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The Energy Crises and Contagion from Europe to World: Evidence via Stochastic Volatility Model

Avrupa'dan Dünya'ya Enerji Krizleri ve Bulaşıcılık: Stokastik Oynaklık Modeliyle Kanıtlar

Anıl Çağlar ERKAN
Asst. Prof. Dr., Mehmet Akif Ersoy University
acerkan@mehmetakif.edu.tr
https://orcid.org/0000-0001-9693-6556

Enes Burak ERGÜNEY
Master Student, Mehmet Akif Ersoy University
enesburakergney@gmail.com
https://orcid.org/0000-0002-1538-1489

Samet GÜRSOY
Asst. Prof. Dr., Mehmet Akif Ersoy University
sametgursoy@mehmetakif.edu.tr
https://orcid.org/ 0000-0003-1020-7438

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ABSTRACT

The new period, which started with the increase in energy prices in Europe, turned into a crisis in a short time and had a serious negative impact on the locomotive economies of the continent. Russia's attempts to reduce the amount of supply, despite the increasing energy demand of the European economies in the recovery effort, appear as the trigger of the crisis process. In this direction, a process has emerged in which we have witnessed the increasing tensions between major European economies and Russia, especially since the second half of 2021. On the other hand, the large increases in energy prices in a short time created the effect of gasoline spilled on the fire in the increase of tensions between the parties. Therefore, the effect of the 2021 energy crisis on the global scale has become inevitable. In the light of all these, first, it was discussed the effect of the European energy crisis on the price changes in the world's leading markets . In this context, important natural gas market data of Europe was evaluated with American and Asian spot and benchmark prices. In the light of the data obtained, the existence or nature of the correlation were analyzed between the price movements in these three important natural gas markets systematically. TTF and Henry Hub are the two important markets to be covered in the analysis. In the light of all these, in the study, it was analyzed whether the process that emerged in Europe, has affected other market prices via the Stochastic Volatility Model. It was found that TTF, Henry Hub and JKM companies, which supply gas to the European market, increased their share returns between 01.12.2017 and 01.12.2021 (crisis periods).

Anahtar Kelimeler:

Stokastik Oynaklık Modeli

Henry Merkezi

Doğal Gaz

Enerji Krizi

Jel Kodları:
K32, P18, Q43

ÖZET

Avrupa'da enerji fiyatlarının artması ile başlayan yeni dönem kısa sürede krize dönüşerek kıtanın lokomotif ekonomilerini ciddi bir şekilde olumsuz etkilemiştir. Avrupa ekonomilerinin toparlanma çabaları çerçevesinde artan enerji taleplerine rağmen Rusya'nın arzı azaltma girişimleri kriz sürecinin tetikleyicisi olarak görülmektedir. Bu doğrultuda özellikle 2021'in ikinci yarısından itibaren büyük Avrupa ekonomileri ile Rusya arasında artan bir gerilim yaşanmaktadır. Diğer yandan enerji fiyatlarında kısa sürede yaşanan büyük artışlar taraflar arasındaki gerilimin artmasına neden olmuştur. Bu nedenle küresel ölçekte 2021 enerji krizinin etkisi kaçınılmaz duruma gelmiştir. Tüm bunların ışığında ilk olarak araştırmada Avrupa enerji krizinin dünyanın önde gelen piyasalarındaki fiyat değişimlerine etkisi tartışılmıştır. Bu kapsamda Avrupa'nın önemli doğalgaz piyasası verileri Amerika ve Asya spot ve karşılaştırmalı fiyatları ile değerlendirilmiştir. Elde edilen veriler ışığında bu üç önemli doğal gaz piyasasındaki fiyat hareketleri arasındaki ilişkinin varlığı veya niteliği sistematik olarak analiz edilmiştir. TTF ve Henry Hub, analizlere dahil edilen iki önemli pazardır. Tüm bunların ışığında çalışmada, Avrupa'da ortaya çıkan sürecin diğer piyasa fiyatlarını etkileyip etkilemediği Stokastik Oynaklık Modeli ile analiz edilmiştir. Avrupa pazarına gaz arzı sağlayan TTF, Henry Hub ve JKM şirketlerinin 01.12.2017 ile 01.12.2021(kriz dönemleri) tarihleri arasında hisse getirilerini arttığına dair bulgulara ulaşılmıştır.

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1.INTRODUCTION

Natural gas markets have been developing significantly in the recent period. It is indisputable that the increasing importance of natural gas in the eyes of consumers and the increasing quality of its functional contribution to the sustainability of economic activities have been extremely influential in the development process. In this direction, it is possible to state that the natural gas trade has developed on an international scale and has reached a lower level of the oil markets.

A very important issue related to the development of natural gas markets is the witnessing of changes in connection with the dynamism of the international arena. One of the typical features of natural gas markets activities within the framework of long-term contracts. However, especially in the last period, it has been witnessed that long-term contracts and price formulas have undergone great changes. In this context, it is possible to say that old habits have lost their effectiveness in today's trade style and have undergone a significant transformation. Nevertheless, it is extremely difficult to talk about a mature market mechanism and structure for the trade of natural gas. However, this expression does not mean that there is no formation in which natural gas is treated as a commercial commodity. So much so that today there are several important formations in which commercial activities related to natural gas are carried out. However, it is seen that these formations were operated in isolation from each other until recently. In this respect, we can say that the natural gas trade, which does not have a fully developed market mechanism yet is traded on platforms with its own characteristics in the international arena. Henry Hub, Title Transfer Facility (TTF) and Japan Korea Marker (JKM) are such important platforms. However, it should be underlined that TTF, Henry Hub and JKM operate in isolation from each other.

The main motivation of the study is that TTF, Henry Hub and JKM are separate entities. In this context, in this study, the nature of these disjointed formations is questioned in today's conditions where globalization has spread to every field. Therefore, the main claim of the study will be questioned the generally accepted assumptions and common beliefs in the literature that natural gas markets operate in isolation from each other. The main reason for this is that almost all the literature studies deal with the subject with qualitative methods and the deficiencies in the analysis through a quantitative systematic model. In the light of all these, the effect of the process that emerged in Europe on energy prices in the world's important markets will be analyzed using the "*Stochastic Volatility Model*".

2. NATURAL GAS AS A STRATEGIC ENERGY SOURCE

Natural gas is one of the hydrocarbon-based energy sources. And its formation dates back millions of years like oil (Demir, 2015:5). In direct proportion to natural gas, which build up to a part of daily life mostly for domestic activities and became one of the key inputs of activities in many fields. Eventually, global consumption of natural gas has increased, and it has become one of the dynamics that directly affects the developments in the international arena.

The qualities of natural gas play an important role in the worldwide increasing consumption. It is possible to deal with these characteristics of natural gas under two headings: structurally and functionally. First, its structural features, the most important characteristics of natural gas are that it is a significant substitute for petroleum, and it is one of the clean energy sources. The reason is that the main content of natural gas consists of one carbon atom and four hydrogen atoms. Natural gas, which is colorless, odorless, and tasteless also its pollutant effects after combustion is at very low levels compared to the other hydrocarbon-based sources. In fact, it is clearly seen that natural gas is very advantageous in terms of environmental factors compared to oil and coal. For instance, compared to the use of coal to achieve the same heat values, natural gas absorbs 50 percent less carbon dioxide and 20 percent less nitrogen oxide, which is one of the indicators of this (Demir, 2015: 7). Herein another title in the characteristics of natural gas emerges. It is possible to relate these qualities, which we can consider under the heading of effects, to externalities in a way. These externalities are mostly associated with climate change. Therefore, it is possible to discuss the important roles it played in reducing the problems that negatively affect energy security, especially its positive contribution to environmental negativities, under this heading. It is inevitable that natural gas will be among the strategic energy sources that are increasingly preferred in electricity generation, industry, and related sectors in many geographies of the world. The fact that natural gas has become one of the strategic energy resources will be more understandable when evaluated together with the activities around the world.

2.1. General Outlook of Natural Gas Activities

Following the first oil crisis in 1973, the importance of energy was better understood by all the countries of the world. However, countries have taken important steps in the diversification of energy resources and the use of alternative energy resources, especially energy importing countries have undertaken various policies for the sustainable use of energy (Gürsoy, 2021: 70).

As a result of the diversification strategy, with the energy security threats becoming more evident after the crises experienced since 1973, the increasing trend towards natural gas has become a resource that is consumed in size, especially since the 21st century. However, the demand for natural gas, which is in the top three of the world's primary energy mix, is expected to increase faster than oil and coal in the medium and long term due to the decrease in prices, the abundance of supply and its role in reducing carbon emissions. The expected increase is expressed as approximately 50 percent over a 25-year period. In sum, there is a noticeable increase in activities related to natural gas, which is one of the strategic energy sources. Although it is at lower levels compared to oil, it is possible to state that the global development of natural gas has the potential to overtake coal.

Colorless, odorless, and non-toxic natural gas is also called "blue fire" because of the color it takes when burned. Blue fire, which is chemically a derivative of petroleum, is asymmetrically distributed over the earth's surface, just like other fossil energy sources. Inferences obtained from statistical data are among the most important indicators of the said asymmetrical distribution. Total natural gas reserves of the world, which is declared as 196.6 trillion m^3. Its distribution is as follows: 75.5 trillion m^3 is at the Middle East, 66.7 trillion m^3 is at Europe and the Commonwealth of Independent States, 18.1 trillion m^3 is Asia-Pacific, 14.4 trillion m^3 is in Africa, 13.9 trillion m^3 is in North America, 8.2 trillion m^3 is in Central and South America. Also, distribution as a percentage of total world natural gas reserves is as follows: 38.4 percent in the Middle East, 33.9 percent in Europe and the Commonwealth of Independent States (CIS), 9.2 percent in Asia-Pacific, 7.3 percent in Africa, and 7.1 percent in North America. and 4.2 percent is the geography of Central and South America (BP, 2019: 30).

For natural gas, data on production and consumption are guiding light. First, it is witnessed that the production of natural gas in the last ten years has increased worldwide. The annual average increase in natural gas production between 2009 and 2021 is expressed as 3.3 percent. In this context, the region in the first place regarding natural gas production activities for 2020 is 28.8 percent North America. The CIS geography ranks second and third, respectively, with a share of 20.8 percent and the Middle East with a share of 17.8 percent. When considered in terms of consumption, the resulting ranking is North America (27 percent), Asia-Pacific (22.5 percent) and the Middle East (14.4 percent). The annual increase in natural gas consumption in the last ten years has been expressed as approximately 3 percent (BP, 2021: 37).

2.2. Overview of LNG Activities

The problems that have arisen in connection with the increase in the consumption of natural gas have brought about the search for different alternatives on a global scale. In other words, along with the advantages of natural gas, some disadvantages have emerged due to its qualities. And there has been a tendency towards alternatives to minimize the negative effects. It is possible to deal with the negativities related to the qualities of natural gas within the framework of transportation and storage. As it is known, natural gas is an energy source that cannot be stored in large quantities and can be transported most efficiently through natural gas pipelines. Its qualities in this context directly transform natural gas into an entity that can be politicized between producer and consumer economies. Therefore, while some of the characteristics of natural gas contribute positively to energy security, others make it a source of threat. It is possible to consider the energy crises related to natural gas between Russia and European countries and the statements in the literature that it has turned into a weapon in this context. Therefore, the serious negative impact of these events on energy security has made it inevitable for alternatives to come to the fore.

Contrary to expectations, the emergence of alternatives has not been within the framework of a new energy source. In this context, it is possible to state that the orientation of the economies in this direction is to introduce practices within the framework of minimizing the negative effects of natural gas as much as possible. Therefore, we can say that the attempts to reduce the negative effects are in the direction of eliminating the problems related to natural gas. It is possible to deal with the increase in LNG consumption, which is one of the derivatives of natural gas, in this context.

Another option, which has become increasingly important in recent years, but also requires a great deal of dedication in terms of cost, is the transportation of natural gas by liquefaction. The new form that natural gas takes because of cooling and compression processes is expressed as LNG. Liquefied and compressed in terms of volume, natural gas can be transported as LNG by custom-built ships. This makes it possible to transmit natural gas, like oil, on a global scale by sea. LNG, which has started to gain more importance with the global natural gas demand, has also increased its share in international trade significantly in the last 40 years. The said increase is an average of 15 percent annually. In future projections, it is claimed that the increase in LNG consumption will reach 23 percent by 2050. ("McKinsey Global Gas Outlook To 2050, 2021"). Considering all this, we can say that LNG has become an important component in the global gas industry. The fact that since the first LNG shipment was made in 1959, the volume of tradable natural gas reached 300 billion cubic meters last year is one of the indicators of this. Qatar and Malaysia are the most important exporters in the global LNG trade, while Japan and South Korea are importers.

2.3. General Outlook of Natural Gas and Markets in International Trade

The increasing trend in the global consumption of natural gas and LNG continues continuously. In this context, it is possible to state that these resources, which have become important commodities in the global energy trade, are becoming more and more preferred fuels. Considering its importance and increasing consumption rates, developments within the framework of formations in which natural gas is handled as a commercial commodity are not yet at the expected level. So much so that today, unlike oil, it is not possible to fully talk about the formation of a market that covers the global natural gas trade. Therefore, it is witnessed that the activities within the scope of today's natural gas and LNG trade are carried out through seemingly disjointed formations in which different pricing methods are used. In this direction, first, the methods used for pricing natural gas will be included in the study.

3. PRICING OF NATURAL GAS

Natural gas prices are generally divided into three categories depending on the degree of regulation, market competitiveness and market liquidity; (Melling, 2010:15).

- Government-regulated prices, usually based on the cost of service (long-term contracts),

-Pricing for substitute fuels (commonly known as oil-indexed pricing)

-Spot market pricing in competitive gas markets (competition of gas with gas).

In this context, it is possible to state that the prices of natural gas are not simply determined by the forces of supply and demand (Stern and Imsirovic 2020:7). In other words, methods that may differ from conventional approaches can be used in the pricing process of natural gas. In this respect, we can say that most of the theoretical information in the literature is not at a level to guide researchers. Because most of the theoretical information in the literature is based on the use of natural gas as an important energy source and commercial commodity. Therefore, it is possible to state that several facts beyond theoretical knowledge should be considered when considering the pricing of natural gas. One thing to consider, for example, is that gas pricing is a product of discriminatory monopoly behavior resulting from natural monopoly in many markets where, thanks to their monopoly position, sellers or buyers can segment local and international markets and charge customers different prices (Stern and Imsirovic 2020:7).

Although the first two of the pricing methods are generally considered together, they are natural gas purchase-sale contracts, which are determined by agreements between the parties and where activities are generally carried out within the scope of long-term contracts. In determining the prices in this context, the prices of energy resources, which are alternatives to natural gas, are commonly taken as a reference or indexed to the prices of alternative fuels. The energy source that is taken as a reference or to which prices are indexed is commonly crude oil. In addition, from time to time, it is possible to encounter contracts in which natural gas prices are indexed to petroleum products or taken as a reference. This methodology for pricing natural gas is also known as oil-indexed pricing. The oil-indexed pricing approach is widely adopted in Continental Europe, North Africa, and Asian markets. The duration of long-term contracts, in which the oil-indexed pricing approach is adopted, generally varies between 20-25 years.

Another method is described as the gas-to-gas competition model. At this point, to better understand the method in question, which is associated with the liberalization of natural gas markets, it is necessary to address several concepts first. It is possible to consider the concept of the hub in this context. In this context, it should be underlined that the concept of the hub, which has been witnessed to be widely used for information systems, has become a part of the energy jargon with the developments in the markets. Therefore, in defining the concept of the hub in energy jargon, it is extremely important to name it as the place where a certain activity is defined. The concept of the hub in energy jargon can be defined as the place where the energy factor is heavily processed physically or virtual. However, the concept in question is a sui generis structure in which its physical and commercial infrastructure is supported and built on basic principles, which expresses a structure different from any formation or platform in many respects. In this context, some requirements become important for the operability of the hub. When we look at world examples, the prominent factor is; For a successful exchange to occur, the legislation that supports the physical and commercial infrastructure together is the necessity of the commercial and the supporting market structure. It is also seen that there are a few activities in the regions or countries that are hubs. These; gas or oil collection and processing, transmission, storage, marketing and trading, distribution retail and value-added services. Whether it is an energy base or an exchange, the commercial purpose of the bases; to provide reference to price formation to support an efficient, transparent, and competitive market (Belet, 2016, ss. 190-198, s. 192).

As a result, we can define the concept of “hub” as market formations where natural gas trade occurs, both raw and converted into LNG form through pipelines, where buyers and sellers come together. The structural and functional characteristics of the mentioned natural gas trade centers vary according to the conditions of the age. In this context, it is possible to consider the physical hubs in the first years of the establishment of natural gas trade centers and the virtual hubs that emerged with the development of technology. To put it more clearly, we can say that natural gas trade centers are structured in two different ways, physical and virtual. For example, Henry Hub, TTF and JKM are internationally referenced entities.

4. METHODOLOGY

The study aimed to investigate the general acceptions in the literature that natural gas markets operate independently of each other. As a matter of fact, these assumptions and claims are mostly based on qualitative methods. In this study, the volatility interaction and transfer between the Henry Hub (HH), Japan Korea Marker (JKM) and Title Transfer Facility (TTF) platforms, which are the pioneers of natural gas trade; The Dynamic Correlation Multivariate Stochastic Volatility (DC-MSV) model was developed by Yu and Meyer (2006).

Stochastic Volatility (SV) models have emerged as an alternative to Autoregressive Conditional Variance (ARCH) models in the analysis of financial time series with characteristic features. Compared to ARCH/GARCH models, these models give more successful results in the case of excessive kurtosis encountered in future forecasts and financial data for the next period (Das et al. 2009: 84). In stochastic volatility models, volatility is modelled as an unobservable, latent variable.

Basic stochastic volatility models were introduced to the literature by Taylor (1986) and Harvey et al. (1994) to a multivariate structure. These models reveal the interdependence of market returns, volatility interactions with each other, and volatility spillovers between markets. The weakness of the basic stochastic volatility models is that the conditional correlation matrix does not have a time-varying structure. As a solution to this problem, the Dynamic Conditional Correlation Stochastic Volatility (DC-MSV) model was developed by Yu and Meyer (2006).

In Multivariate Stochastic Volatility (DC-MSV) models, the time-dependent variation of the correlation coefficient shows a dynamic feature. The DC-MSV model proposed by Yu and Meyer (2006) is as follows:

$$
\begin{aligned}
&r_t = a + \beta r_{t-1} + y_t \\
&y_{A,t} = \exp\left(h_{A,t}/2\right)\varepsilon_{A,t} \\
&y_{B,t} = \exp\left(h_{B,t}/2\right)\varepsilon_{B,t} \\
&p_t = cov(\varepsilon_{A,t}, \varepsilon_{B,t}) = \frac{\exp(q_t) - 1}{\exp(q_t) + 1} \\
&q_{t+1} = \psi_0 + \psi_1(q_t - \psi_0) + \sigma_q v_t \\
&h_{A,t+1} = \mu_A + \phi_A\left(h_{A,t} - \mu_A\right) + \phi_{AB}\left(h_{B,t} - \mu_B\right) + \eta_{A,t} \\
&h_{B,t+1} = \mu_B + \phi_B\left(h_{B,t} - \mu_B\right) + \phi_{BA}\left(h_{A,t} - \mu_A\right) + \eta_{B,t}
\end{aligned}
\tag{1}
$$

The $r_t = a + \beta r_{t-1} + y_t$ model given in equation 1 above is a first-order vector autoregressive process following the mean model that takes bivariate structure into account. It is defined as $r_t = \left(r_{A,t}, r_{B,t}\right)', y_t = \left(y_{A,t}, y_{B,t}\right)'$. The constant parameters μ_A and μ_B in the volatility model represent the p time-varying dynamic correlation coefficient. $h_{A,t}$, A shows the volatility of the variable A, and $h_{B,t}$ indicate the volatility of the variable B. The

ϕ_A parameter measures the persistence volatility of A, the ϕ_B measures the persistence (consistency) volatility of the B parameter.

The statistical significance of these parameters and the fact that they have values close to 1 indicate that the volatility in the variable has a permanent effect. ϕ_{AB} and ϕ_{BA} indicate the interaction between the volatility of the variables. The statistical significance of the ϕ_{AB} shows that the volatility in the B variable has an effect on the volatility in the A variable; The statistical significance of the ϕ_{BA} indicates that the volatility occurring in variable A has an effect on the volatility occurring in variable B. The parameters $\sigma^2_{\eta A}$ and $\sigma^2_{\eta B}$ which are the variances of the volatility processes in the variables, measure the uncertainty (predictability) of the volatilities in the future periods. There is an asymmetrical relationship between the parametersϕ_A and $\sigma^2_{\eta A}$ as well as the parameters ϕ_B and $\sigma^2_{\eta B}$. As the volatility persistence parameter ($\phi_A$or ϕ_B) for the variable in question approaches (1), the variance ($\sigma^2_{\eta A}$ or $\sigma^2_{\eta B}$) of the volatility process approaches zero. This indicates that the volatility in the variable is predictable.

4.1. Data Set

The variables used in the study are listed in Table 1. These variables consist of monthly data between the period of 01.12.2017-01.12.2021.

Tablo 1. Dataset and Descriptive Concepts

Variable	Variable Description	Period	Source
HH	Henry Hub (HH),	01.12.2017-01.12.2021	Investing.com
JKM	Japan Korea Marker (JKM)		
TTF	Title Transfer Facility (TTF		

4.2. Findings

The return series of the variables used in the study were calculated with the formula$r_t = (\ln {}^{P_t}/_{P_{t-1}})$. The graphs of the return series are presented in Figure 1. In this direciton, the volatility interaction and transfer between the pioneers of natural gas trade, Henry Hub (HH), Japan Korea Marker (JKM) and Title Transfer Facility (TTF); The Dynamic Correlation Multivariate Stochastic Volatility (DC-MSV) model was developed by Yu and Meyer (2006).

The DC-MSV model was used to observe the time-dependent correlation between the returns as well as the volatility interaction of the variables. The Markov Chain Monte Carlo (MCMC) method, which is a Bayesian method, is used for the estimation of DC-MSV models. Unlike other estimation methods, the MCMC method does not require numerical optimization, and this feature is important if the number of parameters to be estimated is high. The MCMC method provides the opportunity to provide latent volatility estimates and distributions of these estimates together with the parameters. This method generates variables from a certain multivariate distribution by repeatedly sampling a Markov chain, whose invariant distribution is the target of the density function of interest (Hepsag, 2013:132).

The analysis of the DC-MSV model was carried out with the WinBUGS 1.4 package program. In the analyzes made with 50,000 samples, 40,000 samples were taken into account by excluding the first 10,000 samples as initial values by the estimation method. Estimation results are given in Tables 2, 3 and 4.

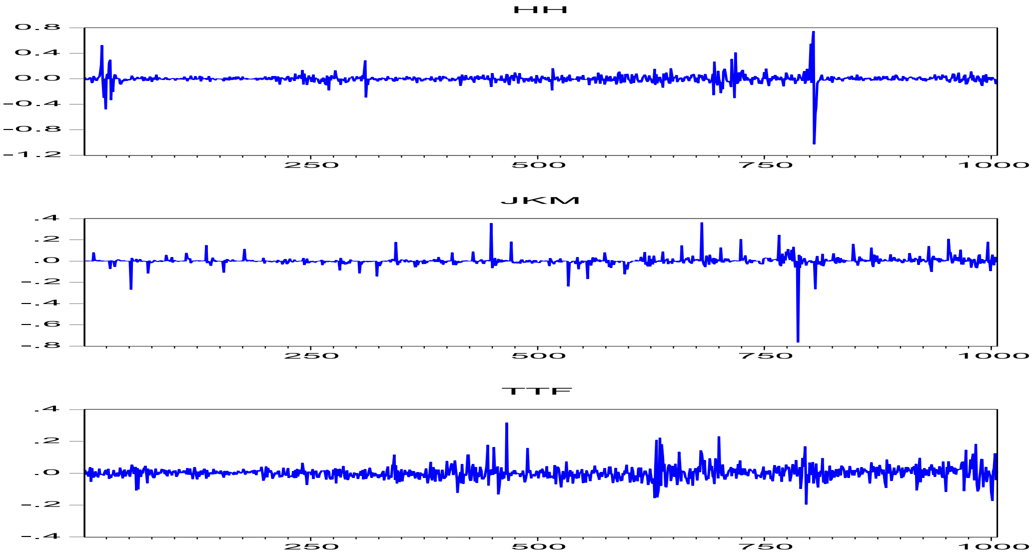

Figure 1. Graphs of Return Series

Table 2. DC-MSV Model Results of HH and TTF

	Medium	**Standard Deviation**	**MC Error**	**Confidence interval (%95)**	
μ_{HH}	-6.623*	0.2764	0.005652	-7.153	-6.046
μ_{TTF}	-6.879*	0.2831	0.008896	-7.378	-6.309
ϕ_{HH}	0.9051*	0.02342	7.66E-04	0.8541	0.9457
ϕ_{HHTTF}	0.07345*	0.02578	7.30E-04	0.02721	0.1282
ϕ_{TTF}	0.9605*	0.01578	5.51E-04	0.9253	0.9869
ϕ_{TTFHH}	0.001859	0.01058	2.84E-04	-0.01776	0.02381
$\sigma_{\eta HH}$	0.5123	0.05972	0.00235	0.4068	0.6372
$\sigma_{\eta TTF}$	0.2867	0.04265	0.002018	0.2023	0.3729
ψ_0	0.105	0.2206	0.01218	-0.08553	0.662
ψ_1	0.8599*	0.09903	0.005367	0.6234	0.9807

*: Statistically significant at the 5% level.

According to the DC-MSV model results of Henry Hub (HH) and Title Transfer Facility (TTF) returns given in Table 2, the ϕ_{HH} parameter, which expresses the Henry Hub index return's own volatility, is statistically significant at the 5% level. The fact that this parameter is close to 1 with a value of 0.9051 indicates that there are intense volatility clusters in the Henry Hub index and that volatility is permanent. A volatility shock in the Henry Hub index has a continuing effect on its volatility. The ϕ_{TTF} parameter, which expresses the volatility of the Title Transfer Facility index return, is statistically significant at the 5% significance level. The parameter close to 1 with a value of 0.9605 indicates volatility clustering.

ϕ_{HHTTF} parameter, which shows the existence of interaction from TTF index volatility to HH index volatility, is statistically significant. Accordingly, there is a direct transfer from the TTF index volatility to the HH index volatility, and the 1% shock that increases the volatility in the TTF index increases the HH index volatility by 0.07%. from the other hand, the ϕ_{TTFHH} parameter, which shows the existence of an interaction from HH index volatility to TTF index volatility, is statistically insignificant.

The fact that the ϕ_{HH} and ϕ_{TTF} take values close to 1 and the $\sigma^2_{\eta HH}$ and $\sigma^2_{\eta TTF}$ take values close to zero indicates that the volatility in both indices is predictable. However, the statistical significance of the ψ_1 parameter shows a dynamic feature that changes over time. Based on the dynamic correlation coefficient obtained as 0.8599, there is a positive and strong relationship between the variables.

Table 3. DC-MSV Model Results of JKM and HH

	Medium	Standard Deviation	MC Error	Confidence interval (%95)	
μ_{JKM}	-8.807*	0.1819	0.001485	-9.168	-8.448
μ_{HH}	-6.685*	0.2513	0.002501	-7.182	-6.187
ϕ_{JKM}	0.5245*	0.05156	8.18E-04	0.4191	0.6209
ϕ_{JKMHH}	0.2184*	0.06293	0.00103	0.09955	0.3465
ϕ_{HH}	0.9347*	0.01878	5.46E-04	0.8943	0.968
ϕ_{HHJKM}	0.001582	0.01427	3.27E-04	-0.02569	0.03027
$\sigma_{\eta JKM}$	1.847	0.09439	0.001586	1.667	2.035
$\sigma_{\eta HH}$	0.4809	0.05224	0.002017	0.3861	0.5901
ψ_0	0.05171	0.1052	0.003704	-0.1637	0.2532
ψ_1	0.9497*	0.0271	0.001399	0.8776	0.9828

*: Statistically significant at the 5% level.

According to the DC-MSV model results of Japan Korea Marker (JKM) and Henry Hub (HH) returns, the ϕ_{JKM}, which expresses the volatility of the Japan Korea Marker (JKM) index return, is statistically significant at the 5% level. The fact that this parameter is not close to 1 with a value of 0.5245 indicates that there is no intense volatility clustering in the JKM index and that volatility is not permanent. The ϕ_{HH} parameter, which expresses the volatility of the Henry Hub index return, is statistically significant at the 5% significance level. A parameter close to 1 with a value of 0.9347 indicates that there is volatility clustering and that a volatility shock in the Henry Hub index has a continuous effect on its volatility.

ϕ_{JKMHH} is statistically significant. Accordingly, there is a direct transfer from the TTF index volatility to the HH index volatility, and the 1% shock that increases the volatility in the HH index increases the JKM index volatility by 0.21%. The ϕ_{HHJKM} parameter, which shows the existence of an interaction from JKM index volatility to HH index volatility, is statistically insignificant.

The fact that the ϕ_{JKM} does not take a value close to 1 and the $\sigma^2_{\eta JKM}$ parameter takes a value far from zero indicates that the volatility in the JKM index is not predictable. However, since the ϕ_{HH} has a value close to 1 and the $\sigma^2_{\eta HH}$ parameter has a value close to zero, it has been determined that the volatility in the HH index is predictable. However, the statistical significance of the ψ_1 parameter shows a dynamic feature that changes over time. Based on the dynamic correlation coefficient obtained as 0.9497, there is a positive and strong relationship between the variables.

Table 4. DC-MSV Model Results of TTF and JKM

	Medium	Standard Deviation	MC Error	Confidence interval (%95)	
μ_{TTF}	-6.944*	0.2613	0.006499	-7.458	-6.406
μ_{JKM}	-8.686*	0.2481	0.004028	-9.194	-8.202
ϕ_{TTF}	0.9608*	0.01646	5.52E-04	0.9248	0.9891
ϕ_{TTFJKM}	0.002974	0.01167	3.77E-04	-0.01915	0.0265
ϕ_{JKM}	0.4938*	0.05532	0.001177	0.3816	0.5972
ϕ_{JKMTTF}	0.4352*	0.09295	0.002456	0.2619	0.6272
$\sigma_{\eta TTF}$	0.2767	0.04056	0.001909	0.1996	0.3584
$\sigma_{\eta JKM}$	1.693	0.08503	0.001563	1.531	1.865
ψ_0	0.1954*	0.08862	0.004491	0.04356	0.3602
ψ_1	0.8435*	0.1204	0.006561	0.5273	0.9694

*: Statistically significant at the 5% level.

According to Table 4, the ϕ_{TTF} parameter, which expresses the volatility of the Transfer Facility (TTF) index return, is statistically significant at the 5% level. The fact that this parameter is close to 1 with a value of 0.9608 indicates that there is an intense volatility clustering in the TTF index and that volatility is permanent. Accordingly, a volatility shock occurring in the TTF index has a continuous effect on its volatility. The ϕ_{JKM} parameter, which expresses the volatility of the Japan Korea Marker (JKM) index return, is statistically significant at the 5% significance level. However, the fact that the parameter is far from 1 with a value of 0.4938 indicates that there is no volatility clustering.

The parameter ϕ_{TTFJKM}, which shows the existence of interaction from JKM index volatility to TTF index volatility, is statistically insignificant. The ϕ_{JKMTTF} parameter, which shows the existence of an interaction from TTF index volatility to JKM index volatility, is statistically significant at the 5% level. Accordingly, there is a direct transfer from the TTF index volatility to the JKM index volatility, and the 1% shock that increases the volatility in the TTF index increases the JKM index volatility by 0.43%.

The fact that the ϕ_{TTF} TTF parameter takes a value close to 1 and the $\sigma^2_{\eta TTF}$ parameter has a value close to zero shows that the volatility in the TTF index is predictable. However, since the ϕ_{JKM} parameter is far from 1 and the $\sigma^2_{\eta JKM}$ parameter is far from zero, it can be said that the volatility in the JKM index is unpredictable. However, the statistical significance of ψ_0 and ψ_1 parameters shows a dynamic feature that changes over time. Based on the obtained dynamic correlation coefficient, there is a positive and strong relationship between the variables.

The fact that the ϕ_{TTF} takes a value close to 1 and the $\sigma^2_{\eta TTF}$ has a value close to zero indicates that the volatility in the TTF index is predictable. However, since the ϕ_{JKM} is far from 1 and the $\sigma^2_{\eta JKM}$ is far from zero, it is possible to interpret that the volatility in the JKM index is unpredictable. However, the statistical significance of the ψ_0 and ψ_1 shows a dynamic feature that changes over time. Based on the obtained dynamic correlation coefficient, there is a positive and strong relationship between the variables.

5.CONCLUSION

Global consumption of natural gas and LNG is increasing day by day. Related to this natural gas markets have become more important. But, when compared to oil, it is extremely difficult to talk about the existence of a fully developed market mechanism for natural gas. However, the expression in question does not mean the absence of market mechanisms through which the commercial activities of natural gas are carried out. Therefore, it should be considered that there is not yet a global market structure for natural gas compared to oil.

Nowadays, it is witnessed that the natural gas trade is carried out through mechanisms that seem to be disconnected from each other. In this context, benchmark structures play an important role in relation to hub formations and pricing. While these hub formations play an important role in the functioning of natural gas markets as physical and virtual trade centers, benchmark formations come into play at the pricing stage. In the light of all these, it is possible to state that the natural gas trade in the world is shaped within the framework of hubs or benchmark formations divided into three disconnected regions. North America, Europe and Asia are the regions in question.

We can claim that it is extremely difficult not to be affected by these disjointed regions in today's conditions. So much so that in the trade of strategic energy resources such as natural gas, although it may seem disconnected in the era of globalization, it does not seem rational that the development in any part of the world triggers the dynamics in another market. To understand this situation more clearly, price movements in European markets should be considered together with those in other markets.

AUTHORS' DECLARATION

This paper complies with Research and Publication Ethics, has no conflict of interest to declare, and has received no financial support.

AUTHORS' CONTRIBUTIONS

Conceptualization, writing-original draft, data collection, editing – AÇE, methodology, formal analysis – EBE, Final Approval and Accountability – SG

REFERENCES

Belet, N. (2016). Avrupa Enerji Birliği (AEB) ve Türkiye'nin Bölgesel Enerji Hub'ı Olabilirliği: Fırsat ve Zorluklar European Energy Association (EEA) and Turkey's Regional "Energy Hub" Possibility: Opportunities and Challenges.

Das, A., Ghoshal, T. K., & Basu, P. N. (2009). A Review on Recent Trends of Stochastic Volatility Models. *International Review of Applied Financial Issues and Economics*, *1*(1), 83.

Demir, İ. (2015). Küresel Enerji Jeopolitiğinde Gaz İhraç Eden Ülkeler Forumu. *Dora Yayınları, Bursa*.

Harvey, A., Ruiz, E., & Shephard, N. (1994). Multivariate stochastic variance models. *The Review of Economic Studies*, *61*(2), 247-264.

Hepsağ, A. (2013). *Çok değişkenli stokastik oynaklık modelleri: petrol piyasası ile finansal piyasalarda işlem gören sanayi sektörü endeksi arasındaki oynaklık etkileşimi üzerine bir uygulama* (Doctoral dissertation, İktisadi Araştırmalar Vakfı).

Melling, A. (2010). Natural gas pricing and its future: Europe as the battleground. Carnegie Endowment, Washington D.C

Gürsoy, S. (2021). Enerji Fiyatları ve Jeopolitik Risk İlişkisi Analizi. *Uluslararası Ekonomi Siyaset İnsan ve Toplum Bilimleri Dergisi*, 4 (2) , 69-80.

Stern, J., & Imsirovic, A. (2020). A Comparative History of Oil and Gas Markets and Prices: is 2020 just an extreme cyclical event or an acceleration of the energy transition?. Research paper Oxford Institute of Energy Studies.

Taylor, S. J. (2008). *Modelling financial time series*. world scientific. Wiley, Chichester.

Yu, J., & Meyer, R. (2006). Multivariate stochastic volatility models: Bayesian estimation and model comparison. *Econometric Reviews*, *25*(2-3), 361-384.

https://www.mckinsey.com/industries/oil-and-gas/our-insights/global-gas-outlook-to-2050, 13 December 2021.