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European Union Electric Energy Sector's Infrastructure Impact on Economic Growth

This paper tests electric energy sector's infrastructure impact on economic growth in the European Union during the 1990-2017 years time span. Paper's empirical research encompasses all 28 European Union countries (at that time) data, and fills the gap of such research in electric energy sector's case in the full European Union area. Two of three proxy variables used for this sector in the modelling are not only physical type, but with ability to encompass the usage of chosen infrastructure sector. It is a new feature in such type of research, which usually uses either raw physical, or raw monetary type infrastructure variables. The research results show (namely in proxy variables with infrastructure usage elements cases), that electric energy sector's infrastructure has no statistically significant long run impact on economic growth in the European Union. However, positive short run impact on economic growth in the European Union was found, with elasticity coefficients raging in [0,26;1,17] interval.

Keywords: European Union, physical infrastructure, electric energy, economic growth, long run, short run, cointegration.

Šiame straipsnyje analizuojamas elektros energijos sektoriaus infrastruktūros poveikis ekonomikos augimui Europos Sąjungos šalyse 1990–2017 m. laikotarpiu. Straipsnio tyrimas apima visų 28 Europos Sąjungos šalių (tuo metu) duomenis, užpildydamas tokio tipo tyrimų šiam infrastruktūros sektoriui trūkumą visos Europos Sąjungos mastu. Du iš trijų tyrime naudotų kintamųjų, atspindinčių elektros energijos sektoriaus infrastruktūrą, yra ne tik fizinės išraiškos pobūdžio, bet atspindi ir patį tiriamo infrastruktūros sektoriaus panaudojimo lygį. Toks rodiklių pasirinkimas yra pakankamai naujas atliekant tokio tipo tyrimus, kuriuose įprastai yra naudojami arba grynai fizinės, arba grynai finansinės išraiškos infrastruktūros kintamieji. Nustatyta, jog ilguoju laikotarpiu elektros energijos sektoriaus infrastruktūra nedaro statistiškai reikšmingo poveikio ekonomikos augimui. Vis dėlto trumpuoju laikotarpiu, ypač rodiklių, atspindinčių infrastruktūros panaudojimo lygį, modeliavimo atvejais rastas teigiamas statistiškai reikšmingas elektros energijos sektoriaus infrastruktūros poveikis ekonomikos augimui, kurio elastingumo koeficientai svyruoja nuo 0,26 iki 1,17.

Reikšminiai žodžiai: Europos Sąjunga, fizinė infrastruktūra, elektros energija, ekonomikos augimas, ilgas laikotarpis, trumpas laikotarpis, kointegracija.

JEL Classifications: O11/O33/O52.

Introduction

From theoretical approach infrastructure is one of the main factors of either country's or region's economic growth. This phenomenon consists of physical and organizational structures and services which are essential for economic growth. In general, infrastructure can be divided into three major sectors: transport,

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telecommunications and energy. According to Dash and Sahoo (2010), infrastructure contributes to economic growth through (1) direct investments on infrastructure, which create production facilities and stimulate economic activities, (2) transaction and trade costs reduction, which help to improve competitiveness and (3) provision of employment opportunities and physical and social infrastructure to the poor. However, lack of relevant infrastructure can disable proper economic growth and/or poverty reduction.

Electric energy sector is being considered one of the major sectors of infrastructure. In empirical research this sector is usually defined as electricity facilities, such as electricity generation or consumption. Most of the recent empirical research (Seethepalli, Bramati & Veredas, 2008; Sahoo & Dash, 2009; Dash & Sahoo, 2010; Sahoo, Dash & Nataraj, 2012; Zhang & Ji, 2018; Urrunaga & Aparicio, 2012; Imran & Niazi, 2011; Mohanty & Bhanumurthy, 2018; Estache, Speciale & Veredas, 2005; Fedderke & Bogetic, 2006) in this field focuses on electric energy sector's impact on economic growth in developing countries in Asia or Africa. Meanwhile in developed countries field there was found just a few empirical research (Easterly & Levine, 1997; Esfahani & Ramirez, 2003; Egert, Kozluk & Sutherland, 2009a, 2009b), so there is a need to fill this gap with research, which covers all European Union countries. All of those countries more or less are being considered as developed countries.

Research object: Electric energy sector's infrastructure impact on economic growth in the European Union countries for 1990-2017 years time span. There is need to evaluate electric energy sector's infrastructure impact on economic growth in the developed countries because recent research in this field were made mainly on the developing countries basis. Also, this paper's empirical research fills the gap of such research in electric energy sector‘s case in the full European Union area.

The aim: To test whether there is long run or short run relationship between electric energy sector's infrastructure and economic growth. If such relationship is found, then try to evaluate electric energy sector's infrastructure impact on economic growth.

The scientific problem: what is the type (long run or short run) and the form of the relationship between electric energy sector's infrastructure and economic growth in the developed countries?

The research methods: The first part of the paper consists of short infrastructure as a phenomena and electric energy sector's infrastructure impact on economic growth theoretical and empirical literature analysis. The second part of the paper consists of research data properties review, methodology and the empirical research. At the end of the paper research conclusions are provided.

The objectives of the article: 1) To analyse scientific literature and to find properties of infrastructure and current relationship between electric energy sector's infrastructure and economic growth; 2) To review research data properties and to describe this paper's research methodology; 3) To make empirical research in the European Union countries for 1990-2017 years time span and provide conclusions about the results.

The Concept of Infrastructure

The concept of infrastructure is quite new in scientific research. It started with seminal work of Tinbergen (1962) where the first difference between infrastructure and superstructure was made. After this work there was vast of other theoretical research articles in this area with different infrastructure definitions and classifications. According to some scientists (Hansen, 1965; Aschauer, 1989; Sturm, Jacobs & Groote, 1995; Buhr, 2003; Prud'homme, 2004; Baldwin & Dixon, 2008; Grubesic, 2009; Torrisi, 2009) it can be concluded, that infrastructure as a whole and its elements should be durable non-movable good, which is built during the long span of time. Other infrastructure features are conditional absence of substitutes in the short run and ability to be one of the major factors which helps to produce goods or provide services for country‘s economy.

In theoretical literature, there are two most common infrastructure categories: economic and social infrastructure. With the reference to Fourie (2006), economic infrastructure could be defined as infrastructure that promotes economic activity, such as roads, highways, railroads, airports, seaports, electricity, telecommunications, water supply and sanitation. According to Gabdrakhmanov and Rubtsov (2014), social infrastructure could be understood as a complex of municipal entity, constructions and institutions which provide the necessary material and cultural living conditions of the population on a certain territory, like institutions of science and art, of the general and vocational education, health and social security and construction of sports and recreational facilities. However, economic infrastructure is a more common type of infrastructure in the empirical research.

Electric Energy Sector‘s Infrastructure Impact on Economic Growth

As it has been already mentioned in the introduction, electric energy sector is being considered as one of the major sectors of infrastructure. Almost in all in the introduction mentioned empirical research papers there was found positive electric energy sector's infrastructure impact on economic growth. Authors in those studies usually used electricity production or electricity consumption, or energy consumption in oil equivalent indicators as the proxy variables of the electric energy sector.

In case of the usage of the electricity production variable, Easterly and Levine (1997) found statistically insignificant and Fedderke and Bogetic (2006) found negative (elasticity coefficient equals to -0,43) electric energy sector's infrastructure impact on economic growth. Other researchers (Esfahani & Ramirez, 2003; Egert et al., 2009a, 2009b; Zhang & Ji, 2018; Urrunaga & Aparicio, 2012; Imran & Niazi, 2011; Fedderke & Bogetic, 2006) found positive impact on economic growth, with elasticity coefficients raging in the [0,06;0,16] interval. In case of the usage of the electricity consumption variable, all analysed researchers (Seethepalli et al., 2008; Sahoo & Dash, 2009; Dash & Sahoo, 2010; Sahoo, Dash & Nataraj, 2012; Mohanty & Bhanumurthy, 2018) found just positive electric energy sector's infrastructure impact on economic growth, with elasticity coefficients raging in the [0,03;1,04] interval. And finally, in case of the usage of energy consumption in oil equivalent variable, all analysed researchers (Sahoo & Dash, 2009; Dash & Sahoo, 2010; Sahoo, Dash & Nataraj 2012;

Mohanty & Bhanumurthy, 2018) also found just positive impact on economic growth with elasticity coefficients raging in the [0,10;0,50] interval. The main take-away point from previous research is that, despite two non-positive impact cases, from all remaining empirical research papers analysis it can be concluded, that electric energy sector's infrastructure has positive impact on economic growth in the developing countries.

It can be seen, that in all three analysed electric energy sector's infrastructure impact on economic growth cases proxy variables for this infrastructure sector are expressed in physical type infrastructure measures. It is because monetary, especially, public investment type, infrastructure measures are considered as having too many drawbacks. According to Urrunaga and Aparicio (2012), public investments type infrastructure measures are not reliable because public infrastructure investments measures do not necessarily encompass all public infrastructure investments exclusively, that is, some amount of it can be spended on the auxillary services or structures. In addition, the private sector's share in the provision of this type of infrastructure is important too, so the public infrastructure investments measures alone could be insufficient. However, it is difficult to measure the amount invested by firms in public infrastructure due to the reason that private companies try to keep their costs as confidential as possible and usually that type of data are not publicly available. Finally, according to Urrunaga and Aparicio (2012), the investment costs often are not related to the quantity of infrastructure amount that is actually built.

Of course, physical infrastructure measures have drawbacks too, because most of the available data do not contain any information on differences in cost and quality (public infrastructure investments measures do not reflect the quality either). For example, the costs of setting up the infrastructure can vary markedly (an additional kilometre of road or rail track would be more expensive if requiring a bridge or a tunnel), while the quality of infrastructure may also vary (well maintained stocks may yield more benefits than poorly maintained ones) (Egert et al., 2009a, 2009b). However, physical infrastructure measures in empirical research are being considered as better ones, because, according to Egert et al. (2009a, 2009b), public infrastructure investments measures are becoming more and more unreliable due to corporatisation, privatisation and market liberalisation.

Theoretical Framework

In theoretical literature in case of infrastructure, it is said that infrastructure is a long lasting long run period good. Due to this assumption, one aim of this article is to test whether there is long run relationship between electric energy sector's infrastructure and the economic growth in the European Union during the 1990-2017 years time span. In case of nonexisting long run relationship, it will be tested whether the short run relationship between these phenomena exists.

The main model is based on the general production function form of:

$$\frac{Y}{L} = A * f(\frac{K}{L}) \qquad (1)$$

where: Y/L – output to labour ratio; K/L - capital to labour ratio; A – expression of the technological progress. Further it is used Cobb-Douglas type production function, so equation (1) becomes to:

$$\left(\frac{Y}{L}\right)_t = A\left(\frac{K}{L}\right)_t^{\beta_2} e^{u_t} \quad (2)$$

where: e is base of natural logarithm and u_t is stochastic disturbance term. After subsequent substitutions of

$$RGDP_t = \left(\frac{Y}{L}\right)_t \text{ and } INF_t^{\beta_2} = \left(\frac{K}{L}\right)_t^{\beta_2}$$

equation (2) takes form of:

$$RGDP_t = A \times INF_t^{\beta_2} e^{u_t} \qquad (3)$$

where: RGDP depicts proxy variable for economic growth and INF depicts proxy variable for electric energy sector's infrastructure. More information about these variables is given in subsection „research data".

Finally, natural logarithm is taken of equation (3) which leads to equation (4) and after substitution $\alpha = \ln A$ comes the final model (5) for this article's empirical research.

$$\ln RGDP_t = \ln A + \beta_2 \ln INF_t + u_t \quad (4)$$

$$\ln RGDP_t = \alpha + \beta_2 \ln INF_t + u_t \qquad (5)$$

Model depicted as equation (5) is used for testing both assumptions about electric energy sector's infrastructure impact on economic growth, either in the long or in the short run. The main interest of this analysis is β_2, which is elasticity coefficient, sign, size and statistical significance. It must be mentioned, that such (5) equations are tested for each of European Union country individually if the particular country's data meet all econometric modelling requirements.

Research Data

Research data consists of four ratio variables, namely real general domestic product (RGDP) per million capita, which is equivalent to economic growth, electricity generation, expressed in terawatt-hours per million capita, electricity net consumption, expressed in billion kilowatthours per million capita and electricity production capacities, expressed in megawatts per million capita which all three are the main equivalents to electric energy sector's infrastructure respectively. Research data covers 1990-2017 years time span and all 28 European Union countries at that time, with these exceptions: there was no available data for Estonia and Malta for electricity production capacities variable and no available data for Malta for electricity generation variable case. RGDP data was taken from United Nations statistics division database and is measured in constant 2010 prices in national currency. Population statistics were taken from Eurostat database and it is the total population of the country on January 1, except France data from 2014 to 2017, which was taken from Worldometer statistical website. Electricity generation and electricity net consumption statistics were taken from Knoema database, and electricity production capacities data was taken from Eurostat database.

Such empirical research data choice for electric energy sector's infrastructure was made due to three reasons. First, all proxy variables for electric energy sector's infrastructure are of the physical type infrastructure measures, which are better than monetary ones. Second, electricity production capacities variable is pure physical type infrastructure measure, which reflects electric energy sector's infrastructure impact on economic growth from the usuall infrastructure theory's point of view. Finally, third, the remaining electricity generation and electricity net consumption proxy variables for electric energy sector's infrastructure are physical type infrastructure measures, but those which also encompass such feature like particular infrastructure sector's usage ratio. Such proxy variables choice was made due to the fact, that European Union countries are being considered as developed countries, so electric energy sector's infrastructure in those countries is already built. Such proxy variable like electricity production capacities may be more suitable for developing countries, because in those countries infrastructure phenomenon is in motion, that is, it is still in the development stage and has upward trend, while in developed countries, like in the European Union, such type of infrastructure variable mainly fluctuates about its current value, because all the major amount of infrastructure in particular infrastructure's sector is already built. According to this reason, proxy variables, which are physical type but also encompass particular infrastructure's usage ratio may be the most appropriate in current European Union case.

Econometric Analysis Tools

In order to achieve this article's aim, econometric analysis tools should be used. All econometric calculations in this article are made using Gretl program. All of regression analysis is based on ordinary least squares (OLS) method, using the standard 0,05 level of significance value. In order to get elasticity coefficients, natural logarithms of relevant time series data were taken. To test, whether there is evidence of the long run relationship between the variables, Engle-Granger two step cointegration test developed by Engle and Granger (1987) is used. Economically speaking, two variables will be cointegrated if they have a long-term , or equilibrium, relationship between them (Gujarati & Porter, 2008). The cointegration regression equation form is the same as equation (5), with no time trend variable being added. If the long run relationship is found, error correction mechanism (ECM) will be used. In equation (6) ECM equation is provided:

$$\Delta \ln RGDP_t = \alpha + \beta_2 \Delta \ln INF_t + \beta_3 u_{t-1} + \varepsilon_t \quad (6)$$

where: ε_t is a white noise term and u_{t-1} is the lagged value of the error term in equation (5).

Time series data type is used in this analysis, so the presence of unit roots should be tested first. In this research the main test to test for unit roots is augmented Dickey-Fuller test (ADF) (Dickey & Fuller, 1979) and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) (Kwiatkowski et al., 1992) test is chosen as the supplementary test, because some times unit roots testing results could be equivocal due to the test specifications or the fact, that relevant time series data exhibits near unit root process. ADF test is used under test down from maximum lag conditions, while KPSS test is used with fixed lag length. Maximum lag length for both tests is calculated using Schwert (1989) l_{12} and l_4 formulas for ADF and KPSS tests respectively.

In order to avoid equivocal situations in unit root testing, the following unit root testing procedure is used:

1. For original logged RGDP per million capita, electricity production capacities, electricity generation and electricity net consumption per million capita data ADF and, if needed, KPSS tests are executed with constant and trend. Then it is executed Φ_3 test (Dickey & Fuller, 1981). If Φ_3 test's H_0 is accepted, ADF, and if needed KPSS tests are executed just with constant; if Φ_3 test's H_0 is rejected, usual t statistic test is used to check the presence of deterministic trend in the data. If trend is found, conclusions about unit root are made from ADF, and if needed KPSS tests with constant and trend specification; but if there is no deterministic time trend, then ADF, and if needed, KPSS tests are executed just with constant and corresponding conclusions about unit roots are made.

2. For the logged first differenced (if needed) RGDP per million capita, electricity production capacities, electricity generation and electricity net consumption per million capita time series data it is made t significance test to test, whether time series mean is statistically equal to zero. If it is so, ADF, and, if needed, KPSS tests are executed using without constant (ADF) and around the level (KPSS) test specifications; if no, then ADF, and, if needed, KPSS tests are executed using with constant (ADF) and around the level (KPSS) test specifications.

It should be noted, that testing original logged time series data supplementary KPSS test is done just then ADF test results show, that data has no unit root. Meanwhile in testing logged first differenced time series data, supplemetary KPSS test is used in cases then ADF test results show that there is unit root in the data. Such preferences are made due to two reasons: 1) according to Wooldridge (2013), the notion of cointegration could be applied when two series are I(1), but a linear combination of them is I(0); 2) to model short run model, both variables should be either I(0) or first differences of I(1) variables, which means that either in original data or first differences of variables should be no unit roots. If KPSS test is used, its results are being considered superior to ADF test results. It should be noted that further than I(1) testing is not executed, because regression with higher order than I(1) variables results does not have economical sense.

In order to test the short run relationship between the economic growth and energetics sector, expressed as electricity production capacities or electricity generation, or electricity net consumption proxy variables, the main test equation depends on data peculiarities. If both time series data are I(0), then model equation is like equation (5). If first differences of variables are being used, then model equation for short run relationship testing is in the following form:

$$\Delta \ln RGDP_t = \alpha + \beta_2 \Delta \ln INF_t + u_t \quad (7)$$

In order to avoid misleading regression results, first order autocorellation, heteroscedasticity and normality of residuals tests are made. Breusch-Godfrey (Breusch, 1978; Godfrey, 1978) test is used for testing for the first order autocorrelation, White test (White, 1980) is used to test whether there is heteroscedasticity in model's residuals and Doornik-Hansen (Doornik & Hansen, 2008) test is used for testing normality of the residuals. If either first order autocorrelation or heteroscedasticity, or both are found, heteroscedasticity- and

Table 1

Summary of cointegration testing procedure with electricity production capacities as proxy variable of electric energy sector's infrastructure

	Cointegration exists	Cointegration does not exist	Possible I(2) versus I(1) variables	I(1) versus I(0) variables	I(0) versus I(1) variables
Country code(s)		BEL, BGR, CYP, CZE, ESP, FIN, FRA, GBR, HRV, HUN, IRL, ITA, LUX, LVA, NLD, ROU, SVK, SVN, SWE	AUT, DNK, POL	DEU, LTU	GBR, PRT

autocorrelation-consistent standard errors (HAC) remedial measure is used. For non-normal residuals case there is no straight remedial measures. In such case there are two possibilities: to apply asymptotic theory or to threat regression results with grain of salt.

Testing for Long Run Relationship

As it was mentioned before, in order to check the presence of the long run relationship both variables in the model should be I(1). Since the original sample size is 28 observations for original and 27 observations for the first differenced data, according to Schwert (1989) l_{12} and l_4 formulas, maximum lag for ADF test was 8 and for KPSS test it was 2. At first, all variables were tested for unit roots. After unit root tests were taken, the presence of cointegration was tested. Table 1 shows summary results of this procedure, when electricity production capacities is chosen as a proxy variable for electric energy sector's infrastructure.

Table 2

Summary of cointegration testing procedure with electricity generation as proxy variable of electric energy sector's infrastructure

	Cointegration exists	Cointegration does not exist	Possible I(2) versus I(1) variables	I(1) versus I(0) variables	I(0) versus I(1) variables
Country code(s)	SVN	AUT, BEL, CYP, CZE, DNK, EST, FIN, GRC, HRV, HUN, IRL, ITA, LUX, LVA, NLD, POL, PRT, ROU	ESP	DEU, LTU	BGR, FRA, GBR, SVK, SWE

Table 3

Summary of cointegration testing procedure with electricity net consumption as proxy variable of electric energy sector's infrastructure

	Cointegration exists	Cointegration does not exist	Possible I(2) versus I(1) variables	I(1) versus I(0) variables
Country code(s)		AUT, BGR, CYP, CZE, DNK, ESP, EST, FIN, FRA, GRC, HRV, HUN, LUX, LVA, MLT, POL, ROU, SVK, SVN, SWE	BEL, GBR, IRL, ITA, NLD, PRT	DEU, LTU

As it can be seen from Table 1, in 7 countries due to data pecularities cointegration existence could not be tested. In the remaining 19 countries data long run relationship between economic growth and electric energy sector's infrastructure, expressed as electricity production capacities, was not found. Cointegration testing results for the case, when electricity generation variable is proxy for electric energy sector's infrastructure are provided in Table 2.

As it can be seen from Table 2, in 8 countries due to data pecularities cointegration existence could not be tested either. In the remaining 19 countries data long run relationship between economic growth and electric energy sector's infrastructure, expressed as electricity generation, was found just in 1 country. Due to this reason there is no need to model cointegrating regression and ECM model for just that one country. Finally, cointegration testing results for the case, when electricity net consumption variable is proxy for electric energy sector's infrastructure are provided in Table 3.

As it can be seen from Table 3, in 8 countries due to data pecularities cointegration existence could not be tested. In the remaining 20 countries data long run relationship between economic growth and electric energy sector's infrastructure, expressed as electricity net consumption was not found also.

Because long run relationship between economic growth and all chosen electric energy sector's infrastructure proxy variables was not found, short run modelling should be done.

Testing for Short Run Relationship

Table 4 shows electric energy sector's infrastructure, expressed as electricity production capacities, impact on economic growth in the short run. In the column 'tests', normality of residuals (first column), autocorrelation (second column) and heteroscedasticity (third column) tests results summary is provided. Those test results are depicted in 'plus' or 'minus' signs for briefness reason. Positive results for normality test is 'plus' sign (disturbances u_t are distributed normally), while for autocorrelation and heteroscedasticity test 'minus' sign shows positive results (no autocorrelation or heteroscedasticity is present in disturbances u_t). In case of existence of autocorrelation either heteroscedasticity, or both, heteroscedasticity- and

Table 4

Electric energy sector's infrastructure, expressed as electricity production capacities, impact on economic growth in short run

Country code	β_2 coefficient	Tests	Country code	β_2 coefficient	Tests
BEL	Not significant	+ / - / -	IRL	Not significant	- / + / -
BGR	Not significant	+ / + / -	ITA	Not significant	- / - / -
CYP	Not significant	+ / - / -	LTU	Not significant	- / + / -
CZE	Not significant	- / - / -	LUX	Not significant	+ / - / -
DEU	0,18[1]	- / - / -	LVA	Not significant	- / + / -
ESP	Not significant	- / + / -	NLD	Not significant	+ / + / -
FIN	Not significant	- / - / -	PRT	Not significant	+ / - / -
FRA	Not significant	+ / - / -	ROU	Not significant	- / + / -
GBR	Not significant	- / + / -	SVK	Not significant	- / + / -
GRC	Not significant	+ / + / +	SVN	-0,06[2]	- / - / -
HRV	Not significant	- / + / -	SWE	Not significant	+ / - / -
HUN	Not significant	- / - / -			

Note: 1 – p value is 0,0582; 2 – p value is 0,0731.

autocorrelation-consistent standard errors (HAC) remedial measure was used. However, there is no remedial measures for nonnormal residuals, but in this case 27 observations may be threated as a large sample.

As it can be seen from Table 4, 23 out of 26 countries data was eligible for short run

Table 5

Electric energy sector's infrastructure, expressed as electricity generation, impact on economic growth in short run

Country code	β_2 coefficient	Tests	Country code	β_2 coefficient	Tests
AUT	Not significant	- / - / -	HUN	Not significant	- / - / -
BEL	Not significant	+ / - / -	IRL	0,77	- / - / -
BGR	0,27	+ / + / -	ITA	0,58	+ / - / -
CYP	0,35[1]	- / - / +	LTU	Not significant	- / + / -
CZE	0,40	- / - / -	LUX	Not significant	+ / - / -
DEU	Not significant	+ / - / +	LVA	Not significant	- / + / +
DNK	Not significant	- / - / -	NLD	Not significant	- / + / -
EST	0,29	- / - / +	POL	0,39[3]	- / - / -
FIN	Not significant	- / + / -	PRT	Not significant	+ / - / +
FRA	Not significant	+ / - / +	ROU	0,75	+ / - / -
GBR	0,39	- / - / -	SVK	Not significant	- / + / -
GRC	0,26[2]	- / + / -	SVN	Not significant	- / + / -
HRV	Not significant	- / + / -	SWE	Not significant	+ / - / -

Note: 1 – p value is 0,0628; 2 – p value is 0,0860; 3 – p-value is 0,0988.

impact modelling. Austria's, Denmark's and Poland's cases were not modelled because electricity production capacities variable was found to be integrated of higher order than 1. Overall, just in 2 countries statistically significant impact on economic growth was found, but that 2 cases also had slightly higher p-value standard 0,05 level of significance. From these results we can conclude, that electric energy sector's infrastructure, expressed as electricity production capacities, does not have statistically significant impact on economic growth in European Union countries.

As it can be seen from Table 5, 26 out of 27 countries data was eligible for this electric energy sector's infrastructure proxy variable case. Spain's time series data was not eligible for short run impact modelling because it was found to be integrated of higher order than 1. In 10 out of 26 countries cases (including cases with p-value up to 0,10) it was found positive electric energy sector's infrastructure, expressed as electricity generation, impact on economic growth with elasticity coefficients raging in [0,26;0,77] interval. However ir 16 countries statistically significant impact on economic growth was not found. Although in this proxy variable case it was found more statistically significant impact on economic growth cases, but still we need to conclude, that electric energy sector's infrastructure, expressed as electricity generation, does not have statistically significant impact on economic growth in European Union countries.

As it can be seen from Table 6, 22 out of 28 countries data was eligible for the last electric energy sector's infrastructure proxy variable short run impact modelling case. Belgium's, Great Britain's, Ireland's, Italy's, The Netherlands' and Portugal's time series data was not eligible for short run impact modelling because it was found to be integrated of higher order than 1. In 21 out of 22 countries cases it was found positive electric energy sector's infrastructure, expressed as electricity net consumption, impact on economic growth with elasticity coefficients raging in [0,28;1,17]

Table 6

Electric energy sector's infrastructure, expressed as electricity net consumption, impact on economic growth in short run

Country code	β_2 coefficient	Tests	Country code	β_2 coefficient	Tests
AUT	0,51	+ / - / -	HRV	0,75	- / - / +
BGR	0,52	- / - / -	HUN	1,17	+ / - / +
CYP	0,33[1]	- / - / +	LTU	1,15	+ / - / -
CZE	1,10	+ / - / +	LUX	0,40	+ / - / -
DEU	0,28	+ / - / -	LVA	1,13	+ / - / +
DNK	0,81	+ / - / +	MLT	0,29	+ / + / -
ESP	0,65	+ / - / -	POL	0,67	- / - / +
EST	0,87	+ / - / +	ROU	0,75	+ / - / -
FIN	0,57	+ / - / -	SVK	0,93	- / - / +
FRA	Not significant	+ / - / -	SVN	0,66	+ / - / -
GRC	0,81	+ / - / -	SWE	0,50	- / - / -

Note: 1 – p value is 0,0996.

interval. It can be seen, that this electric energy sector's infrastructure proxy variable modelling has the most statistically significant countries' cases among all three electric energy sector's infrastructure proxy variables used in this empirical research. So we can conclude, that electric energy sector's infrastructure, expressed as electricity net consumption proxy variable, has positive statistically significant impact on economic growth in European Union countries.

Conclusions

Several conclusions from this article's empirical research can be drawn. First of all, the chosen proxy variables for electric energy sector's infrastructure were the one of physical infrastructure measures type, as it is common in other scientists empirical research, but two of them also encompassed such feature like electric energy sector's infrastructure usage ratio. Second, after econometric modelling no long run impact on economic growth was not found in no one of the used proxy variable's cases. Such absence of long run impact could be explained by the fact, that all European Union countries belong to developed countries group, so infrastructure in them is already built. This means, that there is possibility of no long run impact on economic growth, which usually comes throught new particular sector's infrastructure objects building process.

However, when modelling short run impact, results differed a lot among the used proxy variables. When using pure physical infrastructure measures type electricity production capacities proxy variable for electric energy sector's infrastructure, there was found no statistically significant short run impact on economic growth. This could also be explained by the fact, that infrastructure in the European Union is already built. When modelling electricity generation proxy variable's impact on economic growth, almost in 40% countries there was found positive statistically significant short run electric energy sector's infrastructure impact on economic growth. This variable encompassed infrastructure usage feature, but due to the fact, that more than half of European Union energy (oil, petroleum, natural gas and etc.) needs are covered by imports, electricity production input to economic growth is probably cancelled by the fact that a lot of resources needed for electricity production process, are bought from abroad.

Finally, it was found, that electric energy sector's infrastructure, expressed as electricity net consumption variable, does positive statistically significant impact on economic growth. Such impact elasticity coefficients rage in [0,28;1,17] interval. In case of this proxy variable, such positive results were found due to the reason, that this type of variable fits the analyzing situation in European Union electric energy sector's infrastructure the most. It encompasses existing physical infrastructure amount and usage with no negative side effects, like in electricity generation proxy variable's case.

For the final conclusion there is a need to highlight the fact, that in future research, where researchers will model electric energy sector's infrastructure (or the other main sectors of infrastructure) impact on economic growth in developed countries, it is recommended to use physical type infrastructure measures which also encompass the usage ratio of the particular infrastructure. Talking about electric energy sector's infrastructure in the

European Union, this empirical research showed positive statistically significant impact on economic growth, with elasticity coefficients a little bit bigger than in previous research, which means, that electric energy sector's infrastructure (namely its usage) is even more important in developed than in the developing countries.

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EUROPOS SĄJUNGOS ELEKTROS ENERGIJOS SEKTORIAUS INFRASTRUKTŪROS POVEIKIS EKONOMIKOS AUGIMUI

Santrauka

Teoriniu požiūriu infrastruktūra, kaip visuma, yra vienas iš svarbiausių tiek šalies, tiek regiono ekonominio augimo veiksnių. Infrastruktūra iš esmės yra sudaryta iš trijų pagrindinių sektorių: transporto, telekomunikacijų ir energetikos. Praktiniuose tyrimuose energetikos sektorių dažniausiai atspindi elektros energijos sektorius, o šio sektoriaus infrastruktūrą – įvairūs šį sektorių atspindintys fizinės išraiškos infrastruktūros rodikliai. Straipsnyje minėti autoriai nurodo teigiamą elektros energijos sektoriaus infrastruktūros poveikį ekonomikos augimui, ypač didelį dėmesį skirdami besivystančioms šalims.

Šiame straipsnyje analizuojamas elektros energijos sektoriaus infrastruktūros poveikis ekonomikos augimui Europos Sąjungos šalyse 1990–2017 m. Tyrimas apima visų 28 Europos Sąjungos šalių (tuo metu) duomenis, užpildydamas šio infrastruktūros sektoriaus tokio tipo tyrimų trūkumą visos Europos Sąjungos mastu. Du iš trijų naudotų kintamųjų, atspindinčių elektros energijos sektoriaus infrastruktūrą, yra ne tik fizinės išraiškos pobūdžio, bet atspindi ir patį tiriamo infrastruktūros sektoriaus panaudojimo lygį. Toks rodiklių pasirinkimas yra pakankamai naujas atliekant tokio tipo tyrimus, kuriuose įprastai naudojami arba grynai fizinės, arba grynai finansinės išraiškos infrastruktūros kintamieji.

Nustatyta, jog ilguoju laikotarpiu elektros energijos sektoriaus infrastruktūra nedaro statistiškai reikšmingo poveikio ekonomikos augimui, o trumpuoju laikotarpiu, ypač rodiklių, atspindinčių infrastruktūros panaudojimo lygį, modeliavimo atvejais, rastas teigiamas statistiškai reikšmingas elektros energijos sektoriaus infrastruktūros poveikis ekonomikos augimui, kurio elastingumo koeficientai svyruoja [0,26;1,17]. Taigi, gauti elastingumo koeficientai yra nežymiai didesni už straipsnyje minėtų autorių, tyrinėjusių atitinkamą elektros energijos sektoriaus infrastruktūros poveikį ekonomikos augimui besivystančiose šalyse, rezultatus. Tai leidžia manyti, jog iš esmės elektros energijos sektoriaus infrastruktūra (būtent jos panaudojimas) išsivysčiusiose šalyse yra svarbesnė ekonomikos augimui negu besivystančiose šalyse.