The Econometric Modeling of the Relationship Between Digitalization and Demand for Energy

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ABSTRACT

The goal of this study is to explore the relationship between digitalization and sustainable development. We focus on the links between Internet penetration and electricity consumption, using data for 173 countries for which complete data is available by World Bank for years 1990-2015. Using fixed effects regression method, we find that Internet has non-linear (inverted U-shape) relationship between ICT and energy use. The results remain robust for inclusion of control variables.

CCS CONCEPTS

• **Internet**; • **sustainability**; • **electricity consumption**;

1 INTRODUCTION

The demand for energy has been rising constantly throughout human history. For example, according to World Bank per capita electricity consumption has increased by more than 50% since 1990. Published papers find that various variables are responsible for increase in energy consumption. For example, trade [1], economic growth [2], urbanization [3], financial development [4] among others significantly predicts energy use. The goal of this research is to offer additional evidence on the drivers of energy consumption across the globe by focusing on the relationship between digitalization and electricity consumption.

ICT may have different effects on energy sector. For example, ICT is related to economic growth [5] which in turn has effect on energy consumption. For example, Stanley, and Steel [6] in a meta-analysis of 59 studies after accounting for various scholarly problems confirms that ICT (digitalization) has positive influence on GDP growth. Another study explores the role of ICT in economic

growth of Taiwan, and documents that ICT related infrastructure investments spur economic progress [7].

On the other hand, ICT may increase productivity and efficiency which reduces pressure on energy sector. For example, the effective role of ICT has been documented at a firm level [8], industrial sectors [9], household energy demand [10]. Therefore, the goal of this study is to explore the relationship between digitalization (as proxied by ICT sector) and energy consumption in a sample of more than 170 countries over the period 1990-2015. We make a number of contributions to research. First, we focus on a large sample of countries which allows us to produce results that can be generalized at a global level. Second, we explore potential non-linear relationship between ICT and energy sector. Finally, we offer a number of important policy implications.

Data and methods

In order to explore the relationship between digitalization and energy we use a sample of 173 countries for which complete data is available by World Bank for years 1990-2015. As a measure of energy demand, we use electricity consumption in kWh per capita. Electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants. As a measure of digitalization, we use proportion of population using Internet (%) from the World Bank.

Considering that other factors also influence electricity consumption across countries we include the following variables as a vector of control factors (X) in our model:

GDP per capita adjusted for purchasing power parity from the World Bank

Urbanization rate (%) from the World Bank

Trade as % of GDP from the World Bank

Tourism revenues as % of exports from the World Bank

The final econometric model can be specified as:

$Electricity\ demand = \alpha + \beta*ICT + \gamma*ICT*ICT + \delta*X + \varepsilon$ (1)

Figure 1 plots the visual trends between ICT and electricity consumption for the years 1990-2019 at global average levels. As it can be seen that both demand for energy and digitalization levels have been steadily growing across countries. Figure 2 further plots the scatterplot between ICT and electricity consumption for all 173 countries for the year 2019. The scatterplot confirms positive correlation between Internet and electricity consumption across countries. Thus, Figures 1 and 2 suggest that digitalization is related to electricity consumption both across countries and years.

2 RESULTS

We start reporting the results by providing correlation matrix for our variables in Table 1. There is evident that GDP, ICT, urbanization
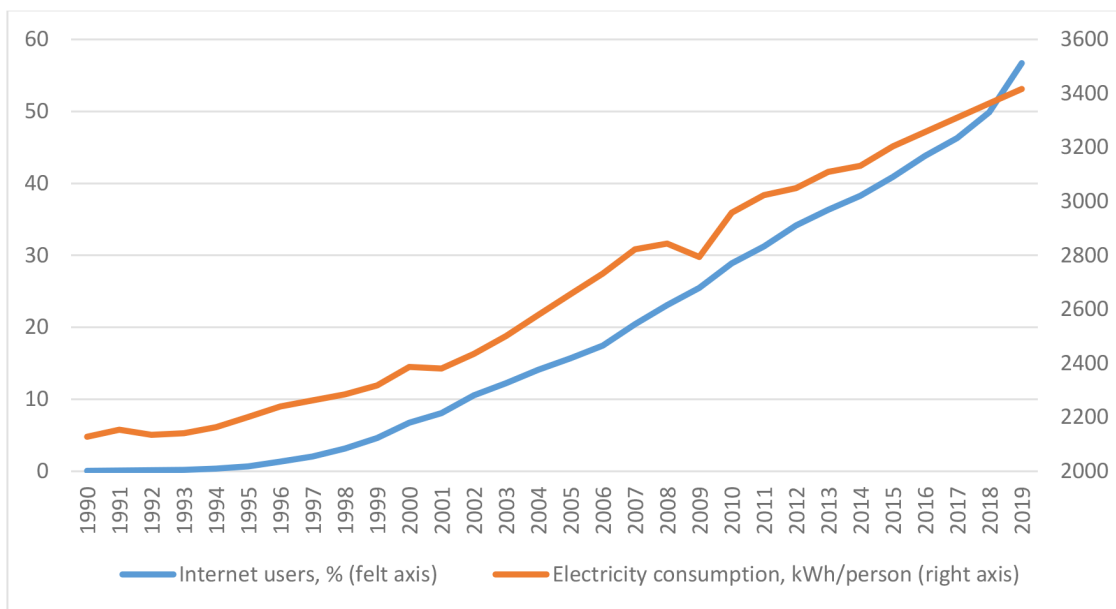
Figure 1: ICT and energy demand, global average
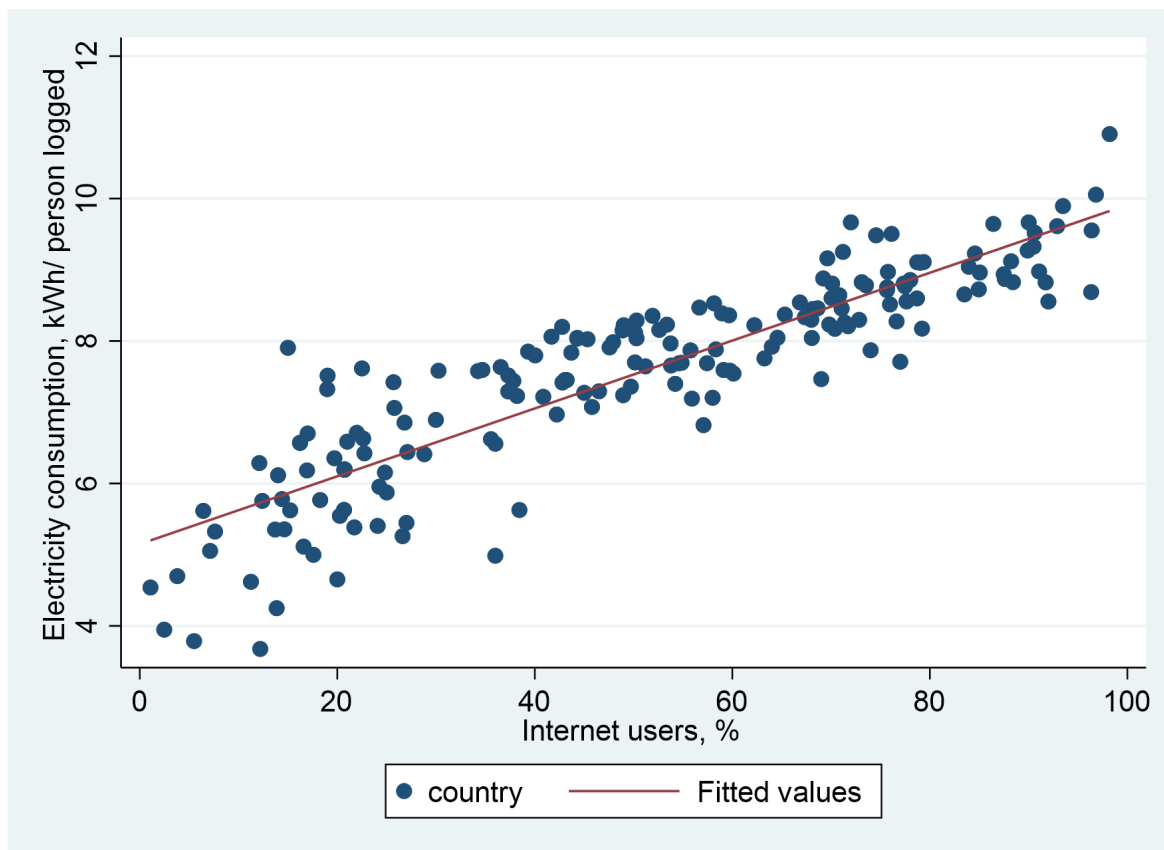

Figure 2: ICT and energy demand, scatterplot

Table 1: Correlation matrix

	Energy	GDP	ICT	Urbanization	Trade	Tourism
Energy	1.00					
GDP	0.92	1.00				
ICT	0.64	0.70	1.00			
Urbanization	0.77	0.83	0.57	1.00		
Trade	0.28	0.33	0.29	0.28	1.00	
Tourism	-0.10	-0.10	-0.09	-0.12	-0.03	1.00

Table 2: Main results

	I	II	III
Internet	0.0058	0.0184	0.0046
	(38.56)***	(44.10)***	(9.68)***
Internet * Internet		-0.0169	-0.0057
		(31.93)***	(11.94)***
GDP per capita			0.5258
			(26.44)***
Urbanization			0.0197
			(17.56)***
Trade			0.0004
			(2.16)**
Tourism			0.0030
			(4.14)***
Constant	7.2853	7.2141	1.2067
	(1,438.28)***	(1,419.48)***	(6.72)***
R2	0.25	0.39	0.61
N	4,612	4,612	3,189

Notes: * $p<0.1$; ** $p<0.05$; *** $p<0.01$

and trade are positively correlated to electricity consumption in our sample. At the same time, ICT is also positively correlated with urbanization and trade. This suggests that Internet penetration is more rapid in urban and globalized countries.

Table 2 presents econometric results estimating Eq. (1) using fixed effects regression estimator. Column 1 reports bivariate association between ICT and energy. The parameter is positive and significant at the 1% level. If ICT rises by 1 percentage point, the demand for electricity increases by 0.58%. However, the relationship between ICT and electricity consumption may be non-monotonic. Therefore, we include ICT squared term in column 2. Our results confirm presence of inverted U-shaped curve for ICT. This implies that at early stages of ICT development, digitalization increases electricity consumption (the GDP enhancing effect). However, once ICT development reaches certain level due to efficiency effect, energy consumption is decreased in the ICT sector. In column 3, to reduce omitted variable bias we include vector X of control variables. All these variables are positively related to energy use. For example, 1% increase in GDP per capita leads to 0.5% increase in electricity consumption. In a similar vein, 1 percentage point increase in trade is responsible for 0.04% increase in energy consumption. The inverted U-shaped relationship between Internet and energy is unaffected.

3 POLICY IMPLICATIONS

This study document that further digitalization of global economy can lead to rising demand for electricity across developing countries. Our econometric result show non-linear relationship between ICT (Internet users) and electricity consumption per capita. Therefore, under the sustainable development agenda and global call to reduce CO_2 emissions it is important to rapidly increase digitalization to transform ICT into effective sector of economy. Therefore, the policymakers need to ensure rapid spread of broadband internet and 4G/5G connectivity towers in towns and rural areas to reduce digital divide within sub-regions. The old ICT infrastructure should be replaced with modern energy-efficient technologies to reduce carbon footprint of the ICT sector. It is important to ensure that digital skills and modern ICT courses are merged into curriculum of education system.

Future studies can extend our results in a number of ways. First, it is important to assess whether the non-linear relationship between ICT and energy use holds for countries with different income groups. Apart from that there is no robust evidence on the role that ICT plays in sustainable development at sub-national level among large countries such as Russia, India or Brazil. Therefore, prospective studies should use sub-national data to fill that gap. Finally, it is important to uncover the direction of causality between

digitalization, environment and energy consumption using more complex methods such as GMM or co-integration.

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