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Macroeconomic and political aspects of energy security – Exploratory data analysis

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ABSTRACT

Although the issue of energy security stands high on the scale of the European Union's priorities, there has been no single accepted definition of energy security thus far. In light of the global economic crisis and political instability, the issue of energy security is directly linked to geopolitical and macroeconomic stability. This paper offers a new method of measuring energy security, which unlike the existing indicators of energy stability, in addition to economic and environmental indicators, also includes the political and social aspects within the composite indicator of country risk. The new *Energy Security Index* (ESI) is defined based on the application of *Principal Component Analysis* (PCA). Analysis of the values of a new ESI indicator shows that energy security is greatly influenced by GDP per capita, country risk, carbon intensity, energy intensity, final energy consumption per capita and electricity prices, while the least importance rests with the share of renewable sources in energy consumption and energy dependence. The values of the Index by country are stable over the entire observed period, but significant differences are noticeable between countries. The highest index values are reported in Luxembourg, Sweden, Finland and Denmark, and the lowest in Bulgaria, Romania, Estonia and Poland. With the aim of robustness check, the results of EU member states rankings were compared to country rankings based on the *Energy Trilemma Index*. Compared to country rankings based on the *Energy Trilemma Index*, three countries recorded the same rank (Denmark, Check Republic and Bulgaria), and the biggest deviation of 9 ranking position was reported by Luxembourg. The results of the research show that there is a statistically important difference in the value of energy security index between the observed groups of countries classified according to the level of macroeconomic stability.

1. Introduction

Energy security stands on a list of priorities of almost all countries, even though there is still no single accepted definition of energy security [1]. There is a number of definitions which can be divided into those focused on the security of supply (short-term energy security) and definitions which take account of a broader concept of energy security (long-term energy security). Wizner (2012) analyzed 36 definitions of energy security and he himself defined energy security as "the continuity of energy supplies relative to demand" [2]. European Commission (2011) defines energy security as "the ability to ensure that future essential energy needs can be met, both by means of adequate domestic resources worked under economically acceptable conditions or maintained as strategic reserves, and by calling upon accessible and stable external sources supplemented where appropriate by strategic stocks" [3]. *International Energy Agency* (2014) defines short-term energy security as the ability of the energy system of a certain country to react promptly and in the best possible way to changes in the supply-demand balance, while long-term energy security is focused on finding and supplying energy in accordance with economic development, along with the need to preserve environmental quality [4].

This research will focus on broader concept of energy security which assumes that energy security is a complex issue based on multidisciplinary approach including economics, political, natural science, engineering, etc. [5,6] However, every discipline analyzes energy security from its point of view, so this could lead to conflict of assumptions. In addition, the very method of defining energy security is associated with a number of challenges because the same factors are not relevant to all countries equally, whereby their importance changes over time [7]. Therefore, it can be said that energy security is a dynamic

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category because the approach varies depending on the analyzed timeframe. Depending on the analyzed timeframe, the difference arises in the perception of the perspective [8] and in the priorities of energy security [9].

Despite a number of definitions and different approaches to energy security, the interest in the very methodology for the calculation of energy security indicators is not so big. This can certainly result from the previously mentioned limiting factors, but high-priority positioning of energy security on the agenda of all countries certainly deserves continuous efforts in finding a reference methodology to assess all aspects and to include the factors of importance. The existing methodologies are quite different from each other primarily depending on the dimension of energy security they analyze, on whether they evaluate energy security on macro (country, region) or micro level, on whether they are related to the security of supply or they include demand as well, and depending on the factors they include, etc. It is therefore necessary to develop new methodologies that will be more comprehensive and that will include as many factors affecting energy security as possible.

Each of the observed factors can have direct and indirect impact on energy security. Oil prices surge just before the outbreak of the global economic crisis did not only have a negative impact on energy security of importing countries, but also had an impact on macroeconomic stability through foreign trade deficit growth [10]. On the other hand, dramatically low oil prices at the beginning of 2016 brought along distortions in the energy market, thus affecting the macroeconomic stability of countries but also resulting in geopolitical consequences. The fact that many factors of importance to energy security are not quantitatively measurable, is an aggravating circumstance. For example, geopolitical conditions, political instability and armed conflicts certainly affect the price of energy, and hence energy security. However, it is difficult to quantitatively measure the countries' political instability [11]. It should also be taken into account that energy security is a dynamic category that follows global changes. Therefore, it is necessary to monitor the global changes but also the changes in the value of a defined indicator of energy security. Only with monitoring of energy security over a longer period of time can certain changes be established and certain conclusions made accordingly.

The aim of this paper is to define a new index of energy security that would include factors reflecting the political, economic and environmental aspects. Application of a new index will be analyzed in a sample of 28 European member states (EU-28) over a period of ten years (2006–2015). In selecting the sample of countries and time period of observation, three important factors were taken into account. First, the sample had to cover as many countries as possible. Second, that data had to be available and, if possible, the data for each factor and for all countries had to be taken from the unique database. Third, a relatively long period had to be covered to allow the analysis of the values of energy security index, but also to consider the differences from the perspective of changes that occurred as a consequence of the global economic crisis.

The paper is organized in four sections in addition to this introduction. Section 2 provides critical review of almost all indicators of energy security developed up to now. Section 3 presents the data and *Principal Component Analysis* (PCA) method for calculation of the new *Energy Security Index* (ESI) and nonparametric technique used for examining the differences between the defined groups of countries (*Kruskal-Wallis test*). Section 4 presents and discusses the results, while Section 5 presents the concluding observations.

2. Literature review

Starting from different concepts and indicators, there have been various attempts to measure and quantify energy security [12]. In many studies, a distinction has been made depending on whether energy security refers to primary energy sources, of which most commonly to oil and its derivatives [13] and gas [14]. Also, the studies can be found in which the security of electricity conversion is analyzed [15] along with impact of applying renewable energy sources on energy security [16,17]. In addition, there are attempts to measure the security of the entire energy system, from supply to end use [18]. The energy system of each country has its own peculiarities in terms of energy resources, import dependence, infrastructure development, energy policy, etc. The literature contains many studies aimed at measuring energy security of individual countries or regions [19–22].

In addition to the characteristics of the energy sector, energy security is affected by a whole range of economic, political, social and environmental factors [23]. The composite indicator, proposed by the Joint Research Centre, was the method most commonly used for measuring energy security. Badea (2011) has developed the ordered weighting averaging method to calculate energy security as a composite indicator based on five simple indicators and three diversity indicators [24]. On the other hand, Sovacool and Mukherjee (2011) went to the other extreme and included 320 simple and 52 complex indicators in calculating energy security [25].

The complexity and attractiveness of an indicator such as energy security impose different approaches but also raises issues in academic discussions and disagreements regarding the selection of relevant indicators and determining of the relative weighting of indicators as well as of their interdependence. Sovacool (2011) wrote about a number of methodological challenges related to definition of energy security index [26]. The most common among them is the discussion about quantitative vs. qualitative assessment of the factors of importance. What matters is the critical approach, according to which energy security should not solely rely on quantitative indicators of importance, especially as qualitative assessments are particularly important for evaluation of political and social aspects. On the other hand, qualitative indicators may be put in question as regards the subjectivity.

There are many different approaches in literature for calculating energy security indices [27,28]. The difference is most commonly made between the indices that recognize the security of supply and ignore the security of demand. In most cases, energy security indices pertain to certain energy generating products (mostly oil and gas), while ignoring nuclear energy and renewable energy resources. Energy security can be jeopardized if energy mix is not diversified. For example, overreliance on hydropower, a drought and regulatory failures jeopardized energy security of Brazil in 2001 [29,30].

Environmental concerns and related policy decision could have a potentially significant impact on energy security in EU-28 countries where carbon reduction is one of development priorities. In the beginning, definitions (interpretations) of energy security were mostly oriented to security of supply, while contemporary definitions are much more comprehensive. They include more aspects of energy security, as well as environmental concerns. For example, “The IEA defines energy security as the uninterrupted physical availability at a price which is affordable, while respecting environmental concerns” [31]. EU indicated energy security and reduction of gasses as one of pillars for the future development. European Energy Security Strategy indicates short term and long term measures in several areas, one of which is “increasing energy efficiency and reaching the proposed 2030 energy and climate goals”, while “energy security and the transition to a low carbon economy should be prioritized in the implementation of the EU financial instruments”. In addition, Strategy indicates that “in the long term, the Union's energy security is inseparable from and significantly fostered by its need to move to a competitive, low-carbon economy which reduces the use of imported fossil fuels” [32]. As energy has come to be a vital part of Europe's economy and future, related policies had been developed, whose main objective is to create a more sustainable energy system in the EU. Thus, due to the EU's 2020 energy and climate policies, energy efficiency and renewable polices and the planned 2030 policies, a range of measures exist to also address security of supply concerns [33].