take-or-pay contracts has contributed to the spread of market pricing through continental Europe (Melling, 2010). This change has also been supported by the increasing availability of liquefied natural gas imports. Market pricing now stretches into the rest of Europe through interconnecting pipelines with major hubs in France at Point d'Exchange de Gaz (PEG) Nord and Sud and in Germany at Gaspool and Netconnect Germany (NCG). However, the spot (day-ahead), forward (month-ahead) and associated derivative securities at the more established pricing hubs in the UK, Belgium and the Netherlands remain the most liquid markets and the likely points of price discovery for natural gas in Europe. As such, these markets are the focus of this study.

[5] Much of this is supplied by Russia's Gazprom.

[6] The German Border Price is not a suitable indicator for natural gas price discovery as it is infrequently released and largely linked to oil prices through formulas specified in the supply contracts (usually crude oil, gasoil and/or heavy fuel oil assessed at a 6 to 9-month lag and sometimes combinations of these that also include an inflation indexation component). Asche et al. (2002) comprehensively describe these long-term take-or-pay contracts.

3. Methodology

We employ two distinct methodologies popular in the finance literature to assess price discovery in the short- and longer-term. Specifically, we use a regression approach to focus on the short-term return dynamics between the securities, and utilise Hasbrouck's (1995) information shares measure to provide evidence on the contribution of each security to the price equilibrium in the longer-term. Our approach is in contrast to the cointegration analysis employed in the studies discussed previously.

3.1. Short-term contemporaneity of returns

Similar to Fleming et al. (1996), we study short-term price discovery by regressing contemporaneous returns of one series ($R_{A,t}$) against the contemporaneous and lagged returns of another series ($R_{B,t+i}$) plus an error correction term equal to the one-period lag of the difference in log prices between the two series, or $z_{A,t-1} = \ln(P_{A,t-1}) - \ln(P_{B,t-1})$. In doing this, we gauge which series appears to react more rapidly to information. Formally, the following model is used:

$$R_{A,t} = \alpha + \sum_{i=-10}^{0} \beta_i R_{B,t+i} + \beta_{A,z} z_{A,t-1} + \varepsilon_t \quad (1)$$

All regressions use the method proposed by Newey-West (1987) to estimate variance–covariance matrices that are robust to autocorrelation and heteroskedasticity and which allow for the calculation of robust *F*-statistics. Conclusions regarding series' relative speed of adjustment to information are drawn from visual inspection of regression coefficients and, where these assessments are inconclusive, from the comparison of average adjusted *R*-squared and robust *F*-statistics.

3.2. Contribution to long-run equilibrium

We use Hasbrouck's (1995) information shares to measure the relative contribution of each security to the variance of innovations in the common factor between them. Decomposing actual prices ($p_{k,t}$) into an unobservable common efficient price (m_t), which follows a random walk ($m_t = m_{t-1} + u_t$), and idiosyncratic transitory factors ($s_{k,t}$), for $k=1,\ldots,K$ securities, Hasbrouck (2002) gives:

$$\mathbf{y}_t = \begin{bmatrix} p_{1,t} \\ \vdots \\ p_{K,t} \end{bmatrix} = \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix} m_t + \begin{bmatrix} s_{1,t} \\ \vdots \\ s_{K,t} \end{bmatrix} \quad (2)$$

Using a multivariate Vector Error Correction Model ("VECM") specification[7] gives:

$$\Delta\mathbf{y}_t = \boldsymbol{\alpha\beta}'\mathbf{y}_{t-1} + \sum_{i=1}^{n-1} \boldsymbol{\Gamma}_i \Delta\mathbf{y}_{t-i} + \boldsymbol{\varepsilon}_t \quad (3)$$

where: $\Delta\mathbf{y}_t$ is a $K \times 1$ vector of first differences in log price levels ($p_{k,t}$); $\Delta\mathbf{y}_{t-i}$ are dependent variables lagged by i periods; $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are $K \times r$ parameter matrices where the number of cointegrating equations is less than the number of I(1) variables, or $r < K$; A trend term is included in the cointegrating vector, $\boldsymbol{\alpha\beta}'\mathbf{y}_{t-1}$, as spot and futures securities are being compared (in the vector $\Delta\mathbf{y}_t$), which may lead to a trend induced by the steady decline in the cost of carry as the futures approach expiry; $\boldsymbol{\Gamma}_1, \ldots, \boldsymbol{\Gamma}_{n-1}$ are $K \times K$ matrices of parameters; and, $\boldsymbol{\varepsilon}_t$ is a $K \times 1$ vector of error terms that are assumed to be normally distributed and serially uncorrelated,

[7] The VECM is a special type of vector autoregressive model for I(1) variables, or those that are non-stationary in levels but stationary in differences, and can account for cointegration among the variables of interest.