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Economic Growth, Electricity Consumption and Internet Usage Nexus: Evidence from a Panel of Commonwealth of Independent States

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ABSTRACT

In this paper we investigate the long- and short-run effects of economic growth and Internet usage on electricity consumption using a panel data for countries – members of Commonwealth of Independent States (CIS) for the period 1991-2017. The study is based on panel unit root test, panel cointegration test, the pooled mean group regression technique and Dumitrescu–Hurlin panel Granger causality test. The results show that internet usage affects electricity consumption in the long-run. A 1% increase in the number of the internet users per 100 people increases electricity consumption per capita by 0.021% in the sampled countries economic growth affects electricity consumption both in the short- and long-run. A 1% increase in economic growth rate cause a 1.45% increase in electricity consumption per capita in CIS states. Results of panel causality test show that Internet usage and economic growth cause electricity consumption.

Keywords: Electricity Consumption, Economic Growth, Internet Usage, Panel Analysis, Causality
JEL Classifications: L94, O4, Q4, Q42, O1

1. INTRODUCTION

Today, there is a large number of studies describing the relationship between economic growth, electricity consumption and the use of the Internet. For example, the papers of Pohjola (2001), Nour (2002) and Vu (2011) are dedicated to the research of the relationship between economic growth and information and communication technologies. To the study of the relationship between electricity consumption and economic growth are devoted the works of Kraft and Kraft (1978), Yoo (2005), Wolde-Rufael (2006), as well as Narayan and Prasad (2008). These studies take into account the specifics of both developed and developing countries.

It should be noted that the number of studies, devoted to the research of the relationship between information and communication technologies and electricity consumption has been growing steadily over the past 20 years. Increasing the share of e-commerce as part of gross domestic product (GDP) in developed and developing countries, accelerating the penetration of ICT into stock markets and classical business operations, enhances their impact and importance in economic growth.

Regarding the impact of ICT on electricity consumption, several channels are identified in the literature. These include direct and indirect channels. (Hilty, 2008) Through a direct channel, ICT has a direct impact on energy consumption through the production, use and distribution of ICT equipment. (e.g., Roth et al., 2002; Laitner, 2002). Indirect channel describes the impact of ICT on energy consumption, related to the fact that the development of ICT increases the demand for energy in connection with the globalization of world markets and distribution of forms of production caused by the growth of telecommunications networks. (Ishida, 2015)

This study aims to assess the impact of Internet use and economic growth on electricity consumption using panel data for the Commonwealth of independent States (CIS). We use the number of Internet users over time as an indicator to measure ICT. This study enriches the existing literature through, on the one hand, the study of the elasticity of energy consumption to internet use in the CIS countries. In contrast to previous studies, examining the short-and long-term effects of ICT on energy consumption in developed and developing countries (Salahuddin and Alam, 2015; 2016; Afzal and Gow, 2016; Rahimi and Rad, 2017), we investigate the sensitivity of electricity consumption in CIS countries to changes in Internet use and economic growth. CIS countries currently include in their members Belarus, Russia, Azerbaijan, Armenia, Kazakhstan, Kyrgyzstan, Moldova, Tajikistan, Turkmenistan and Uzbekistan. To assess the short-and long-term effects, we use the model proposed by Salahuddin and Alam (2016) for OECD countries and approbated by Rahimi and Rad (2017) for D-8 countries.

The remainder of the paper is organized as follows: Section 2 provides an overview of relevant literature; section 3 describes econometric modeling techniques and data used; section 4 presents an analysis of empirical results; section 5 presents the conclusion of the study.

2. LITERATURE REVIEW

As the importance of energy consumption as a key element of national and global production grows, the number of studies on the analysis of factors with potential impact on it increases. According to the conventional function of consumption in the framework of the utility maximization theory, the demand for energy is determined both by changes in income and prices, and depends on the institutional infrastructure, arrangements and the stage of economic development (Sheng et al., 2012). The relationship between energy consumption and various macroeconomic variables is described in a large number of studies in various developed and developing countries. In most cases, empirical research aims to determine the nature and vector of the relationship between consumption, income, the degree of financial development of the national economy, the degree of industrialization, urbanization, as well as electricity prices and trade openness. The relationship between energy consumption and information and communication technologies has also been the subject of research, but the impact of ICT on electricity consumption has received little attention. Given the active transformation of the global post-industrial economy into a digital economy, the growing role of financial technologies and blockchain, the importance of this research area cannot be overestimated.

For example, Collard et al. (2005) examined the impact of investment in information technology on the energy intensity of electricity consumption in the service sector of France for the period 1986-1998. Using panel data combining time series and cross-sectoral dimensions, the authors concluded that the energy consumption of electricity in production decreased with the diffusion of communication devices. At the same time, the energy intensity has increased with the use of computers and software.

Takase and Murota (2004) investigated the impact of information technology investments on energy consumption in the US and Japan through the development of an economic model. The results of the model simulation showed that while investment in information technology is reducing energy intensity in Japan, energy intensity in the US is increasing.

Cho et al. (2007) evaluated the impact of investments in information and communication technologies and energy prices on electricity consumption in various sectors of South Korea's economy. The results of their research show that investments in ICT increase the energy intensity of service industries, as well as manufacturing industries, characterized by a high level of energy consumption.

Sadorsky (2012) examined the impact of information and communication technologies on electricity consumption in 19 developing countries and found a positive statistically significant relationship between ICT and electricity consumption.

Ishida (2015) studied the long-term relationship between energy consumption, economic growth, and information and communication technologies in Japan. Using the autoregressive distributed lag (ARDL) bounds testing approach, he estimated two different multivariate models simulating the production function and the energy demand function, with both functions including ICT investment as an explanatory variable. The study was based on the time period 1980-2010. As a result, the author came to conclusion that investments in ICT can, under other equal conditions, contribute to moderate reducing of electricity consumption. But there was found no evidence of the impact of ICT investment on GDP growth.

Salahuddin and Alam (2015) studied the long-and short-term effects of Internet use and economic growth on electricity consumption in Australia from 1985 to 2012. Annual time series were used for the study. The results of the evaluation of ARDL model showed that the use of the Internet and economic growth increase the consumption of electricity in Australia. The results are statistically significant.

Saidi et al. (2015) investigated the impact of ICT and economic growth on electricity consumption for a panel consisting of 67 countries using a dynamic panel data model. The model was also divided into three sub-panels by income level (high-income, middle-and low-income countries). The study is based on data for the period 1990-2012. The results of the study show a positive and statistically significant effect of ICT on electric power consumption, when measuring ICT as the use of the Internet and mobile phones.

Salahuddin and Alam (2016) assessed the short-and long-term effects of ICT use and economic growth on electricity consumption using panel data for OECD countries for the period 1985-2012. The results of the study show that the use of ICT and economic growth stimulate electricity consumption in the short and long term. The results of tests to establish causation showed that electricity consumption causes economic growth. At the same time, the use of mobile and Internet cause electricity consumption and economic growth.

Tunali (2005) studied the impact of ICT on electricity consumption in the European Union member States between 1990 and 2012. Research has shown that ICT increases the consumption of electricity in sampled countries in the long run.

Afzal and Gow (2016) examined the impact of ICT on electricity consumption in 11 developing countries for the period between 1990 and 2014. Using the dynamic panel data models, they found a positive and statistically significant relationship between ICT and electricity consumption. The indicator for ICT is Internet connections, mobile phones and the percentage of ICT imports in total imports. The results show that the energy intensity of production is reduced in the case of diffusion of communication devices, and increases with the use of computers and mobile phones.

Rahimi and Rad (2017) investigated the relationship between the use of Internet, economic growth and electricity consumption in the case of D-8 countries for the period 1990-2013. The results show that the use of the Internet affects the consumption of electricity only in the long term. However, economic growth affects electricity consumption in both the short and long term. The results of causation imply that the use of the Internet leads to an increase in electricity consumption.

Zaghdoudi (2017) estimated relationship between Internet usage, renewable energy, electricity consumption and economic growth by applying panel ARDL method and dynamic ordinary least squares method. Results of the study show that Internet usage and economic growth have a positive and significant long-run effect on electric power consumption. Economic growth has positive and significant effect on electricity consumption in the short-run as well.

3. MATERIALS AND METHODS

In this study, we aim to assess the impact of Internet use and GDP on electricity consumption for a panel of CIS countries. Following Sadorsky (2012), Ishida (2015) Salahuddin and Alam (2016), Salahuddin et al. (2016), Rahimi and Rad (2017), we define the functional form of the model as follows:

$$EC_p=f(A,GDP_{pc},I_u) \quad (1)$$

or

$$ECp_{it}=A.(GDPpc_{it})^{\beta 1}(Iu_{it})^{\beta 2} \quad (2)$$

Taking the log - linear form both sides of the Equation (2), we obtain the following equation:

$$ln\ ECp_{it}=\beta_0+\beta_1\ lnGDPpc_{it}+\beta_2\ lnIu_{it}+\varepsilon_{it} \quad (3)$$

where *ln* denotes the natural logarithm; *i*=1,….I for each country in the panel, *t*=1,….T denotes the time period. The regression coefficients β_1 and β_2 estimate long-run elasticity of electricity consumption relative to GDP per capita, and Internet usage, respectively. *ECp* denotes logarithmic electricity consumption per capita. *GDPpc* represent logarithmic GDP per capita and I_u denotes logarithmic internet usage.

Annual data for electricity consumption is measured by electric power consumption (kWh per capita), and GDP per capita is measured in constant 2005 US$. ICT variable in this study is represented by Internet usage (per 100 people). Data is obtained from The World Bank's World Development Indicators and official statistics offices of the sampled countries when necessary. The countries, included in the sample and the chosen timeframe are dictated by data availability and the need for a balanced panel over the period of 1991-2017. The sampled countries are the members of the CIS and include Belarus, Russia, Azerbaijan, Armenia, Kazakhstan, Kyrgyzstan, Moldova, Tajikistan, Turkmenistan and Uzbekistan.

4. RESULTS AND DISCUSSION

To test the hypothesis stated in this study, we use econometric tools. The use of econometric research methods allows to consider the behavior of each independent sampled variable on the one hand separately, and on the other hand to study its impact on dependent variables. The first step in the research algorithm is to conduct tests for the stationarity of the sampled time series. In the case of nonstationary sampled variables, their differentiation is necessary to continue the study. The second step in the research algorithm is to conduct a cointegration test using all explanatory variables. In case of cointegration detection, as well as statistical significance, it is possible to build a long-term and short-term models for testing the hypothesis.

Table 1 presents the results of the sampled variables test for the presence of unit root. There is a variety of panel unit root tests, which include Levin et al. (2002), Im et al. (2003) (IPS hereafter), Maddala and Wu (1999). As can be seen from Table 1, the sampled variables are characterized by non-stationarity at level. So the null hypothesis of unit root presence cannot be rejected. In case of their differentiation to the first order, the variables become stationary and we can reject the null.

Therefore, the use of first-order differentiated variables makes it possible to conduct further research. In order to identify causation links between explanatory and resulting variables in the short and long run, it is necessary to determine whether there is cointegration between them.

Cointegration tests are used to determine whether the regression is spurious or not. Spurious regression may occur only as the results of non-stationarity of the sampled variables. Therefore, as can be seen from results of unit root tests in Table 1, each of the variables is stationary. Meeting the requirement of stationarity ensures the next step of the study, that is investigating the existence of the long-run equilibrium between the sampled variables. In this study, following Rahimi and Rad (2017) we employ two types of panel cointegration tests. Pedroni (2004) residual cointegration test results are reported in Table 2. Results of the test show that six out of seven test statistics show statistically significant presence of cointegration between the variables in the model.

Table 1: Panel unit root tests results

Test statistics	LLC	IPS	ADF	PP (Fisher)
Variables in level				
GDP (per capita)	−0.23413 (0.5234)	−1.20743 (0.3854)	32.4686 (0.1894)	18.9238 (0.9521)
Electricity consumption (per capita)	−2.34082 (0.0012)	−0.24591 (0.1238)	24.8461 (0.6803)	25.7631 (0.3911)
Internet use (per 100 people)	−0.89015 (0.4208)	0.59379 (0.7942)	11.6387 (0.2675)	6.23955 (0.8813)
First differenced variables				
GDP (per capita)	−6.29081 (0.0001)*	−5.60712 (0.0002)*	48.6539 (0.0001)*	53.4409 (0.0000)*
Electricity consumption (per capita)	−12.24741 (0.0000)*	−8.53862 (0.0000)*	75.8432 (0.0000)*	78.1345 (0.0000)*
Internet use (per 100 people)	−7.04953 (0.0000)*	−5.84281 (0.0000)*	21.2405 (0.0000)*	69.1452 (0.0000)*

Source: Authors' calculations. *Denotes statistical significance at 1% level and rejection of the null hypothesis (presence of unit root)

To check the obtained results, we refer to the Kao (1999) residual cointegration test. Results of the Kao test are presented in Table 3.

Results, presented in Table 3 also strongly reject the null hypothesis of no cointegration between the variables for CIS sample at significance level of 1%.

Therefore, we can assume that we have obtained a strong evidence of long-run cointegration relationship between the variables for the panel.

Table 4 presents the results from the pooled mean group estimations for Equation (3).

As can be seen from the results, presented in Table 4, for Internet use the estimated coefficient is positive, persistent and significant at 1% level of significance. The long-run estimated coefficient of the variable, that is the number of the Internet users per 100 people equals to 0.021. That means that a 1% increase in the number of the Internet users per 100 people increases electricity consumption per capita by 0.021% in the sampled countries.

The findings in Table 4 also indicate that there exist a positive and statistically significant relationship between economic growth and electricity consumption. The estimated long-run coefficient of economic growth rate (logarithm of GDP per capita) equals to 1.15. This means that a 1% economic growth rate will cause 1.45% increase in electricity consumption per capita. Also, short-run coefficients show the presence of statistically significant relationship between Internet use, GDP and electricity consumption.

Finally, we employ Hurlin and Dumitrescu (2012) causality test to investigate causal linkages between variables of the model.

The results, presented in Table 5, show that Internet use causes electricity consumption in the states-members of the CIS. Also we find evidence that the growth of GDP in sampled countries leads to an increase in electricity consumption. Yet, no statistically significant evidence of causality running from Internet use to GDP is found. The absence of this relationship in the CIS countries may be the result of insufficient digitalization of the economy, the small size of the high technology market as part of the national economy's GDP. However, as the processes of digitalization of national economies and the world economy increase, it is quite logical to assume the strengthening of the link between the use of the Internet and economic growth in the CIS countries.

Table 2: Pedroni residual cointegration test results

Panel cointegration statistics (within-dimension)	Statistics	P-value
Panel v-statistic	−1.140857	0.0215*
Panel PP-statistic	−1.953284	0.0131*
Panel rho-statistic	−3.109375	0.0034*
Panel ADF-statistic	−3.280541	0.0008*
Group mean panel cointegration statistics (between-dimension)		
Group rho-statistic	−0.290745	0.2754
Group PP-statistic	−1.980432	0.0198*
Group ADF-statistic	−1.998563	0.0104*

Source: Authors' calculations. *Denotes statistical significance

Table 3: Long-term equation estimation

ADF	Lag	t-statistic	P-value
CIS states	2	−3.152844	0.0005*

Source: Authors' calculations. *Denotes statistical significance and rejection of the null hypothesis (no cointegration between the variables)

Table 4: Results from PMG estimation for the model (Equation 3)

Dependent variable: Electricity consumption	Long-run coefficients		
	Coefficient	S.E.	P-value
GDP	1.450343	0.020184	0.0000*
Internet use	0.021453	0.000047	0.0000*
	Short-run coefficients		
Error correction coefficient	−0.351931	0.031529	0.0000*
GDP	0.251853	0.113476	0.0313*
Internet use	0.137724	0.049621	0.0463*
Intercept	−0.395721	0.141984	0.0000*

Source: Authors' calculations. *Denotes statistical significance

5. CONCLUSION

This study examines the relationship between Internet use, electricity consumption and economic growth in the long and short term. The study was conducted on the example of the CIS States for the period 1991-2017. Econometric methods of analysis were used for the study. In particular, due to the cross-country nature of the study, we used panel data analysis. To assess the stationarity of time series used tests of Levin et al. (2002), Im et al. (2003) (hereafter IPS), Maddala and Wu (1999). The results of testing the null hypothesis of the presence of a single root showed the non-stationarity of the sampled variables at the level. The differentiation of first-order variables allowed to provide the stationarity of time series. The hypothesis of a long-term equilibrium between the sampled variables was tested by cointegration tests, which included the Kao (1999) and Pedroni (2004) tests.

Table 5: Pairwise Dumitrescu–Hurlin panel causality test results

Null hypothesis	W-statistic	Zbar-statistic	P-value
GDP does not homogeneously cause EC	6.340941	8.134854	0.0001*
EC does not homogeneously cause GDP	1.001364	1.609351	0.3285
IU does not homogeneously cause EC	4.975612	6.129445	0.0012*
EC does not homogeneously cause IU	2.045869	1.195432	0.5348
IU does not homogeneously cause GDP	2.543416	3.124935	0.0627
GDP does not homogeneously cause IU	1.593425	1.798430	0.8643

Source: Authors' calculations. *Denotes statistical significance and rejection of the null hypothesis

The results of testing the null hypothesis of the absence of cointegration allowed to reject the null hypothesis. The test results showed that there is a positive, statistically significant long-term relationship between Internet use, economic growth and electricity consumption in the CIS countries. A 1% increase in the number of the Internet users per 100 people increases electricity consumption per capita by 0.021% in the CIS states. This allows us to assume that the use of the Internet leads to an increase in demand for electricity consumption in the CIS countries. This result is in line with the results of previous studies including Sadorsky (2012), Saidi et al. (2015), Salahuddin and Alam (2016), Rahimi & Rad (2017), Zaghdoudi (2017).

At the same time, the evaluation of the model coefficients in the short term showed that the use of the Internet leads to an increase in electricity consumption in the CIS countries. The result is statistically significant at the 5% level of statistical significance. Being in line with the previous studies (e.g., the case of OECD studied by Salahuddin and Alam (2016)), we have found a positive relationship between Internet use and electricity consumption in the CIS countries both in long- and short-run. This result may be associated with a proportional increase in the share of computers, mobile devices against the background of limited electric capacities, which led to the need for their increase.

We also found a positive and statistically significant effect of economic growth on electricity consumption in the CIS countries. This result is consistent with previous studies (see e.g., Saidi et al., 2015). The obtained results are also confirmed by estimating the relationship through pairwise Dumitrescu–Hurlin panel causality test. The results show a statistically significant causal relationship running from GDP to electricity consumption. Also, we found that the use of the Internet causes electricity consumption.

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