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Article

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How does the Production of Unconventional Resources of Energy Influence Energy Security: Empirical Approach

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ABSTRACT

This paper examines the issue of production of unconventional resources of energy and their impact on energy security. Energy security is influenced by several factors, among them the endowment of natural energy resources, either conventional or unconventional, and the level of their production. A VAR model has been constructed to examine the influence of tight oil production on the price of oil and on other variables, moreover, which variables influence the price of oil most. These findings may be interpreted by generalization as influencing the energy security and by extrapolation the results hold same for the American market than for the rest of the world, as the US largely dictates the price of oil worldwide. Our results inter alia suggest that, unconventional oil Granger causes the price of WTI, and the opposite in not true. We found also that there is a slightly positive correlation between the stocks and tight oil and stocks and oil exports, hence we can conclude that a higher production leads to higher amount of oil stocked and exported. What is more interesting is that tight oil reports greater correlation than conventional oil production.

Keywords: Granger Causality, Oil Price, Energy Security, Unconventional Resources
JEL Classifications: Q32, Q41, Q43

1. INTRODUCTION

Over the last 50 years, the world has gone through developments that have never been seen before. Increases in the standard of living, extension of the length of human life, improved technology, and progress in science are only a part of what kind of improvements the world has undergone. However, these advances could not have been achieved without adequate energy sources and their almost unlimited quantity. The unprecedented availability of energy in the quantities and forms demanded by the economy and society had to be secured from somewhere.

Energy security is defined as the availability of uninterrupted energy supplies at affordable prices. It is to be beard in mind that energy security is a key part of each country's national security, where energy supply flexibility, stability and diversification of suppliers, infrastructure resilience to internal and external impacts, reduced consumption through energy efficiency and environmental sustainability are its important elements (Obadi and Korček, 2013, International Energy Agency [IEA], 2012 and 2013).

Energy security has several aspects. Apart from the above-mentioned elements, it also includes the limited threat of temporary or long-term interruption of imported supplies, the availability of local or imported energy resources to meet the growing demand for energies at reasonable prices.

The main objective of this paper is to analyse the relationship between unconventional energy of oil and gas, more precisely the US unconventional energy boom, and the global energy security, represented by the stability of oil and gas prices.

The US unconventional energy boom (oil and natural gas) could be dated to the beginning of the 21st century, which changed the global energy scene and thereby changed the role of individual global energy giants in the energy market. Thanks to the "shale boom," US fossil fuel production mean the United States has entered a new era of energy security. In addition to that, “the magnitude of the shale revolution as well as the significant drop in oil prices in 2014 and 2015 make the US global market position worth re-examining. In particular, it is worth assessing whether the United States is now a “swing oil producer,” a role historically played by Saudi Arabia and a small number of other OPEC countries who alter the amount of spare production capacity they hold to help moderate shocks to oil supply and demand” (Newell and Prest, 2017).

The paper is divided to generally five sections. The introduction is followed by the second section focused on literature review of the examined issue. The third and fourth sections are about the methodology and results of the empirical analysis. Last section concludes.

2. LITERATURE REVIEW

In the literature, the term energy security begins to be mentioned only with the arrival of the first oil shocks in the 1970s. At that time, energy security was associated with a reduced dependence on oil consumption and imports, particularly in the OECD countries and other leading oil importers. Since then, the definition of energy security has undergone a number of changes. In particular, the increase in the number of energy suppliers, as well as the emergence of new incentives, or the improvement of technology for extracting stocks that were considered impossible to extract or unprofitable during the previous years. Prices have gradually become more flexible and transparent, dictated by market forces, not the cartels. Global tensions and regional conflicts have gradually become less intense, trade has been booming and becoming more loose. The oil sanctions imposed by oil suppliers, which were common in the 1980s, almost disappeared, and on the contrary, the UN and other actors in the international scene are imposing sanctions on oil suppliers. However, none of these phenomena has caused a shortage of oil in one of the markets (Khatib, 2000).

In the context of global energy security, we can assert the following: On the production side, the most significant event in recent years has been the revolution of shale gas extraction in the US, which has the potential to change the rules of the global energy game (Spencer et al., 2014). There has been a decline in the extraction of conventional energy sources in Europe, particularly in the North Sea. New locations in the wider area of the Caspian region, the eastern Mediterranean and Iraq can contribute to the diversification of suppliers in the European and Asian markets. Instability in the Middle East and North Africa markets may lead to a decline in production. However, in the case of a number of new outlets that could enter the energy market in the medium term, these facts are not at risk. On the energy side, demand for competition has risen due to the boom of Asian economies, particularly China and India, which are able to offer better conditions to the supplying countries in a competitive gas and oil struggle, for example by funding the construction of the necessary infrastructure, thus making export for suppliers cheaper (Bak, 2014).

Over the last decades, the world has diversified energy sources and has become less dependent on oil. Even in 1973, oil accounted for 46% of the world’s commercial energy sources, compared with 40% 30 years later. The oil markets have become more similar to the traditional commodity market (with futures options), more transparent and able to react quickly to changing circumstances. Great progress has been made in energy efficiency, notably the gradual reduction of dependence of economic growth on increased oil consumption. Advances in technology have led to a rise in new oil and gas reserves, have reduced the cost of exploring these assets, and have greatly reduced the mining process, expanding the oil base to a proven 1.492,6 billion barrels, of which 81% are in the OPEC (OPEC, 2016). Even in 1995, OECD countries accounted for up to 55% of the world’s total energy demand, China 11%. In 2020, global demand for energy is projected to shrink by reducing OECD countries’ demand to 42% and increasing China’s demand to 16%. Developing countries also considerably increase demand for energy through investment in industrialized countries (Khatib, 2000).

Rosenberg (2014) released a paper which states that one of the most striking effects of shale gas extraction in the US is precisely its role in maintaining low prices over the last decades. New volumes of energy sources from bases have changed the energy market, valuing and forecasting. In the US, domestic gas prices have fallen sharply. On the international oil market, US shale oil production, as an additional source of energy, helps keep prices at lower levels, which also means lowering the likelihood of extreme price fluctuations. Despite the reduced US dependence on fossil fuel imports from abroad, it still remains vulnerable to fluctuations in the global energy market. Although the US imports less oil, its price is still given globally to all consumers, and the world’s economies are deeply entangled. The oil price is affected by many factors such as amount of stocks, current oil production and demand, rates of dollar and euro, interest rates, political decisions, embargoes, import quotas and speculative motives.

An increase in shale oil and gas production in the US has brought great economic benefits to the country. Only in 2012 the sharp rise in unconventional production and the energy-intensive industries that benefited from the boom in mining brought the US economy 2.1 million new jobs and increased the government revenue from its activities by $ 74 billion. Regional competitiveness has been enhanced by the revitalization of many peripheral and economically weak regions. The trade deficit between 2007 and 2012 has dropped by 164.4 billion dollars, which also contributes to strengthening national competitiveness (IHS, 2013).

It is worth pointing out the multiplier effect that has led to the extraction of unconventional oil and gas resources in the US. Increased mining was reflected in lower energy prices for businesses and households that have allocated their savings to consumption. Growth in household consumption and growth in investment by firms have had an acceleration effect on further growth of the overall economy. Estimates show that unconventional energy production may contribute the US $ 380 to $ 690 billion a year to increase the US GDP by 2020.

The United States was a 60-year old clean importer of refined oil products. In 2011, however, it has become a net exporter of these products, as they are able to process light slate oil and convert it to cleaner gasoline and refuelling oil thanks to the extraction of unconventional oil and advanced technology. The US is an example of a country where shale oil and gas have become a systemic change in the energy market (Geny, 2010). The US has changed from a petroleum and natural gas importer to a near-net exporter, which has had a significant impact on their foreign-trade balance and which has a significant impact on the global energy security.

Many VAR models have been run with the aim to model the global or US oil market. However, the majority of them take into account either only the conventional production or production as a whole, conventional and unconventional sources combined (Kliesen, 2008; Ghalayini, 2011; Hosseini, 2014; Ahmed, 2016; Foudeh, 2017; Alekhina and Yoshino, 2018). The literature lacks studies in which the role of unconventional sources of energy was stressed out (Kilian, 2014; Ahmed et al., 2018). Hence, we focus our model on tight oil production, which includes the shale and tight oil extracted by unconventional methods and its impact on the price of oil WTI, and other factors.

3. METHODOLOGY AND DATA DESCRIPTION

Our dataset runs from January 2000 until March 2018. We have 219 observations in our sample. Based on the literature review earlier, the price of oil and unconventional oil production, are the two variables of our interest. Supply and demand are the two most important factors that influence the price of oil. On the supply side we chose indicators - crude oil production, which we divided between tight oil production and conventional oil production. The demand side is harder to model; we tried to find a good proxy to the demand of oil. We know that real oil price is correlated with real GDP (Kilian and Vigfusson, 2014). As economic activity of a country increases, so does the demand for energy sources that fuels the increased production. World GDP is measured at quarterly frequency in US dollars in PPP, it is broadly accepted, however, many economic modellers often turn to a monthly indicator of global economic activity. World production index does not exist, OECD is sometimes used as a proxy for world production index, Killian developed his own Killian index of global real economic activity, sometimes referred to as the National Activity Index (Kilian, 2010). Another index similar to Killian index has been developed by Ravazzolo and Vespignani (2016), named World steel production.

Since we focus on the US market, we choose to use the The Chicago Fed National Activity Index (CFNAI), which is a weighted average of 85 economic activity indexes and drawn from four broad categories of data: (1) production and income (23 series), (2) employment, unemployment, and hours (24 series), (3) personal consumption and housing (15 series), and (4) sales, orders, and inventories (23 series) (Brave, 2009). Furthermore, we include US GDP despite the fact that most studies use NYMEX, oil price futures, rather than GDP, but as pointed out in Alquist et al. study, these forecasts are worse than economic forecasts (Alquist et al., 2011). Moreover, in our model we included $/€ exchange rate, which greatly influences the price of oil, oil imports and exports.

The data used in the model are mainly from open access database of the US Energy Information Administration (EIA), from the IEA, Federal Reserve Economic Data, and the World Bank. We used interpolation to convert quarterly GDP data into monthly data.

We have constructed a VAR model in order to examine the correlation and causal effects among a set of indicators. Our VAR model of p order looks as follows:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + \mu_t, t = 0, \pm 1, \pm 2 \ldots, \tag{1}$$

Where $y_t = (y_{1t}, \ldots y_{Kt})'$ is a (K × 1) vector, Ai are fixed (K × K) coefficient matrices, $v = (v_1, \ldots, v_K)'$ is a fixed (K × 1) intercept vector, which allows for a non-null mean $E(y_t)$, where, $u_t = (u_{1t}, \ldots, u_{Kt})'$ is a K-dimensional white noise or innovation process, meaning that $E(u_t) = 0$, $E(u_t u_t') = \Sigma_u$ a. for $s \neq t$ (Lutkepohl, 2007). The vector of indicators is:

$$y_t = \begin{bmatrix} y_{1,t} \\ y_{2,t} \\ y_{3,t} \\ y_{4,t} \\ y_{5,t} \\ y_{6,t} \\ y_{7,t} \\ y_{8,t} \\ y_{9,t} \end{bmatrix} \begin{matrix} \text{price of oil WTI} \\ \text{conventional oil production} \\ \text{tight oil production} \\ \text{oil imports} \\ \text{oil exports} \\ \text{stocks} \\ \text{\$ / ‹ exchange rate} \\ \text{CFNAI} \\ \text{GDP} \end{matrix}$$

Price of oil WTI was in dollars per barrel. Convention oil production was counted as total oil production minus tight oil production. Tight oil production was in million barrels per day for all plays, it needed to be converted to thousand barrels and multiplied by the number of days in a month. Oil imports and stocks were already in thousand barrels. Oil exports were in thousand barrels per day, we multiplied them by the number of days in a month. Exchange rate was measured daily, not seasonally adjusted, converted to a monthly indicator by us. CFNAI is generally reported on a monthly basis. GDP is measured quaternary, we used interpolation to create monthly values. The term tight oil was chosen based on EIA terminology and includes all forms of unconventional oil production.

The goal of the study is the identification of the specific influence of tight oil production on the price of oil and on other variables, moreover, which variables influence the price of oil most. Hence, these findings may be interpreted by generalization as influencing the energy security and by extrapolation the results hold same for the American market than for the rest of the world, as the US largely dictates the price of oil worldwide (Spencer et al., 2014).

Other important factors affecting the price of oil are the current state of stocks, which represents the variable stocks in the US, the exchange rate of the dollar to the euro, the CFNAI as the economic activity proxy for demand of oil and GDP of the country as an indicator for economic growth. Unpredictable events such as natural disasters or political decisions also affect the price of oil, but we cannot measure them, so they are included in the error term.

As part of the structural analysis of VAR models, Granger's causality test is used to find out if the variable x affects the variable y, thus whether y can be interpreted as an effect of x variable, or whether the lag values of x help predict today values of y (Granger, 1969). Granger causality may not be sufficient to analyse all interactions among a set of variables. In practice, it is often desirable to know what reaction one variable will have to the shock or impulse of another variable in a system that contains a number of other variables. In this paper, we use Impulse responses to tell us the duration and magnitude of the response of one variable to the shock of another variable, confirming the causal relationship between the variables examined.

Firstly, for the reason of a better interpretability of data and for the reduction of heteroscedasticity problem, we converted all data except CFNAI to natural logarithm. CFNAI had a lot of negative numbers, we would have lost a lot of important data by changing them to missing values. Therefore, we have decided not to transform this variable.

For the stationarity testing we used the Augmented Dickey Fuller test (ADF test). If the absolute value of test statistics is larger than the 5% critical value, furthermore the P = 0.000, we can reject the null hypothesis, therefore our model is stationary. We have tested the variables on first and second ADF model (also with a trend). It resulted in WTI, tight oil, conventional oil production, exchange rate being transformed to first differences to become stationary. All the other variables were stationary as level variables.

Table 1 shows the correlations among variables. WTI and the exchange rate are positively correlated, and the same relationships hold true for tight oil and oil exports; tight oil and oil production, as well as oil production and oil exports. The latter relationship makes sense since higher production leads to higher exports. We found negative correlation between tight oil and oil imports, as well as oil production and oil imports, confirming the evidence from theory that higher domestic production leads to less imports needed.

There is a slightly positive correlation between the stocks and tight oil and stocks and oil exports. Hence, higher production leads to higher amount of oil stocked and exported. What is more interesting is that tight oil reports greater correlation than conventional oil production, thus going in hand with the literature that more and more oil extracted is of unconventional origin in the U.S. (Owyang, 2018).

In next step we were choosing the lag length for our model. Lag selection criteria - Hannah Quinn and Schwartz chose 1 lag, as shown in Table 2. Thus, we have a model with one lag.

4. RESULTS

Standard practice in VAR analysis is to report results from Granger-causality tests and impulse responses. Because of the complicated dynamics in the VAR, these statistics are more informative than the estimated VAR regression coefficients (Stock and Watson, 2001). Most of the times also the R^2 statistics go unreported, however, we offer them, along with the other results in Table 3.

We have 217 observations. The sample runs from January of 2000 until March 2018. We see that all the variables are significant for the model, as P>F is significant at 0.05 level, 8 of them are highly significant, marked with ***. The variations in the variables with high R^2 are best explained by the model, such as oil exports (85.36%), oil imports (73.85%), CFNAI (55.33%). Least of the variations is explained in the price of oil itself (12.65%), the exchange rate (14.91%) and the GDP (11.45%).

4.1. Granger Causality

In the Table 4 below, we only state the results for significant findings, i.e., only for those with value of Prob > F lower than 0.1. The row "excluded" tests the null hypothesis that all coefficients on lags of the variable of the row "excluded" in the equation are equal to zero, against the alternative that at least one is not equal to zero.

The P-values show that unconventional oil Granger causes the price of WTI on a significance level 0.05. This is the most important relationship we wanted to test. Kilian (2014) examines how the shale oil revolution has shaped the evolution of US crude oil and gasoline prices. He shows that the shale oil production has an effect on the price of oil because shale and tight oil replace oil imports, reducing the demand for oil in global markets (and enlarging the oil reservoirs to feed the growing world demand for oil), thus pushing the prices of oil down. We came to the same

Table 1: Correlation matrix

	CFNAI	GDP	WTI	Stocks	Tight oil	Oil production	Oil imports	Exchange rate	Oil exports
CFNAI	1.0000								
GDP	0.2097	1.0000							
WTI	0.0428	0.2279	1.0000						
Stocks	0.1155	0.3776	0.3870	1.0000					
Tight oil	0.1599	0.3538	0.3805	0.5510	1.0000				
Oil production	0.2412	0.2622	0.0244	0.4091	0.9012	1.0000			
Oil imports	−0.1161	−0.2067	−0.1573	−0.2846	−0.8097	−0.7713	1.0000		
Exchange rate	−0.0373	0.1607	0.8545	0.3357	0.1585	−0.1642	0.0518	1.0000	
Oil exports	0.1821	0.2932	0.2654	0.5629	0.8922	0.8462	−0.6969	0.1274	1.0000

Source: Own calculations

Table 2: Lag length

Lag	LL	LR	DF	P	FPE	AIC	HQIC	SBIC
0	1138.16				2.1e-16	−10.55029	−10.4957	−10.4113
1	1850.72	1425.1	81	0.000	5.8e-19	−16.4553	−15.8833*	−15.0397*
2	1974.66	247.88	81	0.000	3.9e-19	−16.8566	−15.7698	−14.167
3	2085.63	221.94	81	0.000	3.0e-19*	−17.1367*	−15.535	−13.173
4	2147.49	123.72*	81	0.000	3.6e-19	−16.9578	−14.8413	−11.7201

Endogenous: CFNAI GDP dWIT dtightoil dexchangerate conventional stocks oilimports oilexports Exogenous: _cons Source: Own calculations

Table 3: Results of VAR model

Sample	2000 m1–2018 m6			Number of obs.	217
Log likelihood	1867.536			AIC	−16.38282
FPE	6.21e-19			HQIC	−15.81655
Det (Sigma_ml)	2.71e-19			SBIC	−14.98102
Equation	RMSE	R-sq	F	P>F	
DWTI	0.083695	0.1265	3.330834	0.0008***	
Doilproduction	0.047629	0.3751	13.80527	0.0000***	
Dtightoil	0.043823	0.3873	14.53754	0.0000***	
Oilimports	0.06389	0.7385	64.95217	0.0000***	
Oilexports	0.606253	0.8535	134.1153	0.0000***	
Stocks	0.123459	0.3273	11.18941	0.0000***	
Dexchangerate	0.022415	0.1491	4.029408	0.0001***	
CFNAI	0.580234	0.5533	28.49267	0.0000***	
GDP	0.16761	0.1145	2.974476	0.0024**	

Source: Own calculations, **: Statistically significant, ***: Highly statistically significant

Table 4: Granger causality Wald tests

Equation	Excluded	Prob >F[#]
dWTI	Dtightoil	0.0203**
Doilproduction	Oilimports	0.0000***
Doilproduction	Oilexports	0.0359**
Dtightoil	Doilproduction	0.0002***
Dtightoil	Oilimports	0.0005***
Dtightoil	Oilexports	0.0239**
Oilimports	Doilproduction	0.0466**
Oilimports	Oilexports	0.0019**
Oilexports	Oilimports	0.0002***
Oilexports	GDP	0.0474**
Stocks	Oilexports	0.0000***
Stocks	CFNAI	0.0457**
Stocks	GDP	0.0581*
Dexchangerate	Doilproduction	0.0040**
Dexchangerate	Dtightoil	0.0040**
CFNAI	DWTI	0.0017**
CFNAI	Doilproduction	0.0429 *
GDP	Oilexports	0.0424**

Source: Own calculations. [#]Prob>F*** at the significance level 0.001; ** at the significance level 0.05; *at the significance level 0.1

conclusion, that the unconventional production has an influence on the price of oil. This is also supported by a recent article written by Ahmed et al. (2018). In addition to higher unconventional production, mainly in non-OPEC countries, advancements in market efficiencies also play a role in the persistent downward trend of oil prices.

However, we have not found an opposite relationship, of oil price influencing the unconventional production, which is largely discussed in the literature. The aforementioned article also states that low oil prices in 2016 have de-accelerated the activity of unconventional non-OPEC production in addition to a reduction in its rate.

In our model, the price of oil itself only Granger causes the CFNAI on a significance level 0.05 and so does the conventional oil production. A study done by Kliesen (2008) shows a Hamilton's model augmented with the CFNAI that estimates the negative effects of a rise in the price of oil and its impact on real GDP. The price of oil has a significant effect on the economic activity, which was proven by numerous studies (Ghalayini (2011), Foudeh (2017), Ahmed (2016).

Oil imports Granger cause the conventional oil production and vice-versa with high statistical significance. These results are highlighted with a same colour background. Another pair of significant results for which the Granger causality runs in both directions is oil imports and oil exports, which is logical given basic trade theories. Export is a component of GDP, therefore has a direct influence on it. Hosseini (2014) ran a VECM model to see how oil and non-oil exports effected the Iranian economic growth. He found out that export of oil and gas products, export of non-oil products, capital and total imports Granger-cause economic growth. This is in line with the results of our testing.

4.2. Impulse Responses

Impulse responses trace out the response of current and future values of each of the variables to a one-unit increase in the current value of one of the VAR errors, assuming that this error returns to zero in subsequent periods and that all other errors are equal to zero (Stock and Watson, 2001).

As we have nine variables, doing Impulse responses for 9 × 9 iterations is ineffective. We want to look at the price of oil and unconventional oil production, and how they influence the other variables. By looking at all the other iterations we have not found any strong relationship (for more information see the Annex).

However, having a closer look at the responses of the system by a shock in either the price of oil as seen on Figure 1 or the unconventional oil production as seen on Figure 2 showed us a bit different results from what we saw in the Granger Wald tests.

An impulse of a magnitude of one standard deviation in the oil price causes CFNAI to grow by 0.18 times the change in percentages in the first 2 months. The response vanishes off after 10 months. This confirms the outcome of the Granger test that dWTI Granger causes the CFNAI.

The other significant graph is oil price shock affecting oil exports. We have not found such relationship in the Granger Wald tests. The Impulse response function shows that a shock in the oil price affects the oil exports for over 20 months. The effect is not necessarily big, since only the 95% interval covers the range of the effect, but surely there is some. This is in line with existing literature (Alekhina and Yoshino, 2018) and basic economic theory – prices have an impact on supply and demand, in our case with rising price of oil, both conventional and tight oil production will go up and exports will grow.

Figure 1: Impulse responses for price of oil WTI (dWTI)

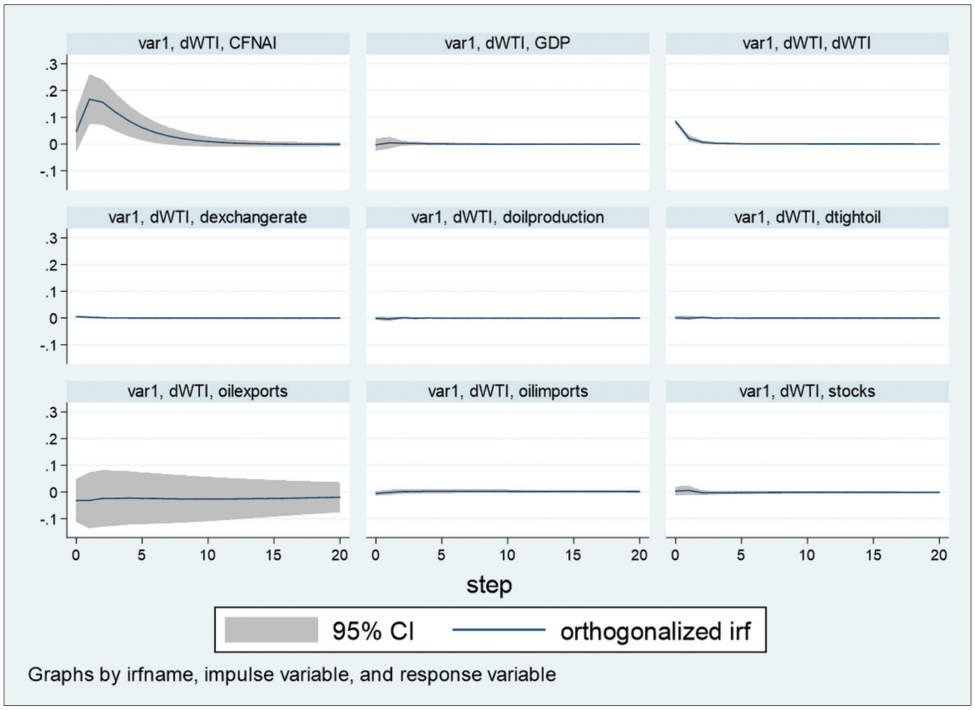
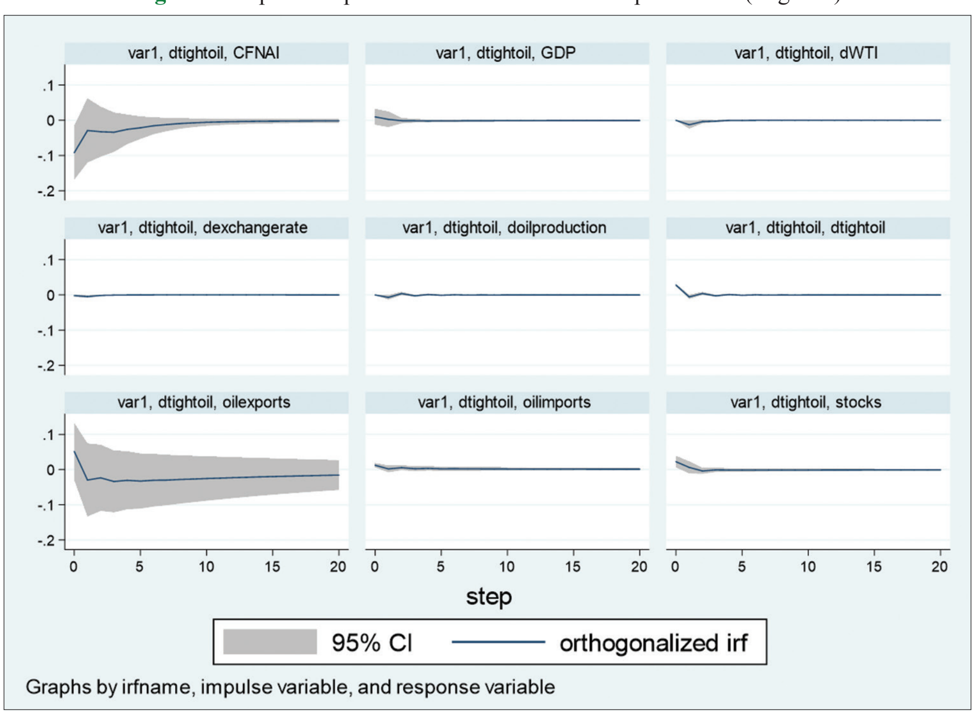


Figure 2: Impulse responses for unconventional oil production (dtightoil)



The other graphs do not show any significant response to a shock in the impulse variable. Neither a causal effect coming from the price of oil to other variable was shown by the Granger Wald test.

The Granger causality test showed an effect going from the tight oil production towards the price of oil and the exchange rate. None of these findings were proved by the Impulse responses graphs. As it was the case of a shock in the price of oil, a shock in the unconventional oil production causes a response in the CFNAI index and the oil exports. There might be a slight effect on the GDP, just another indicator of the economic activity such as CFNAI, and stocks.

A one standard deviation shock in the production of tight oil causes CFNAI to immediately drop in the 1st month and then gradually rise until the 6th month when the reaction vanishes off. This might be related to higher cost of unconventional oil extraction in the initial stage. The rising of CFNAI in the second stage might be explained by less imports needed, therefore savings for the economy and cheaper energy for industries, since CFNAI is an industrial production index.

The shock of tight oil production to oil exports is reasonable since higher production in both, conventional and unconventional oil, leads to higher exports of oil. This response lasts for more than 20 months and is initially higher; 0.5 times the change in the percentage change of oil exports and then gradually vanishes away. An increase in the production of unconventional oil affects the stocks of oil only marginally and for a short period of time, up to 2 months. With higher production, the stocks of oil are rising.

4.3. Linear Predictions of Historical Values

Figures 3 and 4 show linear predictions for the price of oil WTI and unconventional oil production. These predictions are to serve as a control mechanism of goodness of the model.

It can be seen from Figure 3 above that our model cannot predict the total magnitude of fluctuations in the price of oil since the beginning of the period under review. However, the trend and direction of flucctuations is well in line with the real developments.

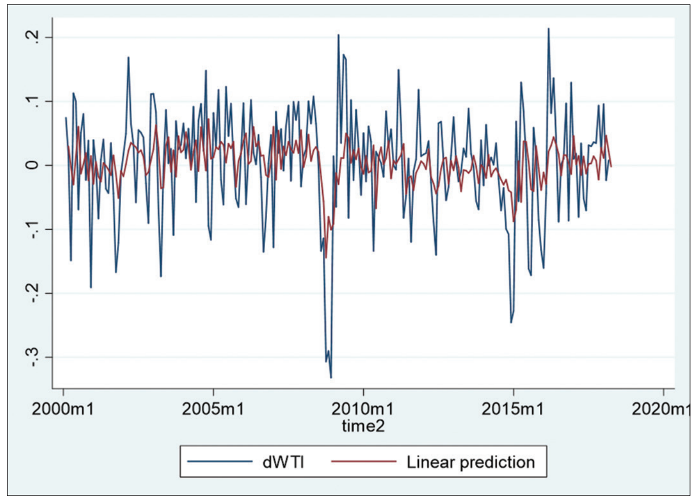
Our model has done a worse job predicting the developments in unconventional oil production, compared with the price of oil WTI. The model was unable to predict increases in the unconventional production in 2011 onwards. Instead, it has been underestimating the forecast for increased production until 2015. Ever since, the linear prediction keeps the real trend of unconventional production of oil.

5. CONCLUSION

Energy security has become important for countries importing energy raw materials to ensure a sustainable supply of energy at affordable prices as well as for exporting countries to ensure continued sales revenues. While energy security in each country appears to be safe, new risks and threats to energy security have emerged in recent years. Regional shortcomings and the possibility of not ensuring stable energy supplies due to trade distortions and the reduction of strategic reserves as a result of conflict or sabotage, are still present. These situations point to the need to strengthen global as well as regional energy security and to develop country's dialogue on energy security and energy policy.

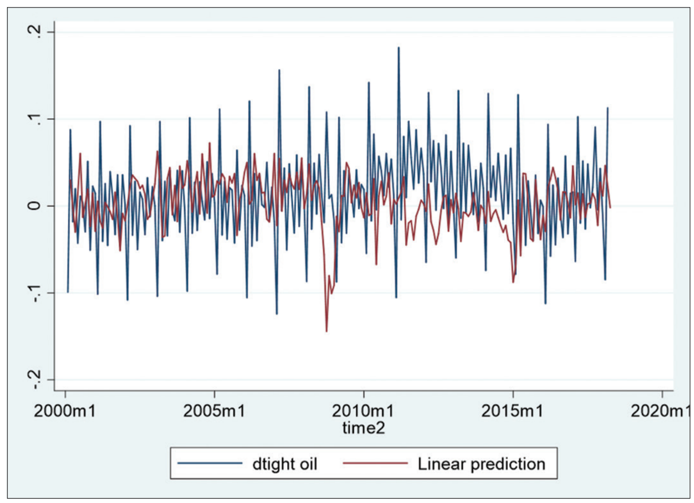
The main objective of this paper is to examine the impact of the production of unconventional energy resources on energy security, represented by the stability of oil and gas prices. For this purpose, we employed VAR model with ten variables during the period 1M2000 - 3M2018. In the same time we ran Granger causality test to identification the relationship between variables. Our results suggest that unconventional oil resources Granger causes oil prices (WTI), which could be interpreted that, the more production of unconventional oil resources the more energy security, since low oil price leads the energy of oil more affordable for oil importing countries. Impulse responses, however, showed different results, where we find that an increase in the production of unconventional oil, affects the stocks of oil only marginally and for a short period of time, up to 2 months. This is not far away from reality, since the majority of stocks of oil are influenced more or less by conventional oil production.

Figure 3: Linear prediction of price of oil WTI (dWTI)



Source: Own calculations

Figure 4: Linear prediction of unconventional oil (dtight oil)



Source: Own calculations

The linear prediction, as a control mechanism, showed better results for the price of oil WTI, which in most cases, was able to keep the trend with reality. Forecasting the historical values of the unconventional production showed less realistic imagine, mainly the model was unable to predict the increased production of tight oil between 2011 and 2015, thus underestimating the results.

One of our conclusions is that the unconventional production has an influence on the downward trend of the price of oil. In addition to higher unconventional production, mainly in non-OPEC countries, advancements in market efficiencies also play a role in the persistent downward trend of oil prices. This could be generally explained, assuming other factors fixed, that the energy security of at least oil importing countries is better secured or ensured.

We are aware of the fact that the results of our analysis are concentrated more or less on the cost side of the energy security (oil price), but it could be enough to explain the development of energy security. On the other hand, however, the use-efficiency, which is an important factor of the cost side, is not described by the model. That is our proposition for further research engagement in the field of unconventional energy sources.

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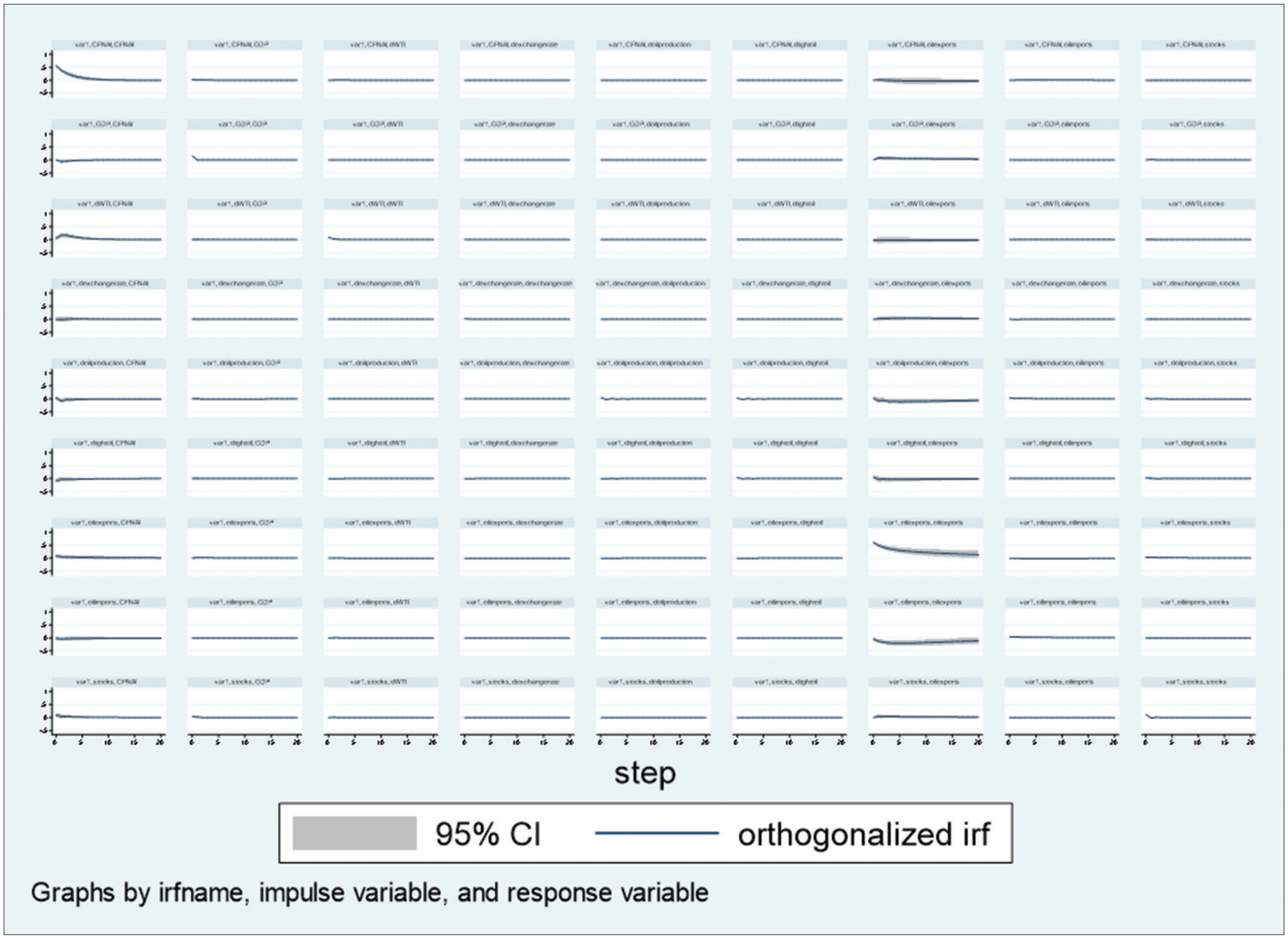
ANNEX


step
95% CI
orthogonalized irf
Graphs by irfname, impulse variable, and response variable