# ECONOMIC IMPLICATIONS OF ENERGY SECURITY IN THE SHORT RUN[1]

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***Abstract.*** *Energy security is one of the primary goals of the European Union energy policy as the region relies mostly on imports to meet its energy resources demand. In 2013, the share of the net imported energy resources was as high as 54.5% of total energy consumption in the 28 member states of the European Union. Research on energy security involves a detailed analysis of economic, technological, and socio-political factors. The main objective of this study is to find out the economic consequences in the short run due to changes in the level of the security of energy resources supply. In order to acquire quantitative measures of the research object, the energy security index calculation methodology proposed by Jansen et al. (2004) is applied. To explore what effects, if any, energy security has on the economy of the EU, five economic indicators, with which the probable short-term impact of energy security is the most likely, are distinguished: real GDP, inflation, current account balance, foreign direct investment, and employment. Granger causality tests of the panel VAR model reveal that in the short run employment may be negatively affected by energy security. The effect itself is relatively small and short-lived. No short term causality is observed running from energy security towards the remaining macroeconomic variables of the panel VAR model. Such conclusions would suggest making the European Union energy policy decisions without prioritizing possible swings of the energy security level in the short run.*

***Key words:*** *energy security, panel VAR, Granger causality, energy policy*

## 1. Introduction

Energy consumption is historically an inherent aspect of economic activities that creates value-added output. From manufacturing up to transport and from the service sector up to agriculture – every area of the economy requires a secure and timely supply of energy resources for its daily operations. Therefore, all sectors of the economy are affected by risks of the energy supply that might result in temporary or in some cases permanent interruptions and shocks of supply chain of the energy resources.

[1] The paper is an individual work of the author and does not represent the views or work methods of the Lietuvos bankas in any way.

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The European Commission considers the security of energy supplies as being crucial for the welfare of citizens and the whole EU economy[2]. Nevertheless, it is worth underscoring that the European Union itself is not only highly dependent on imported energy (in 2013 net imports accounted for 54.5% of the total primary energy supply, 94.1% of oil supply and 65.3% of gas supply), but the dependence is constantly growing – as recently as in 2003 energy imports accounted for less than 50% of gross inland energy consumption, and projections for the future point to the further increase (European Commission, 2014). Not all EU member states are equally energy-dependent. Lithuania, for example, is the most insecure country in the EU in terms of energy resources supply. Net imports of energy secured 70.4% of TPES in Lithuania in 2013, lacking proper diversification of energy suppliers and types of energy sources in its energy mix. Another highly energy-dependent countries include Estonia, Ireland, and Poland. On the contrary, countries like Denmark, Sweden, and Romania have broadly diversified energy-mixes and locally produce the majority of consumed energy. As a result, they are among the most energy secure countries in the EU. High dependency on imported energy makes the economy especially vulnerable to unfavorable changes in prices and (or) supply volumes of energy sources. The ***problem*** arises: how much does energy security affect the economy as a whole?

The ***objective*** of this research is to examine how the economy of the European Union is affected by energy security in the short run. The authors select the real GDP, CPI, FDI stock, current account balance and employment as the macroeconomic variables representing the economy as a whole.

Energy security as a complex concept is a relatively new topic among researchers, although energy-security-related problems have been analyzed for a few decades. Early works (Mork & Hall, 1979; Burbidge & Harrison, 1984) investigate economic consequences of two subsequent oil supply shocks. Since the second half of the 2000s, multiple dimensions of energy security (Winzer, 2012; Cherp & Jewell, 2014), potential risks (Soderbergh et al., 2010) and methodologies for the evaluation of energy security level (Jansen et al., 2004; Sovacool & Mukherjee, 2011; Augutis et al., 2012) have been assessed.

The following ***tasks*** are set in order to distinguish the effects of energy security on economy:

- to review literature relevant to the topic;
- to analyze different methods of energy security evaluation;
- to study to which macroeconomic ratios the security of energy supply possibly relates;
- to research econometric models that are used to investigate the relations between macroeconomic and energy variables;
- to determine and evaluate the effect of energy security on selected economic variables;
- to deliver conclusions and policy suggestions based on empirical findings.

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[2] European Commission. (n.d.). *Security of Energy Supply*. Retrieved November 15, 2014 from http://ec.europa.eu/energy/security_of_supply_en.htm.

The research includes a review and analysis of scientific publications published in Lithuanian as well as foreign journals and books, retrieval and analysis of the data series of macroeconomic indicators and calculation of the energy security index. A panel VAR econometric model is employed to determine the short-run causality relationships between the energy security index and selected macroeconomic variables. Additionally, impulse-response functions and variance decompositions are derived to explain the sign and magnitude of economic impact arising from fluctuations in the energy security level. Our theoretical framework is informed by world-systems analysis.

The article is structured in the following way. The second chapter provides a review of literature related to the topic. The third chapter discusses the problem of energy security and hypotheses set to test in the empirical research. The fourth chapter presents the data, methodology, and results of the study. Finally, conclusions and policy recommendations are provided in the fifth chapter.

## 2. Literature review

To the limits of the authors' knowledge, there is no empirical study done analyzing the implications of energy security on economic variables at the time of writing. As a result, the literature used to ground the theoretical assumptions of the paper is selected from the scientific publications that analyze problems related to the sufficiency, affordability and continuity of energy resources supply as presented previously in the definition of energy security.

Two periods can be outlined in terms of the energy security problem popularity in scientific literature. The first period is the first half of the 1980s after the two oil crises in 1974 and 1979, which raised concerns over the consequences of oil supply disruptions on the economy. Most of those works concentrate on analyzing the effects of just one type of energy sources – oil – shocks on the economy. Mork & Hall (1979) are among the first economists to explore the economic implications of energy price shock by simulating macroeconomic models. They investigate the response of the American GDP, employment and inflation to the surge of oil price in 1974 and conclude that large and unpredicted changes in the price of energy have substantial disruptive effects on economy by depressing real output, increasing inflation and unemployment rate[3]. Burbidge & Harrison (1984) are among the pioneers who apply the VAR econometric model in order to investigate the effects of a sharp rise in price of oil on the price level and industrial output of the USA and four other OECD countries (Japan, West Germany, UK, and Canada). The research produces the outcome that there is a significant difference between the effects of two oil crises in 1974 and 1979[4]. The VAR methodology has since been used in numerous publications

[3] Mork & Hall (1979, p. 33).

[4] Burbidge & Harrison (1984, p. 460).

on energy supply shock consequences in the USA. Bernanke et al. (1997) created a VAR model to analyze responses of the output, prices and federal funds rate to shocks in oil prices. They find that oil prices significantly contribute to inflationary pressure in the short run. A rise in the price level is responded with monetary policy tools that drive the changes in real output. As a result, oil price shocks have a muted effect on the real economy as the monetary policy response is the dominant source of the real effects of an oil price shock[5]. Blanchard & Gali (2007) employ the VAR model to determine and compare the short-term macroeconomic effects of steep oil price rises that occurred during four different periods. They discover that the later price shocks of the first half of the 2000s affected the economy to a much lesser extent than the first shocks of 1974 and 1979, despite being similar in amplitude. Kilian (2008) overviews recent empirical models on the effect of energy price shocks to the US economy. He concludes that energy price shocks have a relatively small effect on aggregate consumption and investment expenditures.

Since the second half of the 2000s the energy security regained its popularity among researchers analyzing relationships among energy resource supply, transformation and consumption. The related publications shifted the focus from the exceptional dominance of interest on effects of the oil price and supply shocks on the US economy to more topics and a more geographically dispersed approach. Energy security as a multidimensional concept has been analyzed, particularly paying attention to its specification, because of multiple interpretations of the subject. Winzer (2012) and Cherp & Jewell (2014) discuss the concept of energy security and narrow it to the few major dimensions. Sovacool & Mukherjee (2011) propose possible indicators suitable for the energy security level evaluation. Frances et al. (2012) examine the effect of renewable energy sources on energy security by using the portfolio theory and find out that an enhanced usage of renewables contributes to increasing the supply security of energy resources. Alekseyko & Giedraitis (2013) provide an empirical evidence for a negative association between energy dependency and economic growth in Lithuania and also propose to increase the consumption of renewable energy sources in order to enhance the level of energy security. Augutis & Matuzienė (2012) apply the probabilistic risk assessment methodology in order to evaluate the dynamics of the energy security level under different supply scenarios of energy resources. However, quantitative researches have been mostly concentrated on changes in the level of energy security but not on its direct impact on economy.

An important part of the literature review is dedicated to the inquiry of different energy security level assessment methods, because at the time of the paper writing no historical time series data have been publicly available. The quantification of the object of analysis is essential for the further empirical research. One of the mathematical methods used most frequently in the evaluation of energy security is the calculation of the energy security

[5] Bernanke et al. (1997, p. 124).

index that aggregates the quantitative information of an energy system into one single figure[6]. Jansen et al. (2004) are among the first to propose a simple dual concept of the Shannon–Wiener diversity index-based indicator for energy security calculation. In total, four different aspects of energy security are evaluated, resulting in one basic index that can be complementarily augmented with one of the three additional components: energy import dependency, socio-political stability, and resource depletion factors. Scheepers et al. (2006) provide a more complex supply / demand index for the assessment of the energy security level (with an updated version of the index following in 2007). The main difference of this index as compared to other indices is that it attempts to grasp the whole energy spectrum, including conversion, transport and demand, since a decrease in energy use lowers the overall impact of supply disruptions[7]. IEA proposes two indicators for energy security measurement – energy security price ($ESI_{Price}$) and energy security volume ($ESI_{Volume}$) indices. These indicators address the two different components of energy security independently: the price and the physical availability of energy[8]. The primary focus of the IEA is the determination of the causes of energy insecurity: the major causes are defined by separate indices. The $ESI_{Price}$ index is computed using HHI and is based on the evaluation of suppliers' market concentration. The other method offered by IEA is the $ESI_{Volume}$ index that is based solely on gas imports (oil-indexed and pipeline-based) share in TPES. The higher is this share, the less secure is a country's gas supply[9]. The first energy security index is applied for competitive and liberalized markets where many suppliers operate. The latter is applied in regulated markets where the present pipeline infrastructure does not allow switching among suppliers. Bollen (2008) introduces the willingness-to-pay function. It determines what percentage of private consumption (and thus indirectly GDP) the region is willing to spend in order to avoid the loss of welfare, resulting from the lack of security of either gas or oil supply[10]. Gupta (2008) presents the oil vulnerability index (OVI) concentrating on oil as the benchmark of energy insecurity and calculates the index using PCA[11]. OVI is computed as a weighted sum of seven PCs corresponding to seven variables (including the geopolitical oil market concentration risk and market liquidity), where weights are the variances of successive PCs[12]. One of the most recent notable works on energy security calculation is created by the Institutes for 21st Century Energy (2011). This study evaluates the energy security level and its dynamics in the USA by creating the energy security index which itself is divided into four sub-indexes: geopolitical,

[6] Groenenberg & Wetzelaer (2006), p. 2.
[7] Kruyt et al. (2009), p. 2170.
[8] IEA (2007), p. 13.
[9] Ibid., p. 14.
[10] Bollen (2008), p. 27.
[11] It is a multivariate statistical approach that transforms a set of correlated variables into a set of uncorrelated variables called components. These uncorrelated components are the linear combinations of the original variables (Gupta, 2008, p. 1201).
[12] Ibid.

economic, reliability, and environmental. Weights are assigned to sub-indexes, and they are further divided into nine categories with 37 metrics in total. Augutis et al. (2012) suggest another energy security level assessment algorithm that takes into account technical, economical, and socio-political variables. These three variables correspond to three major blocks which themselves are divided into groups of indicators that describe each block. Weights are equal for every block and every indicator in its group, whereas every group has its own weighting to be calculated (group weights in socio-political block are equal). Computed results are represented in the energy supply security evaluation scale.

Kruyt et al. (2009) compare different energy security evaluation methodologies. They are grouped into four sectors that define the energy security concept (sometimes referred to as four "A" of energy security):

- Availability – or elements relating to geological existence
- Accessibility – or geopolitical elements
- Affordability – or economical elements
- Acceptability – or environmental and societal elements.

The researchers assign one of the sectors to each methodology and point out that the security of energy sources supply as a concept is open to various interpretations, and it is not possible to unambiguously assess the whole concept based on a single indicator[13]. Energy security indexes that are discussed both in this literature review and in Kruyt's et al. (2009) study are depicted in the following graph.

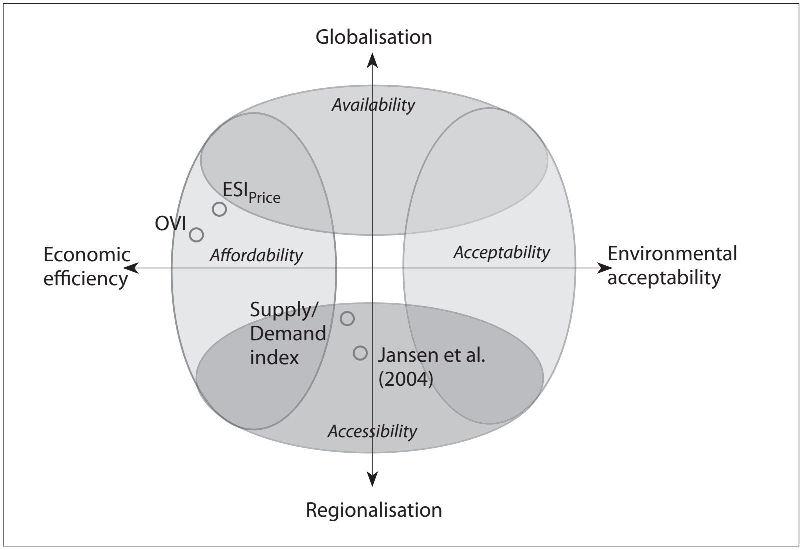


FIG. 1. **Energy security indexes and elements of energy security spectrum they focus on**

*Source:* Kruyt (2009, p. 2171).

[13] Kruyt (2009), p. 2177.

The variety of different energy security calculation methods outlines the research object's complexity and multidimensionality. In this paper, the energy security level is calculated using the energy security index presented by Jansen et al. (2004) and augmented with the energy import dependency factor. The decision to employ this methodology is based on a few assumptions.

Firstly, input data for the above-mentioned energy security index are available publicly to a full extent. Several other energy security indices include a wide variety of indicators, and for some of them data series are not currently publicly available. Secondly, the selected energy security index takes into account all of the possible energy sources and does not concentrate only on one source of energy like Gupta's (2009) model on oil or IEA's $ESI_{Volume}$ on gas.

## 3. Predicted economic implications of energy security

Usually, disruptions of energy supply result in an immediately decreased output and increased prices of energy that lead to further increases of the CPI as almost all of economy is affected. The longer last the disruptions, the greater damage to the economy is done in the short run as in the long run the economy tends to adjust to the shocks. The example of such pattern is proved by oil price shocks that occurred in the USA in 1973, 1979, 1999 and 2002–2005. The first two shocks resulted in an increased inflation and recession as a 10 percent rise in the price of oil caused an increase of more than 1 percentage point in inflation after 2–3 quarters and a decrease of 1 percentage point in output after 2 years[14]. Nevertheless, the further two shocks resulted in muted effects on economy, mainly due to the decrease in real wage rigidities, increased credibility of monetary policy, and a decrease in the share of oil in consumption and in production[15]. However, oil is just one type out of many other energy resources that are being used in output production, and fundamentals of it differ from the others. As a result, possible risks of negative supply and price shocks of other energy resources cannot be underestimated as examples of gas supply crises in Ukraine in 2006 and 2009 and blackouts in the Northeast US and Southeast Canada in 2003 and India in 2012 reflect.

The selection of the potential factors that could be influenced by energy security is based on the approach that costs of production or individual expenses increase due to insecurity in energy resources supply. The need for affordable prices is one of the cornerstones of the energy security concept. Energy consumers may face a decreased affordability of energy resources and pay a higher price for the lack of competition in the energy market. Moreover, they incur losses during the shutdowns of energy supply

[14] Blanchard & Gali (2007, p. 33–38).
[15] Ibid., p. 65.

or trying to hedge the risks of unexpected shutdown. Sometimes the availability of demanded energy sources is limited due to the lack of supply networks. There also may be risks of unexpected terminations of energy flow resulting from the geopolitical confrontation among the trading countries. In this way, energy security related costs are set as a primary measure that evaluates potential changes in the variable.

Inflation is affected by swings in prices of energy resources as they represented 10.7% of EU-28 HICP in 2015[16]. If the demand for energy resources is inelastic, appreciating or volatile energy prices can force consumers to reduce spending in order to meet budget constraints (OECD, 2008). Energy security helps to ensure that prices would be set according to market and competition principles. Thus, it would be plausible to presume that energy security negatively influences the rate of inflation. In other words, inflation tends to recede as the security of energy resources supply increases.

Furthermore, it is highly likely that energy security directly weighs the net export. As the European Union produces locally less than half of its total energy needs, it would be feasible to presume that price fluctuations affect the total amount spent on the imports of energy. On the other hand, the shrinking affordability of energy resources puts the costs of local production under upward pressure, resulting in diminished competitiveness. The decrease of local producers' ability to compete tends to lower country's exports. As the measure of net exports is included into real GDP (calculated by the expenditure approach), the second hypothesis aims to claim that energy security has a positive impact on the real GDP development.

To analyze if the energy security level positively affects changes in international trade directly, the current account balance is selected as a variable tracking the changes in the export–import balance. Although such balance is included into the real GDP, the latter variable is more like the aggregate of various indicators. Thus, it would be feasible to raise the third hypothesis stating that if the energy security level increases, the current account balance reacts positively.

The World Economic Forum addresses the quality of electricity supply as one of the key factors that determine the overall competitiveness of a country or a region[17]. Energy resources available at reasonable prices as well as a stable, reliable supply are among the most influential determinants for investors to choose to which country their investments should be directed. The energy security situation and perspectives thus are worth paying an increased attention for every investor and for every government as the latter is interested in attracting investors. The reliability of energy resources supply affects the profitability of all the businesses and especially of those whose production is energy-intensive. It is a sound argument that energy security is directly related to investments. In order to

[16] Eurostat.

[17] World Economic Forum (2013, p. 5).

analyze the probable relations between these two variables, the fourth hypothesis that the level of energy security positively affects the amount of foreign direct investments is raised. To better reflect the influence of energy security on investments, the measure of FDI instead of the total investments indicator was selected. Foreign enterprises are better fostered to weigh their decisions on investments by comparing the present security level of energy resources supply. Local investors invest regardless the dynamics of energy security, because they already operate in the market.

Energy security is understood as a benchmark for the probability of unhindered energy supply. It would be plausible to presume that in order to attract investments of energy-dependent industries, the region must possess a sufficient level of energy security. Moreover, a certain level of security of energy resources supply chain helps the energy-consuming businesses ensure the development and expansion of existing operations by employing a new staff. As a result, the authors raise the fifth hypothesis concluding that energy security is positively correlated with the rate of employment.

## 4. Data, methodology, and results

In this study, the implications of energy security on economy are investigated using data from 23 European Union member states. For this purpose, the energy security index (denoted as the ESI) is constructed by using annual data from the Eurostat energy statistics database. Real GDP, CPI and current account balance data are retrieved from the IMF World Economic Outlook database, data for the FDI stock are sourced from the database of the United Nations Conference on Trade and Development, and the employment time series are extracted from the Eurostat and the International Labour Organization databases.

The dynamics of changes of the energy security index is treated as a part of six-variables system which also takes into account the rest of the measures: real GDP (denoted as Y), FDI stock (denoted as FDI), employment (denoted as EMP), current account balance (% of GDP, denoted as CAB) and the average inflation of consumer prices reflected by the consumer price index (denoted as CPI).

There are 2898 annual observations in total, running from 1993 till 2013. Data for Luxembourg, Bulgaria, and Romania are omitted from the analysis in order to reflect as long time period as possible in the empirical model, because the first country does not provide the statistics of FDI stock until 2002 and the latter two experienced a prolonged transitional period in their respective economies that led to an excessive volatility in the macroeconomic variables. Additionally, observations of Cyprus and Malta are excluded from analysis due to their abnormal and unrepresentative energy security level, caused mainly by geographic conditions preventing the diversification of energy sources used in the energy mix.

It is worth noting that before conducting the econometric analysis some variables have to be transferred from the nominal to the real and (or) to the logarithmic form. In this research, the logarithms of the following variables are used: real GDP, FDI stock, employment, and CPI. ESI is not in the logarithm form because it is based on the Shannon–Wiener index which includes the sums of logarithms in its equation formula. The Eviews 8 software was used for the econometric modelling of this research.

The energy security level in every economy is determined by calculating the energy security index. The concept was developed by Jansen et al. (2004) and is based on the Shannon–Wiener index composition methodology. The energy security index is described as

$$ESI = -\sum_{i=1}^{M}[c_i \times p_i \times \ln(p_i)]. \quad (1)$$

With the subject to

$$c_i = 1 - m_i\left(1 - \frac{S_i^m}{S_i^{m,max}}\right), \quad (2)$$

where

1) $p_i$ = share of primary energy source $i$ in TPES;
2) $i$ = 1, M (primary energy sources index with M sources distinguished);
3) $c_i$ = correction factor to $p_i$;
4) $m_i$ = share of net import in the primary energy supply of the source I;
5) $S_i^m = -\sum_{j=1}^{N}[m_{ij} \times \ln(m_{ij})]$ (Shannon index of import flows of resource $i$)
6) $j$ = 1, N (regions of import of energy sources origin, with N regions distinguished);
7) $S_i^{m,max}$= ln(N) (maximum value of the Shannon index of import flows of the resource $i$).

The primary energy sources are outlined into eight groups: oil, gas, coal, nuclear power, hydro prower, modern biofuels, traditional biofuels, and renewables not specified elsewhere. Furthermore, energy trade balances are considered among the EU and other 16 world regions. Figure 2 depicts the calculated energy security levels for 23 EU countries from 1993 to 2013.

One of the most commonly applied methods of analysis in exploring the impacts of energy price shocks on economic indicators is the VAR[18] econometric model as the review of literature expressed. Such a model is applied in this study as well.

[18] As the panel data are analyzed in empirical research, the econometric model is further in the text denoted as the PVAR.

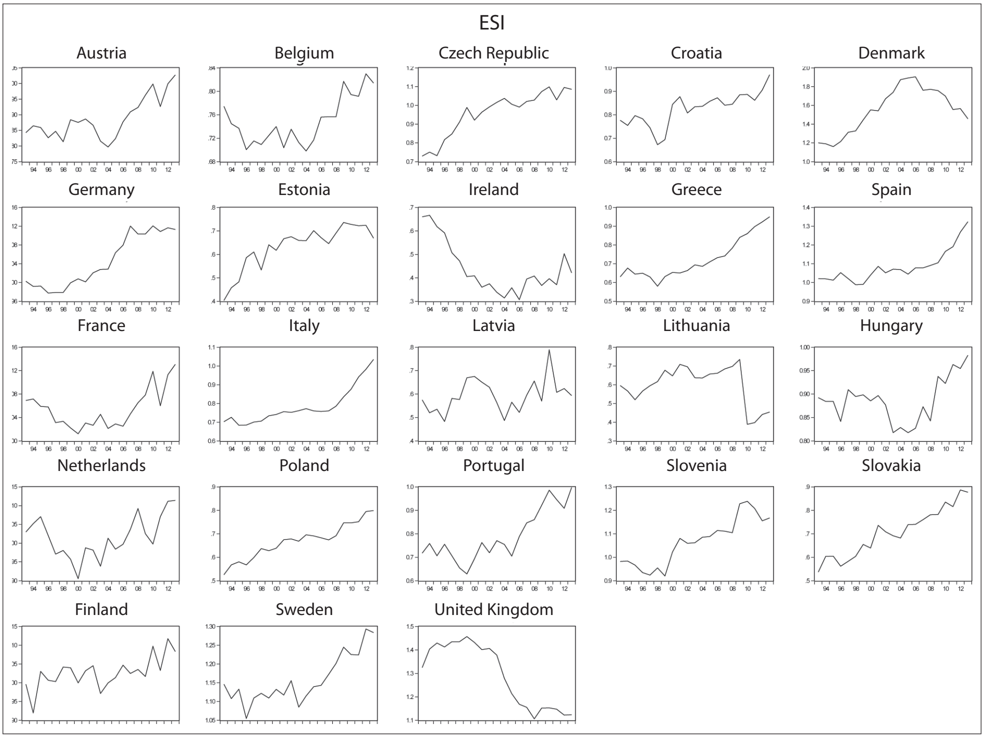


FIG. 2. **Energy security indices for 23 EU countries, 1993–2013**

The first step of the PVAR model specification is testing for data stationarity. The authors of the research select the augmented Dickey–Fuller (ADF), Phillips–Perron (PP) and Levin, Lin & Chu (LLC) panel unit root tests to detect the order of variables in the PVAR system of equations and to get stationary data. All the tests analyze three different processes in the observed data series:

a) random walk

$$\Delta y_{it} = \gamma y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + e_{it}, \tag{3}$$

b) random walk with intercept

$$\Delta y_{it} = \delta + \gamma y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + e_{it}, \tag{4}$$

c) random walk with intercept and trend

$$\Delta y_{it} = \delta + \gamma y_{it-1} + \phi t + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it-j} + e_{it}, \tag{5}$$

where:
$i$ = 1, 23 cross-section data series observed over time periods $t$ = 1, T;
$j$ = 1, $p_i$ number of lags used in every cross-section;
$\Delta y_{it}$ – first difference of respective dependent variable (Y, FDI, CPI, ESI, EMP, CAB);

$\gamma$, $\beta_{ij}$ – estimates of parameters;
$\delta$ – intercept;
$\varphi$ – trend parameter;
$e_{it}$ – residuals.

Three hypotheses are set to test whether the analyzed variable is not stationary:

- $H_0$: γ = 0 and $H_1$: γ < 0 for random walk process;
- $H_0$: γ = δ = 0 and $H_1$: γ < 0, δ < 0 for random walk with intercept process;
- $H_0$: γ = δ = φ = 0, $H_1$: γ < 0, δ < 0, φ < 0 for random walk with an intercept and trend process.

Test statistics and their probability values are calculated and compared with the level of significance of 10%. If the test statistics probability, the value is lower than the predefined level of significance, the null hypothesis claiming that the process is not stationary and is rejected. The summary of all unit root tests is presented in Table 1.

TABLE 1. **Results of unit root tests**

| **Variable** | **Process** | **Unit root test, p-values** | | |
|---|---|---|---|---|
| | | LLC | ADF | PP |
| ESI | Random walk | 1 | 1 | 1 |
| | Random walk with intercept | 0.9511 | 0.2089 | 0.5033 |
| | Random walk with intercept and trend | 0.0122 | 0.0189 | 0.3132 |
| CAB | Random walk | 0.0004 | 0.0159 | 0.0231 |
| | Random walk with intercept | 0.4443 | 0.2135 | 0.2817 |
| | Random walk with intercept and trend | 0.7412 | 0.0417 | 0.5385 |
| logEMP | Random walk | 1 | 1 | 0.9999 |
| | Random walk with intercept | 0 | 0.0160 | 0.5894 |
| | Random walk with intercept and trend | 1 | 0.5230 | 0.9999 |
| logRGDP | Random walk | 1 | 1 | 1 |
| | Random walk with intercept | 0 | 0.0023 | 0 |
| | Random walk with intercept and trend | 1 | 0.9877 | 1 |
| logCPI | Random walk | 1 | 1 | 1 |
| | Random walk with intercept | 0 | 0 | 0 |
| | Random walk with intercept and trend | 0 | 0 | 0 |
| logFDI | Random walk | 1 | 1 | 1 |
| | Random walk with intercept | 0 | 0.0004 | 0 |
| | Random walk with intercept and trend | 0.9987 | 1 | 1 |
| ΔESI | Random walk | 0 | 0 | 0 |
| | Random walk with intercept | 0 | 0 | 0 |
| | Random walk with intercept and trend | 0 | 0 | 0 |
| ΔlogRGDP | Random walk | 0 | 0 | 0 |
| | Random walk with intercept | 0 | 0 | 0 |
| | Random walk with intercept and trend | 0 | 0 | 0 |
| ΔlogCPI | Random walk | 0 | 0 | 0 |
| | Random walk with intercept | 0 | 0 | 0 |
| | Random walk with intercept and trend | 0 | 0 | 0 |
| ΔlogFDI | Random walk | 0 | 0 | 0 |
| | Random walk with intercept | 0 | 0 | 0 |
| | Random walk with intercept and trend | 0 | 0 | 0 |
| ΔlogEMP | Random walk | 0 | 0 | 0 |
| | Random walk with intercept | 0 | 0 | 0 |
| | Random walk with intercept and trend | 0 | 0 | 0 |

The majority of tests performed at the data level represent the evidence that ESI, RGDP, CAB, EMP and FDI contain a unit root and are not stationary at level. Such conclusion is backed by the probability value (p-value) of all of the above-mentioned tests that is larger than the critical value of ten percent and, as a result, the authors could not reject the null hypothesis stating that the data are not stationary at the significance level of ten percent or lower. However, the economic theory presents the evidence that the current account balance is stationary in the long run[19]. As a result, it is feasible to include CAB into the PVAR model at the level.

Analogous unit root tests for the rest of variables present that CPI does not contain a unit root and is stationary at level. Nevertheless, consumer prices tend to increase constantly over time, meaning that their mean values also change constantly. Graphs for every country confirm this theory, thus the authors treat this variable as non-stationary at level.

The same unit root tests are run again for those variables which are considered to be non-stationary at level. This time, the first differences of the CPI, ESI, employment, real GDP and FDI stock data are used. Results of these tests portray all of the variables becoming stationary when differenced in the first order. All of the unit root tests for ESI, real GDP, employment, CPI and FDI stock data possess p-values of zero, meaning that the null hypothesis of non-stationarity can be rejected at a very accurate level of significance of 1%.

With the help of unit root tests, the order of integration is determined for all the variables that enter the PVAR model: the current account balance data series are integrated of order I(0) and enter the PVAR system at level. On the other hand, the energy security index, real GDP, employment, consumer price index and FDI stock data series are integrated of order I(1), meaning that these variables have to enter the system of the PVAR model equations only after differencing them once. All of the unit root tests are performed using an automatic lag length selection option based on the Akaike information criterion.

Once the stationary forms of variables are determined, the appropriate lag length of the PVAR model is explored. In order to select the most suitable number of lags, three different information criteria are calculated and compared: Akaike (AIC), Hannan–Quinn (HQ) and Schwarz (SC) with the maximum of eight lags to be included. The results of lag length selection tests are presented in Table 2.

TABLE 2. **Results of lag length selection tests**

| Lag | AIC | SC | HQ |
|---|---|---|---|
| 0 | -12.05110 | -11.97239 | -12.01951 |
| 1 | -15.22883 | -14.67790* | -15.00775 |
| 2 | -15.45528 | -14.43212 | -15.04471* |
| 3 | -15.52610 | -14.03072 | -14.92603 |
| 4 | -15.60715 | -13.63954 | -14.81758 |
| 5 | -15.67090 | -13.23106 | -14.69183 |
| 6 | -15.69717* | -12.78511 | -14.52861 |
| 7 | -15.67698 | -12.29269 | -14.31892 |
| 8 | -15.69379 | -11.83727 | -14.14623 |

[19] Clower & Ito (2012, p. 8).

The number of lags which minimize these information criteria is different: the SC criterion offers to include one lag into the PVAR model, HQ advises two lags induction, and AIC suggests six lags to be included. Complementary to the lag length criteria test, the authors check the autocorrelation of residuals and compare the correlograms (Figure 3) of the residuals of variables.

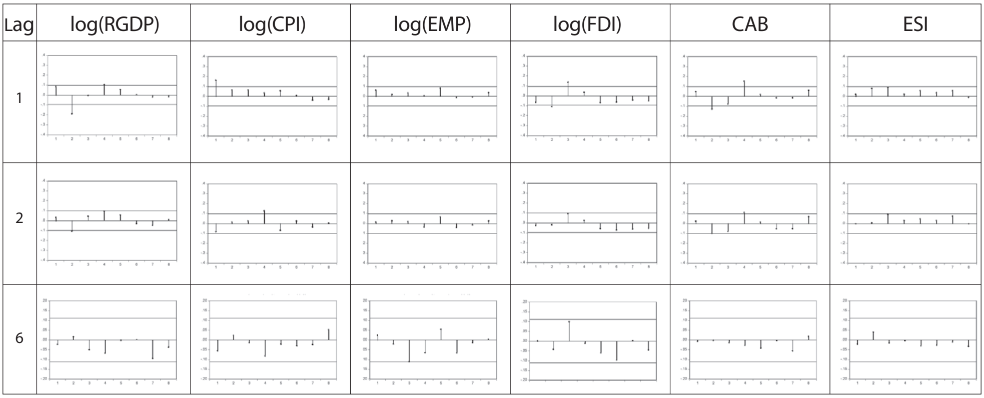


FIG. 3. **Correlograms of the residuals of PVAR model variables**

Correlograms of the PVAR model with one lag reveal that a correlation among the residuals exists for at least one of the variables. Correlograms of the model with two and six lags included show no obvious correlations between the residuals of variables and the residuals of their own lags. The authors decide to include two instead of six lags into the PVAR model in order not to over-parameterize the model and adjust it to the short run analysis.

After the selection of stationary forms of data series and the number of lags, the PVAR model is described and begun to analyze with the primary objective to determine if causality relations exist between the energy security index and macroeconomic variables, and if they do, are the variables positively or negatively affected by energy security. The system of six endogenous equations forming the background of the multivariate PVAR(2) model is written in the following form:

$$\Delta \ln Y_{it} = \alpha_{10} + \sum_{k=1}^{2} \beta_{11ik}\Delta \ln Y_{it-k} + \sum_{k=1}^{2} \beta_{12ik}\Delta \ln CPI_{it-k} + \sum_{k=1}^{2} \beta_{13ik}\Delta \ln FDI_{it-k} + \sum_{k=1}^{2} \beta_{14ik}\Delta ESI_{it-k} + \sum_{k=1}^{2} \beta_{15ik}\Delta \ln EMP_{it-k} + \sum_{k=1}^{2} \beta_{16ik}CAB_{it-k} + \varepsilon_{1it} \quad (6a)$$

$$\Delta \ln CPI_{it} = \alpha_{20} + \sum_{k=1}^{2} \beta_{21ik}\Delta \ln Y_{it-k} + \sum_{k=1}^{2} \beta_{22ik}\Delta \ln CPI_{it-k} + \sum_{k=1}^{2} \beta_{23ik}\Delta \ln FDI_{it-k} + \sum_{k=1}^{2} \beta_{24ik}\Delta ESI_{it-k} + \sum_{k=1}^{2} \beta_{25ik}\Delta \ln EMP_{it-k} + \sum_{k=1}^{2} \beta_{26ik}CAB_{it-k} + \varepsilon_{2it} \quad (6b)$$

$$\Delta \ln FDI_{it} = \alpha_{30} + \sum_{k=1}^{2} \beta_{31ik}\Delta \ln Y_{it-k} + \sum_{k=1}^{2} \beta_{32ik}\Delta \ln CPI_{it-k} + \sum_{k=1}^{2} \beta_{33ik}\Delta \ln FDI_{it-k} + \sum_{k=1}^{2} \beta_{34ik}\Delta ESI_{it-k} + \sum_{k=1}^{2} \beta_{35ik}\Delta \ln EMP_{it-k} + \sum_{k=1}^{2} \beta_{36ik}CAB_{it-k} + \varepsilon_{3it} \quad (6c)$$

$$\Delta ESI_{it} = \alpha_{40} + \sum_{k=1}^{2} \beta_{41ik}\Delta lnY_{it-k} + \sum_{k=1}^{2} \beta_{42ik}\Delta lnCPI_{it-k} + \sum_{k=1}^{2} \beta_{43ik}\Delta lnFDI_{it-k} + \sum_{k=1}^{2} \beta_{44ik}\Delta ESI_{it-k} + \sum_{k=1}^{2} \beta_{45ik}\Delta lnEMP_{it-k} + \sum_{k=1}^{2} \beta_{46ik}CAB_{it-k} + \varepsilon_{4it} \quad (6d)$$

$$\Delta lnEMP_{it} = \alpha_{50} + \sum_{k=1}^{2} \beta_{51ik}\Delta lnY_{it-k} + \sum_{k=1}^{2} \beta_{52ik}\Delta lnCPI_{it-k} + \sum_{k=1}^{2} \beta_{53ik}\Delta lnFDI_{it-k} + \sum_{k=1}^{2} \beta_{54ik}\Delta ESI_{it-k} + \sum_{k=1}^{2} \beta_{55ik}\Delta lnEMP_{it-k} + \sum_{k=1}^{2} \beta_{56ik}CAB_{it-k} + \varepsilon_{5it} \quad (6e)$$

$$CAB_{it} = \alpha_{60} + \sum_{k=1}^{2} \beta_{61ik}\Delta lnY_{it-k} + \sum_{k=1}^{2} \beta_{62ik}\Delta lnCPI_{it-k} + \sum_{k=1}^{2} \beta_{63ik}\Delta lnFDI_{it-k} + \sum_{k=1}^{2} \beta_{64ik}\Delta ESI_{it-k} + \sum_{k=1}^{2} \beta_{65ik}\Delta lnEMP_{it-k} + \sum_{k=1}^{2} \beta_{66ik}CAB_{it-k} + \varepsilon_{6it} \quad (6f)$$

where:

$i = 1, 23$ cross-section data series observed over time periods $t = 1, T$;

$k = 1, 2$ lagged periods;

$\alpha$, $\beta$ – estimated coefficients;

$\varepsilon_{it}$ – shocks of equations (or innovations).

In order to analyze if there are any causality relations in the PVAR model among energy security index, real GDP, inflation, FDI stock, employment and current account balance, the authors perform Granger causality tests. A null hypothesis of the Granger causality test is formulated as "the explanatory variable does not Granger-cause the dependent variable". Table 3 depicts the null hypotheses and implied restrictions that were set for Granger causality tests to evaluate the results of the tests. All tested variables are in the stationary form as described previously.

TABLE 3. **Granger causality tests and implied restrictions on the PVAR model**

| Hypothesis | | Implied restrictions | p-value |
|---|---|---|---|
| 1 | Lags of ESI do not explain current Y | $\beta_{14ik} = 0$ | 0.4486 |
| 2 | Lags of ESI do not explain current CPI | $\beta_{24ik} = 0$ | 0.8962 |
| 3 | Lags of ESI do not explain current FDI | $\beta_{34ik} = 0$ | 0.1520 |
| 4 | Lags of ESI do not explain current CAB | $B_{64ik} = 0$ | 0.7955 |
| 5 | Lags of ESI do not explain current EMP | $B_{54ik} = 0$ | **0.0290** |
| 6 | Lags of Y do not explain current ESI | $\beta_{41ik} = 0$ | 0.6719 |
| 7 | Lags of CPI do not explain current ESI | $\beta_{42ik} = 0$ | 0.1525 |
| 8 | Lags of FDI do not explain current ESI | $\beta_{43ik} = 0$ | 0.5511 |
| 9 | Lags of CAB do not explain current ESI | $\beta_{46ik} = 0$ | 0.2622 |
| 10 | Lags of EMP do not explain current ESI | $\beta_{45ik} = 0$ | 0.1131 |

The results of Granger causality tests demonstrate that there is a unidirectional causality relationship running from ESI to employment. The p-value is lower than the minimum of ten percent, thus the authors cannot reject the null hypothesis suggesting that the lags in the energy security level do not cause the movements in employment. However, further tests reveal no causal relationships running from the energy security index to real GDP, inflation, FDI stock, and current account balance as p-values of these tests are higher than the least acceptable level of significance of ten percent. Thus, the authors cannot reject the null hypotheses of the Granger causality tests stating that the lagged values of the energy security index do not cause changes in the equations of respective dependent variables. There is also no evidence of reverse causality running from real GDP, CPI, employment, FDI stock and CAB to the energy security index, meaning that these variables and the energy security index are independent. In this case, the authors presume that the level of energy security is strongly exogenous in the equation of employment.

The Granger causality tests disclose that the energy security level could cause movements in the employment level. However, there is no explanatory power of the past values of the energy security index to the other current values of macroeconomic variables entering the PVAR model. This fact also supposes that the current level of energy security does not cause any statistically significant influence for the future values of the real GDP, inflation, FDI stock and current account balance.

Causality tests by their nature cannot describe whether relations among the variables are positive or negative, how much time takes for the effects to manifest, and how long such effects last. Thus, the final step of the PVAR model analysis is to calculate the impulse–response functions and variance decompositions in order to demonstrate and graphically reproduce the sign and magnitude of relations among the energy security index and the real GDP, CPI, FDI stock, employment, and current account balance.

The impulse–response function generated by applying the Cholesky decomposition method (Figure 4) displays that the energy security level can negatively influence employment in the third period, albeit only marginally as indicated by the upper band of standard errors. The negative impact dies out from the fourth period. The remaining impulse–response functions present clear tendencies that energy security does not significantly influence any of the rest analyzed macroeconomic variables. Insignificance of CPI, real GDP, FDI and current account balance responses to the energy security index shocks is underlined by the standard error bands of respective functions. Both bands fluctuate with a very low magnitude around the zero level without bouncing above or dipping below (both at one time). Moreover, the impulse–response functions do not disclose any gains of energy security importance during a time scale of up to 10 years, indicating that energy security does not become a more influential phenomenon on macroeconomic variables over time.

The evidence of impulse–responses confirm hypotheses of the Granger causality tests stating that the energy security index values can cause statistically significant negative changes in employment, but no statistically significant changes are evident in the present and future values of the rest of macroeconomic variables concerned by this analysis. As a result, the fears that negative shocks in energy security would significantly reduce the real GDP and FDI, increase inflation and lead to deficits of current account balance are not supported by impulse–response functions. The short-lived, small and negative influence of energy security shock on the employment level could be explained by a need for industries to restructure. A rise in energy security possibly leads to a reduction of energy use and rise in unused import capacities. Employment in related industries could decrease faster than new working places are created in competent energy-related sectors and due to the need of fixed investments for companies to adjust to the improvements in energy security.

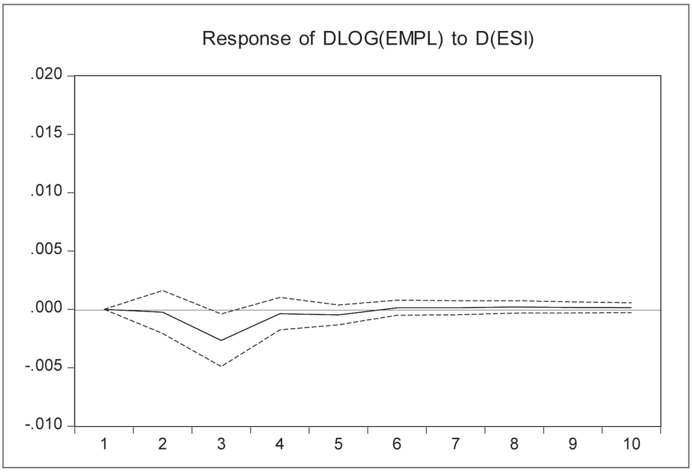


FIG. 4. **Response of employment to the shock of energy security**

Variance decompositions of the energy security PVAR model (Table 4) confirm that most of the forecast variance originates from the own shocks of variables. In the case of energy security variable, a very low activity of the energy security index innovations is evident in the developments of forecast variances in all observed macroeconomic variables. The error terms of the energy security index explain no more than 0.18% of forecast variances in CPI, 0.33% in real GDP, 1.33% in employment, 0.77% in FDI stock, and 0.34% in the current account balance. The results of these findings enable the authors to presume that whatever the shocks in the energy security index, macroeconomic indicators generally will not react swiftly to these changes. Analysis of variance decompositions (the third and final part of the PVAR model) produces identical outcomes like the previously discussed Granger causality tests and impulse–response functions: movements in the energy security index neither cause the fluctuations in the values of real GDP, inflation, FDI stock and current account balance nor closely correlate with them, whereas the negative impact on employment is only marginal.

TABLE 4. **Variance decompositions of the respective variables and ESI shares**

| Period | ΔlnY | ΔlnCPI | ΔlnFDI | ΔlnEMP | CAB |
|---|---|---|---|---|---|
| 1 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.057274 |
| 2 | 0.094103 | 0.011213 | 0.081161 | 0.010740 | 0.109196 |
| 3 | 0.319475 | 0.096646 | 0.740935 | 1.327909 | 0.236732 |
| 4 | 0.317766 | 0.133643 | 0.765024 | 1.315649 | 0.303130 |
| 5 | 0.317862 | 0.157553 | 0.767979 | 1.318059 | 0.317725 |
| 6 | 0.325221 | 0.169926 | 0.767832 | 1.290757 | 0.329803 |
| 7 | 0.330867 | 0.178259 | 0.769513 | 1.271245 | 0.334077 |
| 8 | 0.333564 | 0.182517 | 0.769945 | 1.261953 | 0.336235 |
| 9 | 0.334422 | 0.185304 | 0.769985 | 1.254722 | 0.337370 |
| 10 | 0.334628 | 0.187060 | 0.769906 | 1.249196 | 0.338241 |

## 5. Conclusions

This study is one of the first attempts to explore the relationships between the energy security level and various macroeconomic indicators. Energy security is a multidimensional concept, and an appropriate analysis of its dimensions is necessary in order to formulate the theoretical background for the hypotheses set to test.

Empirical findings of the PVAR model of pooled panel data suggest that the energy security level moderately contributes to the economic development. The analysis presented in the paper reveals that energy security in the short run negatively influences the employment level in the economies of the EU countries. However, there is no short-run reverse causality running from employment to energy security. It indicates that the latter term is a strongly exogenous variable in the equation for employment, implying the unidirectional short-run causality running from energy security towards employment. Furthermore, the research of the short run causality relations between the energy security level and real GDP, inflation, accumulated FDI and the current account balance witnesses a very limited and statistically insignificant influence that energy security is able to cause on the analyzed economic indicators. In the short run, energy security and real GDP, inflation, FDI stock and current account balance are independent variables. As a result, economic decisions would prove to be more effective without providing preference for the short-run developments in the energy security level. The focus of energy policy should be firstly devoted to technological advance and efficiency of energy consumption that would prove to be a better response to the short-run shocks of energy supply.

Nevertheless, the lack of publicly available data on energy consumption, trade and transmission variables prevent the authors of the paper from inclusion of different energy security evaluation methods into econometric modeling. Instead, the analysis is based only on one energy security index proposed by Jansen et al. (2004). The research results depend on energy security index data, and the lack of an independent comparison of econometric models that would include different energy security indices is one of the shortcomings of this study. As a result, the authors propose to perform further academic studies that would employ several different energy security evaluation methodologies. Another shortcoming is the quality of energy trade data as observations with no origin of energy source (indicated as "Not specified" in the Eurostat database) can comprise a significant share of total imports of respective energy sources in certain periods of time. Moreover, only annual energy statistics data were publicly available at the time of the paper writing in the Eurostat database. The short-term analysis that VAR models are structured to perform is more efficiently conducted by using more frequent data and a longer time series. Additionally, one of the shortcomings of the VAR model is its inability to capture long-run relations among the endogenous variables of the system. The VAR model is instead specialized to formulate, analyze and forecast the dependencies among the variables in the short run, while the long-run associations are not taken into account. Thus, the authors of this research would recommend the further empirical analysis that would trace the long-run interconnections between the set of macroeconomic variables and energy security and (or) include different techniques to measure the energy security level.

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