# MEASURING VOLATILITY SPILLOVER BETWEEN NATURAL GAS FUTURES AND FORWARD CONTRACTS: A EUROPEAN PERSPECTIVE

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## Overview: forward and future contracts

Market microstructure notion implies that in a market with asymmetrically informed agents, trades convey information causing a persistent impact on the security price. The magnitude of the price effect is positively correlated with the proportion of potentially informed traders in the population, with the probability that such traders are informed, and with the precision of the private information. It is important then to measure the dependence of prices on these factors. Moving from the seminal work of Cox et. al (1981) on the difference between forward prices and futures prices, we examine the joint dynamics of the returns volatility of the two contracts via a wide range of volatility models, including GARCH representations, using data at high frequency and unequally spaced. The main aim of the paper is to discover the sources of correlation between the two markets and how information disclosure tramist from one market to the other. Forward and futures contracts have distinct features. First, futures contracts are exchange-traded and, thus standardized contracts, while forward contracts are private and bilateral agreements between parties and are not as rigid in their stated terms and conditions. For forward contracts , there is always a chance that a party may default on its side of the agreement. This counterpart risk is a crucial factor to understand the difference between those contracts. Futures contracts have clearing houses that guarantee the transactions, which drastically lowers the probability of default to almost never. The second distinct feature concerns with the settlement and delivery dates. For forward contracts, the settlement of the contract occurs at the end of the contract, while for futures contracts are market-to-market daily, which implies that daily changes are settled day-by-day until the end of the contract. Furthermore, settlement for futures contracts may occur over a range of dates, while forward contracts have only one settlement date. Finally, because futures contracts are frequently employed by speculators, they are usually closed out prior to maturity and delivery usually never/rarely happens. On the other hand, forward contracts are mostly used by hedgers willing to minimise volatility, and delivery of the asset or cash settlement usually takes place. In this paper, we focus on natural gas contracts, and we show that, though the price for a given quantity at a specific time should be the same, as expected in practice this does not occur and we provide a measure and identify determinats of the difference between the two prices and measure volatility spillover between contacts.

## Modelling and estimation

Several studies assess the factors affecting natural gas prices and their volatility. Under a GARCH framework and using daily natural gas futures data, Mu (2004) examines how market fundamentals affect the volatility of returns in the U.S. natural gas market using a weather surprise variable as a proxy for demand shocks and investigating its effects on the returns volatility. Pindyck (2004) assesses the behavior of natural gas and crude oil price volatility since 1990 and during the bankruptcy of Enron Corporation in 2001. Estimating GARCH models with daily futures price data, Pindyck tests for the presence of time trends in volatilityfor persistence of changes in volatility to study the relationship between volatility fluctuations and value of financial gas- or oil-based derivatives. Spargoli and Zagaglia (2008) investigate the transmission mechanisms of volatility in the natural gas forwards traded in the NYMEX over 1994-2007 using a BEKK-GARCH model and daily data. Focusing on the oil market instead, Ghalayini (2011) uses a GARCH formulation with daily data to examine the relationship between spot oil price and the NYMEX oil futures market activity during the last decade. See also Henning et al. (2003), EIA (2007), and Alterman (2012). The importance of volatility in financial decisions and the need to provide consistent estimates and forecasts of volatility comovements have increased the interest in market microstructure research and price discovering models managing intra-day transaction data. Moving from the original contribution of Hasbrouck (1991), who estimates the effects of trading activity on prices using a VAR approach, Engle and Russell (1998) mark the interest in dealing with high frequency data which are inherently unequally spaced. To model the main features of irregularly time-spaced financial data, the authors propose the Autoregressive Conditional Duration approach to model the durations between trades. Furthermore, Engle and Russell's seminal work (2004) links the econometric models of duration data to the huge body of literature of GARCH suggesting that, if the spacing of data is ignored, volatility modelling of transaction by transaction data can be dealt with standard econometric approaches. However, standard approaches may be misleading in presence of unequally spaced. This concern has generated a significant strand of literature dealing with discretization methods for irregularly spaced data and the estimate of missing observations. Based upon estimating missing observations, Harvey and Pierse (1984) propose maximum likelihood estimation of autoregressive-integrated-moving average models using Kalman filter, which allows a recursive estimation of unobserved and time-varying parameters with stationary and non-stationary time series. Erdogan et. al (2005) suggest the autoregression approach to analyze irregularly spaced data and covering irregular time series to regular time series by resampling. Following Calvet, Fisher, and Thompson (2006) we also implemented a multifrequency volatility decomposition of two prices and show that components with similar durations are strongly correlated across series. We compare the performance of this approach with the standard multivariate GARCH both in- and out-of-sample. An alternative route followed is a consistent and efficient estimator of the high-frequency covariance (quadratic covariation) of two arbitrary assets, observed asynchronously with market microstructure noise as recently suggested in Ait-Sahalia, Fan, and Xiu (2010).

## Data and preliminary results

In this paper, we use two datasets, containing intraday transactions data for the natural gas National Balance Point (NBP) contracts with different delivery month. The first dataset is based on the OTC Forward contracts, traded through major international brokers, while the second collects information on the ICE Futures contracts, traded on the ICE platform. For both dataset we consider 6 delivery months (from January to June 2011). To compare forward and futures contracts, we consider intraday trading activity bids/asks on futures market calculating the weighted average price by volume between bid prices and ask prices on tick-by-tick basis. Since the data are initially recorded to the one thousandth of a second over irregular time interval and given that the time $t$ is also measured in milliseconds, it is rather frequent that more than one observation occurs per time interval. In order to reduce the impact of the excessive discreteness in the data and to better manage issues related to computational analysis, we resample the series over time intervals of 1, 5, 10, 20 and 30 minutes. We implemted four alternative GARCH models for futures and forwards series for the 6 deliveries spanning from January to June 2011. There is evidence of an overall dominance of the EGARCH model with respect ARCH, GARCH, GJR models across the various delivery times. The returns in the two series, as expected, show similar underlying volatility structure presenting similar high persistence and clear dominance of positive news for the deliveries considerd. This feature, with very small number of exception, characterises the full set of exercise. The evidence showed by almost one hundred models call for a multivariate analysis consisting in the implementation of DCC model which allows to indentify time-varying correlation structures between the volatility of forward and futures returns together with a causality structure where the future clearly dominates the forward. The availability of time-varying correlations allows to identify common and idiosyncratic factors affecting the volatilities in the two series. Interesting insights are offered by the indentification of the main features of conditional correlations, including the information content of relevant jumps in the series. We also address that in the multivariate case, estimating covariances becomes tricky in presence of non-synchronous trading (Hayashi and Yoshida, 2005) with covariances will converge to zero. Finally, Maller, Muller and Szimayer (2008) shows how to fit this model to irregularly spaced time series data using discrete-time GARCH methodology, by approximating the COGARCH with an embedded sequence of discrete-time GARCH series which converges to the continuous-time model.

## Conclusions

There is clear evidence that the futures markets provide better conditions for the efficient hypothesis to hold. The analysis of correlation amongst prices at different delivery and alternative time intervals/frames provide useful insights and information about the adjustment process that the two markets incur before the contact reaches its deliver time.

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