Empirical Paper

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Energy security as a source of international competitiveness in new EU member states

https://doi.org/10.2478/ijme-2023-0015
Received: July 15, 2022; accepted: June 06, 2023

Abstract: Energy security and international competitiveness are two of the most fiercely discussed topics – especially in the light of the European Union (EU)'s dependence on Russia's gas, oil, and coal. Both mentioned concepts are of special importance for the so-called EU new member states (EU NMS), which are undergoing the energy diversification process. The main goal of this paper is to analyze how energy security influences the international competitiveness of these countries. The study uses trade theories related to productivity differentials (Ricardian hypothesis) and differences in factor endowments (Heckscher–Ohlin hypothesis) as a basis for our econometric modeling. The results show that relative energy supply as well as physical and human capital relative endowments have a statistically significant impact on international competitiveness of the studied economies.

Keywords: energy security, factor endowment theory, Heckscher–Ohlin trade model, international competitiveness, Ricardian trade model
JEL classification codes: Q43, F14, N74

1 Introduction

Energy security is one of the most fiercely discussed topics as energy dependence and green transformation are key elements of international policy, both in the European Union (EU) and the world as a whole. It is an issue for every country in the world regardless of its economic, political, or military position. Energy security also seems to be a challenge for energy producers and energy consumers alike. This concept is of particular importance in Europe – especially in the light of the Ukraine–Russia conflict and related sanctions placed on the Russian economy. According to Eurobarometer survey [2019], 92% respondents agree that the EU must secure energy supply to all its citizens. This concern is especially important for post-communist countries. Their special situation results from the fact that before the 90s of the 20th century, all those states were focused on domestic energy production or imports from Russia – with the latter still playing a major role also in case of developed European economies, e.g., Germany. Since the collapse of the USSR at the end of the past century, post-communist countries were forced to re-adjust their energy policy to the new political and economic landscape.

Nowadays, this group of countries is (largely) comprised of the EU member states that joined the community in 2004 or later (the so-called EU new member states [EU NMS]: Bulgaria, Czechia, Estonia,

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Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia). Their accession to the EU has been predetermined by a long process of economic and political adjustments. From the perspective of the past decade and a half, it appears that this group of countries is still catching up with the so-called "old EU member states" like Germany, France, Spain, Italy, etc. Even though new and old EU member states may differ in the number and types of issues currently at hand, all of them place the ability to compete in the international markets high on the political agenda.

International competitiveness is important especially in regions like the EU where reduced trade barriers encourage free-market behaviors. EU members, therefore, compete with both, price and non-price mechanisms. However, their ability to compete results also from their endowment in factors of production. These include the labor pool with different skill sets, physical capital, technology, and natural resources. Resources such as metals, agricultural products, or energy can determine the country's comparative advantage. Hence, they determine its position in international trade. This study therefore addresses the question of whether energy security – a combination of natural resource endowment and quality of institutions – might be a similar comparative advantage determinant.

The main goal of this paper is to analyze if and how energy security influences international competitiveness. This aim will be achieved by econometrically testing a research hypothesis that there is a statistically significant and positive impact of energy security on international competitiveness. The study uses trade theories of productivity differentials (Ricardian hypothesis) and differences in factor endowments (Heckscher–Ohlin hypothesis) as the basis for the empirics used in the present research. To the authors' knowledge, this is one of the relatively few studies exploring energy security influence on international competitiveness (this literature gap was also noticed, e.g., by Nyga-Łukaszewska and Chilimoniuk-Przeździecka [2017]). Additionally, this research question has previously never been addressed within the theoretical framework of trade models applied to EU NMS. To some extent, a similar approach is provided in the study of Nyga-Łukaszewska and Napiórkowski [2022].

The remainder of this paper is structured as follows. The forthcoming section provides a literature review of previous works on energy security and the international competitiveness nexus. Subsequently is explained the methodological approach and data used in the study. The fourth section presents results and their discussion, while the last part offers policy implications.

2 Literature review

Energy security is a concept with a variety of definitions. Only between 2001 and 2014 there were more than 104 papers with 83 different ideas on what energy security is [Ang et al., 2015]. Researchers have so far reached a consensus that the energy security concept is blurred [Loeschel et al., 2010], ubiquitous [Chester, 2010; Sovacool and Mukherjee, 2011], widely disputed [Kisel et al., 2016], and remains poorly or at least not clearly defined [Winzer, 2012; Glynn et al., 2017]. Scientists indicate additionally that they have difficulty in interpreting energy security definitions [Li et al., 2016]. While the present authors are aware of the complexity of interdisciplinary energy security literature, they also acknowledge that a comprehensive discussion on its meaning is beyond this study's goal. For a comprehensive discussion on energy security phenomenon see, e.g., Bohi and Toman [1996]. Due to the unclear nature of the energy security phenomenon, the present authors have decided to use an idea introduced by an internationally recognized body specializing in energy security, i.e., the International Energy Agency (IEA). This agency "defines energy security as the uninterrupted availability of energy sources at an affordable price" [IEA, 2020]. IEA breaks the concept into two time horizons: short- and long-term. The former pertains to the ability to respond to prompt changes in energy supply–demand balance and the latter refers to timely investments answering development and environmental challenges [IEA, 2020]. This research is positioned by the present authors within the long-term energy security perspective including availability, affordability, and environmental aspects. This way of thinking about energy security is present in various studies [Sovacool and Mukherjee, 2011; Ang et al., 2015].

2.1 International competitiveness and comparative advantage

Alike energy security, international competitiveness also lacks a single, widely accepted definition. It can be analyzed on a national, regional, or industry/company level. Competitiveness as a macroeconomic character is less established in economic theory than its microeconomic counterpart [Siggel, 2006]. Yet, there are various definitions of international competitiveness on a macroeconomic level. Alike with energy security, in this study, the present authors use internationally recognized theoretical frameworks introduced by two leading organizations specializing in assessing international competitiveness: World Economic Forum [WEF, 2014] and Institute of Management in Lausanne [IMD, 2014]. The first depicts international competitiveness as "the set of institutions, policies, and factors that determine the level of productivity of a country. The level of productivity, in turn, sets the level of prosperity that can be reached by an economy" [WEF, 2014, p. 4] and the second treats it as the "ability of a nation to create and maintain an environment that sustains more value creation for its enterprises and more prosperity for its people" [IMD, 2014]. In the present study, the concept of international competitiveness is scrutinized through the perspectives of the WEF and the IMD, understanding the phenomenon as a set of institutions, and factors conditioning the prosperity of nations. A deeper discussion on international competitiveness is presented, e.g., by Misala [2011], but one that best applies to our approach can be found in the study of Nyga-Łukaszewska and Napiórkowski [2022]. There, the authors boil down the discussion on various definitions of international competitiveness to a simple relationship: international competitiveness comes from higher international comparative advantage that translates into higher exports. In other words, the more internationally competitive a country is, the higher will its exports be as compared to other economies (i.e., the world). Such logic fits the approach to international competitiveness presented, e.g., by OECD [2022], and Zhang [2015].

Unlike international competitiveness, Ricardo's idea of comparative advantage is theoretically straightforward. Thus, what is referred to is not the original roots of the idea but, since the phenomenon is well established, the focus is rather on its contemporary understanding. Comparative advantage nowadays can be understood either in a traditional Ricardian model of trade (with its various extensions such as the model of Dornbush–Fisher–Samuelson), the Heckscher–Ohlin model of trade, or (more generally) as any other trade determinant of what Siggel [2006] calls "generality" of comparative advantage. In the former line of reasoning, e.g., intra-industry trade, Vernon's differences in the product life cycle or Krugman's economies of scale would not constitute comparative advantage as they would in the latter [Siggel, 2006]. In the present study, Siggel's logic, in which energy security is treated as a trade determinant, is followed, which in consequence builds a country's comparative advantage and thus international competitiveness.

The present authors do not treat comparative advantage and international competitiveness as equal phenomena. They are aware of several differences between "comparative advantage" and "international competitiveness" as economic terms. First, comparative advantage does not include trade distortions that are included in the concept of international competitiveness. Second, comparative advantage has a rather "natural, structural" character, whereas international competitiveness can change because of macroeconomic changes. Third, usually comparative advantage is assessed in different groups of commodities, while international competitiveness compares the same set of products from different countries [Qineti et al., 2009]. Recognizing these differences and modeling limitations, the present authors look at international competitiveness through the methodological lenses of comparative advantage. At the same time, they assign their methodological approach to a category of research limitations.

2.2 Energy security and international competitiveness

Energy is generally treated as a part of the international competitiveness idea, but mainly as an input factor. Some of the authors call it "energy competitiveness" [Zachmann and Cipollone, 2013]. In this sense, energy is treated as a factor influencing competitiveness in international markets [Falkowski, 2018]. Zachmann and Cipollone [2013], similarly to Bureau et al. [2013], look specifically at the cost of electricity as a determinant behind the competitiveness of the manufacturing industry in Europe. This idea treats energy as a production

factor and corresponds closely with the argument of Velthuijsen and Worrell [2002] that electricity prices can be treated alike. Energy is treated as a production factor determining international competitiveness by Lieber [1980] and Klein [1988] as well as in the McKinsey report [2009], and also as an input determining industrial costs and export competitiveness (e.g., APERC, [2016]). Katic et al. [2016] represent a similar approach when analyzing international competitiveness indicators and the role of the energy components in different measures or rankings.

To this paper authors' knowledge, there are relatively few studies looking at how energy security determines international competitiveness, among them: Berk et al. [2006], Scott [2013], Nyga-Łukaszewska [2016], Bilan et al. [2017], Nyga-Łukaszewska and Chilimoniuk-Przeździecka [2017], and Nawaz and Alvi [2018]. The analysis is chiefly centered around either the idea of energy poverty and thus efforts aimed at ensuring access to energy [Nawaz and Alvi, 2018] or energy imports [Bilan et al., 2017]. Nawaz and Alvi [2018] claim that energy security translates into the international competitiveness of domestic companies. However, they highlight that energy security can be achieved by an increased domestic resource base and decreased by energy imports. It seems that such reasoning relates to quasi-autarky energy management. Bilan et al. [2017] on the other hand argue that even though Germany is highly competitive in international markets it does not enjoy energy security due to the high share of natural gas imports from Russia. Although Bilan et al. [2017] claim that energy security relates to international competitiveness, they find the German example to be a paradox. Scott [2013] looks at the energy sector as an important industry determining international competitiveness, but his way of defining energy security is closer to the IEA's idea. He is more concerned with price volatility and an adequate supply of fuels rather than their origins. Scott [2013] claims that for low developed countries, high energy costs and its inadequate supply influence their international competitiveness.

This study adds to the existing literature as it looks at energy security and international competitiveness beyond theoretical analysis (conducted, e.g., by Nyga-Łukaszewska [2016]). Apart from Nyga-Łukaszewska and Chilimoniuk-Przeździecka [2017], such an approach has been rare. Additionally, this paper investigates the sample of the EU NMS while existing studies focused on specific countries like Azerbaijan [Falkowski, 2018], Germany [McKinsey, 2009; Bilan et al., 2017], the Netherlands [Berk et al., 2006], Pakistan [Nawaz and Alvi, 2018], Poland [Nyga-Łukaszewska, 2016], Serbia [Katic et al., 2016], or their groups: Europe in general [Zachmann and Cipollone, 2013], low-income countries [Scott, 2013], or the world's biggest energy consumers [Nyga-Łukaszewska and Chilimoniuk-Przeździecka, 2017] or energy exporters [Nyga-Łukaszewska and Napiórkowski, 2022]. The sample of countries used in the present study is to some extent similar to that used in the study of Głowacka [1996], who was analyzing the group of Central and Eastern European economies in transition. However, Głowacka's [1996] study focused on assessing the role of energy efficiency in the creation of national competitive advantage according to Porter's idea, while in the present research, the focus is on energy security. Third, to the present authors' knowledge, no prior studies have embedded energy security and international competitiveness analysis in a wider framework of international trade models as is carried out in the present research.

Based on the above, this research question (as indicated in the introduction) refers to the relationship between energy security and international competitiveness. The aim of the modeling process used in this study is to test the hypothesis about the positive impact of energy security on the international competitiveness of selected EU NMS.

3 Methodology and data

Econometric modeling is used in the present research to test our research hypotheses in a manner similar to that of Amoroso et al. [2011]. Amoroso et al. [2011] investigate the pattern of Mexico's comparative advantages in manufacturing, vis-à-vis its closest competitors. The authors look for an answer to the question of whether international competitiveness measured by revealed comparative advantage (RCA) is related to productivity differentials (the Ricardian hypothesis) or with differences in factor endowments (the Heckscher–Ohlin hypothesis). In this sense, Amoroso et al. [2011] check if Mexico's trade patterns

follow the Ricardian or Heckscher–Ohlin models of trade. By analogy, the present research ascertains whether Poland's international competitiveness follows the Ricardian or Heckscher–Ohlin hypothesis. A similar approach has also been used by Nyga-Łukaszewska and Napiórkowski [2022].

In conformity with the approach of Amoroso et al. [2011], the present authors first identify the pattern of comparative advantages of Poland and its main competitors – the EU NMS. The present research analyzes the extent up to which Poland's pattern of comparative advantage, as compared to the EU NMS, is related to energy security, productivity differentials, and resource endowment. That is why this model, similarly to Amoroso et al. [2011], looks at RCA determinants including differences in factor endowments – the Heckscher–Ohlin hypothesis – and productivity – the Ricardian hypothesis.

Poland was selected as a point of reference for our study for a few reasons. First, Poland is one of the fastest growing economies in the EU (Figure 1). Second, exports play an increasingly important role in determining Poland's GDP with Polish exports increasing despite such setbacks as the Russian embargo or pre-Brexit actions (it may be noted in this context that the UK is the third biggest destination for Polish exports), as demonstrated in Figure 2. Third, in terms of total primary energy supply, Poland ranks above the EU (28) per country average (Figure 3), while at the same time it has the lowest relative share of renewable energy in gross final energy consumption in the studied group (Figure 4; excluding Malta). This last argument's

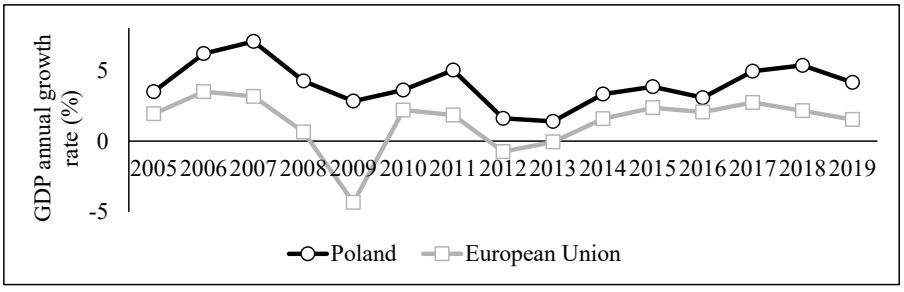


Figure 1. Poland's and EU's GDP annual growth rate (%) 2005–2019.
Source: Own work based on data from the World Bank [2020].

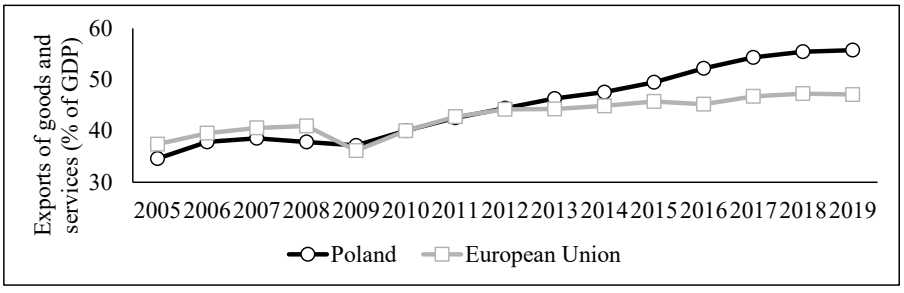


Figure 2. Poland's and EU's exports of goods and services (% of GDP) 2005–2019.
Source: Own work based on data from the World Bank [2020].

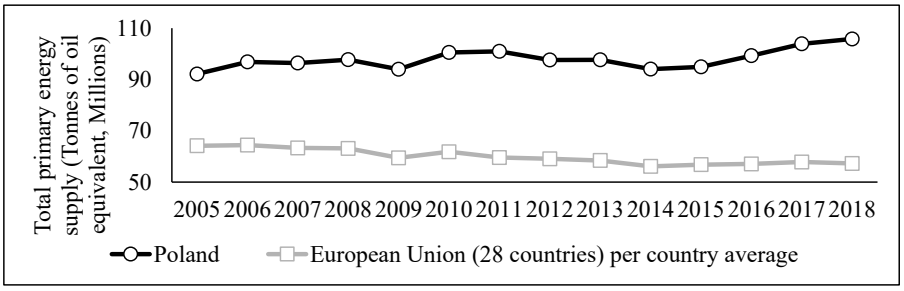


Figure 3. Poland's and EU's total primary energy supply (tons of oil equivalent, millions) 2005–2018.
Source: Own work based on data from the OECD [2020].

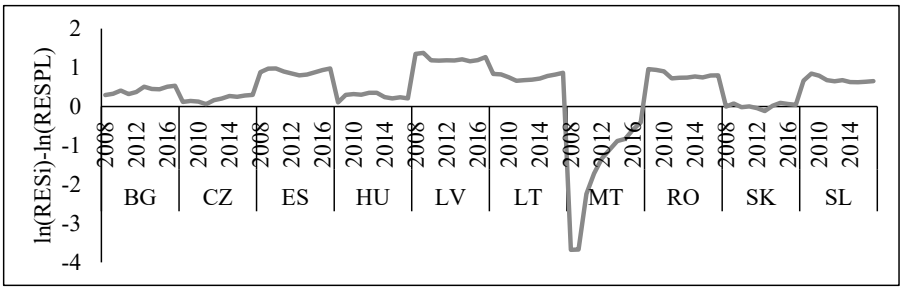


Figure 4. Relative share of renewable energy in gross final energy consumption 2005–2018. BG, Bulgaria; CZ, Czechia; ES, Estonia; HU, Hungary; LT, Lithuania; LV, Latvia; MT, Malta; RO, Romania; SK, Slovakia; SL, Slovenia.
Source: Own work based on data from the Eurostat [2020c].

importance is highlighted by the fact that the Polish government has been very vocal on the EU stage on possible negative effects of "green upgrading," quoting possible consequences for labor market and GDP.

Amoroso et al. [2011] rely on methodology presented by Nunn [2007], and Levchenko [2007]. The latter study reflects our approach the most. Levchenko [2007] is investigating to what extent institutions affect trade. The resemblance to his study stems not only from the modeling assumptions but also from the fact that both analyses include unmeasurable and elusive variables. Levchenko [2007] tries to operationalize institutional quality while they aim at capturing energy security.

Energy security, as an independent variable, is described in this model in a multidimensional manner, similarly to the approach adopted in the researches of Nyga-Łukaszewska and Chilimoniuk-Przeździecka [2017]. The present authors are aware of the complexity of energy security measures. However, they follow the argument of Sovacool and Mukherjee [2011] claiming that each complex index is based on selection of simple indicators that are subjected to the analyst's choice. Sovacool and Mukherjee [2011] argue it is more feasible to collect data for one or two simple indicators, as it may not be possible to collect data for a variety of metrics for particular countries.

Details for energy security variables are presented in Table 1. Energy security variables include: total primary energy supply (TPES, in million tons of oil equivalent), energy import dependence (EID, in percentage), use of renewables (RES, in percentage), energy intensity (EI, energy intensity of GDP in chain linked volumes for 2010 measured with kilograms of oil equivalent per €1,000), and GHG emissions (GHG, in index, base year = 1990). This set of variables effectively captures physical availability of energy and environmental aspects of its use at the same time. Availability is described by primary energy supply, energy imports, and renewables' use, while environmental aspect is covered by GHG emissions and energy intensity. This variables' breakdown reflects on selection of the energy security metrics presented by Sovacool and Mukherjee [2011]. At the same time, awareness of a variety of energy security indicators also prevails. Due to constraints on price data availability, and more specifically, due to a lack of access to reliable and country-differentiated information on oil and gas prices, the present authors decided to skip that aspect. This way, the present research addresses energy prices and their effects on competitiveness in the same way as done in the study of Tvaronaviciene et al. [2015], who neglected energy prices in their analysis claiming that since energy must be affordable at least to the industry sector, its price does not affect competitiveness of export. Similarly to Tvaronaviciene et al. [2015], the present authors attribute the missing price aspect to a category of research limitations.

Explanatory variables representing non-energy relative resource endowment and productivity have been constructed according to the procedure presented by Amoroso et al. [2011]. The difference in relative physical capital (K) per unit of labor (L) endowment – $\ln\left(\frac{K_i}{L_i}\right) - \ln\left(\frac{K_{PL}}{L_{PL}}\right)$ – is multiplied by a fraction of physical capital to gross value added (at basic prices, constant 2010 USD; GVA; $\frac{K_i}{GVA_i}$), with the said fraction representing physical capital intensity. Data on labor force and gross value added have been obtained from the World Bank [2020] and on physical capital from the Penn World Table v9.1 [Feenstra et al., 2015;

Table 1. Variables description

Group	Description (source)	Formula
Dependent variable	Relative RCA*	$\ln\left(RCA_i^*\right)-\ln\left(RCA_{PL}^*\right)$
Heckscher–Ohlin theory	Relative physical capital per worker endowment	$\left[\ln\left(\frac{K_i}{L_i}\right)-\ln\left(\frac{K_{PL}}{L_{PL}}\right)\right]\frac{K_i}{GVA_i}$
	Relative human capital endowment	$\left[\ln\left(H_i\right)-\ln\left(H_{PL}\right)\right]\frac{w_i}{\bar{w}}$
Ricardian theory	Relative labor productivity	$\ln\left(\frac{GVA_i}{L_i}\right)-\ln\left(\frac{GVA_{PL}}{L_{PL}}\right)$
Energy variables	Total primary energy supply [OECD, 2020]	$\ln\left(TPES_i\right)-\ln\left(TPES_{PL}\right)$
	Energy import dependency [Eurostat, 2020b]	$\ln\left(EID_i\right)-\ln\left(EID_{PL}\right)$
	Share of renewable energy in gross final energy consumption [Eurostat, 2020c]	$\ln\left(RES_i\right)-\ln\left(RES_{PL}\right)$
	Energy intensity [Eurostat, 2020d]	$\ln\left(EI_i\right)-\ln\left(Ei_{PL}\right)$
	Greenhouse gas emissions [Eurostat, 2020e]	$\ln\left(GHG_i\right)-\ln\left(GHG_{PL}\right)$

Note: The time subscript t has been omitted to ensure clarity.
Source: Authors' own input.

University of Groningen, 2019a]. Relative endowment in human capital (H, University of Groningen [2019a]; $\ln(H_i)-\ln(H_{PL})$ is multiplied by the ratio of annual net earnings of a full-time single worker without children earning an average wage (Eurostat [2020a]; w) to its mean value for the entire group $\left(\frac{w_i}{\bar{w}}\right)$. This multiplier ratio represents human capital intensity. Human capital is represented by an index calculated based on years of schooling as well as returns to education (for detailed information on human capital index calculation see: University of Groningen [2019b]). Finally, the model includes labor productivity differences measured as gross value added divided by labor force: $\ln\left(\frac{GVA_i}{L_i}\right)-\ln\left(\frac{GVA_{PL}}{L_{PL}}\right)$.

To measure international competitiveness, the RCA is used [Balassa, 1965], as illustrated in Eq. (1) below:

$$RCA_{is}=\left(\frac{X_{is}/\sum_{s=1}^{S}X_{is}}{\sum_{i=1}^{I}X_{is}/\sum_{s=1}^{S}\sum_{i=1}^{I}X_{is}}\right) \tag{1}$$

where the RCA of country i in good s (RCA_{is}) is a function of the value of that country's total exports (X_{is}). This functional form was selected as it closely resembles that presented originally by Balassa [1965], but (as found done in the existing literature) it has been modified within the scope of the present research to ensure applicability on an aggregate level of total exports and imports. Finally, this measure (as noticed by Nyga-Łukaszewska and Napiórkowski [2022]) meets the criteria of a measure of competitiveness established by Durand and Giorno [2023]. The present authors recognize that RCA was designed to focus on industries and is not without flaws [Misala, 2011; Laursen, 2015] and that it is just one aspect of international competitiveness, which is a multi-layered concept [Schwab and Zahidi, 2020]. At the same time, application of RCA to represent international competitiveness is both used in the literature [Oelgemöller, 2012; Guan et al., 2019; Shuai et al., 2019] and needed for the operationalization of the above research hypothesis. Khatibi [2008], whose study is very close to the present research, investigated what influence rich energy resources have on RCA, by taking up the particularized case of the competitiveness of Kazakhstan (vis-à-vis

world exports to the EU-27 and intra-exports between the EU-27 member countries). RCA has also been used as a measure of international competitiveness of China's biomass products by Shuai et al. [2019]. Therefore, the link between the energy sector and RCA is also well established. Such modifications of RCA – partly due to its limitations – are therefore quite common in the empirical literature (see, e.g., Algieri et al. [2018]; Su et al. [2020]; Shuai et al. [2022]).

With a modification, keeping the "spirit" of the original RCA, Eq. (1) can be transformed to represent competitiveness of an entire economy. For the purpose of our model, $RCA_{it}^{\star}$ (Eq. [2]; an "⋆" is used to distinguish it from the traditional, industry-level RCA) in time t has been calculated based on data from the World Bank [2020] as the ratio of country's i exports (X_i) to its imports (M_i) relative to the same ratio for the world $\left(X_w/M_w\right)$. If the value of exports is greater than the value of imports for a given country for a given year ($X_i > M_i$), then the numerator of this formula will be greater than 1 $\left(\frac{X_i}{M_i}>1\right)$, i.e., country i has positive net exports. If this relationship is greater for country i than for the world $\left(\frac{X_i}{M_i}>\frac{X_w}{M_w}\right)$, this country is seen as being internationally competitive. In other words, the ratio of world's demand for country i's goods and country i's demand for world's goods is greater than this same ratio on a world level. Therefore, values greater than 1 suggest that country i has a relative comparative advantage against the world average, while values less than 1 suggest the opposite (for an example of application and further discussion of this measure, see: Nyga-Łukaszewska and Napiórkowski [2022]).

$$RCA_{it}^{\star} = \frac{X_{it}/M_{it}}{X_{wt}/M_{wt}} \tag{2}$$

Data have been collected for 11 countries (Bulgaria, Czechia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia) for 2008–2017. Other economies, which entered the EU in 2004 or later, have been excluded owing to reasons pertaining to data availability. This allowed for the maximization of the overall number of observations and recency of data – while having a balanced panel.

Variables were tested for multicollinearity using the variance inflation factor (VIF; Table 2). Since the used independent variables are compound macroeconomic variables (i.e., they are a result of mathematical operations) with some common elements (e.g., GVA), multicollinearity is expected. At the same time, exclusion of variables with high VIF values would limit the explanatory value of this study. This conclusion falls in line with Wooldridge's [2014] notes on multicollinearity and VIF.

Table 2. Values of VIFs

Variable	$\ln\left(TPES_i\right)-\ln\left(TPES_{PL}\right)$	$\ln\left(\frac{GVA_i}{L_i}\right)-\ln\left(\frac{GVA_{PL}}{L_{PL}}\right)$	$\left[\ln\left(\frac{K_i}{L_i}\right)-\ln\left(\frac{K_{PL}}{L_{PL}}\right)\right]\frac{K_i}{GVA_i}$	$\ln\left(RES_i\right)-\ln\left(RES_{PL}\right)$	$\ln(GHG_i)-\ln(GHG_{PL})$	$\ln(EI_i)-\ln(Ei_{PL})$	$\left[\ln(H_i)-\ln(H_{PL})\right]\frac{w_i}{w}$	$\ln(EID_i)-\ln(EID_{PL})$	**Mean VIF**
VIF	10.480	5.540	3.930	3.370	2.980	2.760	2.590	2.490	4.270

Source: Own calculations with STATA 15 based on data from the World Bank [2020], OECD [2020], University of Groningen [2019a], and Eurostat [2020a-e].

4 Results and discussion

The international competitiveness of Poland between 2004 and 2017 exhibited a positive trend (Figure 5). Following an initial increase in international competitiveness after joining the EU, Polish RCA* fell from 2005 (0.941) to 2008 (0.885), increasing later until 2013 (1.028). Interestingly, Poland's international competitiveness registered its greatest gains during the 2008 financial crisis and its aftermath. This can be related to the fact that Poland wasn't significantly impacted by the said crisis and to a relatively quick recovery of the German economy, which is the biggest recipient of Poland's exports.

Comparing values for Poland with the RCA* values of other countries ($\ln(RCA_i^*) - \ln(RCA_{PL}^*)$; Figure 6), the studied economies can be divided into three groups. The first group is comprised of countries that had a constantly lower international competitiveness than Poland (Bulgaria and Latvia); the second, of economies with a falling relative international competitiveness (Estonia and Lithuania); and the third, of economies that constantly displayed higher international competitiveness than Poland (Czechia, Hungary, Slovakia, Slovenia, and Malta – with 2013 being an exception).

The initial model takes the form presented in Eq. (3) with 10 cross-sections (i = Bulgaria, Czechia, Estonia, Hungary, Latvia, Lithuania, Malta, Romania, Slovakia, and Slovenia) and 10 years (t) and includes cross-section (γ_i) and period (δ_t) effects. In conformity with the methodology followed in the study of Amoroso et al. [2011], values for the 10 countries included in the study are directly compared to values for Poland. On the left-hand side of the equation, a positive value of the described difference in RCA* shows that country i has a greater international competitiveness than Poland; and vice versa. On the right-hand side, such a specification allows for a direct comparison of resource endowment and productivity between country i and Poland, i.e., it operationalizes the Heckscher–Ohlin and Ricardo trade theories.

Models' coefficients have been estimated using ordinary least squares with fixed effects (Stata code: *xtreg ..., fe*) as designated by the Hausman test (*hausman fe re*) and robust standard errors (*xtreg ..., fe cluster()* – also possible *xtreg ..., fe vce(robust)*) to account for possible residual (ε_{it}) issues of autocorrelation (tested with the Lagram-Multiplier test – also known as the Wooldridge test for autocorrelation in panel

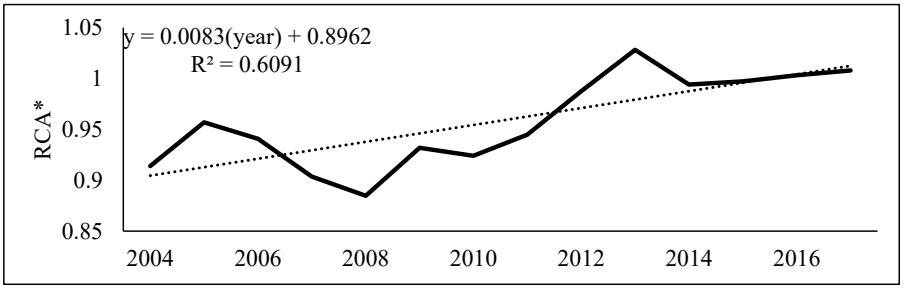


Figure 5. Poland's RCA* 2004–2017.

Source: Own work based on data from the World Bank [2020].

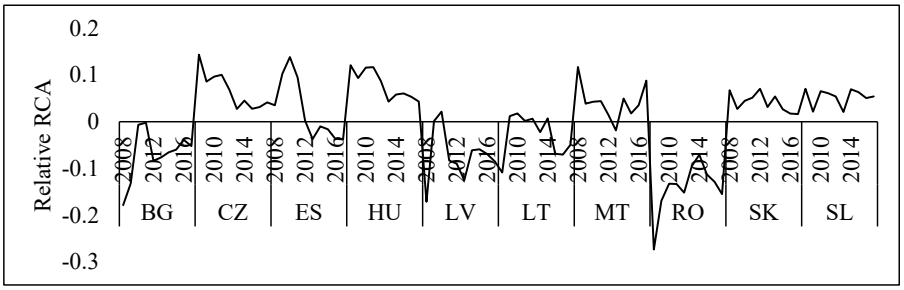


Figure 6. Relative RCA* for the analyzed economies. BG, Bulgaria; CZ, Czechia; ES, Estonia; HU, Hungary; LT, Lithuania; LV, Latvia; MT, Malta; RO, Romania; SK, Slovakia; SL, Slovenia.

Source: Own work based on data from the World Bank [2020].

data – *xtersial ...*) and heteroskedasticity (tested with the Modified Wald for group-wise heteroskedasticity test *xttest3*). Each model's residuals have been tested for the presence of a unit root (Levin–Lin–Chu – *xtunitroot llc* – and Harris–Tzavalis – *xtunitroot ht* – tests) and normal distribution (Jarque–Bera – *jb* – and Shapiro–Wilk – *swilk* – tests).

The modeling process moved from estimating an unrestricted (Eq. [3]) to a restricted (Eq. [5]) model. This was achieved by a process of elimination of explanatory variables, whose coefficients were statistically insignificant at a 10% level of statistical significance (Table 3). Such an approach is dictated by the difficulty (mentioned earlier) in defining and therefore measuring energy security. Allowing for different energy variables minimizes potential issues related to measurement error. Given the importance of relative resource endowment and productivity differentials as literature- and theory-derived control variables representing the Heckscher–Ohlin and the Ricardian hypotheses accordingly, they were kept in all versions of the model.

Table 3. Results of econometric modeling

	Model 1 (Eq. [3])		**Model 2 (Eq. [4])**		**Model 3 (Eq. [5])**	
$\ln\left(RCA_i^{\star}\right)-\ln\left(RCA_{PL}^{\star}\right)$	Coef.	*P* > t	Coef.	*P* > t	Coef.	*P* > t
$\ln(TPES_i)-\ln(TPES_{PL})$	−0.220*	0.058	−0.213**	0.023	−0.170*	0.078
$\ln(EID_i)-\ln(EID_{PL})$	−0.013	0.743	-	-	-	-
$\ln(RES)-\ln(RES_{PL})$	−0.018**	0.047	−0.020**	0.018	-	-
$\ln(EI_i)-\ln(EI_{PL})$	−0.031	0.671	-	-	-	-
$\ln(GHG_i)-\ln(GHG_{PL})$	0.021	0.684	-	-	-	-
$\left[\ln\left(\frac{K_i}{L_i}\right)-\ln\left(\frac{K_{PL}}{L_{PL}}\right)\right]\frac{K_i}{GVA_i}$	195.925*	0.094	191.537	0.105	212.377*	0.068
$\left[\ln(H_i)-\ln(H_{PL})\right]\frac{w_i}{\bar{w}}$	1.482**	0.015	1.519**	0.015	1.533**	0.016
$\ln\left(\frac{GVA_i}{L_i}\right)-\ln\left(\frac{GVA_{PL}}{L_{PL}}\right)$	−0.058	0.680	−0.045	0.760	−0.057	0.700
β_0	−0.600	0.021	−0.595	0.006	−0.515	0.026
Lagram–Multiplier	0.001		0.001		0.001	
Modified Wald	0.000		0.000		0.000	
Jarque–Bera *P*-value	0.016		0.021		0.126	
Shapiro–Wilk *P*-value	0.000		0.000		0.017	
Levin–Lin–Chu *P*-value	0.000		0.000		0.000	
Harris–Tzavalis *P*-value	0.000		0.000		0.000	
R^2 within	0.263		0.259		0.235	
R^2 between	0.235		0.239		0.277	
R^2 overall	0.193		0.196		0.228	
Prob. > F	0.000		0.001		0.001	

Note: ** and * denote significance at the 5% and 10% levels, respectively.

Source: Own calculations with STATA 15 based on data from the World Bank [2020], OECD [2020], University of Groningen [2019a], and Eurostat [2020a-e].

$$\begin{aligned}\left[\ln\left(RCA_i^{\star}\right)-\ln\left(RCA_{PL}^{\star}\right)\right]_{it} &= \beta_0+\beta_{TPES}\left[\ln\left(TPES_i\right)-\ln\left(TPES_{PL}\right)\right]_{it}\\ &+\beta_{EID}\left[\ln\left(EID_i\right)-\ln\left(EID_{PL}\right)\right]_{it}+\beta_{RES}\left[\ln\left(RES\right)-\ln\left(RES_{PL}\right)\right]_{it}\\ &+\beta_{EI}\left[\ln\left(EI_i\right)-\ln\left(EI_{PL}\right)\right]_{it}+\beta_{GHG}\left[\ln\left(GHG_i\right)-\ln\left(GHG_{PL}\right)\right]_{it}\\ &+\beta_K\left\{\left[\ln\left(\frac{K_i}{L_i}\right)-\ln\left(\frac{K_{PL}}{L_{PL}}\right)\right]\frac{K_i}{GVA_i}\right\}_{it}+\beta_H\left\{\left[\ln\left(H_i\right)-\ln\left(H_{PL}\right)\right]\frac{w_i}{\bar{w}}\right\}_{it}\\ &+\beta_{LP}\left[\ln\left(\frac{GVA_i}{L_i}\right)-\ln\left(\frac{GVA_{PL}}{L_{PL}}\right)\right]_{it}+\gamma_i+\delta_t+\varepsilon_{it}\end{aligned} \tag{3}$$

$$\begin{aligned}\left[\ln\left(RCA_i^{\star}\right)-\ln\left(RCA_{PL}^{\star}\right)\right]_{it} &= \beta_0+\beta_{TPES}\left[\ln\left(TPES_i\right)-\ln\left(TPES_{PL}\right)\right]_{it}\\ &+\beta_{RES}\left[\ln\left(RES\right)-\ln\left(RES_{PL}\right)\right]_{it}+\beta_K\left\{\left[\ln\left(\frac{K_i}{L_i}\right)-\ln\left(\frac{K_{PL}}{L_{PL}}\right)\right]\frac{K_i}{GVA_i}\right\}_{it}\\ &+\beta_H\left\{\left[\ln\left(H_i\right)-\ln\left(H_{PL}\right)\right]\frac{w_i}{\bar{w}}\right\}_{it}+\beta_{LP}\left[\ln\left(\frac{GVA_i}{L_i}\right)-\ln\left(\frac{GVA_{PL}}{L_{PL}}\right)\right]_{it}\\ &+\gamma_i+\delta_t+\varepsilon_{it}\end{aligned} \tag{4}$$

$$\begin{aligned}\left[\ln\left(RCA_i^{\star}\right)-\ln\left(RCA_{PL}^{\star}\right)\right]_{it} &= \beta_0+\beta_{TPES}\left[\ln\left(TPES_i\right)-\ln\left(TPES_{PL}\right)\right]_{it}\\ &+\beta_K\left\{\left[\ln\left(\frac{K_i}{L_i}\right)-\ln\left(\frac{K_{PL}}{L_{PL}}\right)\right]\frac{K_i}{GVA_i}\right\}_{it}\\ &+\beta_H\left\{\left[\ln\left(H_i\right)-\ln\left(H_{PL}\right)\right]\frac{w_i}{\bar{w}}\right\}_{it}+\beta_{LP}\left[\ln\left(\frac{GVA_i}{L_i}\right)-\ln\left(\frac{GVA_{PL}}{L_{PL}}\right)\right]_{it}\\ &+\gamma_i+\delta_t+\varepsilon_{it}\end{aligned} \tag{5}$$

The first (unrestricted; Eq. [3], Table 3) model included all energy variables, both capitals and labor explanatory variables. In this model, coefficients of TPES (P-value = 0.058), RES (0.047), physical capital (0.094), and human capital (0.015) variables have been found to be statistically significant (P-value for labor productivity was equal to 0.680). Retaining only statistically significant energy independent variables within the model yielded two energy variables (Eq. [4]), namely TPES (0.023) and RES (0.018).

Eventually, the model took a restrictive form, as presented in Eq. (5). Based on the results of the Hausman test (prob. $>\chi^2 = 0.0006$), the fixed effects model was selected. The Jarque–Bera (P-value = 0.126) test suggests that residuals are normally distributed, but the Shapiro–Wilk (P-value = 0.017) test speaks in favor of the alternative hypothesis. Considering the number of observations (n = 100) and that with large samples the Shapiro–Wilk test tends to yield statistically significant results [Field, 2013], based on the Jarque–Bera test, the model's residuals are treated as normally distributed. Next, the restricted model's residuals were tested for the presence of a unit root using the Levin–Lin–Chu (P-value < 0.001) and Harris–Tzavalis (P-value < 0.001) tests. Both tests confirmed that residuals are stationary; therefore, they do not exhibit characteristics of a spurious regression. Finally, on residuals, they have been shown to suffer from both autocorrelation (P-value = 0.001) and heteroskedasticity (P-value < 0.001); hence, the robust standard errors option was used. P-value of the F-statistics (0.001) allows for a rejection of a null hypothesis of all estimated coefficients being equal to 0 and the overall R^2 equals 22.8%.

TPES, physical capital (albeit with *P*-value of 0.105 in Model 2), and human capital coefficients are statistically significant in all three models. Therefore, these can be considered as robust determinants of relative international competitiveness (again, as measured by RCA*). The impact of a unit-change in relative TPES on relative RCA* varies across models between −0.220 and −0.170; between 212.377 and 191.537 for physical and between 1.533 and 1.482 for human capital. The model's results therefore correspond to the Heckscher–Ohlin hypothesis pertaining to trade theory, but not to the Ricardian hypothesis.

5 Conclusions and policy implications

The present research analyzed energy security's impact on international competitiveness for EU NMS during 2008–2017. Their model shows that among all variables used to model energy security, endowment in energy as a resource (a sum of energy production and net imports corrected against stock changes) proved to have a statistically significant impact on our dependent variable. The other explanatory variables, namely endowments in physical and human capital, were the only two to have statistically significant coefficients.

More specifically, this model shows that countries with relative greater energy supply enjoy relatively lower international competitiveness. Therefore, the present authors' research hypothesis of a statistically significant and positive impact of energy security on international competitiveness has been rejected. This result is in line with the idea that energy consumption, in general, has a negative impact on energy security (supply; Erdal [2015]).

Interestingly, when thinking about energy security, greater energy availability is one of the energy security determinants [APERC, 2007; Erdal, 2015] associated with supply security improvement [Khatib, 2000], which could suggest a validation of the present study's research hypothesis. The present authors believe that the sign of the impact of energy supply (proxing for energy security) depends on the level of development of the studied economy and the type and the efficiency of the energy mix it uses. For example, more developed economies (e.g., Germany), where renewable energy is a significant part of the energy mix, can have lower energy security than less developed economies characterized by energy being derived chiefly from coal (e.g., Poland).

The results of the present study confirm the idea of "energy competitiveness," according to which energy influences the international competitiveness. Surprisingly, only TPES remained statistically significant in the model's most restrictive version (Eq. [5]), although other energy security variables such as renewables component were significant in the intermediate model. The insignificance of energy intensity was an unexpected result as well. The present researchers assumed, after Nyga-Łukaszewska and Chilimoniuk-Przeździecka [2017], that this variable would be of importance for international competitiveness and for export of intermediate goods; further, they were under the impression that that since export capacity is determined by energy intensity, the international competitiveness of a country would be, as well – but it turns out that it is not.

One possible explanation for these results might be the difference between the sample compositions in both studies. This study includes EU NMS while Nyga-Łukaszewska and Chilimoniuk-Przeździecka [2017] focus on large energy user-countries. Probably, for the latter, anything decreasing energy use would be of importance, while the former enjoys, at least to some extent, unified EU energy standards even without a formal common energy policy in the EU. Another possible explanation might be the aggregation level applied in the analysis employed in the present research vis-à-vis that in the research of Nyga-Łukaszewska and Chilimoniuk-Przeździecka [2017]; whereas the former has focused on the macro-level, the latter examined the export of specific product groups.

According to the assumptions adopted in the study of Amoroso et al. [2011], the studied group of countries, against the backdrop of the fact that these are relatively well-developed, should rather exhibit validation of the Ricardian hypothesis. However, development homogeneity, in this case, does not outweigh the importance of differences in factor endowment. This study confirms this by showing that relative endowment in physical and human capital does impact the international competitiveness positively,

while labor productivity differentials have no impact at all. In other words, differences in international competitiveness in EU NMS can be modeled using the Heckscher–Ohlin model, but not necessarily with the Ricardian trade theory.

The results described in this study have far-reaching policy implications. First, it proves that energy security is highly context-dependent [Winzer, 2012] and therefore is deeply rooted in the country's energy profile. It can be treated as the rudimentary factor behind energy security, influencing the country's international competitiveness. This conclusion shows policymakers that any measures decreasing energy use in the country serve toward improving its capacity to compete in international markets. Linking that argument with high energy security contextuality leads to another conclusion: Any strategy involving facilitating international competitiveness through energy security must be country-tailored. A "one fits all" policy approach cannot be implemented in that area. Even though Euroskeptics will find this argument against common energy policy, the present researchers believe that it cannot be treated this way. They reckon that the role of the EU in laying grounds for common but differentiated energy standards cannot be underestimated. Thus, the inclusion of a variety of energy supply sources in the shaping of EU policy seems to be the crucial factor determining also the EU's international competitiveness. Naturally, great differences in energy mixes make the discussion on common European standards difficult, but not impossible. Regardless of the degree of sophistication of the measures designed, the very simple factor endowment would play a role. From the European policy perspective, that is why Article 194 of the Treaty on the Functioning of the European Union (TFEU) plays a ground-breaking role. Even though some aspects of energy policy are shared competences in the EU, each member state maintains sovereignty in determining the conditions for exploiting its energy resources, its choice between different energy sources, and the general structure of energy supply.

Data availability is the first limitation of this study. Data limitations concerning energy prices especially made it relatively difficult, but some broad patterns emerge from the estimates used for the present research. Since this study is designed within the context of the Ricardian and Heckscher–Ohlin theories, the authors omit other determinants constituting trade, even though they are responsible for the international flow of goods, capital, and services. This group includes sector/industry specific factors, economies of scale, technological progress, and connected with it, demand similarity or conditions in market competition. Another limitation of this study is its specific approach to international competitiveness. The present researchers look at it through the perspective of energy security trying to capture other determinants in remaining variables referring to capitals, labor, and value added; as noted earlier, they know that competitiveness is impacted by a series of other variables that have not been included in this model, e.g., inward foreign direct investments (FDIs) [Napiórkowski, 2017a]. However, including FDI, for instance, would lead to a significant problem of severe multicollinearity, as such independent variables as physical and human capital are themselves impacted by FDI [Napiórkowski, 2017b]. In addition to the problem of multicollinearity, an attempt to include all possible explanatory variables would lead to the model's over-specification.

As further research steps, the authors suggest two possible solutions. First, this study showed that energy resource accumulation affects adversely international competitiveness. In order to better understand that relationship, the authors would like to suggest further research in that area, in particular focused on greater data disaggregation. They assume that dividing energy production category into fossil and non-fossil fuels, or even deeper into different fossil energy types, might be helpful in better understanding the above relationship. Second, they see a possibility of changing variable proxies for energy security (e.g., TPES) since the concept is vague and elusive [Chester, 2010; Loeschel et al., 2010; Sovacool and Mukherjee, 2011] and its operationalization is subjected to a wider discussion. They have attempted this to a large degree; however, their set of possible representatives of energy security has been limited by data availability. Finally, it would be advantageous to see if results are stable across other measures of international competitiveness – ones not necessarily based on RCA. The authors believe that the approach taken by them in this study to using RCA as a measure of international competitiveness is sound, but as they have shown in their literature review, it is not the only or ultimate one.

Acknowledgement

This publication was prepared within the statutory research with funding provided by the Warsaw School of Economics; project title: "Capturing the value added: advancement, stagnation or degradation. Selected case studies"; project No. KGS/S20:1.3.

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