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Article

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Reference: Obadi, Saleh Mothana/Korcek, Matej (2020). Driving fundamentals of natural gas price in Europe. In: International Journal of Energy Economics and Policy 10 (6), S. 318 - 324.
https://www.econjournals.com/index.php/ijeep/article/download/10192/5458.
doi:10.32479/ijeep.10192.

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2020, 10(6), 318-324.

Driving Fundamentals of Natural Gas Price in Europe

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Received: 19 June 2020 **Accepted:** 09 September 2020 **DOI:** https://doi.org/10.32479/ijeep.10192

ABSTRACT

This paper attempted to examine the factors driving the price development of the Title Transfer Facility (TTF) month-ahead contract using linear regression over the period 2016-2019 when the TTF market became the most liquid natural gas hub and primary reference source for gas prices in Europe. We examined the possible fundamentals and used OLS methodology to estimate the linear regression model, which explained the development of TTF MA. We concluded the price based on factors determining marginal demand and supply. The most significant factors seemed to be the variables representing the price of German power and the price of coal since the competition between coal and gas in power generation determines the marginal demand, which sets the price for gas. The change in total demand was another significant factor, although its impact was smaller. The significance of the LNG variable indicated the exposure of European natural gas price to the global supply and demand. The model also suggested the importance of storage capacity for the whole system.

Keywords: Natural Gas Price, Linear Regression, Commodity Prices, Title Transfer Facility
JEL Classifications: Q40, Q42

1. INTRODUCTION

The price of natural gas is of significant economic interest for various stakeholders. Not only does gas play a crucial role as a primary fuel in the residential and commercial heating market, but it also serves as an important input for industrial applications and electricity generation. Consequently, understanding the drivers of natural gas prices is essential from both a macro and firm-specific perspective. However, the price formation at liberalized natural gas hubs is complex, since these markets are faced with a variety of fundamental demand and supply influences, such as meteorological conditions, business cycles, international trade flows, and substitution effects among energy commodities. Moreover, unforeseen disruptions in gas supply may induce significant repercussions in these markets. This holds true especially for the continental European natural gas market that has been exposed to supply disruptions due to the Russian-Ukrainian gas transit dispute of January 2009, production outages caused by the Libyan civil war in the spring of 2011, and the cut in Russian gas deliveries in February 2012 (Nick – Thoenes, 2014).

From the outset of the gas industry in the 1960s, for a period of almost 40 years, take-or-pay contracts were entered into when no real market for gas existed in Europe, and therefore, no transparent reference price could be used to determine the gas price delivered under any such a contract. With the liberalization of the gas industry in continental Europe in the past decade, several gas trading hubs were created where the gas market prices were transparently published. These prices peacefully coexisted since gas-on-gas indexation and oil-indexed prices were moving at the same pace. Consequently, gas sold under long-term contracts in continental Europe continued to be linked to the price of competing fuels in the energy market, such as oil and oil products.

Since 2008, the economic crisis, the decrease of oil prices and shale gas, and other factors have resulted in events never seen before in international gas commerce with virtually all buyers seeking radical renegotiation of prices and a major increase in international arbitration, and consequently, gas supply agreements that link the contract price to the oil prices risked departing significantly from the real market conditions affecting the parties. As a result, an increasing number of buyers have triggered the price review mechanisms in their gas supply agreements. This decoupling between oil-based and gas-on-gas-based prices of natural gas has triggered price reviews under many European gas long-term sales and purchase contracts (Lorefice, 2017), and oil indexation was to a large extent replaced by gas hub indexation. This is at least partially valid for all the natural gas exporters to Europe.

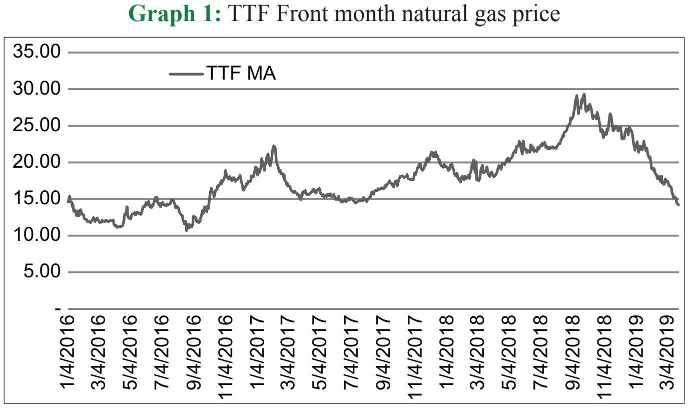
Since then trading at gas hubs such as the National Balancing Point (NBP) in the United Kingdom and the Title Transfer Facility (TTF) in The Netherlands has gained rapid importance (Heather, 2012). Historically, the most important trading hub in Europe was British NBP. This changed in recent years in the wake of the BREXIT insecurity. Since 2016, Dutch TTF became the hub with the highest trading volumes in Europe as it serves as a primary option for hedging and trading activities of European gas entities. The annual volume traded at the TTF hub in 2018 can be estimated at some 60% of total trades in the European market (ICIS, 2019). TTF enables trading in the wide range of structured futures products; the most liquid being the gas with the next day (day-ahead) and next month delivery date (month-ahead). Day-ahead product is used to a large extent for balancing the portfolios, and in theory, is almost exclusively driven by the immediate supply and demand needs of entities operating in a given market. The month-ahead price can be used for hedging and speculative purposes as well as for the portfolio management of a larger set of global players. The longer delivery date also partially mitigates the volatility. Therefore, we decided to work with the price of the month-ahead contract.

The goal of this paper is to examine the factors driving the price development of month-ahead contract using linear regression over the period when the TTF market became the primary reference source for gas prices in Europe. As future contracts are informational superior compared to the spot market (Nick, 2016), we decided to investigate month-ahead contract due to its high liquidity ensuring its optimal value and a wider range of usage, which makes it a more important price reference point.

1.1. Development of Natural Gas Price

Graph 1 below depicts the volatile development of natural gas price on most liquid European Hub TTF (Title Transfer Facility) in Netherlands, during the observed period between January 2016 and March 2019. The average price for given period is

Graph 1: TTF Front month natural gas price



Source: Based on data from Refinitv, Eikon

17.92 EUR/MWh ranging from minimum of 10.7 EUR/MWh in august 2016 up to 29.33 EUR/MWh in September 2018. The Gradual rise of natural gas prices during observed period were driven by fundamental changes in European gas market, due to declining endogenous production a larger exposure to international demand for natural gas.

The average wholesale gas price on the Dutch TTF fell by 29% year-on-year in 2016 from 19.84 EUR/MWh to 14.06 EUR/MWh. The price reached the lowest level in April 2016, at EUR 11.92 EUR/MWh. It started to recover in September in response to the technical issues of French nuclear power plants, which were accompanied by the below-average temperatures during the winter of 2016 and an almost complete rerouting of the European LNG supplies towards more expensive Asian markets (Obadi, 2017). The combination of these factors pulled the gas prices in January 2017 to up to an average of 19.8 EUR/MWh. The TTF gas price started to decline as a result of more moderate temperatures and the resumption of LNG flows to Europe in March 2017. Further downward pressure came from the decline in oil prices. Despite this downward correction, the average gas price during the first half of 2017 had risen by 30% on a yearly basis (16.9 EUR/MWh in the first half of 2017 compared to 12.9 EUR/MWh in 2016).

Gas prices then started another period of growth in August 2017. There were multiple fundamental reasons behind the price move, starting from nervousness concerning natural gas storages after Britain had decommissioned the storage facility Rough, which had represented 70% of the overall U.K. storage capacity. This led to a situation where Europe's second-largest gas market was to be dependent for the first time to a large extent on the continental storage capacities. Also, European storages were filled to below-average levels. This was caused by the lack of supply due to the absence of LNG (liquefied natural gas) deliveries to North-West Europe as Asia, led by China, was able to absorb the new available production coming from the newly-commissioned liquefied natural gas export capacities. The end of 2017 was also marked by the outage of the Forties pipeline system in the North sea, which significantly constrained the U.K. gas production and the explosion of the compressor station in Austria that limited transit of Russian natural gas for a few days (Obadi, 2018). Overall, the price of natural gas averaged 17.3 EUR/MWh in 2017.

An unexpectedly cold end of winter in 2018 led to a record emptying of the European storage facilities. Storage injections determined by the need to refill storage facilities to secure levels before winter resulted in high demand during the summer, which lifted the price of natural gas across European markets as Europe was competing for marginal supplies with Asian countries. The first half of 2018 recorded a 17% increase of TTF gas price averaging 19.7 EUR/MWH. The price impact of fundamental shortage of natural gas in Europe was accentuated by several exogenous shocks, causing growing price of coal (due to increased demand in power generation), oil (expectation of Iranian sanctions, economic crisis in Venezuela), and EUA (expectation of impact of Market Stability Reserve) (Obadi et al., 2019). The growth of natural gas stalled in the fourth quarter of 2018, although the yearly average price in 2018 increased by 29% on a yearly basis. The unexpected end of the growth trajectory of natural gas had been caused by the postponed sanctions against Iran, a number of new LNG export facilities that were commissioned during 2018, milder winter, and fears of a recession. All this contributed to the price going down by 50% between October 2018 and March 2019.

2. LITERATURE REVIEW

After the liberalization of the gas industry, trading hubs have emerged in Europe. Although these hubs appear to be liquid marketplaces fostering gas-to-gas competition, the mechanism of price formation on the gas market remains a topic of interest. The price of oil, which was subject to plenty of studies estimating the factors behind its movement, limited availability of data, and relative youth of hub-based natural gas trading in Europe so far limited similar type of studies.

Hulshof et al. (2015) analyzed the day-ahead spot price at the Dutch gas hub over the period 2011–2014. They found that the oil price had a small positive impact on the gas price. Changes in the concentration on the supply side did not affect the movement in gas prices. The availability of gas in storages and the outside temperature negatively influenced the gas price. They also found that the gas price was related to the production of wind electricity. Overall, they concluded that the day-ahead gas prices were predominantly determined by the gas-market fundamentals.

Several authors have established long-run co-integrating relationships between gas and oil prices—Asche et al. (2006) for the European gas market and Villar and Joutz (2006) for the U.S. gas market. Some papers have emphasized the role of other supply and demand fundamentals, in particular for the short-run price development, because individual energy commodities differ in fuel density, and accordingly in production, transportation, and environmental costs (Brown and Yücel, 2008).

Ramberg and Parsons (2012) showed that the vector error-correction model typically applied in the eco-integration framework did not perform very well in explaining short-run gas price development. Brown and Yücel (2008) found that a long-run relationship between natural-gas prices and crude oil prices existed between June 1997 and June 2007. However, Roberts, G. (2019) found that the long-run relationship appeared to be broken during the recent decade as the Johansen procedure failed to reject the null hypothesis of zero cointegrating vectors between the natural-gas prices and crude-oil prices when the procedure was applied to the full new sample (June 1997 to June 2017). He concluded that the emergence of shale gas extraction in the U.S.A. had broken the relationship and caused a structural shift in the trajectory of natural gas prices.

In another fashion, Nick and Thoenes (2014) investigated the effect of market shocks in a structural vector autoregressive model and found that temperature, storage, and supply shocks lead to relatively short-lasting effects on the gas price, whereas oil and coal price shocks result in more persistent effects on the gas price. Stern (2009) concluded that the reduced share of explicit oil indexation and the reduced options for short-run gas–oil substitution in North-west Europe might have caused the supply and demand fundamentals to become more important for the development of the gas price at liberalized hubs.

The decoupling of prices in Europe could be attributed to the development of liquid spot markets in Europe that fostered gas-on-gas competition, which has led to the decline in oil-indexed contracts. Similar conclusions were obtained by Ramberg and Parsons (2012) in the U.S.A., who found that the cointegration relationship between oil and gas prices was not stable over time. They also argued that the price of oil has only weak explanatory power for short-term gas price fluctuations.

The differences among regional natural gas markets were also revealed in a study by Geng et al. (2016). Their study concluded that most of the natural gas price fluctuations in the North American market were mainly caused by the short-term disequilibrium between the market supply and demand and significant events, such as the disruption of natural gas production caused by the hurricanes. In contrast, the Japanese and European natural gas prices were affected by the overall trend of international crude oil prices. The shock impacts of the significant events suffered by the international crude oil market caused significant fluctuations in the natural gas prices in both the European and Asian markets. However, the fluctuations caused by the short-term disequilibrium between supply and demand in the international crude oil market were transmitted to the European and Asian natural gas markets, only causing weak short-term fluctuations for the natural gas prices for both. The strong link between the price of European natural gas and oil price in this study was very likely influenced by the chosen price benchmark, defined as the CIF (cost, insurance, and freight) natural gas prices for exports to Germany from Russia, due to prevailing oil indexed pricing in long run contracts that covered significant share of imported gas.

Nick (2016) empirically investigated the price discovery and arbitrage activity between spot and futures natural gas markets in Europe. The study revealed that price formation has generally taken place on the futures market. Nick claimed this could be explained by the broader scope of market participants being present in the futures market, as the futures contracts provide the opportunity to trade the contract multiple times before maturity, and thus, to close out the trading position without taking physical delivery. This enabled their use for hedging and speculation by participants not interested in physical delivery, who dominate the spot market. Apparently, this structural difference between both markets yields the futures market to be significantly informational superior compared to the spot market. Nick concluded that an indexation on the futures market prices rather than on spot market prices, therefore, promises to provide more valid price signals.

Green et al. (2017) investigated the transmission of news and volatility spillovers between electrical power, gas, coal, and carbon in the German market. The study covered the period from January 2008 to March 2016 and examined the spillover effects that news originating in the gas, coal, and carbon markets have on the variance of power. Green et al. (2017) concluded that there are significant spillover effects from gas, coal, and carbon affecting the variance of power. These effects showed large variation across commodities and over time. Spillovers from coal were substantial throughout our sample period, but with a significant time variation on a daily basis. Spillovers from gas were also substantial during 2008 – 2010, after which they started to decrease in magnitude and turned negative for the majority of 2013, possibly due to unprofitability of gas-fired power plants. As the price of natural gas decreased in 2014 and natural gas power plants regained its competitiveness spillover effects from gas to power could be observed once again.

The interrelation between the prices of natural gas, coal, and carbon and German power was investigated also by Everts et al. (2016). The study employed the fundamental model to replicate wholesale market prices and to analyze the impact of a change in single price drivers such as coal prices or subsidies on new renewables. The study claimed that approximately 50% of the wholesale power price decrease in Germany between 2008–2014 could be attributed to market effects such as the decrease of coal and gas prices as well as the decrease in electricity demand. Only approximately 30% of the price decrease could be directly associated with the subsidies for new renewable energies such as wind and solar. Lopez – Nursimulu (2019) came to qualitatively similar conclusions. They found that short-run and medium/long-run price drivers differ and vary over time. In the case of the spot market, the determinants of prices were renewable infeed and electricity demand, while in the futures market, the main drivers are natural gas, coal, and carbon prices.

The brief overview of previous studies suggests multiple factors being in a position to influence the formation of natural gas price formed by gas-on-gas prices and the existence of mutual relations between the energy commodities traded in European markets. Based on this analysis, we identified several variables which we used in our model. The fundamental reasoning for our choices follows in the next part.

3. DESCRIPTION OF DATA

Primary source of data used in our paper is database of Refintiv, Eikon. We collected data series for natural gas price on TTF market, Brent crude oil price, data on storages, German power, API 2 coal price, daily consumption of gas in northwest Europe area (Netherlands, Germany, France and Belgium), weather forecasts in terms of expected consumption, and price of emission allowances (EUA). In case of price indices we use the most liquid contract – front month contracts for all but EUA price, where contract with December delivery of current trading year is the most widely used as a reference price. For the purposes of our regression we used monthly averages of daily closing prices in order to eliminate the excessive noise in data. The data spans from January 2016 to March 2019 (see Graph 2).

We decided to work with the TTF front-month contract due to the maturity of the gas market in the Netherlands. The TTF market has the highest churn rate in Europe since 2014 and the highest traded volume since 2016 when TTF passed NBP (OIES, 2017), as risks of Brexit and declining endogenous production of natural gas in the U.K. together with the slower inflow of Qatar LNG to the U.K. led to a decline in the interest of trading natural gas in the U.K. TTF now serves as a reference point for natural gas traded throughout the Europe and multiple markets set their prices based on the transport costs from Netherlands, especially markets of northwestern Europe directly connected to the Dutch pipeline network. During the last year, TTF even became the reference pricing point for globally-traded LNG as Europe had once again become the attractive destination for LNG exporters thanks to the flexible demand resulting from the large fleet of natural gas power plants and excessive natural gas storage capacities. According to Timera (2018), the European natural gas power plants represent some 30 bcm/y (billion cubic meters/year) of flexible demand, while the storage capacities in Europe offer space for more than 100 bcm of natural gas, representing over 20% of yearly demand.

As we mentioned in previous parts of the article, the natural gas price was traditionally linked to the development of oil price. This was due to the lack of transparent pricing via gas-on-gas competition and the demand from companies to be able to hedge investments into new production. The practice of oil indexation still remains in some long-term contracts up until today. The second channel via which oil influences natural gas price in Europe is the Asian LNG pricing. In those contracts, the price of LNG is set as a slope to the oil price, usually reaching 15%; since the end of 2018, there was pressure from buyers for downward revision towards 11-12% (Reuters, 2018). Large trading houses and portfolio players in the global LNG market are able to move LNG cargoes quite flexibly, and they search for exploiting arbitrage options between regional markets with differing pricing schemes.

The European natural gas storage system is essential for the efficient and secure operation of the whole continental natural gas system. It serves as an extra source of supply during the winter and it allows coping with lower seasonal consumption during the summer since consumption during the winter tends to be on average more than two times larger compared to summer. The source for our information on storage was the portal Gas Infrastructure Europe. Our variable for storage is expressed as a difference against the historical average, expressed as a percentage of total capacity. Shippers in Europe operate some 113 bcm of natural gas storage capacity, which covers up to 25% of yearly natural gas consumption.

Another variable is the price of German power. We chose the German price index due to the fact that it is the most traded and serves a similar role as Dutch natural gas. Dutch and German natural gas markets are well interconnected, and since Germany has a large fleet of natural gas power plants (14,4 GW capacity according to data by Refinitiv, 2019), and a significant share of intermittent renewable energy source, the German natural gas power plants often play the role of marginal electricity suppliers; therefore, they have a direct impact on the natural gas price in Europe.

Since marginal demand for natural gas is often determined by the demand from the power sector, the competition between coal and natural gas power plants and their position in merit order is of crucial importance. Therefore, our explanatory variables include the price of coal (European front-month coal price - API2).

In theory, foreign exchange should be fundamental in determining the price of the European natural gas market as well, despite gas being traded in the common currency. There are two currencies that have a special position. The first is the US dollar since oil remains to be to a large extent traded only in USD and the persisting oil-gas link. The second important factor supporting the case for the role of USD affecting the price of European natural gas price is the fact that international trade with LNG is executed in USD. Since LNG is a marginal source of supply for the European market, USD should influence the price of European natural gas even after long-term oil-indexed gas contracts expire. The second currency with an impact on the price of natural gas in continental Europe is British pound (GBP). The reason for that is the interconnectedness of the U.K. and continental natural gas networks. For instance, in case the GBP strengthens against EUR, the natural gas denominated in EUR gets cheaper for British shippers who can pull away supply from the European market. This works *vice versa* as well as there are bidirectional pipelines between the U.K. and Netherlands, resp. Belgium. The empirical testing, however, revealed that during the observed period foreign exchange was not a significant driver of price development.

The last two variables used in this study are weather forecasts and the consumption of natural gas in northwest Europe. Both these variables are expressed in the size of demand in TWh/d. In the case of the weather forecast, we used the average forecasted consumption for the following seven days provided by Refintiv Eikon on a daily basis. The consumption itself shows the consumption of natural gas in northwest Europe for a given day.

The data for the individual price indices were converted to their logarithmic form.

4. METHODOLOGY

We estimated the simple OLS regression model in order to empirically examine the theoretical relations we described above.

The first step in our analysis is the testing of the time series of interest for the presence of unit-roots. For the time-series data, especially for regression, it is vital to test whether the time series is stationary or not. In other words, whether the data has a unit root or not. The use of nonstationary time series data may lead to spurious regression (Stock and Watson, 2006). In the spurious regression, the value of R2 could be high when two variables are trending over time even though they are not related. All the time series variables of interest were tested for unit root using the Augmented Dickey-Fuller Unit Root Tests (ADF tests). The results are reported in Table 1.

Secondly, we estimated a linear regression model to investigate how the above-mentioned variables contribute to the short-run development of the gas price (*PTTF*). This allowed us to identify the existence and strength of a relationship between the gas price and the selected market fundamentals. The used model includes the following explanatory variables: the Brent oil price *P Brent*, the price of power, the price of Coal (*PCoal*), the storages (Stor), weather forecasts (WFC), and demand. We included a dummy variable representing the state of LNG supply to Europe[1]. The General model has the following form.

$$\Delta lnPTTF_t = \propto_0 + \beta_1 \Delta lnPBrent_t + \beta_2 \Delta lnPDEBL_t + \beta_3 \Delta lnPAPI2_t + \beta_4 \Delta Stor_t + \beta_5 WFC_t + \varepsilon$$

5. RESULTS

Stationarity in the strict sense means that probability distributions of data do not change in the course of time (Lukáčiková – Lukáčik, 2008). For practical research, the time series can be considered stationary when their mean, variance, and covariance do not depend on time. Economic time series often includes trend, and are, therefore, often non-stationary with respect to mean. If this trend is linear simple, first differencing the data will restore stationarity. A logarithm transformation of variables is another useful way to obtain stationary data. It is important to cover non-stationary variables in the stationary process. Otherwise, they do not drift toward long-term equilibrium (Bekhet – Yusop, 2009). We used the Schwarz information criteria to select the lag length. When considering whether to confirm or reject the null hypothesis of unit root existence, we used 1% level of significance. The results show that apart from the variable describing weather forecast, our data needed to be differenced in order to comply with this condition.

We used the OLS method to estimate the regression. The results of which are summarized in Table 2. The independent variables we used in our model are the price of oil, power, and coal, the

1 Our dummy variable gets the value 0 until September 2016 – this is the period where Britain decommissioned its main underground storage facility Rough, and the whole continent started being more dependent on flexible deliveries of LNG.

Table 1: Results of ADF unit root test

Variable	t-stat	
	Levels	First differences
LPTTF	−1.333	−29.062*
LPBrent	−1.863	−30.511*
LPDEBL	−0.894	−27.801*
LPAPI2	−1.948	−24.515*
LCons	−2.549	−21,694*
Storage	−1.320	−7.771*
WFC	−5.637*	
*1% level of significance		

Source: Authors calculation

Table 2: Results of regression analysis

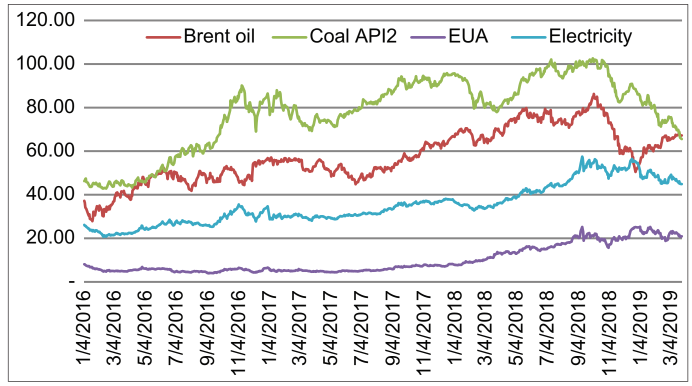
Variable	Coefficient	Standrad error	t-statistic
D (LPBrent)	0.116481	0.114759	1.015004
D (LPDEBL)	0.998677*	0.188772	5.290379
D (LAPI2)	0.393064***	0.197584	1.989350
Storage	−0.247221***	0.132470	−1.866238
WEATHER	0.008373	0.005622	1.489528
D (LCons)	0.029741*	0.006958	4.274651
DUMMY_LNG	−0.051616***	0.026298	−1.962748
C	−0.044167	0.026125	−1.690629
*1% level of significance; ***10% level of significance			
R-squared		0.820812	

Source: Authors calculation

fullness of storages, and the demand and weather forecasts expressed as predicted change in expected consumption. Some of the independent variables may suffer from an endogeneity bias due to reverse causality. The storage and power and coal price are possibly a function of the gas price themselves because coal and gas are competing fuels while the storage facilities may react to gas price fluctuations, and the price of power is directly determined by the price of gas. It could be argued that these variables are influenced by the expected future gas prices, which would invalidate the exogenity of the instruments. Other credible alternative exogenous instruments are, however, difficult to find (Hulshof et al., 2016). Being aware of the imperfections of this study, we move to the interpretation of the regression results.

Starting with price of oil, the positive sign of coefficient can be observed. This means higher price of oil is having positive impact on price of natural gas, the coefficient is however insignificant. The Research by Hulshof et al. (2016) came to conclusion of small positive impact of price of oil on natural gas in years ending 2016. The difference can be explained by different time span our study covers and the fact that natural gas market in Europe has rapidly moved away from oil indexation in recent years which could explain the lowering significance of oil on natural gas prices. As expected, power prices have significant positive effect on natural gas prices. The reason is quite straightforward; power plants are usually the marginal source of demand for natural gas. As Germany is getting more dependent on power sourced by solar and especially wind power plants, the importance of flexibility of natural gas power plants increases. And more often, the fleet of natural gas plants is being called upon to supply marginal power into network which leads to higher volatility (as cheapest power plants are being replaced by the most expensive) in power prices and consequently affecting the price of natural gas. The positive sign of coal price (API2) significant at 10 % can be theoretically justified as well. For instance, as coal gets more expensive compared to gas, coal power plants are being substituted by gas power plants which increase the demand and henceforth the price of natural gas as well. The negative sign of natural gas storage level significant at 10% level suggests that levels that are below historic average implies higher tightness on natural gas market which inevitably pushes the price of natural gas up, either to attract additional supply from flexible source, or in order to limit the usage of natural gas in power generation. Weather forecast which is expressed as expected change in 1future natural gas consumption show positive sign, as expectation of higher demand is priced in by market participants, however its effect seems to be of lesser significance. Maybe surprisingly, since we are estimating the price of front month contract, the actual demand is significant at 1%, although its effect is relatively small 10% increase in consumption increase the price of natural gas by only 0.3%. This also implies spot market is driving the future market, as the instant demand must primarily impact the price on physical market and the observed relation with futures market is of indirect nature. The dummy variable we incorporated into our model reflects the importance of LNG for European gas system. It is significant at 10% and the effect is negative meaning, extra supply coming in form of LNG has is lowering the price of natural gas traded on European market. R^2 value indicates that approximately 82% variation in price of natural gas can be explained by explanatory variables.

Graph 2: Price of Brent oil, coal, EUA, Electricity



Source: Based on data from Refinitv, Eikon

5. CONCLUSION AND POLICY IMPLICATIONS

European natural gas pricing has gone through a period of radical changes. Oil linked gas pricing that was in place for several decades started to a large extent be replaced by hub-based pricing and the emergence of trading hubs in Europe.

The relative novelty of the rising importance of natural gas hub trading in Europe so far limited the number of studies attempting to quantify the driving factors of natural gas price. Our paper has attempted to contribute in this area by characterizing the variables influencing the formation of natural gas price on the most liquid European hub - TTF.

Our examination of the price of the month-ahead contract at the TTF hub for the period 2016 –2019 has shown the price of gas formation is based on factors determining its demand and supply. The elasticity coefficients suggested that the demand determined by the price signals of the German power market and European price of coal are the most important factors. This is fundamentally sound as power generation is the most flexible source of natural gas demand. The competition between coal and gas in power generation determines the marginal demand, which sets the price. The change in total demand was another significant factor, although its impact was smaller, as the European gas system was robust and able to meet the overall demand. The significance of the LNG dummy variable captured the exposure of the European natural gas price to meet the global supply and demand. The model also suggested the importance of storage capacity for the whole system.

Our paper is in line with the findings of Hulshof et al. (2016), which state that the policy measures implemented in the North-west European countries to introduce competition in wholesale gas markets and to integrate these markets by reducing cross-border barriers appear to have been successful in realizing an efficiently working gas market. Our results give relevant insights for market participants who seek to optimize the trading strategies in European natural gas futures markets.

6. ACKNOWLEDGMENT

This paper is supported by the scientific project VEGA No: 2/0007/2019.

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