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Examining the Drivers of Natural Gas Price in Europe- Focus on the Role of Speculators

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ABSTRACT

This paper examines the role of fundamentals and speculators for the price of natural gas market in Europe expressed in TTF front month index. The Granger causality test is used to investigate the relationship between variables determining supply and demand factors as well as activities of speculators expressed in futures TTF contracts held on ICE exchange, data reported by the European Securities and Markets Authority-ESMA. Existence of unidirectional granger causality was revealed running from prices of oil, temperatures towards prices of natural gas, bidirectional causality was found with prices of coal and emission allowance. No Granger causality was found between storages, PMI, positioning of speculators and natural gas price. Granger causality running from storages to speculators was identified. We concluded this indicates the market positioning of speculators is driven by fundamental factors and it is not the main factor driving the price of natural gas.

Keywords: Natural Gas, Price, Granger Causality, Speculators
JEL Classification: Q41

1. INTRODUCTION

Long-term supply contracts were for a long-time primary way of setting gas prices in Europe. The natural gas prices in long term contracts were indexed to prices of different oil products like gas oil, heavy fuel oil, and crude oil, as well as other energy carriers such as power and coal. These long-term contracts were complicated by conflicting interests of importing and exporting companies. Importers demanded flexibility of imported volumes as demand for natural gas is seasonal and weather dependent and volume flexibility would enable them to adjust to changes in downstream demand in a cost-effective way. This contrasted with exporters who need to make large investments that required continuous and stable demand, preferably at specific price, that would guarantee profitability of committed investment (Maissonier, 2005).

Natural gas market in Europe has changed significantly since first deregulatory measures were taken in the late 1990's. The UK market for natural gas has served as leading example for Continental Europe. Following the privatization of the British Gas Corporation and after several adjustments to the regulatory and competitive environment, a fully liberalized market came into existence. For several years NBP has been the most liquid trading place for natural gas in Europe and has become the basis for OTC volumes and delivery point for futures markets. Trading have then commenced in continental Europe, namely Zeebrugge in Belgium where Interconnector pipeline connects British gas system to continent. In neighboring Netherlands, the Title Transfer Facility (TTF) hub developed in 2003 and started rapidly maturing into an important trading point for gas market participants in Northwest Europe, in 2017 clearly overtaking NBP as the most liquid hub in Europe (Heather, 2020). Parallel to this development, the convention of explicitly linking the gas price to the oil price has lost importance. According to IGU (2014) gas-to-gas competition became the dominant price mechanism. The IGU (2014) estimated that the share of oil indexation in North-west Europe decreased from 72% in 2005 to just 20% already in 2013, with pure oil indexed contracts now being almost completely abandoned in most of the Europe apart from Turkey and Spain (IGU, 2022). This price mechanism enabled importers to accept imports of fixed volumes since indexation to spot price enabled importers to manage the volume risk related to changing demand. On the other hand, exporters became more exposed to fluctuation in prices, however their volume risk is largely covered.

Liberalization of natural gas market led to creation of liquid trading hubs with several hundreds of active participants. The rising liquidity of this market attracted financial investors, who unlike utilities does not have any stake in physical market, and while they inarguably add liquidity to the markets, extreme moves in European prices of natural gas in recent years has arisen the questions concerning their impact on the market.

The main goal of this paper is to investigate whether speculators affect the price of natural gas market in Europe expressed in TTF front month index and to also test for relationships of other supply and demand factors with the natural gas price. This paper is divided to five sections. After the introduction, we investigate existing literature examining factors influencing the price of natural gas in second section. Based on literature review, we selected several variables, which we analyze in the third section. The forth section describes the Granger causality test which we use to investigate for relationships among selected variables. The test results are discussed in the fifth section. The paper concludes with interpretation of the results in the context of analyzed supply and demand factors discussed in previous sections.

2. LITERATURE REVIEW

The research concerning the natural gas prices in the world and Europe has grown in recent years as the market has developed and became subject of interest to increasing number of subjects. The predominant agenda of energy security was extended for research of market factors affecting the price after the market liberalization. However, compared to research examining the price creation of oil prices, the research of natural gas prices is still relatively scarce. During the years following deregulating legislature, several types of spot markets have developed in Europe. Financial derivatives trading has also emerged alongside to physical spot gas markets in the UK as well as in Continental Europe. Although long term contract indexed to oil and oil products, still dominated the market in terms of quantity for some time.

Neumman and Cullamnt (2012) analyzed the evolution of natural gas trading places in Europe using day-ahead data. They investigated the integration of European market between period 2009-2011 and found the existence of various degree of price convergence over the observation period among European gas hubs. They found that neighboring market areas do not necessarily reveal similar price signals when operated by different TSOs. They concluded that a reduction of the number of market areas in Europe based on technical and economic considerations could produce more efficient trading places in terms of quantities and price adjustments.

Proponents of the spot trading indicated that the uniqueness of gas and its supply system will lead to independent pricing if the market is sufficiently competitive. On the other hand, Neumman and Cullamnt (2012) claimed, if gas is highly substitutable with crude oil for the marginal buyer, there is no reason to expect an independent price determination process for natural gas even in a competitive market. This is evident also in research by Asche et al. (2013) who investigated the degree of market integration between the three most liquid natural gas spot markets, oil prices and price in the long-term contracts. According to them European gas market is highly integrated market, with no evidence of an independent price determination process for natural gas. They found crude oil price was determining the spot gas prices as well as the long-term contract gas price. They claimed, that even if spot gas trading has increased in the recent years it is still the oil price, that determines both the spot markets and the contract gas price. Although, already at that time they were able observe short periods of peak load pricing, when price of spot gas was determined by gas fundamentals.

In similar vein Yorucu and Bahramian (2015) explored the relationship between the prices of natural gas, crude oil and taxation among selected EU-12 countries over the period of 2001-2012. They concluded that not only crude oil prices, but also taxation have significant impacts on natural gas prices within the EU-12 countries.

As customers in northwest Europe have generally paid less for natural gas under market pricing systems in years following gas market liberalization, it has increasingly become the dominant basis for new long-term contracts. Schultz and Swieringa (2013) attempted to better understand both short-run and longer-term aspects of the price formation process in European natural gas markets. They found that liquidity matter for price discovery while examining monthly future contract traded on NBP and spot physical gas prices traded at the major hubs in Northwest Europe.

Similar investigation was conducted by Nick (2016), who claims that price signals of commodity in both spot and futures markets are of economic significance, as they tend to ensure an efficient allocation of resources. However, the extent to which commodity spot and futures prices fulfil their function crucially depends on the informational efficiency of the respective market. Economic theory suggests that sufficient market liquidity facilitates the processing of information into valid price signals. Nick (2016) empirically investigated price discovery and arbitrage activity between spot and futures natural gas markets in Europe. The study revealed that price formation generally has taken place on the futures market. Nick claimed this could be explained by broader scope of market participants being present on 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 non-interested in physical delivery who dominate on the spot market. Apparently, this structural difference between both markets yields the futures market to be significantly informational superior compared to the spot market.

Deeper understanding of spot market became priority as gas-on-gas pricing has become the prevailing way of price setting in Europe. According to Zhang (2018), this price mechanism is preferable compared to oil indexed way of price determination. The arguments in favour of a hub-based pricing mechanism are based on the fact, that natural gas and crude oil are not perfect substitutes and have different fundamentals. Zhang claims, if the true fundamental value of natural gas is not known, prices tend to deviate from it, which results in abnormal price dynamics. Hulshof et al. (2016) analyzed the day-ahead spot price at the Dutch gas hub TTF over the period 2011-2014 and found that the oil price had a small positive impact on the gas price. Changes in the concentration on the supply side of various importers did not affect the movement in gas prices and therefore the market prices are not distorted by a lack of competition. Fundamental factors affecting demand or supply in the gas market have significant effects, as the availability of gas in storages and the outside temperature negatively affected the gas price. The correlation between the gas price and production of wind electricity was also observed. They concluded that the gas prices at hubs can be viewed as prices resulting from gas-to-gas competition, since even though there still exist link between price of oil and natural gas, it is not strong anymore.

Similar conclusions were observed by Nick and Thoenes (2014) who investigated the effect of market shocks 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. Paper by Zhang (2017) investigated how much supply and demand market fundamentals, global economic conditions, and oil prices contribute to variations in gas pricing in Japan, USA, and Germany, representing the world's three major gas markets. Their analysis shows that oil price changes are the most important contributor to the dynamics of natural gas prices in Japan and Germany, while consumption and production are the most important factors in determining natural gas prices in the US market, although collectively account for only around 27% of price variation.

Obadi and Korcek (2020) examined factors affecting price of TTF front month future and found correlations with German power futures and coal futures naming the competition between coal and gas in power generation as a determinant of the marginal demand for gas and its price. Fulness of natural gas storages, LNG supply and to a lesser extent the level of demand were identified as further factors affecting the price of natural gas. It needs to be said, importance of gas storages for the price of natural gas is long time observed fact (Brown and Yücel, 2008).

The price dynamics between coal and natural gas prices is not unique to Europe. Li et al. (2017) examined relationship of coal and natural gas in the international market. As there is not an integrated market for natural gas in the international market, they investigated for individual local markets. Mature, North American market, liberalizing, European market, and oil indexation dominated Asian market. They claim that on general the influence of natural gas on coal is bigger than vice versa, only in Japan the influence of natural gas on coal is weaker compared with other regions.

As the international energy markets have experienced an increasing trend of financialization since the 2008 global financial crisis, the price of energy commodities, such as oil and gas, are more likely to behave like financial assets, meaning these markets are more likely to become subject of speculation. Therefore, some research already looked into question of speculation and its impact on hub-based pricing. Paper by Su et al. (2017), for example, finds that oil prices have multiple periods where price development was not purely determined by supply demand factors as oil price experienced explosive bubbles. Using similar methodology Zhang (2018) tested for bubbles in prices of natural gas in Japan, EU, and USA. EU and especially Japanese natural gas prices showed greater tendencies to price bubbles compared to USA, according to this paper that claims that hub-based pricing mechanism can better reflect fundamental values in the gas markets and thus is less subject to speculations.

This does not mean prices gas-on-gas pricing drives levels of prices lower. Hub-based pricing should be neutral for both importers and exporters, it just ensures existence of more efficient market. However, this research also states, that oil market is much larger and contains more market players, and thus it is less likely to be manipulated.

Zhang (2017) further claims that, given the recent trend toward the financialization of energy markets, natural gas prices are expected to respond less to market fundamentals and more to financial markets and trading mechanisms.

The aim of current paper is to expand the research dedicated to investigation of impacts of financial speculation on hub-based natural gas prices. Our analysis relies on publicly available data on positioning of various groups of entities trading on the most liquid hub in Europe-TTF marketplace Intercontinental Exchange (ICE). This data has recently started being compiled by EU's financial markets regulator and supervisor body – The European Securities and Markets Authority - (ESMA). Our investigation uses methodology of Granger causality (GC) as developed by Engle and Granger (1987).

3. CORRELATION OF PRICES OF ENERGY COMMODITIES

A factor which may affect both the demand and the supply of gas is the price of oil. The price of oil can be relevant because of substitution properties of gas and oil (Villar and Joutz, 2006) as well as the price formation of long-term natural gas contracts. As we stated in the introduction, the pricing mechanism evolved in time and moved towards gas-on-gas pricing in long term contracts with the European major natural gas import sources – Russia, Norway, LNG imports, Algeria, and Libya. In early 2020's Norway and Russian selling prices are almost entirely based on gas-on-gas pricing. In one of its Investor Days in 2021, Gazprom announced that 56.1% of its export portfolio was linked to the Day-ahead and Month-ahead contracts, 30.9% was linked to forwards (quarter, season, and year) and 13% was indexed to oil (Rene, 2022). On the other hand, pipeline imports from Algeria and Libya that are integral part of natural gas supply mix in Europe rely still to a certain extent on oil indexation in their long-term contracts for

Table 1: Commodity correlations – development since 2010

2010-2012	Coal	Gas	Oil	EUA	2013-2015	Coal	Gas	Oil	EUA
Coal	1,00				Coal	1,00			
Gas	0,34	1,00			Gas	0,75	1,00		
Oil	0,45	0,75	1,00		Oil	0,94	0,61	1,00	
EUA	0,38	- 0,56	- 0,47	1,00	EUA	- 0,90	- 0,76	- 0,88	1,00
2016-2019	**Coal**	**Gas**	**Oil**	**EUA**	**2020-2022**	**Coal**	**Gas**	**Oil**	**EUA**
Coal	1,00				Coal	1,00			
Gas	0,85	1,00			Gas	0,92	1,00		
Oil	0,59	0,61	1,00		Oil	0,91	0,79	1,00	
EUA	- 0,05	0,12	0,63	1,00	EUA	0,86	0,82	0,93	1,00

Source: Authors calculation

natural gas deliveries (IGU, 2022). This brings another dynamic into European gas markets, since both Italy and Spain as primarily recipients of these imports have several options in their sourcing, and they can switch between natural gas with prices based on oil indexation on one hand and LNG resp. long term contract with Russia and Norway whose prices are set on European natural gas hubs. This means imports from North Africa are usually stronger when prices of oil are relatively lower compared to the price of natural gas. Since pricing formulas usually includes indexation over longer period (3-9 months) with several months lags lower oil prices spill over to gas prices only gradually. This explains the low imports of natural gas from North Africa in the first half of 2020, when prices of gas on European hubs reached record lows, as prices of natural gas gradually recovered in second part of the year and low oil prices translated into favorable price of long-term contracts, imports in second half of 2020 increased by 76%.

As for demand side Stern (2009) argues that short-run fuel switching is hardly relevant anymore in West Europe because oil has virtually disappeared in most stationary energy sectors. According to recent estimates, the Europe has potential to replace just three billion cubic meters of gas by oil as fuel of choice in power plants (Bella, 2022). Even though the substitution of oil and natural gas in Europe is nowadays limited, the correlation between price of oil and natural gas remained relatively stable since the inception of TTF gas hub. This is not entirely surprising, as despite the fundamental changes in pricing, the oil and natural gas is traded to a large extent by the same set of investors and affected by the same macroeconomic event. Furthermore, even if the oil indexation slowly waned from European long-term contracts, it plays major role in long term LNG contracts for Asian off takers. And since LNG is often in the role of marginal supply for European continent (LNG share on European natural gas imports varied between 13 and 36% depending on the tightness of global LNG supply (BP, 2022), oil prices still matter for European gas market.

While the price of oil affects supply side of gas balance equilibrium equation, the demand side is more affected by the price of other commodities. Gas demand from the industrial, commercial, and residential sectors is relatively unresponsive to price in the shorter term. In contrast, liquid power markets across the Europe mean that gas demand from the power sector responds directly to gas market price signals. Therefore, if production costs of coal power plant is less favorable to production costs from natural gas power plant, the former is being displaced from generation mix and vice versa. The relative profitability of power generation from those sources are also affected by the price of EU carbon allowances (EUA), which intend to promote power generation from the less CO_2 intensive source, i.e., the higher the price of EUA the higher the costs of production from coal are (compared to gas). This logic only applies if available switchable power generation exist.

As the correlation matrix in Table 1 shows, the dynamics among commodities on EU wholesale energy commodity market evolves. We can observe high correlation between oil and natural gas at the beginning of decade as oil indexation was the main price setter for natural gas delivered to EU via pipelines based on long term contracts. Lower correlation since 2013-2022 could be interpreted in the context of rising importance of gas-on-gas competition and the return of higher correlation coefficient since 2020 can be seen as a result of influx of LNG to EU, and the price setting mechanisms based largely on oil indexation in Asian long term LNG contracts. Correlation between gas and coal has become gradually stronger since 2010. We think this evolution results from gradual abandonment of oil indexation, which moved coal-gas competition in power generation to the position of main pricing mechanism. Positive correlation suggests that when price of coal increases, the price of natural gas increases as it becomes more competitive in power generation therefore demands for it rises. The correlation of EUA with natural gas became important only in recent years after reforms, as up until 2017 EUA price level below 10 EUR/ton was insufficient to alter the merit order in power generation.

3.1. Storage of Natural Gas (SNG)

Gas storages are typically used to synchronize production with consumption of natural gas. The consumption of gas is seasonal while the production and transportation infrastructure has generally more limitations to adapt its levels accordingly. Some 65% of European demand is typically consumed in winter. Since the production volumes and pipeline imports do not vary that much, the supply gap is much larger in winter than in summer (OIES, 2020). SNG capacities in Europe offer space for approximately 106 bcm of natural gas (AGSI, 2022), representing over 20 % of yearly demand.

Brown and Yücel (2008) have found that relative fullness of natural gas storage influences the price of natural gas. This notion was later empirically observed by Fulwood and Sharples (2020). To confirm these findings, in the context of years examined in this article, the Table 2 is attached. It clearly shows that in 2018 and

Table 2: TTF Front month gas price levels and Natural gas storage

Year	Average Price (TTF FM)	Yearly change in Average price	Average percentage dev. of SNG fullness to 2011-2021 average
2019	14.6	−34%	7.55
2020	9.6	−34%	14.18
2021	47.5	393%	−10.70
2022	135.6	185%	−8.89

Source: Authors based on data from ICE and AGSI

2019, when SNG were filled above the historical average, the outturn price of natural gas was lower not only in absolute terms but also on year over year change basis. And *vice-versa,* in 2021 and 2022, when storages were from various reasons filled below the historical average, natural gas prices rose significantly higher.

As the trade flows of natural gas became more globalized, while the SNG capacities in Asia (the most important LNG market) are still limited, the SNG in Europe gained global importance. The flexibility, European SNG offers, now basically extends to Asia. For example, during the period of extreme weather in Asia during winter 2020-2021, the flexibility of European storages enabled Asian buyers to divert almost all LNG cargoes to Asia, while Europe draw more heavily from their storage. For instance, the European LNG send-out in January 2021 reached just 40 TWh compared to 106 TWh average of years 2020 and 2022 (ALSI, 2022). This however inevitably leads to less redundancies in the system, implying higher volatility of natural gas prices in stress situations (Fulwood, 2021). Figure 1 depicts variability of storage filling trajectories in individual years, that were resulting from various balances of supply and demand of natural gas in Europe.

Our variable SNG is calculated as the difference between the storage on a given day and the average for that day over the past n years. This can be represented as follows:

$$\varnothing_t = S_t - \left(\frac{1}{n} S_{t-365} + \ldots + \frac{1}{n} S_{t-n*365}\right)$$

St is percentage of total capacity filled on a given day and Øt is the actual deviation from the average filling grade of the past n years, measured in percentages. In this paper we use a period of = n 5 years for weekly data. In case of monthly data, we use maximum value of for given month. However, as the Table 2 clearly documents, 5-year time frame is not the only setting where the relation between storage fulness and natural gas price can be observed.

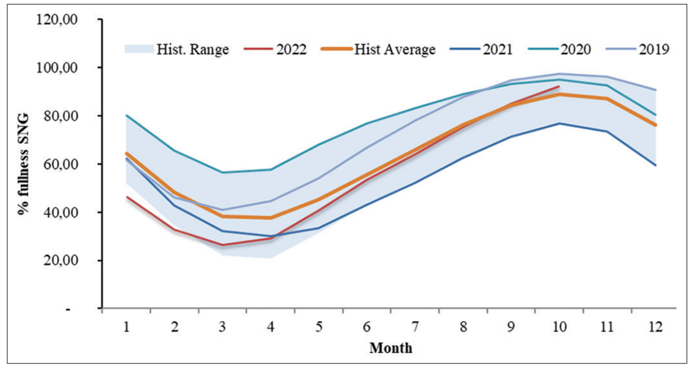
3.2. Heating Degree Days

Natura gas is mostly used for heating purposes; therefore, weather factor is of major significance for natural gas demand. Hulshof et al. (2016) empirically confirmed that demand fundamentals are important for short-run price determination. Heating degree day (HDD) index is a weather-based technical index designed to describe the need for the heating energy requirements of buildings. We use data on HDD published by Eurostat where HDD are calculated followingly:

If $T_m \leq 15°C$ Then [$HDD = \sum_i (18°C - T^i_m)$] Else [$HDD = 0$]

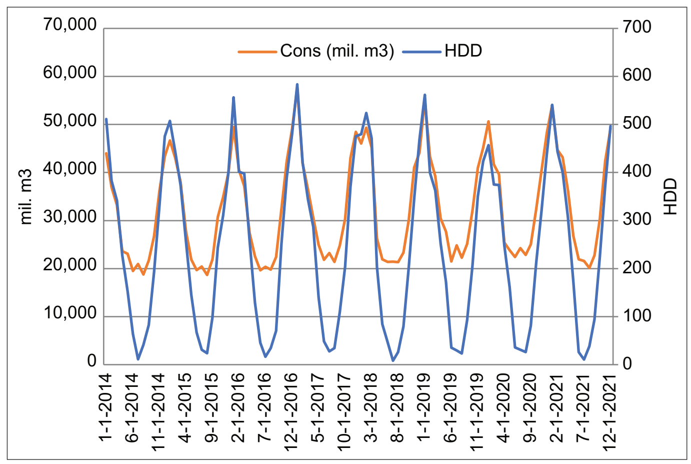
where T^i_m is the mean air temperature of day i.

Figure 1: Historical development of SNG fullness in Europe



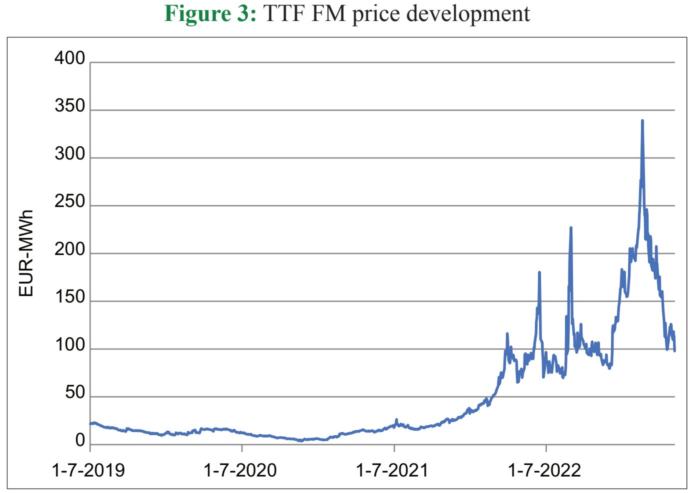
Source: Authors, based on AGSI data

Figure 2: Correlation of natural gas consumption and HDD



Source: Authors, based on data published by Eurostat

Figure 3: TTF FM price development



Source: Authors, based on ICE data

The correlation index between HDD and EU27 monthly natural gas consumption reaches 96.5 (Figure 2). And despite its relative stability, typical yearly differences in HDD are in order of up to 5% but there are instances of more extreme weather patterns. During the short time span of observations used in this research, years-2019-2022, we experienced such year when HDD in 2021 were 13 % higher than previous year. There is a strong expectation that the strong increase in related consumption must have effect on prices.

3.3. Development of Price of Natural Gas in Europe (TTF)

TTF gas hub has seen a phenomenal rise in trading activity since 2014. Traded volumes has grown almost exponentially in recent years and TTF has become the mature risk management hub, not just for the Netherlands but for the whole Europe and beyond, as it now also serves as a pricing hub for some LNG cargoes into north-west Europe (OIES, 2022). The hub serves the largest number of participants, providing the widest range of traded products. The traded volume in 2019 reached more 40 390 TWh, almost three times more than those of NBP (the second most liquid hub, and almost twenty times more than the third most liquid hub NCG), to put it differently TTF volumes represented 79 % of all traded volumes. This brings TTF churn rate to over 97, compared to 14 for NBP and 4 in case of NCG (Heather, 2020)[1]. In this article we use Front month contract traded on TTF as a proxy variable for price of natural gas due to its informational superiority compared to the spot market (Nick, 2016), level of liquidity supporting price discovery process, and wide range of usage, which makes it an extremely important price reference point.

The Price of natural gas is in its nature volatile due to low demand elasticity. The historic average value of TTF FM contract of 2014-2018 was 19 EUR/MWh, with average intra year volatility of some 40%. Yearly changes in consumption averaged just 5% during that period whole yearly changes of natural gas price averaged 32%.

As can be seen on Figure 3, after the relatively calm year of 2019 when price of gas moved mostly within its historic boundaries averaging 14,61 EUR/MWh, the average yearly price of TTF FM contract averaged just 9,7 EUR/MWh in 2020 due to combination of mild winter, and pandemic shock on demand which pushed the price under 4 EUR/MWh. These price levels, being under the production costs of nearly all producers (Fulwood, 2019), however, did not last for long, and 2021 seen extreme price swing in the other direction, as cold winter in Asia tighten the supplies of natural gas in Europe during winter which led to quick emptying of storages. Those (especially ones) under management of Gazprom were not filled during the summer, which led to panic on European gas market and price increased by 400% to 47.85 EUR/MWh in 2021 with highs of 180 EUR/MWh. The seminal event for European gas market in 2022 was Russian invasion to Ukraine leading to gradually diminishing flows between Russia and Europe. At the end of august, only some 900 GWh/d of gas flew through Ukraine route and Turkstream pipeline to Europe as Nord Stream pipeline was damaged and Yamal pipeline sanctioned by Russia. The Russian exports to Europe now represent only 10% of EU imports (EC, 2022) down from 41%, when Russia exported 1 488 TWh of natural gas to EU (EC, 2022). In 2022 (January-August), decline of 43 bcm flows from Russia was replaced by combination of higher LNG imports (+32 bcm), pipeline imports from other countries (+17 bcm) and decrease in consumption of 25 bcm during first two quarters 2022 compared to previous year, which helped to fill storages of natural gas (EC, 2022).

Simple arithmetic exercise shows that decline of natural gas flows was more than compensated, which arise the question of justification of inflated prices EU experienced in 2022. The price of TTF FM averaged 126 EUR/MWh in first half of 2022 with highs of 339 EUR/MWh and lows 69.8 EUR/MWh. In this article we attempt to shed a light on the role of speculators in the price evolution since 2019 on TTF market.

3.4. Data on Speculative Activities

ICE's exchange based in continental Europe, provides liquid European gas, emissions and power markets that enable energy firms to manage their risk exposure. The Dutch wholesale market for natural gas, also known as the Title Transfer Facility or TTF, is a virtual marketplace operated by Gasunie Transport Services. The TTF was established in 2003 to promote the trading of natural gas thereby enhancing the liquidity of the Dutch natural gas market. Since then, gas trading on the TTF has increased significantly to around 3 700 terawatt hours (TWh) per month, making the Dutch hub the largest natural gas market in continental Europe. Today, there are some 167 active participants on TTF market (Gasunie, 2022). The physical gas market in the Netherlands is relatively small as compared to the traded market. The TTF futures contract is available for trading in different amounts of monthly strips, up to eight consecutive years. (ESMA, 2022). An ongoing position monitoring and reporting obligation of different categories of persons as part of an exchange's position management controls in accordance with MIFID II regulation was introduced recently. Weekly Commitment of Trader Reports showing the aggregate positions held in commodity derivatives traded on ICE trading venue are publicly available on the website of The European Securities and Markets Authority (ESMA), published on weekly basis, on Friday, for the previous week.

This reporting divides active entities on TTF gas market into four types of groups: investment firms or credit institutions (typically banks), investment funds (entities holding investments directly in the commodity derivatives market as a form of collective investment scheme), other financial institutions (pension funds) and commercial undertakings (non-financial entities dealing in physical commodities such as producers, end users, processors, manufacturers, shippers and merchants) (ESMA, 2022). For our purposes we combine data on both investment funds and other financial institutions and these categories define as speculators[2].

The Figure 4 depicts the positioning of individual groups of

1 Generally, the market is considered to be liquid with churn rate above 10.

2 The reason for such treatment of data is clear change in classification during the period of reporting, when during September 2021 majority of position up to that time reported under category other financial institution was moved under the headline of investment funds.

entities. For instance, commercial undertakings typically hold long position as they hedge their planned off take of the commodity. The period of first half of 2021 when the position of commercial undertakings flipped to net negative, could be explained by excessive hedging on the part of energy producer after extremely low prices of 2020. Such hypothesis is supported when splitting the net position into longs and shorts. It can be observed that short position increased from 400 TWh to almost 1 000 TWh, while at the same time the long position in the segment of commercial undertaking increased from approximately 600 TWh to some 900 TWh. The activities of commercial undertakings are to a large extent mirrored by investment firms, whose activities help commercial undertakings to mitigate the risks resulting from their core business of natural gas production/supply.

The most intriguing category in this overview remain Investment funds (IF) and other financial institutions. Unlike CU that are mostly long and Investment firms-that are short most of the time, Speculators are not bound by their physical liabilities, and they can flip their position based on their believes on future development of price. They undeniably add liquidity to the market as their share of open interest on ICE exchange reached above 50 % during certain periods, however they lowered their exposition during the volatile year 2022 to just some 10% of open interest, which was most likely driven by the need to limit the financial exposure, since the price of natural gas has risen dramatically.

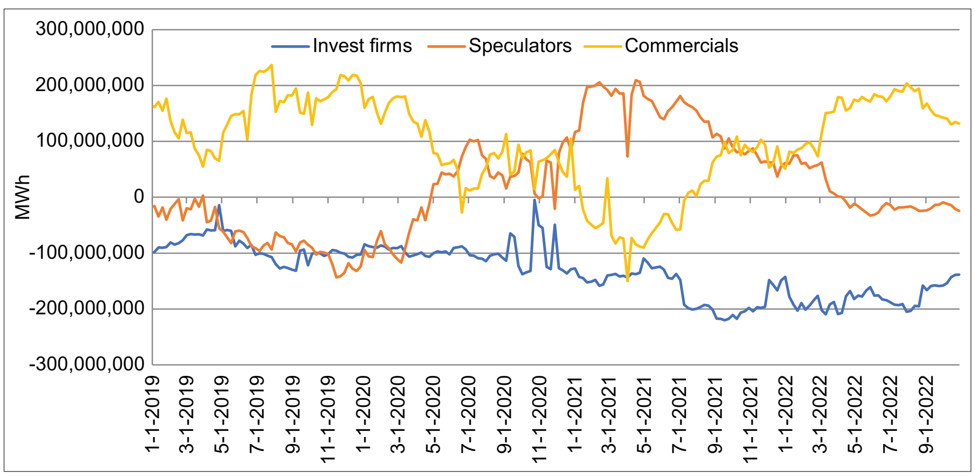
As shown on the Figure 5, the positive correlation between the lagged values of development of natural gas prices and positioning of individual groups of persons suggests, that unlike commercial undertakings and investment firms, speculators historically tend to anticipate the movements of price of natural gas correctly, however we do not see the evidence they might be the sole reason why the price of commodity move. The only positive correlation between movement of price and positioning in real time can be observed in case of commercial undertakings, which can be explained by the fact that this group of persons trade the largest volumes, on average being responsible for 50 % of open interest.

4. METHODOLOGY AND DATA

Presented research covers period from January 2019 to June 2022. The observed period is determined by data availability on financial positioning of individual entities trading TTF natural gas on ICE and made available on ESMA website on regular, weekly basis.

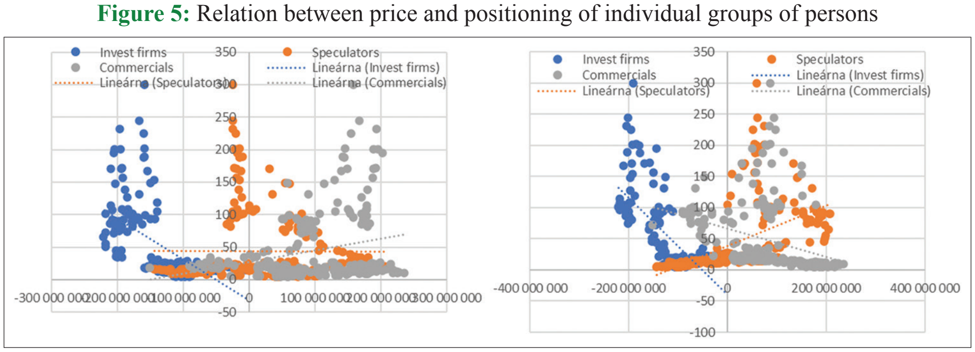
The other variables used in this study are fulness of natural gas storages, price of oil, coal, emission allowances, ISM

Figure 4: Positioning of individual groups of persons on ICE exchange TTF natural gas



Source: Authors, based on data published by ESMA

Figure 5: Relation between price and positioning of individual groups of persons



Source: Authors, based on data collected by ESMA, ICE

Left Figure: Correlation among net position of individual groups of persons and average price of TTF Front month.

Right Figure: Correlation among net position of individual groups of persons and average price of TTF Front month lagged by 30 weeks.

manufacturing index for Europe (monthly indicator of economic activity also known as PMI), price of oil and temperatures measured in HDD. As the data are published in various frequencies, we test for granger causality on both weekly data and monthly data (PMI, HDD by Eurostat). In case of testing for GC on monthly data, we simply average the data for weeks corresponding the given month, if one of the datasets is available in greater granularity. Apart from our primary goal of investigation whether speculators affect the price we also test for other supply demand factors driving the price.

In this paper we used standard Granger causality test to investigate the relationship among variables. Examining the causality requires the data to be stationary. We applied Augmented Dickey Fuller (ADF) unit root test to determine whether time series we work with are stationary. If the series contains a unit root, this means that the series is nonstationary. Otherwise, the series will be categorized as stationary. Our data were used in the form of first differences in their logarithmic transformations where possible and they were stationary. According to Altunbas and Kapusuzoglu (2011) in the case of absence of stationary data the standard method of Granger causality testing needs to be applied.

Granger's (1969) concept of "causality" assumes a different meaning with respect to the more common use of the term. The statement(y) Granger causes (x) or vice versa, in fact, does not imply that (y) and (x) is the effect or the result of (y) and (x), but represents how much of the current (y) and (x) can be explained by the past values of (y) and (x) and whether adding lagged values of (y and x) can improve the explanation. For this reason, the causality relationship between (y and x) can be evaluated by estimating the following regressions.

$$\ln X = \alpha_1 + \sum_{i=1}^{m} \beta_i X_{t-i} + \sum_{j=1}^{n} \lambda_j \ln Y_{t-j} + v_t$$

$$\ln Y = \alpha_2 + \sum_{i=1}^{n} \gamma_i Y_{t-i} + \sum_{j=1}^{n} \delta_j X_{t-j} + \varepsilon_t$$

- constants; vt εt - white noise; i, j - lag length; t - time period.

Following this approach, the null hypothesis that (x) does not Granger cause (y) in regression (4) and that (y) does not Granger cause (y) in regression (5) can be tested through the implementation of a simple F-test for the joint significance of, respectively, the parameters βi and γi.

When testing for Granger causality, estimation of lag length is a crucial aspect. So far multiple studies have clearly shown that cointegration test, VECM and causality test are very sensitive to the selection of lag length. If chosen lag length is less or more than the true lag length the results are likely to be biased (Gelo, 2009). Eviews software tool, that evaluates optimal lag length based on lowest values, offers optimal lag lengths estimates under consideration according to the following criteria: LR-test statistic; FPE-final prediction error; AIC-Akaike information criterion; SC-Schwarz information criterion; HQ-Hannan-Quinn information criterion. In each individual case we chose lag length recommended by the majority of criterions as the appropriate lag length.

Table 3: Augmented Dickey Fuller stationarity test results

Variable	Level		First difference	
	t-Statistic	Prob.	t-Statistic	Prob.
Invest. Funds	−1.420459	0.5720	−15.99643	0.0000
Oil	−1.111635	0.7116	−13.01442	0.0000
TTF	0.756978	0.9931	−11.22569	0.0000
Storage	−2.951926	0.0411		
HDD	−9.361990	0.0000		
PMI	−1.305458	0.6177	−5.397648	0.0001
Coal	−0.114955	0.9450	−11.97228	0.0000
EUA	−0.512654	0.8848	−10.12932	0.0000

Source: Authors' calculation

Table 4: Granger causality test results

Null Hypothesis:	F-Statistic	Prob.	No. lags	Obs
Granger causality test on weekly data				
Invest. Funds does not Granger Cause TTF	2.19724	0.0893	3	229
TTF does not Granger Cause Invest. Funds	0.49390	0.6869		
Storage does not Granger Cause Invest. Funds	5.69380	0.0002	4	228
Invest. Funds does not Granger Cause Storage	2.40028	0.0510		
TTF does not Granger Cause Oil	1.62098	0.1556	5	227
Oil does not Granger Cause TTF	3.08857	0.0103		
TTF does not Granger Cause Storage	1.59141	0.1776	4	228
Storage does not Granger Cause TTF	1.04073	0.3871		
Coal does not Granger Cause TTF	2.39320	0.0181	8	184
TTF does not Granger Cause Coal	1.71835	0.0974		
TTF does not Granger Cause EUA	5.75794	2.E-06	8	184
EUA does not Granger Cause TTF	2.90114	0.0047		
Granger causality test on monthly data				
TTF does not Granger Cause HDD	1.79970	0.1742	3	31
HDD does not Granger Cause TTF	3.44423	0.0326		
TTF does not Granger Cause PMI	0.18512	0.8321	2	32
PMI does not Granger Cause TTF	1.75830	0.1915		

Source: Authors' calculation

The above equations were estimated using selected number of lags of each variable which should represent and adequate lag-length over which one series could help to predict the other.

5. RESULTS

Testing for Granger causality requires data to be stationary. For practical research the time series can be considered stationary when their mean, variance and covariance do not depend on time. It is important to cover non-stationary variables into stationary process. Otherwise, they do not drift toward long term equilibrium (Bekhet and Yusoff, 2009). Augmented Dickey-Fuller (ADF) unit root tests are used to test for the presence of unit roots in the variables. We report the test results for levels and after first difference in Table 3. We used Schwarz information criteria to select the lag length. When considering whether to confirm or reject the null hypothesis of unit root existence we used 5% level of significance.

Apart from variables representing fulness of natural gas storages and HDD, ale the remaining variables need to be first differenced to become stationary.

Standard Granger causality test was executed on data in their stationary form. Where available, test was conducted on weekly data, in case we managed to obtain data only in monthly granularity, we use simple arithmetic averages of daily values for respective variables when tested for Granger causality on monthly basis. The aim of this paper is to test for importance of speculation for TTF price development, drivers of speculators positioning, and factors influencing the price of TTF. The pairs of variables, we tested for Granger causality, is selected accordingly.

Our results (Figure 5) indicate that the prices of TTF front month natural gas contact is dependent on prices of other energy commodities. On 5% confidence level we see Granger causality running from oil towards natural gas. The causal relation is unidirectional which is expected. Reasons for that are the size and maturity of the oil market, as well as more limited substitutability between gas and oil, as the usability of oil is more universal. Apart from demand substation, production of associated gas when mining for oil can be cited as another factor connecting these commodities.

Granger causality between natural gas, respectively natural gas and EUA seems to be bi-directional. We observed granger causality running from coal to gas at 5% level of confidence and from natural gas to coal at 10% level of confidence. In case of EUA and natural gas, granger causality is significant at 5% level. We believe this can be related to direct competition between coal and natural gas in European power generation, when based on price signals coal changes place with natural gas as source of marginal generation of electricity. The sole purpose of EUA is to provide price signals in such way that natural gas is more competitive than coal. Higher EUA price penalizes use of coal, which should be replaced by gas therefore increasing demand and consequently price of commodity. The causality running back from natural gas back to EUA can be explained by similar mechanism however, i.e., high relative natural gas to coal requires even higher EUA price to do its job, pushing market participant to replace the environmentally dirtier commodity. This self-reinforcing loop can lead to undesirable results at times, when low availability of natural gas combined with ambitious environmental policies push the price of the whole commodity mix higher, without the desired effect of decarbonization.

As for other demand factors, the weather influence measured in HDD proved to have unidirectional granger causal relation with TTF price, confirmed at 5% level. We found no existence of granger causality between industrial activity measured by PMI readings and natural gas price. These findings seem plausible as heating is the primary use of natural gas, while the role of natural gas as a feedstock in other industrial processes is smaller part of overall consumption. The non-existence of causality running from natural gas price to PMI can be explained by its relatively small importance for the overall level of industrial output in Europe.

To our surprise we find no Granger causality running between fullness of storages and the TTF front month natural gas price during observed period. We think, this might be caused by existence of more complex relationship between variables.

At 5% level of confidence, we do not observe existence of Granger causality running from speculators to TTF price. This statistical test does not support the claim that speculator affect price of natural gas. As we stated in previous part of the text, the unidirectional size of bets speculators place on movements of natural gas market are relatively small compared to the overall size of the market, as their average share on open interest hovers around 9%. It does not mean they are not able to affect the price when creating/liquidating some substantial positions. But it seems to us that rather than directly affecting the price of natural gas, they more likely attempt to estimate the movement of the price of natural gas and benefit from expected movement in prices.

As we mentioned importance of natural gas storage for the price of natural gas is well documented in the literature. With this in mind, we tested for granger causality between storage fulness and positioning of speculators. We found existence of Granger causality running from natural gas storages to speculators at 5% confidence level. This result is intriguing to us. We suppose it could be inferred that financial speculators on European gas market seems to study development of supply and demand factors, which condense in the movement of levels of natural gas in storages. Since movement of gas in storage is less volatile and basically more predictable, than any other variable affecting price of natural gas it makes perfect sense to study exactly this indicator when placing long term bet on price evolution.

6. CONCLUSION

Price of natural gas measured in the TTF front month price index has experienced extreme development, going from lows of 3,45 EUR/MWh in 2020 to more than 339 EUR/MWh in August 2022. Supply and demand shocks from pandemic shutdowns of economies to war in Ukraine can be cited in explaining this price movement. However, especially in public discourse, financial speculators have been frequently blamed (Spectator, 2022). In presented paper we attempted to investigate this question using data compiled by EU's financial markets regulator and supervisor body ESMA. Data are systematically collected since 2019 for the most traded market with natural gas in Europe – Dutch TTF on the most liquid exchange – ICE. Long and short positions of four groups of entities are presented on weekly basis. These data clearly show that groups of entities which we define as speculators for the purpose of this paper are responsible only for relatively small fraction of the overall market open interest in recent year.

Our correlation analysis showed it is more hedging activities of commercial players that drive immediate movements of TTF price in short run. The buying and selling of speculators is positively correlated with the price movement with a considerable lag. We suppose this infers speculators attempt to estimate the movements of the price in advance to benefit from them. We further use Granger causality test to identify whether it is speculators or other fundamental factors that drive the price of European natural gas. At 5 % confidence level our results show that price of natural gas seems to be driven predominantly by other supply and demand factors. Unidirectional granger causality running from price of oil and temperatures towards price of TTF was found. Bidirectional causality was identified between price of gas, coal, and emission allowance. At 5% confidence level no relation between speculators, PMI and price movement can be corroborated. This statistical test therefore does not support the notion that speculators Granger cause the price of natural gas.

Intriguingly we identify Granger causality running from variable representing fulness of natural gas storage towards positioning of investment funds. This supports our claim, that speculators base their investment decision on supply demand fundamentals of European natural gas market, as natural gas storages are documented to be good predictor the price development. Since fundamental factors drive the financial positioning of speculators, their role could be found beneficent for the market as their actions only fasten the price discovery that is taking place on the market while adding the liquidity required for risk managing activities of other commercial entities.

We are aware that results presented in our article cannot be deemed conclusive. The employed statistical tests provide only first glance into the subject and deeper understanding demands furthers research in this area.

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