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Electricity Consumption and Information and Communication Technology in the Next Eleven Emerging Economies

Munshi Naser Ibne Afzal[1,2]*, Jeff Gow[3,4]

[1]Department of Economics, Shahjalal University of Science & Technology, Sylhet, Bangladesh, [2]School of Commerce, University of Southern Queensland, Toowoomba, Australia, [3]School of Commerce, University of Southern Queensland, Toowoomba, Australia, [4]Department of Agricultural Economics, Stellenbosch University, Stellenbosch, South Africa.
*Email: munshi.naser@gmail.com

ABSTRACT

In this study, the impact of information communication technologies (ICT) on electricity consumption in the next eleven (N-11) emerging economies over the period 1990-2014 is examined. This period coincides with high economic growth rates in those countries and associated rapidly increasing electricity consumption as well as the ICT revolution that saw the rapid uptake of new ICT by its peoples. Little has been published on the relationship between ICT and electricity consumption in the N-11 emerging economies. This paper examines the hypothesis that increased use of ICT increases electricity consumption. Secondly, how different measures of ICT affect electricity consumption and finally, what are the short-run and long run elasticities of electricity demand with respect to ICT in N-11 countries? The methods used included dynamic panel data models (mean group [MG], pool mean group [PMG], system generalized methods of moments) and show a positive and statistically significant relationship between ICT and electricity consumption where ICT is measured using internet connections, mobile phones or the import percentage of ICT goods of total imports. Long run ICT elasticities are smaller than income elasticities but because ICT growth rates are so much higher than economic growth rates, the impact of ICT on electricity consumption is greater than the impact of income on electricity consumption. Electricity demand projections in emerging economies, which do not include ICT as an explanatory variable, may underestimate actual electricity demand. This can lead to unplanned electricity shortages if actual electricity demand exceeds planned electricity demand. Thus, the paper gives policy recommendations based on the empirical results for the N-11 countries to address this problem.

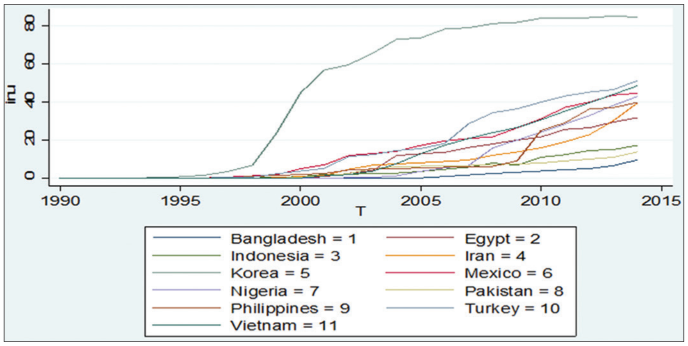
Keywords: Next Eleven Countries, ICT, Electricity Consumption, Panel Data, Mean Group Estimation, Pool Mean Group Estimation, System Gneralized Methods of Moments
JEL Classifications: L94, O1, N17, O10, Q43, J21

1. INTRODUCTION

This paper investigates how electricity consumption is related to information and communication technologies (ICT) and associated infrastructure usage in the next eleven (N-11) emerging countries. The N-11 consists of Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, Philippines, Turkey, South Korea, and Vietnam. In 2005, Goldman Sachs identified them as the potential emerging markets of the world and as future economic rivals to the Brazil, Russia, India and China. The N-11 accounts for 7% of global gross domestic product (GDP) and 9% of the world's energy consumption (EC). The rapid increased adoption of internet connections, mobile phone subscriptions and personal computers brings up an interesting question: How does the increased use of ICT affect electricity consumption? Moreover, it appears that ICT and e-business affects the demand for electricity primarily by the fact that ICT requires electricity to operate and the installation and operation of ICT increases the demand for electricity. However, it is not yet known how different measures of ICT affect electricity consumption and what are the short-run and long run effect of electricity demand with respect to ICT in N-11 countries. Answers to these questions can help in developing a more complete understanding of the impacts of ICT on electricity consumption.

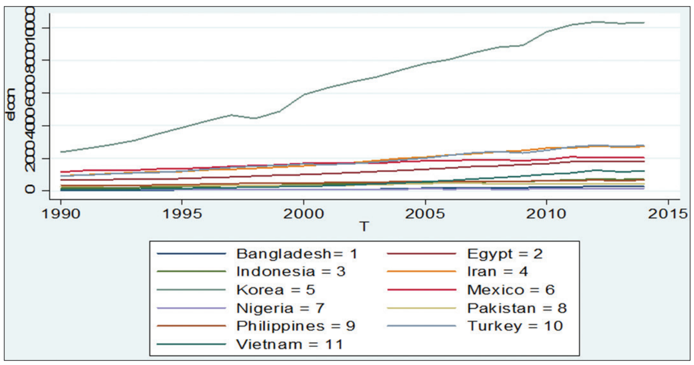
Figures 1 and 2 shows the recent trends of internet users and electricity demand in the N-11 countries over the past 25 years.

Figure 1: Internet users per 100 people in next eleven countries: 1990-2014



Source: WDI-2013

Figure 2: Electricity demand in next eleven countries: 1990-2014



Source: WDI-2013

Prior to 2000 internet usage for all countries except South Korea was very low (under 10%). On average, the growth patterns of internet usage of the N-11 countries have increased rapidly over the last 25 years especially the last 10 years. South Korea's internet use increased sharply from 6% in 1998 to 85% in 2014. Turkey is the second highest internet user starting with 2% in 1990 to 51% in 2014.

The N-11 countries are rapidly growing economies accompanied by increased EC. In terms of electricity consumption, South Korea has the highest moving from 2373 (kWh) in 1990 to 10299 (kWh) in 2014. Turkey followed a similar pattern of surging electricity demand. From this analysis, it can be seen that there is a significant relationship between the number of internet users (which is a major component of ICT) and electricity consumption in the N-11 countries.

2. LITERATURE REVIEW

According to Romm (2002), the internet is not driving an acceleration of electricity demand instead, it appears likely to be driving efficiencies. Looking into the future (Laitner, 2002) speculated that it is less clear how ICT will affect electricity consumption. This is especially the case if a host of new ICT products are developed and mass adopted.

Ishida (2015) examined the relationship between economic growth and EC in Japan over the period 1980-2010. The hypothesis to be tested was that ICT contributes to both a reduction in energy use and an increase in economic growth. Using production function and demand function specifications reveal a long run stable relationship between the variables that are statistically significant in both specifications.

Salahuddin and Gow (2016) estimate the effects of Internet usage, financial development and trade openness on economic growth using annual time series data for South Africa for the period 1991-2013. Results from the ARDL estimates indicate a positive and significant long run relationship between Internet usage and economic growth in South Africa. Also, there is significant positive relationship between financial development and economic growth. However, the short run relationship among the variables was found to be insignificant. The Granger causality test reveals that both internet usage and financial development granger-cause economic growth in South Africa. Based on these findings, this study recommends that the South African government continue with policies that aim to invest more resources into its Internet infrastructure to further expand its network and usage.

Cho et al. (2007) investigated the relationship between ICT investment and electricity consumption from 1991 to 2003 in South Korea's manufacturing industries using a dynamic logistic growth model. It was found that ICT investment in some specific manufacturing sectors is conducive to a reduction in electricity consumption, whereas ICT investment in the service sector and most manufacturing sectors increases electricity consumption. In general, there was support for the hypothesis that increased use of ICT increases energy efficiency.

From the above brief discussion, it is evident that although there are some of studies examining the direct and indirect effects of the ICT use on electricity consumption in different country perspective, such a study in the N-11 countries' context is absent, to the best of the authors' knowledge. The current study is an attempt to fill this gap. This study will also be methodologically stronger than earlier studies in that it simultaneously adopts almost all existing panel methods to analyze and cross check the validity of the data and results obtained.

There is so far but one panel study (Sadorsky, 2012) which has estimated the empirical relationship between ICT investment and electricity consumption in 19 emerging economies. Overlapping countries to this study include Egypt, Indonesia, Mexico, Philippines, South Korea and Turkey. Using a dynamic panel model, it employed the generalized methods of moments (GMM) technique to investigate the link between the ICT and electricity consumption for a sample of emerging economies. The study found that ICT use increases electricity consumption in these countries.

Other studies by (De Vita et al., 2006; Ferguson et al., 2000; Sari and Soytas, 2007; Wolde-Rufael, 2006; Dahl et al., 2011; Yoo, 2006) examined the directional causality of energy or electricity use: Whether energy or electricity use leads to economic growth or *vice-versa*. Ferguson et al. (2000) also made the argument that electricity consumption is far more relevant to the measurement of ICT use in the emerging countries context.

Besides there are prominent studies which shows the economic growth, electricity consumption in particular and overall economic development in general in their findings (Balan, 2015; Broersma and Van Ark, 2007; Cho et al., 2014; Hall et al., 2012; Lawson et al., 2007; Mills, 1999; Walker, 1985; Wolde-Rufael, 2014; Yousefi, 2011). In addition to those, some notable studies such as, Bouoiyour et al., 2014, has applied meta-analysis techniques for 43 studies announced between 1996 and 2013. They found that the conservation hypothesis is widely associated to American and European countries. Due to this reason, it has an adverse effect on the economic growth in Asian and MENA countries.

Awad and Yossof (2016) investigate the linkages between economic growth, electricity production and employment in Sudan from the period 1980-2013. By using cointegration and causality techniques they find that lower demand for the electricity will lead to fall in the economic growth over time, the effect will extend to include reduction in the number of employment. They suggest that, the Sudan's government to give emphasize in the electricity production, because of having positive impact on the country's economic development.

Ogundipe et al. (2016), used an extended neoclassical model to examine the relationship between electricity consumption and economic development from 1970 to 2011. They showed that causality test provides a unidirectional relationship running from economic development to electricity consumption. They also recommended re-strategizing investment into the power sector and strengthening institutions or agencies saddled with the responsible of electricity production and distribution.

Ozturk and Acaravci (2011) examine the causal relationship between electricity consumption and economic growth for 11 MENA countries from the period of 1971 to 2006. They found cointegration and causal relationship in Egypt, Israel, Oman and Saudi Arabia. They also showed that, there is no relationship between the electricity consumption and the economic growth in most of the MENA countries.

Acaravci and Ozturk (2010) studied long-run relationship and causality between electricity consumption and growth for the selected 15 European Transition countries for the 1990-2006 periods. Pedroni panel cointegration tests do not confirm long-term equilibrium relationship between the electricity consumption per capita and the real GDP per capita. Finally they found that that the electricity consumption related policies have no effect or relation on the level of real output in the long run for these countries.

Ozturk et al. (2010) have illustrated EC and economic growth (GDP) for 51 countries from 1971 to 2005. The empirical results of panel cointegration tests show that EC and GDP are cointegrated for high, middle and low-income countries. By using panel causality test which provides that, there is a long-run Granger causality running from GDP to EC for low income countries and bidirectional Granger causality running between EC and GDP for the lower middle and upper middle income countries.

3. METHODS - MODEL AND DATA

This paper uses an innovative approach for measuring the relationship between electricity consumption and ICT usage by using recent panel methods such as mean Group (MG), pool mean group (PMG), system GMM method and Dumitrescu and Hurlin panel causality test.

3.1. Model

The model is specified as a dynamic panel data model of electricity consumption (demand). Electricity consumption (*e*) depends upon income (*y*), price (*p*), and a measure of ICT (*ict*).

$$e_{it} = \sum_{j=1}^{2} \alpha_j e_{it-j} + \sum_{j=0}^{1} \beta_{1j} rgdp_{it-j} + \sum_{j=0}^{1} \beta_{2j} cpi_{it-j} + \beta_3 ict_{it} + v_i + \psi_t + \in_{it} \quad (1)$$

In (1), countries are denoted by the subscript *i* and the subscript *t* denotes the time period. It is a fairly general specification which allows for dynamic electricity demand effects, individual fixed country effects (*u*), fixed time effects (*c*), and a stochastic error term ($\in$). The lag lengths are chosen to ensure that the residuals are random. Provided the variables are measured in natural logarithms, the ARDL specification in (1) facilitates the calculation of short-run and long run elasticities.

Panel data is used to estimate an error correction model (ECM) to determine the short and long run effect of ICT on electricity consumption. This is a common approach to finding the causal relationship between variables using Engle-Granger tests. Three new techniques are used for the non-stationary dynamic panel estimation. These are MG, PMG and system GMM estimators. GMM estimators are particularly useful for panel data estimation with a relatively small time dimension (t), compared to the number (n) of cross sections (Roodman, 2008). In contrast, as *t* becomes larger, the GMM estimator can produce inconsistent and misleading coefficient estimates unless the slope coefficients are identical across cross sections (Pesaran and Smith, 1995). This problem is addressed given the relatively large time dimension (t = 24, n = 11) by estimating separate regressions for the sub period of 2010-2014. If there is a long run causality relationship running from variables to output growth, then the system GMM panel data estimator can be used to deal with the issue of the endogeneity of the regressors (Mileva, 2007). This enables to search for the varying effects of ICT across time. In contrast, for full panel time series like here the PMG technique where the estimator relies on a combination of pooling and averaging of coefficients can be used (Blackburne and Frank, 2009). Further, if there is long run causality running from variables to output growth then the system GMM panel data estimator can be used to deal with the issue of endogeneity of the regressors.

Thus, this study performs the following estimations:

i. A number of panel unit root tests verified the stationarity of data
ii. The Kao's co-integration test verified the presence of long-run relationships among the variables
iii. PMG estimated the short and long-run relationships and the speed of error correction

iv. Dumitrescu and Hurlin Panel causality test assessed the causal link among the variables
v. A system GMM panel data estimator dealt with the issue of the endogeneity of regressors.

3.2. Data

This study used a dynamic panel dataset for 11 emerging countries for the period 1990-2014. The data set commences from 1990 because before that time there are too many missing values for the ICT variables. The core variables were: Electricity consumption is measured by electric power consumption (kWh per capita) (electricity) (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). Real GDP per capita is measured in constant 2005 international dollars (gdp pcap) as a proxy for income. Many emerging economies do not provide electricity price data or if it its available the price series contain little variability as electricity prices are often fixed by government in many emerging economies. In response, Sadorsky (2012) suggested using the consumer price index (CPI) as a proxy for electricity prices. What the CPI does measure is movements in consumer prices and consumer prices tend to follow the business cycle. More accurately, the CPI should be thought of as a business cycle indicator reflecting overall movements in a basket of consumer goods and services that may or may not proxy for electricity prices. In this paper, the CPI (Price, 2005 = 100) is used to proxy overall price changes. ICT variables include internet users per 100 people, (Internet), mobile cellular subscriptions per 100 people, (Mobile) and ICT imports as a percentage of total exports, (ICT). Panel data for the past 25 years (1990-2014) for all these variables were obtained from the World Bank Data Bank (Previously, World Development Indicators [WDI] database).

4. RESULTS AND DISCUSSION

4.1. Tests for Unit Roots

Before proceeding to using co-integration techniques, it is necessary to determine the order of integration of each variable. The panel unit root test of Im, Pesaran and Shin (2003) (hereinafter IPS) does this which allows for heterogeneity on the coefficients of the dependent variable. This test provides separate estimations for each cross-section allowing different specifications of the parametric values, the residual variance and the lag lengths. This test was ideal in this study because of balanced panel data considers the same sample period for all cross sectional units.

First generation panel data integration tests such as IPS (2003) assume cross-sectional independence among panel units (except for common time effects), whereas second generation panel data unit root tests like Pesaran (2007) allow for more general forms of cross-sectional dependency (not limited to common time effects). The variables are: Electricity consumption (elcon), GDP (RGDP), mobile cellular subscription (mcs), internet user (inu), cpi and ICT import (ictim) are used. All variables are in natural logs.

The results of the IPS (2003) test are presented in Table 1. For all six variables, the null hypotheses of the unit roots cannot be rejected. These results indicate that the variables in level terms are non-stationary and become stationary only in first-differences.

4.2. Panel Cointegration Test

The basic idea behind co-integration is to test whether a linear combination of variables that are individually non-stationary is itself stationary. Kao's et al. (1999) residual-based test was an ADF stationary test on residuals of a first difference model with all variables. Since the (Pedroni, 2004) co-integrating test limits the number of variables, the Kao et al. (1999) co-integration test was used.

The test results (Table 2) show that all six variables in the N-11 countries are co-integrated. Therefore, the ECM and hence causality test can be employed.

To examine the causal links between electricity consumption and ICT use, the panel Granger causality test is applied in Table 3 which accounts for heterogeneity across the cross-section units (Hurlin and Dumitrescu, 2012). Ignoring the heterogeneity across the cross-section units in panel causality testing leads to faulty conclusions, inferring a causal relationship in all the cross section units yet it may be only present in a subset of them or by rejecting the presence of a causal relationship for all the cross-section units yet it is present in at least one of them. The (Hurlin and Dumitrescu, 2012) methodology proceeds first by testing the homogeneous non-causality hypothesis, that is, under the null hypothesis, there is no causal link between two variables in all the cross-section units of the panel. Hurlin and Dumitrescu, (2012) consider that under the alternative hypothesis, there are some cross-section units, (N1) of the panel, for which there is no causality and (N-N1) cross-section units for which there is causality between the variables. The structure of the test proposed is similar to the panel unit root test in heterogeneous panels suggested by IPS et al. (2003).

4.3. PMG Estimation

In Table 4 the regression results obtained from the PMG method are presented. For comparison purposes, results obtained using

Table 1: Panel unit root test results

Variables	Im, Pesaran and Shin (2003) IPS W-Stat (trend and intercept)
Ln elcon	
Level	−1.0206 (0.1537)
First-difference	−4.5495 (0.0000)*
Ln RGDP	
Level	5.3472 (1.0000)
First-difference	−5.1584 (0.0000)
Ln CPI	
Level	−0.1755 (0.4303)
First-difference	−2.9287 (0.0017)
Ln inu	
Level	−2.2152 (0.5787)
First-difference	−2.6810 (0.0037)
Ln ictim	
Level	0.3410 (0.6334)
First-difference	−7.8188 (0.0000)
Ln mcs	
Level	−2.6338 (0.6545)
First-difference	−1.5395 (0.0618)

Notes: The null hypothesis is that the series is a unit-root process i.e., H_0. All panels contain unit roots. *Indicates the parameters are significant at the 5% level the MG estimator are also reported. The constraint of common long-run coefficients from MG and PMG has yielded almost similar standard errors and speed of adjustment. In testing the hypothesis of slope homogeneity, the Hausman (1978) test was used. The P values associated with the Hausman test for PMG and MG are <0.05 meaning that the long-run homogeneity restriction hypothesis is rejected, i.e., there is heterogeneity in cross-section units. The Hausman test rejects the null hypothesis that the PMG is significantly different from the consistent MG.

The results of Table 4 show the co-efficient, t (P) values and corresponding signs of the target variables both in short run and long run context of the sample countries. The long-run coefficients of real GDP, mobile phone subscriptions per 100 inhabitants, internet users per 100 inhabitants and CPI are significant at the 5% level and contribute positively to electricity demand except price level (CPI) which has a negative sign as expected. In comparison, in the short run PMG model, except mcs and rgdp, all other variables are insignificant. The probable reason behind this may be, ideally internet users, ictim and cpi variables take time to create an impact on electricity demand. The internet users, cpi (proxy for electricity price) and ICT import variables make a significant impact after a certain time period and therefore in long run these variables are significant with the expected sign. However, in the case of the MG model only the mobile cellular subscribers (mcs) variable is significant in the long run. The results suggest that the PMG technique is more efficient and presents a robust result consistent with the theory. In literature PMG results are preferred in many analyses as compare to MG model (Shin et al., 1999). Another reason as to why the MG model does not show any long run or short run relationship between the variables is that there is no cross-section dependency in the residuals (Table 5). The Pesaran (2007) CD test in Table 5 cannot reject the null hypothesis which means there are no correlation among the residuals which can help to explain the conclusion of an insignificant outcome from the MGE model.

Table 2: Residual co-integration test results

		Lag[a]	t-statistic	P
N-11 Countries	ADF	3	−3.318185*	0.0005

Note: Null hypothesis: No co-integration, [a]Lag selection using Parzen Kernel. *Indicate that the parameters are significant at the 5% level

Table 3: Panel causality direction results

Direction of causality	Wald F-test
cpi ↔ elcon	(7.E-05)
	(4.E-05)
elcon → ictim	(0.0400)
inu ↔ elcon	(0.0002)*
	(0.0016)
mcs → elcon	(3.E-05)
elcon → rgdp	(0.032)
cpi → ictim	(3.E-05)
inu ↔ cpi	(0.060)
	(1.E-13)
mcs ↔ inu	(5.E-13)
	(0.0400)
rgdp ↔ inu	(0.090)
	(0.025)
rgdp No casuality mcs	(0.524)
inu No casuality ictim	(0.234)

Note: The reported values are the P values of the F-test. *Indicates significant at 5% level

4.4. System GMM Analysis

The system GMM method is then applied (Arellano and Bond, 1991) as it is designed for use in datasets with many panels and few periods. This method assumes that there is no autocorrelation in the idiosyncratic errors and require the initial condition that the panel level effects be uncorrelated with first difference of the first observation of the dependent variable. Moreover, system GMM uses moment conditions from the estimated first differences of the error term and the levels of the residuals as well. Therefore, the system GMM method is more efficient, especially if its assumed that there are weak instruments applied in the model. The problem of the relatively large time dimension (t = 25, n = 11) is addressed by estimating separate regressions for the sub period of 2010–2014 for system GMM analysis to deal with the issue of endogeneity of the regressors in a short time span analysis.

Table 6 presents the estimation results where the estimated coefficient on the internet variable is positive and statistically significant at the 1% level, indicating that increases in internet connectivity increases electricity consumption. The estimated coefficient on the mobile phone variable is positive and statistically significant at the 5% level indicating that increases in mobile phone adoption increases electricity consumption. The estimated coefficient on the ICT import variable is positive and statistically insignificant from zero at the 5% level. This indicates that increases in the number of ICT goods imported increases electricity consumption. Each of the ICT variables has a positive and statistically significant impact on electricity consumption. Furthermore, the test, which examines for serial correlation fails to reject its null hypothesis, implying that the error term does not exhibit serial correlation in first and second order correlation.

Table 4: Pooled mean group results

Variables	Long run		Short run	
	MG	PMG	MG	PMG
Ln mcs	0.0648642 (0.017)	0.0648613 (0.000)	0.0116789 (0.766)	0.0219283 (0.094)
Ln cpi	0.1466026 (0.387)	−0.4982935 (0.005)	−0.1181793 (0.294)	−0.064364 (0.561)
Ln inu	0.0000942 (0.996)	0.0503267 (0.000)	−0.0099551 (0.435)	0.0067603 (0.467)
Ln RGDP	0.2287403 (0.501)	0.3638147 (0.016)	−0.6165543 (0.373)	0.3016713 (0.046)
Ln ictim	0.0864769 (0.111)	0.0399301 (0.274)	0.0449376 (0.109)	0.0017393 (0.944)
Error correction term			0.9287822 (0.000)	0.0912098 (0.343)

Number of observation: 240, Hausman statistic: 15.76 (0.0076). MG: Mean group, PMG: Pool mean group

Table 5: Residual cross-section dependence test results

Residual cross-section dependence test			
Null hypothesis: No cross-section dependence (correlation) in residuals			
Equation: Untitled			
Periods included: 25			
Cross-sections included: 11			
Total panel (unbalanced) observations: 251			
Test employs centered correlations computed from pairwise samples			
Test	**Statistic**	**d.f.**	**P**
Breusch-Pagan LM	510.1557	55	0.0000
Pesaran scaled LM	42.34859		0.0000
Bias-corrected scaled LM	42.11942		0.0000
Pesaran CD	−1.458811		0.1446

Table 6: System GMM results

Variable	SDPD
Electricity (−1)	1.011962
	0.000
RGDP	0.5459398
	0.000
RGDP (−1)	−0.400764
	0.000
RGDP (−2)	−0.1566795
	0.053
CPI	−0.0215768
	0.644
CPI (−1)	−0.0806219
	0.072
CPI (−2)	0.0943403
	0.011
MCS	0.013649
	0.070
INU	0.0010718
	0.0702
ICTIM	0.0204141
	0.017
Constant	18.07832
	0.002
AR (1)	−1.5287
	0.1263
AR (2)	0.49512
	0.6205

5. DISCUSSION

This paper makes five contributions to the literature.

First, while most authors have studied the relationship between ICT and electricity consumption at the country or sector level for developed economies there is little known about this relationship for N-11 countries until now. Emerging economies currently adopting mobile phone usage, internet connections and are importing ICT goods much faster than developed economies and the impact that ICT adoption has on electricity consumption in emerging economies is an important yet under studied area.

Second, this paper presents what is, believed to be the second panel data study of electricity consumption and ICT usage and the first from the perspective of the N-11 countries.

Third, a limitation of homogenous panel data approaches such as the difference GMM technique that was employed in Sadorsky (2012) is that it allows the intercept to differ while constraining all other parameters to be the same thus still imposing a high degree of homogeneity but ignoring the potential cross-sectional heterogeneity in the panel. Usually first difference GMM uses moment conditions from the estimated first differences of the error term and therefore imposition of such a method of homogeneity has the potential risk of producing biased results. The current study overcomes this limitation by employing panel estimation by the PMG technique (for whole panel time series) and system GMM approach (for short period time series) to investigate cross-country heterogeneity and moment conditions. This is important to help understand the short run and the long run relationship of the variables to a greater extent. Additionally this study examines the causal links between electricity consumption and ICT usage by applying panel Granger causality tests which accounts for heterogeneity across the cross-section, a methodology advanced by Hurlin and Dumitrescu (2012). One limitation of the study may be that the data sample is small due to missing data that required the application of more econometric methods to test the hypothesis. In future, the first difference GMM method with short time span, and the panel dynamic ordinary least square technique (DOLS) for testing the VECM model to check the serial correlation problem and the variance decomposition model to investigate the pass-through of external shocks to each variable in the model could be deployed.

Fourth, three measures of ICT were used: The number of internet connections per 100 inhabitants, the number of mobile phone subscriptions per 100 inhabitants and ICT imports as a percentage of total imports, instead of the number of PCs per 100 inhabitants. This method was used in (Sadorsky, 2012) which is the only panel study that has been previously done by using these differing variables in different samples. Therefore this current study provides a more complete understanding of how these different measures of ICT affect electricity consumption.

6. CONCLUSIONS AND POLICY IMPLICATIONS

This paper examined the hypothesis that how the increased usage of ICT affected electricity demand. Secondly, how different measures of ICT affect electricity consumption and thirdly, what are the short-run and long run elasticities of electricity demand with respect to ICT in N-11 countries? To date, very little has been published on the relationship between ICT and electricity demand in emerging economies.

The purpose of this paper was to investigate the impact that ICT has on the demand for electricity in the N-11 emerging economies. This topic is likely to grow in importance as emerging economies continue to develop and expand their usage of ICT. Recently developed dynamic panel modeling techniques were used to model and estimate the relationship between ICT and electricity consumption in these 11 emerging economies. The resulting empirical models fit the data well and pass a number of diagnostic tests.

The results show that increases in ICT, measured using internet connections, mobile phone subscriptions or ICT goods imported, increases the demand for electricity in the N-11 emerging economies. More specifically, the estimated coefficients on each of the ICT variables has a positive and statistically significant impact on electricity consumption which offers support for the main hypothesis of this paper that increased usage of ICT increases electricity consumption. The estimated long-run ICT elasticities are smaller than the estimated long-run income elasticities but since ICT is growing so much faster than GDP, the effect of ICT on electricity consumption is actually greater than the effect of income growth on electricity consumption.

This paper offers the first set of results on how ICT affects electricity consumption in the N-11 emerging economies. Electricity demand projections in emerging economies, which do not include ICT (internet connections, mobile phone subscriptions, ICT goods import) as an explanatory variable, may underestimate actual electricity demand. This can lead to unplanned electricity shortages if actual electricity demand exceeds planned electricity demand. Finally, government should consider the introduction of policies and mechanisms that aid investment in the electricity sector and ICT development to enhance future economic growth.

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