Attractiveness of Clean Energy Stocks in Europe: The importance of shocks in oil and gas prices

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Abstract

Europe is heavily dependent on both oil and gas imports. This article identifies supply and demand shocks in the oil and gas market using monthly data (from January 2008 to December 2021) and explores their impact on clean energy stock returns in Europe. Our results show that a negative gas supply shock positively affects clean energy stocks, while a negative shock in global oil supply does not have a significant effect on clean energy stocks throughout the period studied. Moreover, both oil-specific demand shocks and gas-specific demand shocks positively affect the stock returns of clean energy companies. Finally, the positive effect of economic demand shocks on the stock returns of clean energy lasts longer in the model with oil price shocks than in the model with gas price shocks. The previous results suggest that clean energy is a substitute to gas and oil. Consequently, as prices increase, like in today´s context due to the Ukrainian conflict, we are to observe a sharp increase in clean energy returns.

Keywords: oil, gas, clean energy, EU, Europe, VAR, value-at-risk

JEL Classification: C2, D12, Q4

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1. Introduction

Europe is heavily dependent on oil and gas imports. In the context of rising oil and gas prices, the question of whether this context will push for more investment in clean energy gains importance as an alternative way for Europe to ensure the security of supply. Herein we

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investigate how the EU's clean energy stock returns respond to oil and gas price shocks. In the related literature, there are studies examining the effects of oil price shocks on different dynamics such as macroeconomic aggregates and agriculture. The relationship between oil price shocks and macroeconomic aggregates has been examined for the first time by Hamilton in 1983 for the US market. Studies focusing on the effects of oil price shocks on macroeconomic aggregates such as production or employment rates have proliferated since then (see, Kilian, 2009; Kilian and Vigfusson, 2011; Herrera et al., 2019; Wen et al. 2021, amongst others). Other related studies have focused on the impact of oil price shocks in the industrial sector (Scholtens and Yurtsever, 2012; Herrera, 2018), or in monetary policy (Natal, 2012; Kim et al., 2017). In fact, the relationship between oil price shocks and financial markets has been a hot topic in recent years (Kilian and Park, 2009; Degiannakis et al., 2014; Ready, 2016; Krokida et al., 2020; Demirer et al., 2020; Kielmann et al., 2021)as well as the impact of oil price shocks on agricultural commodity pricing (Wang et al., 2014; Umar et al., 2021).

There is a vast literature that investigates the relationship between natural gas and crude oil prices (Pindyck, 2004; Brown and Yücel, 2008; Zamani, 2016; Jadidzadeh and Serletis, 2017). Besides, numerous studies have been conducted to understand the behavior of the natural gas market, particularly what drives natural gas prices (Nick and Thoenes, 2013; Hou and Nguyen, 2018; Ji et al., 2018; Hailemariam and Smyth, 2019; Rubaszek et al., 2021).

However, only a few studies have examined the interaction between natural gas and the stock returns of clean energy companies. For example, Xia et al. (2019) focus on the link between five fossil energy-related products (including oil and gas) and renewable energy stock returns (ERIX) by using a network approach. They create four networks of returns, namely original, positive, negative, and extreme returns, to better explore the interdependence between fossil energy-related and renewable energy prices in common, good news, bad news, and extreme market conditions. They show that electricity, oil, and coal have different impacts on renewable energy development regarding the first network, i.e. at the “original” return level; this means that there is a strong substitution relationship between these three sources and renewable energy. Ghabri et al. (2021) investigate how oil and natural gas price shocks affect clean energy stock markets, especially due to post-pandemic oil price shocks by applying a time-varying VAR model and find that ECO returns are more affected by oil price shock than ERIX returns. Besides, after the crude oil shocks, renewable energies did not respond to the natural gas shocks. In turn, Wang et al. (2022) try to predict the volatility of clean energy stock returns and natural gas prices by using five uncertainty indices and seven global economic conditions. They detect that global economic conditions have more power than uncertainty indices to predict the volatility of natural gas and clean energy exchange-traded funds (ETFs). Existing literature doesn't focus on the relationship between gas price shocks and stock returns of clean energy companies as we do herein. Instead, there are few studies identifying gas price shocks. For example, Hou and Nguyen (2018) identify gas price shocks for the US as supply (represented by gas production), demand (represented by US industrial production index), and specific demand (represented by gas price) by employing a Markov switching VAR. They focus on the US natural gas market and analyze the US gas market's response to structural shocks in various regimes without focusing on the stock returns of clean energy. In addition to studies examining the effects of oil price shocks on clean energy stock returns using structural VAR (Henriques and Sadorsky, 2008; Zhao, 2020; Maghyereh and Abdoh, 2021[2]; Zhou and Geng, 2021), others study this same interaction with different models such as Markov-switching vector autoregressive models and multivariate GARCH models (Managi and Okimoto, 2013; Inchauspe et al., 2015; Pham, 2019; Zhang et al., 2020). The closest paper to this contribution is, Zhou and Geng (2021) that use risk shocks instead of an oil-specific demand shock and find that the oil demand and risk shocks have significant explanatory power on the returns of all new energy markets, while the oil supply shock has a minor effect. Aside from this methodological difference, herein we are the first ones to focus on the EU and specifically consider gas markets.

Studies at the European level look at the dynamics of oil price shocks at the industrial level (Scholtens and Yurtsever, 2012), and the relation between oil price shocks and the stock market (Degiannakis et al. 2014; Krokida et al. 2020). To the best of our knowledge, no study focuses on the relationship between oil price shocks and clean energy stock returns at the European level, which is our first contribution.

Additionally, especially due to the recent developments in the natural gas markets, herein we look at the effects of the changes in gas prices in terms of investment in clean energy technologies. The European Commission's endorsing gas as a transition fuel due to its capacity of serving as backup for intermittent renewables raises the question of whether gas is considered as a complementary energy source in European financial markets. Europe's high dependence on Russian gas and the increased risk of gas shortages due to of the conflict in Ukraine further emphasized the importance of understanding the impact of changes in gas prices. Herein we

[2] Maghyereh and Abdoh (2021) and Zhou and Geng (2021) apply different models in addition to SVAR.

contribute in this direction, by investigating the effects of gas price shocks on clean energy stock returns at the European level.

Our study contributes to the existing literature in three ways. First, while the literature generally focuses on crude oil price shocks, we extend this literature by describing the impact of shocks in the price of another fossil fuel: natural gas. In this regard, following the three structural shocks in the oil market described in the literature, we use the same method to identify gas price shocks. Then, knowing that the gas market is mostly regional, even after the introduction of the North American shale gas, we provide a complete representation of these shocks in Europe. Second, current literature mostly focuses on the relationship between oil price shocks and clean energy stock returns at the global level or in individual countries in Europe. Therefore, we extend the existing literature by focusing on the relationship between oil price shocks and clean energy stock returns at the European level, which seems to be the most appropriate given the importance of the European energy market. Third, we contribute to the literature by identifying the gas price shocks at the European level and then examine the effects of three different gas price shocks (gas supply shock, demand shock, and gas-specific demand shock) on the clean energy stock returns.

The main findings are as follows. First, a negative gas supply shock positively affects clean energy stocks, which means that clean energy is a substitute to gas for European investors. Instead, a negative shock in global oil supply does not have a significant effect on clean energy stocks throughout the period studied. This means that rising oil prices in the global market do not encourage investors to switch to clean energy in the European market. Second, the positive effect of the economic demand shock on the stock returns of clean energy lasts longer in the model with oil price shocks than in the model with gas price shocks. Third, both the oil-specific demand shock and the gas-specific demand shock positively affect the stock returns of clean energy companies. The previous results suggest that, as expected, there is a substitution effect between oil and clean energy stocks. Similarly, there is a substitution effect between gas and clean energy stock returns. This last result shows that, in terms of investment, gas is not really being considered as a complement to intermittent technologies as the recent considerations of the EU Commission could suggest.

The remainder of the paper is organized as follows. Section 2 describes the data. Section 3 describes the empirical methodology. Section 4 presents and discusses the empirical results. Section 5 concludes.

2. Data

We use monthly data over the period January 2008 to December 2021. The data is collected mainly from DataStream and the Bloomberg terminal. The period has been determined according to the availability of data.

2.1. Oil price shocks and clean energy

Our data consist of global crude oil production, Brent spot prices, the EU industrial production index (IPI), and the European renewable energy index (ERIX). In order to detect the oil supply shock, we will use the percent change in the global crude oil production by taking the log difference of world crude oil production in thousand barrels per day, instead of just the oil production in Europe. Because the EU relies on net imports for 96.96% of consumed crude oil and petroleum products. If ERIX is going to substitute oil production in Europe, oil production in the EU alone will not have a significant impact. To obtain the real oil price, the nominal price of Brent is deflated by the harmonized index of consumer prices (HICP). The real oil prices are expressed in log levels. To capture the EU's economic activity, we use the EU monthly industrial production index, take the first difference of the natural logarithm, and convert the index into a growth rate. We use EU IPI because we are looking at the local market, which is a net importer but has its demand dynamics. Regarding the stock returns of clean energy companies, we use ERIX to represent renewable energy development. ERIX is Europe's most representative renewable energy market index, comprising the ten largest and most liquid stocks in biofuels, geothermal, marine, solar, water, and wind (Societe Generale, 2022). The ERIX index is used in log levels.

2.2. Gas price shocks and clean energy

Our data consist of natural gas production, Dutch TTF (Title Transfer Facility) gas prices, the EU industrial production index, and ERIX. To define gas supply shock, we use natural gas production in terajoules[3]. There are basically two sources of gas supply in the EU which are production and gas storage capacity (Stern and Rogers, 2014) since the EU is a net importer of gas. Since imports are determined by the equilibrium of demand from the EU and supply from exporting countries, to consider an exogenous supply shock we consider total production (and not just imports) from the countries that serve the EU region. The total supply for Europe is then constructed summing its own production plus imports from its suppliers: Russia, Norway, and Algeria, and only to a lesser extent Qatar. Natural gas production enters the model as the percent change by taking the first difference of the natural logarithm. Then, the nominal price

[3] Since gas production data for Russia is obtained in million cubic meters, it is converted to terajoules.

of TTF is deflated by the harmonized index of consumer prices (HICP) to obtain the real price of gas[4] and expressed in log levels. We consider the Dutch TTF gas price because it is a leading European benchmark price[5]. Finally, we express the EU monthly industrial production index as the percentual change and ERIX is in log levels as indicated in the model above.

Fig. 1 shows the historical development of all the data used over the sampling period. The percent change in global crude oil production remained relatively stable until Covid-19. However, we observe that the percentage change in natural gas production fluctuates a lot. Weather events are an important factor in the demand for gas. One reason is that a difference between a cold and warm winter in Europe can easily increase gas demand by 20-30 bcm (Honoré, 2020). Covid-19 caused a slowdown in industrial production and mobility due to containment measures, as we can also observe. The real prices of oil and gas react to various developments in the markets. For example, both prices start to decrease after 2008, 2014, and 2019 in conjunction with the 2008 financial crisis, an increase in shale gas and oil production, and the global pandemic, respectively. After Covid-19, the rate of increase in gas price is higher than the rate of increase in oil price. This is partially the case because after the pandemic, storage was not sufficiently full and, when the economic activity regained dynamism, gas prices increased more than proportionally. ERIX experienced a rapid decline after the 2008 financial crisis. One of the most important reasons for this is the temporary stimulus packages implemented to promote clean energy before the crisis. Cuts in subsidies due to unregulated government support made the clean energy sector more fragile during the years following the financial crisis. Germany cut solar subsidies in 2010, while Italy limited subsidies for solar power that same year due to the crisis (Victor and Yanosek, 2011). The Czech Republic and Spain reduced tariffs on solar energy in 2010 (Tirado and Bloom, 2013). It was only in 2012 that ERIX started to increase.

[4] To obtain the real price of gas, we used HICP rather than US CPI that we use for obtaining the real price of oil because, unlike oil markets, natural gas markets are not global. Natural gas prices are mainly determined by regional supply and demand.

[5] Algeria and Qatar are not included in the empirical analysis due to data unavailability on monthly gas production.

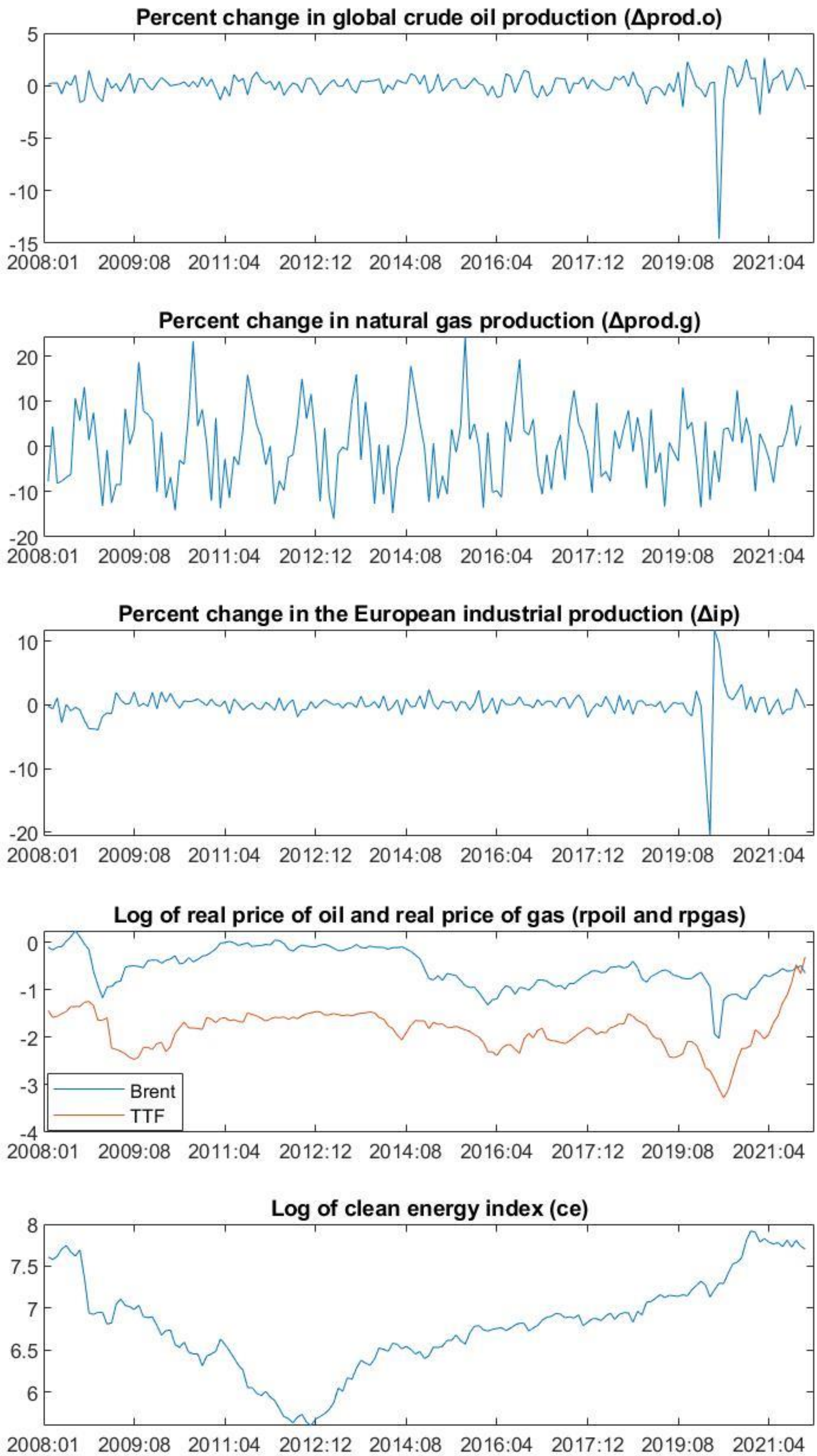


Fig.1. Historical evolution of the series, 2008:1-2021:12

3. Empirical Strategy

3.1. Model for the relation between oil price shocks and clean energy

Following the global crude oil model proposed by Kilian (2009), we add a fourth dimension and estimate a SVAR model using monthly data of the variables described in the previous section. Precisely we estimate the SVAR for the vector of time series $z_t = (\Delta prod.o_t, \Delta ip_t, rpoil_t, ce_t)$, where $\Delta prod.o_t$ is the percent change in global crude oil production, Δip_t is the percent change in EU industrial production index, $rpoil_t$ is the real price of oil, and ce_t is the clean energy index. Since we are interested in studying the European market, we use the EU industrial production index instead of the index in Kilian (2009) to capture fluctuations in crude oil demand. This index has been widely used as a measure of real economic activity at both country and global levels.

3.2. Model for the relation between gas price shocks and clean energy

We estimate the SVAR model using monthly data for the vector of time series $z_t = (\Delta prod.g_t, \Delta ip_t, rpgas_t, ce_t)$, where $\Delta prod.g_t$ is the percent change in gas production, Δip_t the percent change in EU industrial production index, $rpgas_t$ is the real price of gas, and ce_t denotes the stock returns of the clean energy companies.

3.3. Identification

The SVAR representation is

$$(1)\ A_0 z_t = \alpha + \sum_{i=1}^{24} A_i z_{t-i} + \varepsilon_t$$

where ε_t denotes the vector of serially and mutually uncorrelated structural innovations, $\varepsilon_t = (\varepsilon_t^{\Delta prod.o(\Delta prod.g)}, \varepsilon_t^{\Delta ip}{}_t, \varepsilon_t^{rpoil(rpgas)}, \varepsilon_t^{ce})'$. A_0 and A_i indicate the contemporaneous and lagged coefficient matrices, respectively. Assuming that e_t is the reduced-form error of the corresponding VAR innovations decomposing according to the expression $e_t = A_0^{-1}\varepsilon_t$, where A_0^{-1} has a recursive structure. The structural model of the form is

$$(2)\ e_t \equiv \begin{pmatrix} e_{1t}^{\Delta prod.o,t\ (\Delta prod.g,t)} \\ e_{2t}^{\Delta ip,t} \\ e_{3t}^{rpoil,t(rpgas,t)} \\ e_{4t}^{ce,t} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{pmatrix} \varepsilon_{1t}^{oil\ (gas)\ supply\ shock} \\ \varepsilon_{2t}^{economic\ demand\ shock} \\ \varepsilon_{3t}^{oil(gas) specific\ demand\ shock} \\ \varepsilon_{4t}^{clean\ energy\ stock\ shocks} \end{pmatrix}$$

Eq. (2) assumes that economic activity, real price of oil (gas) and clean energy stock returns don't have a simultaneous effect on supply of oil (gas), but with a delay of at least one month. This is because only exogenous events can affect oil (gas) production, i.e. OPEC production quota affects oil production while weather events affect gas production. On the other hand, supply of oil (gas) affects economic activity, real price of oil (gas) and clean energy returns contemporaneously, implied by the restrictions $a_{12}=a_{13}=a_{14}=0$. Also, it assumes that economic activity is only affected by supply shock and economic demand shocks, whereas oil (gas)-specific demand shock and clean energy stock shocks don't have a contemporaneous effect on economic activity, according to $a_{23}=a_{24}=0$. Accordingly, real price of oil (gas) changes instantaneously in response to oil (gas) supply shock, economic demand shock and oil(gas)-specific demand shock, but that real price of oil (gas) doesn't contemporaneously react to clean energy stock shocks ($a_{34}=0$). Finally, clean energy stock returns are affected by oil (gas) supply shock, economic demand shock, and oil(gas)-specific demand shock contemporaneously.

We explain fluctuations in the real oil (gas) prices in terms of three structural shocks: shocks to the global crude oil production (gas production) ("oil (gas) supply shock" denoted by ε_{1t}), shocks to the demand driven by EU economic activity, ("demand shock" denoted by ε_{2t}), and shocks from changes in precautionary demand for oil (gas) ("oil (gas)-specific demand shock" denoted by ε_{3t}).

Following Kilian (2009), we decompose the real oil price into three structural oil price shocks; the oil supply shocks, the demand shocks, and the oil-specific demand shock by using a structural VAR with lag order 24. The same order was applied in the model we defined gas price shocks. The period of study is from 2008:01 to 2021:12, including the Eurozone debt crisis, the pandemic period, and the OPEC+ agreement.

4. Results

Fig. 2 shows the time path of the structural shocks implied by the model. We find two important results. First, in the period of oil supply and gas supply disruptions after the 2011 Arab Uprising and the Eurozone debt crisis, clean energy stock returns decreased more in the model with gas price shocks. This can be explained by the fact that the gas market has an important local component whereas oil is a worldwide commodity. Moreover, clean energy stock returns clearly increased in 2013, when we observed gas price shocks suggesting an increase in the attractiveness of clean energy. Second, while the clean energy stock shock did not decrease after the global pandemic, there was a decrease in all other shocks. This may suggest the beginning of the decoupling between fossil fuel energy sources and economic activity through the increasing investment in clean energy.

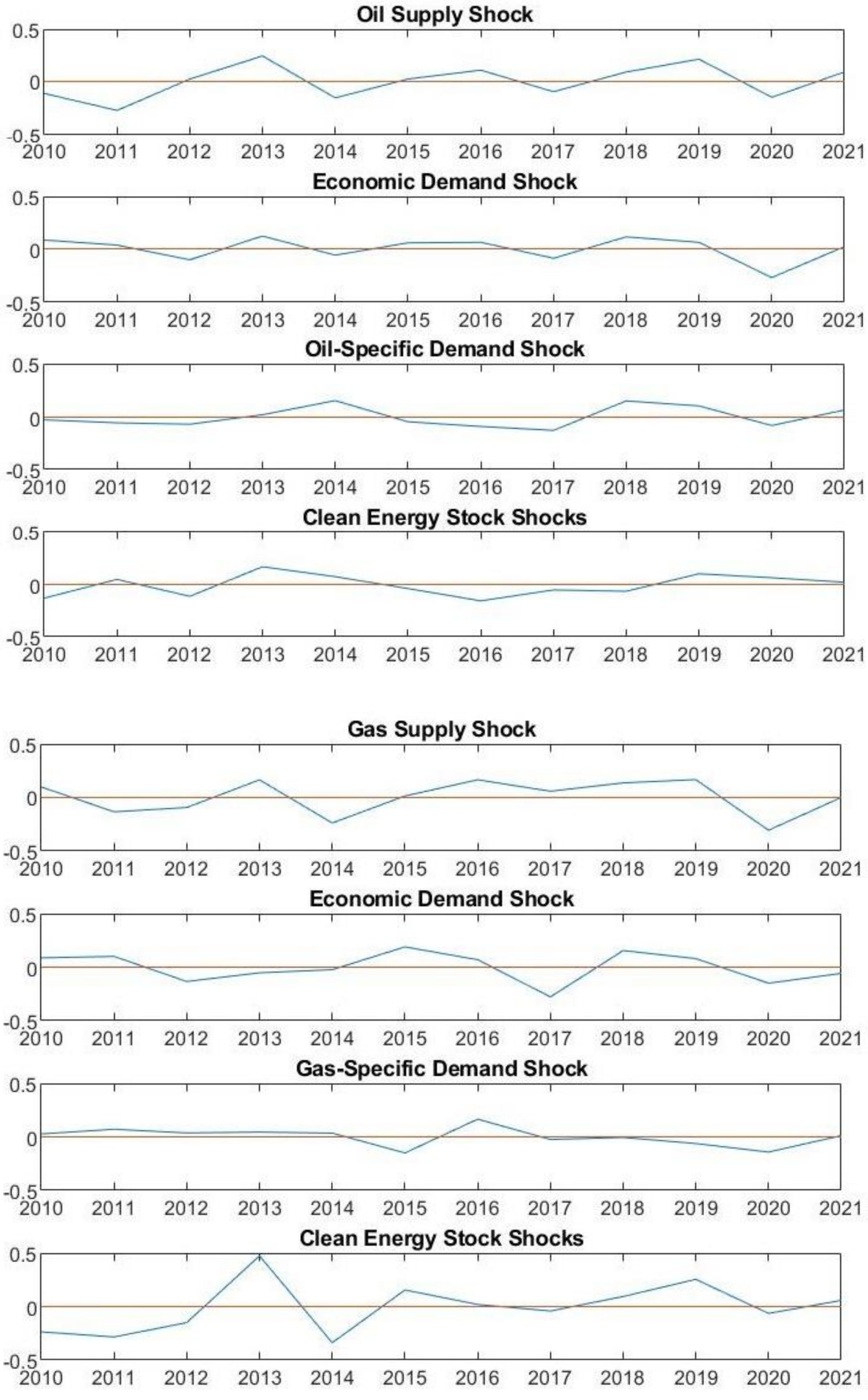


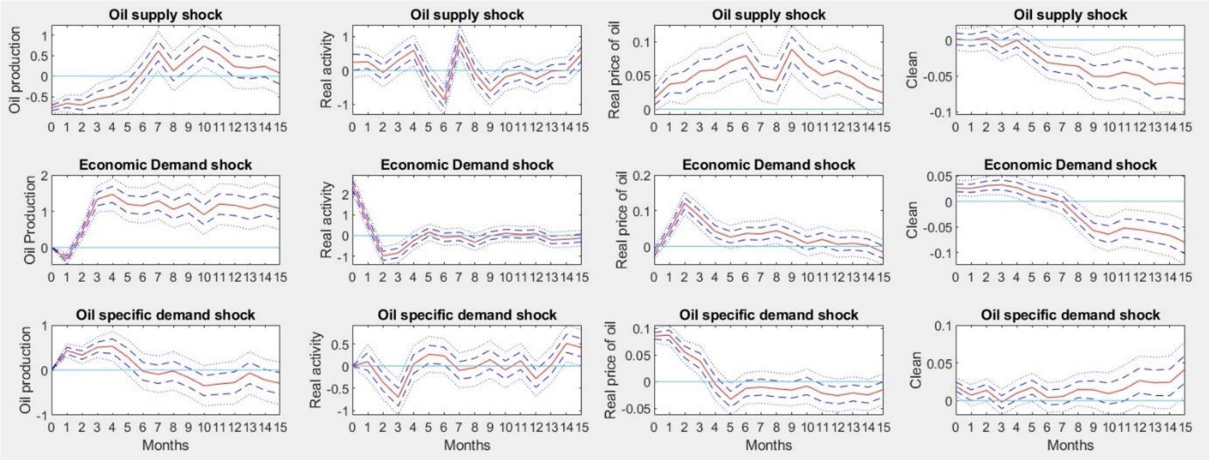
Fig.2. Historical evolution of the structural shocks

Fig. 3 represents the responses of global oil production, economic activity, the real price of oil, and clean energy stock returns to the three structural shocks. We observe that the oil supply shock has no stable effect on oil production.[6] Similarly, the impact of an oil supply shock on real activity is not significant throughout the whole period. Moreover, a negative shock in global oil supply has a statistically insignificant effect on clean energy stock returns in the first six months, followed by a statistically significant negative effect on clean energy stock returns. This means that rising oil prices in the global market do not encourage investors to switch to clean energy in the European market. Instead, oil-specific demand shocks inside the European region positively affect the clean energy stock returns. This supports the hypothesis of substitutability between oil and clean energy in the region.

The explanation of this result lies in the fact that oil-specific demand shocks capture the factors that affect oil prices because of the relationship between precautionary demand and the availability of future crude oil supply (Melek et al., 2015). The IEA (2020) predicts a decrease in global oil demand by 2040 compared to the pre-COVID scenarios. If there is increasing uncertainty about future oil supply shortfalls, precautionary demand for oil will increase and this will lead to a sudden increase in oil prices. Thus, some of the demand for oil will go to clean energy sources and there will be a substitution.

In terms of demand shock represented here by the EU's economic activity, the positive effect of the increase in economic activity on the stock returns of clean energy lasts for eight months and turns into a negative effect afterward. The positive effect can be explained by the fact that when there is a positive aggregate demand shock, oil demand will increase, and this will cause an increase in oil prices. The effects of rising oil prices on oil-importing countries will positively affect renewable energy investment in the EU (Karacan et al., 2021). Then, an economic demand shock causes a decrease in the real price of oil after the second month and a decrease in clean energy stock returns.

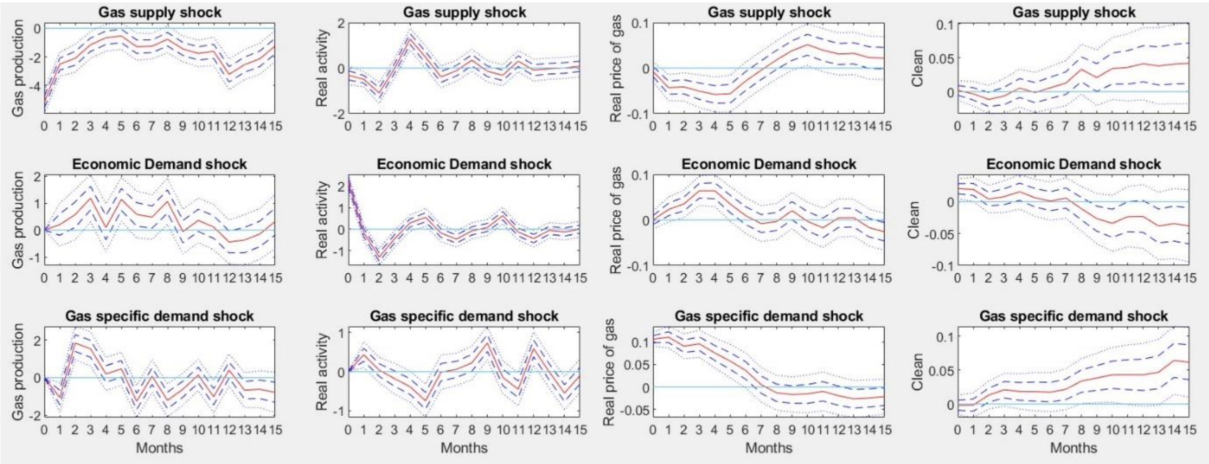
[6] In the first 5 months, there is an increase in oil production from -0.5 to 0. Then, in the sixth month, the standard error bands cross the zero axis, which means that oil supply shock has no significant effect on oil production. In the seventh month, a negative oil supply shock reduces oil production, then in the eighth month, the standard error bands cross the zero axis again. After that, oil production increases for 2 months, then falls again. At 12 months, it again has a statistically insignificant effect.



Note: One-standard error and two-standard error bands are represented by dashed and dotted lines, respectively.

Fig.3. Responses to one-standard-deviation structural shocks

Fig. 4 shows the responses of natural gas production, economic activity, the real price of gas, and clean energy stock returns to the three structural shocks. An unexpected decrease in gas production has a positive and statistically significant effect on clean energy stock returns according to one standard error band after the tenth month. This is probably explained by the fact that rising gas prices encourage investors to switch to clean energy. This substitution effect can also be observed in the positive effect of a gas-specific demand shock on clean energy stock returns. If the current demand for gas decreases, this may indicate that gas producers are switching to renewable energy. The positive effect of the demand shock on the stock returns of clean energy lasts for seven months but this positive effect is statistically insignificant after the first month and turns into a negative after the eighth month (and statistically significant based on a one-standard error band). In Europe, gas is used for both heating and electricity generation. Also, in some countries, such as France, gas is used as a transition fuel meaning that its usage is coupled with renewables. Instead, in countries like Germany, gas is used to generate electricity as a baseload. Therefore, Europe, which is dependent on gas imports for both heating and electricity generation, is greatly affected by the changes in natural gas prices. One of the best ways to get out of this situation is seen as the transition to renewable energy. The record high gas prices, especially after Covid-19, brought this transition to the fore. However, the transition to renewable energy did not go as expected. One of the reasons for this is that gas is used for heating. Even if gas prices rise drastically, the switch to renewable heat, such as heat pumps, is not easily encouraged to replace gas used for heating. Most homeowners need to change their heating source, but this is very difficult, so sudden changes in prices are not enough to encourage the transition to renewable heat (Keating, 2022). The share of fossil sources in electricity generation in the EU has decreased and has been replaced by renewable energy sources. The most important share of this decrease is the decrease in coal because in the period until Covid-19 Europe focused on coal, not natural gas. While gas prices rose to very high levels in Europe with Covid-19, renewable energy prices fell to very low levels. However, this did not encourage a large increase in renewables, instead causing renewable energy to replace gas (Keating, 2022; Moore, 2022). Ghabri et al. (2021) reveal that the announcement of Covid-19 affected the ERIX index more than the ECO index because Covid-19 created more uncertainty in Europe than in the US, especially in the early days of its spread. They also find that gas prices and the ERIX index are moving in the same direction. In the impulse response function above, a demand shock decreases both the real price of gas and clean energy stock returns after the third month.



Note: One-standard error and two-standard error bands are represented by dashed and dotted lines, respectively.

Fig.4. Responses to one-standard-deviation structural shocks

5. Conclusion

This study tackles the question of how different oil and gas price shocks affect the stock prices of clean energy companies in Europe by using a structural VAR. To the best of our knowledge, this is the first study of the relationship between oil price shocks and clean energy stock returns at the European level. In addition, previous studies on the natural gas market do not separately identify gas price shocks at the European level.

Our main findings are as follows. First, a negative gas supply shock positively affects clean energy stocks, which means that clean energy is a substitute to gas for European investors, contrary to what we could expect given the labeling of gas as green by the European Commission in July 2022. Instead, a negative shock in the global oil supply does not have a statistically significant impact throughout the period studied. This means that rising oil prices in the global market do not encourage investors to switch to clean energy in the European market. This may be showing a lack of credibility in the European agenda on green transportation. Second, we reasonably find that both the oil-specific demand shock and the gas-specific demand shock positively affect the stock returns of clean energy companies, meaning that there is a king-of-scale effect in demand that extends to all energy sources. Finally, we find that the positive effect of the economic demand shock on the stock returns of clean energy lasts longer in the model with oil price shocks than in the model with gas price shocks.

The previous results show there is a substitution effect operating in Europe, where a shock that decreases competitivity of fossil sources positively affects clean energy stocks. Zhao (2020) and Maghyereh and Abdoh (2021) find that oil-specific demand shocks are much more important than oil supply and aggregate demand shocks in explaining the variability in clean energy stock returns. This is because a negative supply shock is a temporary reduction in production caused by the interruption of supply in the short term. This may be due to a shock such as an unexpected military intervention in an oil-exporting country. We do not expect this kind of event to produce an immediate substitution in oil-importing countries. Wang et al. (2014) emphasize that crude oil production consists of long-term investments that are capital-intensive.

The previous results are important to draw the lines for future energy policy. Firstly, they show that, even if the European Commission endorsed gas as a green course thinking to its complementarity with intermittent renewables, investors do not consider gas this way, and shocks in the market generate substitution towards clean energy. Secondly, in the actual context of rising fossil fuel prices due to the Ukrainian conflict, we are likely to observe a strong substitution of those sources with clean energy, good news for European energy sovereignty as well as for the transition to a net-zero economy.

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