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The Nexus between Information and Communication Technology (ICT), Electricity Access, Governance and Human Development: Evidence from Asia-Pacific Countries

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Abstract: The Asia-Pacific region has recorded the sharpest increase in human development progress globally and has seen shrinking gaps in basic standards and capabilities. However, inequalities around technology remain a cause for concern for the region, especially when countries with lower human development reportedly have limited access to technologies compared to countries with higher human development. Therefore, this study investigated the effects of information and communication technology (ICT), electricity access, and governance on human development in the Asia-Pacific region. A panel dataset of 46 countries from 2010 to 2019 was estimated using the Driscoll–Kraay standard error regression approach. Our findings revealed that ICT has a strong positive impact on human development for countries with high and medium human development. Internet usage is particularly significantly correlated with human development for both country groups, while mobile cellular subscriptions emerged as significant only for countries with high human development. The study also revealed significant positive effects of electricity access and governance on human development. The findings suggest that increased ICT adoption and electricity access, coupled with good governance, are crucial in improving people's quality of life, thereby promoting greater human development. Limitations of the study include omission of the low human development group and a limited number of indicators used to measure ICT and governance.

Keywords: human development; ICT; electricity; governance

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1. Introduction

Economic growth and human development are two distinct paradigms that rest on different conceptualizations of what development is. While economic growth can be viewed as a measure of progress in wealth over time, human development, on the other hand, is the process of expanding people's opportunities and choices to live according to their needs and interests. The concept of human development is anchored by Sen's (1985) capability approach, which focuses on various combinations of valuable functions and capabilities that enable people to live a quality life. In determining how well people are doing, Sen (1985) argued that what people can be and do effectively should be given more emphasis, rather than merely their commodities and wealth. The United Nations Development Programme (UNDP), through its 1990 Human Development Report, was the first to undertake an effort in developing a quantitative approach in measuring human development by combining various socioeconomic indicators into one single composite index called the Human Development Index (HDI). The HDI captures three core dimensions of human development: (1) to lead a long and healthy life, (2) to acquire access to education, and (3) to achieve a decent standard of living.

One of the key findings reported in the 2019 Human Development Report was that the Asia-Pacific region had experienced the most rapid human development progress globally. It is catching up to other more developed regions, particularly in the life expectancy,

education, and health dimensions. However, the region may be susceptible to new forms of inequality, particularly around technology. The current wave in information and communication technology (ICT) has made achievement of basic standards and capabilities insufficient. New and enhanced capabilities are now becoming fundamental to harnessing the full potential of modern ICTs. According to the 2019 Human Development Report, countries with high human development experienced greater access to technology than countries with low human development. The report additionally noted that while gaps in access to basic technologies such as mobile phones are narrowing, gaps in advanced technologies such as fixed broadband remain wide across groups. Therefore, inequalities in ICT access and usage persist, especially within the Asia-Pacific region, because it comprises countries spanning the full spectrum of human development groups, from low to high.

Distribution of increased income spurred by economic growth paves the way for improvements in standard of living (Ranis 2004). In this regard, ICT is seen as a significant contributor to both economic growth (Latif et al. 2017; Pradhan et al. 2018; Sepehrdoust and Ghorbanseresht 2019) and human development (Aksentijević et al. 2021; De la Hoz-Rosales et al. 2019), where greater adoption of technologies enables further development of human capital needed to attain greater development gains. Moreover, there is also increasing recognition of the need for a stable electricity supply to support ICT for development initiatives (Bailey et al. 2019). A handful of studies found that electricity access and consumption is positively correlated to human development (Kanagawa and Nakata 2008; Niu et al. 2016; Wijaya and Tezuka 2013) and is particularly crucial for enhancing the well-being of people in developing countries (Mazur 2011). In a related study by Touray et al. (2013) and Poloamina and Umoh (2013), governance also appears to be one of the critical success factors in promoting access to and usage of both ICT and electricity. This implies that poor governance may hinder the effective delivery of basic public services and infrastructure needed to achieve crucial human development objectives.

This study, therefore, attempted to investigate the effects of ICT, electricity access, and governance on human development in the Asia-Pacific region. Considering that the human development effects of ICT, electricity access, and governance could be different across country groups, this study divided the countries of the Asia-Pacific region into two levels of human development: high and medium. Additionally, two forms of ICT were tested in this study: (1) mobile cellular, representing ICT access to a basic form of technology, and (2) internet, representing ICT usage with an advanced form of technology. Hence, this study aimed to contribute to the existing body of literature by looking at how ICT influences human development in countries with different human development levels, as opposed to studies that usually focus on countries with different income or development levels. This study also provided valuable empirical evidence for the mixed impact of basic and modern technologies on human development, as well as data on the rarely studied role of electricity and governance in influencing human development.

2. Literature Review

2.1. ICT, Economic Growth, and Human Development

Numerous empirical studies have primarily engaged in assessing how ICT impacts economic growth across various country groups and development levels. Studies by Sepehrdoust and Ghorbanseresht (2019) and Latif et al. (2017) employed a composite index of ICT as a measure of ICT development and showed that ICT had a determinant role in boosting the economic growth of developing OPEC countries and BRICS countries, respectively. Pradhan et al. (2018) confirmed a significant and positive effect of ICT infrastructure (broadband adoption and Internet users) on the economic growth of selected G-20 countries, which comprises 19 member countries plus the European Union (EU). Furthermore, their study also provided evidence of a long-run causality proceeding from ICT infrastructure to economic growth. This finding is in line with studies by Salahuddin and Gow (2016), who similarly indicated a long-run causal link between Internet usage and economic growth in South Africa. The evidence of long-run causality implies that effective

utilization of ICT is crucial for economic gains. Nevertheless, such causality effects may vary depending on a number of differences between countries, including those related to their economic systems, infrastructure development levels, political stability, and even cultural differences (Pradhan et al. 2016).

While it is common to observe a significant and positive relationship between ICT and economic growth, some studies indicated otherwise. Using an autoregressive distributed lag (ARDL) bounds testing approach, Ishida (2015) found that ICT investment did not contribute to an increase in economic growth in Japan. This result was also supported by Niebel (2018), who revealed that ICT investment did not have any statistically significant impact on economic growth, particularly in developing and emerging economies. The varying impacts of ICT are also observed when different measures of ICT are tested for their impacts, as noted in the study by Haftu (2019). The study indicated that although both mobile cellular subscriptions and Internet users are positively correlated with economic growth in Sub-Saharan African countries, only Internet users, however, did not emerge with a significant effect. This could be due to poor ICT adoption and the skills needed to fully reap the benefits of ICT in most parts of the region.

Despite the growing role of ICT in almost every aspect of economic and societal activities, the evidence outlining its impacts on key dimensions of human development remains scarce. Human development has a bidirectional linkage with economic growth: on one hand, economic growth produces the resources needed to support human development, and on the other hand, advances in human development enhance workforce productivity and thereby sustain economic growth (Chiappero-Martinetti et al. 2016). One of the few recent studies that investigated the relationship between ICT and human development is by Aksentijević et al. (2021). The study segregated 130 countries by income levels, and the findings demonstrated that ICT had a significant positive effect on human development in lower-middle-income and low-income countries, while ICT emerged as insignificant in the case of high- and middle-income countries. De la Hoz-Rosales et al. (2019) similarly examined how ICT use at various levels affects human development, measured by the Social Progress Index (SPI) and the Human Development Index (HDI). The findings of their study showed that individual use of ICT has a significant positive effect on human development, especially on each dimension of the HDI, regardless of the country's level of development. In addition, it was also found that business use of ICT only appeared significant at the global level, while government use of ICT was revealed to have significant effects only on certain dimensions of the HDI (the "decent standard of living" and "long and healthy life" dimensions) when controlled for developed countries (De la Hoz-Rosales et al. 2019). Findings from other studies (Asongu and Le Roux 2017; Bankole et al. 2014; Gholami et al. 2010; Ngwenyama et al. 2006) also corroborated the significant and positive association between ICT and human development, suggesting that ICT advancement proves to be a key driver in promoting human development.

The complexity of ICT implementation can result in inconsistent ICT effects due to several underlying factors. According to Balouza (2019), these factors could be the mismatch between ICT infrastructure and availability of skilled human capital, sufficiency of the educational system, and public awareness of the important role of ICT. In their study, Balouza (2019) found a significant positive impact of ICT use on human development in six Gulf Cooperation Council countries (GCC), but the assumption of this significant and positive relationship does not hold for ICT access. When assessing for impacts on each dimension of the HDI, the study revealed that ICT access and usage may not necessarily produce significant positive effects; in fact, they may also be insignificant or negatively correlated to human development. In order for ICT strategies and policies to be successfully implemented, it is therefore imperative to take into account the complementarities between ICT dimensions and investments in other sectors.

2.2. Electricity Access and Human Development

Access to modern energy not only forms the bedrock for fulfilling basic human needs, it is also essential to supporting ICT for development initiatives (Bailey et al. 2019). Growth in electricity use, for instance, is often associated with improvements in quality of life and lifestyle changes (Niu et al. 2016; Wijaya and Tezuka 2013). Several studies have investigated the correlation between electricity access and human development. For example, Kanagawa and Nakata (2008) found that an increase in electricity access significantly influences socioeconomic factors, such as health and education. The study also revealed that electricity access has substantial ripple effects on other factors, such as the economy, gender equality, and the environment, especially in rural areas of developing countries. Niu et al. (2013) employed panel data from 1990 to 2009 for 50 countries that were grouped based on income levels and found evidence of a long-run bidirectional causality between electricity consumption and human development. Furthermore, the results revealed that the higher the income of a country, the greater its electricity consumption and the higher its level of human development. Although electricity consumption is essential to improving well-being in less-developed countries, particularly in heavily populated countries such as China and India, Mazur (2011) demonstrated that increases in electricity consumption were not accompanied by improvements in quality of life among industrialized nations. The study argued that further increases in electricity consumption may produce little if any benefit to quality of life, given that wealthy nations have improved so much in some areas of well-being.

2.3. Governance and Human Development

Realizing the full potential of ICT as a driver of human development requires careful formulation and design of public policies and strategies. Malloch-Brown (2000) highlighted the importance of quality of governance in determining the success or failure of a country in improving its people's well-being. According to Khan (2015), good governance is typically characterized by transparency, accountability, participation, decentralization, privatization, impartiality, diversity, and good performance. Such governance allows for market regulation, fosters greater participation, builds inclusive communities, promotes peace and social harmony, and encourages corporate and social responsibility (Cheema and Maguire 2001). A previous work by De Muro and Tridico (2008) showed that better governance promotes human development through efficient distribution of resources. This finding is further supported by Gaur and Kant (2020), who similarly revealed evidence of a significant positive relationship between effective governance and human development. Khan (2015) also established that higher levels of good governance contribute to significant progress in human development among developing countries. In the context of provision of adequate and sustainable basic infrastructure, the role of governance becomes even more pronounced as good governance enhances the efficiency of public policy and effective and equitable delivery of public services, especially those related to the energy sector, which in return supports the ICT sector. Sarkodie and Adams (2020) posited that the joint effort of increased access to affordable electricity and a good governance environment would result in enhanced access to knowledge, a longer and healthier life, and improved standard of living.

3. Methodology

3.1. Data and Description of Variables

This study is based on a panel dataset of 46 countries from the Asia-Pacific region from the period 2010–2019. Post-2010 data was used following the major changes made in calculating the HDI during that year, and the latest data available for the HDI are for 2019. The rationale of selecting countries from the Asia-Pacific region owes to the fact that the region saw the greatest leap in human development progress during that time and has made substantial gains in basic standards and capabilities (UNDP 2019). However, the 2019 Human Development Report revealed that inequalities in ICT remain widespread;

countries having a higher level of human development experience greater access to and use of technologies, and inequalities are greater for advanced forms of technology. Therefore, in assessing the effects of ICT on human development in the Asia-Pacific region, this study decided to group the sampled countries according to their human development levels, and considered two forms of ICT, notably: (1) mobile cellular, representing basic technology, and (2) the Internet, representing advanced technology.

A total of 46 Asia-Pacific countries were selected for the study and were further grouped based on their human development levels as of the year 2019, whereby 31 countries were categorized under high human development and 15 countries were categorized under medium human development. Following the definitions established by the UNDP (2020), this study associates high human development with HDI values ranging from 0.70 to 1.00, whereas medium human development has HDI values ranging from 0.55 to 0.69.

Table 1 below presents all the variables used in this study, including their measurements, descriptions, and sources from which the data were collected. Our main variable of interest, human development, was measured by the HDI, which is the average of achievement in three principal dimensions: health and long life, knowledge, and basic living standards. ICT variables were measured by two indicators: mobile cellular subscriptions and Internet users, representing ICT access and usage of different forms of technology. Access to electricity and governance also served as part of the independent variables tested in the study, given that availability of basic infrastructure and good governance may potentially have an influence on human development. Based on the six dimensions of governance defined by Kaufmann et al. (2010), this study used government effectiveness as the indicator measuring governance.

Table 1. Measurement of variables.

Variable	Indicator	Measurement	Data Source
Dependent variable	Human Development Index (HDI)	A single-index measure that captures achievements in 3 key dimensions of human development: a long and healthy life, being knowledgeable, and having a decent standard of living.	UNDP
Independent variables	Mobile cellular subscriptions	The number of mobile cellular subscriptions (per 100 people)	World Bank—World Development Indicators
	Internet users	The percentage of individuals using the Internet (% of population)	
	Access to electricity	The percentage of access to electricity (% of population)	
	Governance	Measured by government effectiveness, which captures the perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	World Bank—World Governance Indicators
Control variable	GDP per capita	GDP per capita growth (annual %)	World Bank—World Development Indicators

3.2. Model Specification

To examine the effect of ICT, electricity access, and governance on HDI, this study transformed the econometric model adapted from the work of Aksentijević et al. (2021) into a static panel data model as expressed below:

$$HDI_{it} = \beta_0 + \beta_1 MOB_{it} + \beta_2 INTR_{it} + \beta_3 ELCT_{it} + \beta_4 GOV_{it} + \beta_5 GDP_{it} + \mu_{it} \quad (1)$$

where the *HDI* is the dependent variable measuring human development in country i in year t, *MOB* is mobile cellular subscriptions in country i in year t, *INTR* is Internet users in country i in year t, *ELCT* is electricity access in country i in year t, *GOV* is governance in country i in year t, and *GDP* is GDP per capita in country i in year t. β_0, β_1, β_2, β_3, β_4 and β_5 represent the parameters to be estimated, while μ_{it} represents the error term.

3.3. Econometric Methodology

The empirical analysis of this study is based on static panel data regression analysis, where we employed the Driscoll–Kraay (DK) standard error regression approach (Driscoll and Kraay 1998). This method considers the issue of cross-sectional dependence that occurs when units in the same cross-section are correlated, due to the effect of some unobserved common factors such as technological evolution and world prices (Henningsen and Henningsen 2019). Ignoring the potential presence of dependencies across countries may result in biased and inconsistent estimates (Baloch et al. 2019). Therefore, the preference for using the DK standard error approach over other estimators lies in the fact that it is not only robust against cross-sectional dependence, but it also counters heteroskedasticity, spatial and serial dependency, and missing values, and is suitable for balanced and unbalanced panel data (Baloch et al. 2019; Sarkodie and Strezov 2019).

Before estimating the static panel data model, several important diagnostic tests were conducted. First, a variance inflation factor (VIF) test was performed to test for multicollinearity issues, whereby a VIF value of more than 5 signals the presence of highly collinear variables (Montgomery et al. 2001). Next, we ran the modified Wald test and the Wooldridge test to check for heteroskedasticity and serial correlation issues, respectively, in the panel data. The decision rules for these tests indicate that the rejection of a null hypothesis of absence of heteroskedasticity and serial correlation problems warrants the use of a panel data estimation technique with robust standard errors (Hoechle 2007). This study performed the Pesaran CD test to detect the existence of cross-sectional dependence in the panel data model residuals (Pesaran 2004). Rejection of the null hypothesis by the Pesaran CD test implies that the residuals are cross-sectionally dependent. Therefore, in the presence of potential cross-sectional dependence, heteroskedasticity, and serial correlation in the panel data, this study preferred the DK standard error regression approach.

4. Results and Discussion

Table 2 below reports estimation results obtained from static panel data regression analysis of the relationship between ICT and human development in the Asia-Pacific region. The small VIF values of less than 2 for both groups of countries suggested that the model did not suffer from any serious multicollinearity problems. Meanwhile, the statistically significant p-values produced by the modified Wald test, Wooldridge test, and Pesaran CD test confirmed the presence of heteroskedasticity, serial correlation, and cross-sectional dependence issues in the panel data. Regression estimates obtained from the DK standard error approach are, therefore, robust against these problems.

From the DK standard error regression results, ICT variables showed strong significant and positive effects on the HDI for countries with both high and medium human development levels. Coefficients of Internet usage particularly revealed that its effect on HDI is higher for countries with a medium human development level compared to countries with a high human development level. This finding suggests that a one-percent increase in Internet users leads to a 0.09 increase in the HDI for countries with a medium human development level. In contrast, the HDI for countries with a high human development level increases by 0.07 when their Internet users increase by one percent. Additionally, mobile cellular subscriptions appeared to have a significant and positive relationship with the HDI only in the case of countries with a high human development level. This finding implies that a one-percent increase in mobile cellular subscriptions is associated with a 0.02 increase in the HDI for countries with a high human development level.

Table 2. Driscoll–Kraay standard error regression estimates.

Variables	High HDI	Medium HDI
MOB	0.0191 ***	0.0057
	(0.0029)	(0.0045)
INTR	0.0671 ***	0.0935 ***
	(0.0022)	(0.0074)
ELCT	0.0137	0.0403 ***
	(0.0296)	(0.0072)
GOV	0.0177 *	0.0271 *
	(0.0086)	(0.0144)
GDP	0.0648 ***	0.0082
	(0.0163)	(0.0519)
Constant	72.7796 ***	53.4685 ***
	(3.1740)	(0.6880)
No. of observations	310	150
No. of countries	31	15
Variance Inflation Factor	1.67	1.47
Modified Wald test	2582.40 ***	1301.14 ***
Wooldridge test	151.090 ***	65.458 ***
Pesaran CD test	4.990 ***	5.187 ***

Notes: Values in parentheses are Driscoll–Kraay standard errors, whereby ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. High HDI refers to country groups with a high human development level, whereas medium HDI refers to country groups with a medium human development level.

The statistical significance and positive relationship between ICT and human development is consistent with previous studies (Aksentijević et al. 2021; Asongu and Le Roux 2017; De la Hoz-Rosales et al. 2019), indicating that ICT plays an important role in promoting human development. Countries with a higher human development level are expected to experience greater access to technology, thus allowing them to have a greater ability to use the technology productively. This is evident in the study's findings, where both indicators of ICT access (mobile cellular subscriptions) and ICT usage (Internet users) were found to improve the HDI for countries with a high human development level. Effective access and usage of present-day technologies experienced by countries with a high human development level proved to have led to enhanced capabilities, such as access to high-quality education, health services, and improved standard of living.

While it is interesting to note that the study failed to confirm a significant effect of ICT access (mobile cellular) on the HDI specifically for countries with a medium development level, this result echoed Balouza's (2019) work, which similarly found no significant relationship between ICT access and the HDI. This possibly hints at the existence of demand-side barriers and lack of a supportive policy environment for mobile services to reach their full potential in countries with a medium human development level. Issues related to affordability, digital skills, and awareness, relevance in content and services, and security may hinder the full enablement of mobile services and their benefits for development.

In addition, the study found that access to electricity is significant and positively correlated to the HDI, but only for countries with a medium human development level. This was in line with previous studies (e.g., Kanagawa and Nakata 2008; Niu et al. 2016; Wijaya and Tezuka 2013) which suggests that greater accessibility to electricity allows for better living conditions and standards, and thus improves human development. Interestingly, our findings also revealed that electricity access does not significantly affect the HDI for countries with high human development levels. A possible reason for this finding is that countries with high human development are generally well-developed countries, where nearly all their citizens have access to basic services such as clean water, electricity, and so on. Given such conditions, certain aspects of their quality of life may be approaching saturation to the point where there is little room for human development gains through any additional access to electricity. This finding is also consistent with Mazur's (2011) study, where it was found that an increase in energy and electricity consumption does not significantly affect the quality of life of wealthy industrial nations.

Moreover, the results also showed that governance has a significant and positive relationship with HDI for both groups of countries. The significance of governance found in this study concurs with results obtained by Gaur and Kant (2020) and Khan (2015), who revealed that improvement in the quality of governance promotes human development. As Kamalu and Wan Ibrahim (2021) argued, governance may act as a conditional factor for expanding human capabilities in achieving higher human development. This can be realized through efficient allocation and utilization of public resources to enhance the economy's health as well as educational and income status, thereby promoting human development. Furthermore, it is also established that good governance offers a framework for policymakers to formulate policies and programmes that deliver essential services to the public, which directly influences productivity growth and development (Andrés et al. 2017). Therefore, quality governance is crucial in developing a good institutional framework for translating available capabilities into higher human development.

5. Conclusions and Recommendations

This study aimed to examine the impact of ICT, electricity access, and governance on human development in 46 countries from the Asia-Pacific region from 2010 to 2019, using the Driscoll–Kraay standard error regression approach. This study contributes to the existing body of knowledge by demonstrating that ICT strongly enhances the HDI for countries with both high and medium human development levels. When comparing the two forms of technology tested in this study, it was found that Internet usage was particularly important in improving human development for both country groups, compared to mobile cellular subscriptions, which emerged with a significant and positive effect only in the case of countries with a high human development level. In recognition of this contribution, widespread access to and use of ICT across all levels and sectors of the economy should be further encouraged and supported. Policymakers should design and implement policies directed at keeping ICT prices low and demand high, as well as creating supportive conditions for ICT adoption. These can be further complemented by offering digital literacy training programmes or education opportunities for all to develop their digital skills in line with current needs.

The findings of this study also provided evidence of a significant and positive relationship between electricity access and HDI. This reinforces the important role of electricity access as an essential condition in improving people's quality of life. As reliance on electricity is expected to increase along with rapid advancements in technology, urbanisation, and industrialisation, it is therefore imperative for policymakers to mobilise and scale up investments to increase the availability and accessibility of electricity. Moreover, the significance of governance in achieving greater levels of HDI is also highlighted in this study. This implies that proper institutional arrangements resulting from good governance help to ensure that resources are delivered to the public efficiently, thereby improving people's well-being. Hence, with better institutional mechanisms and good governance in place, nations can move up the growth and human development ladder.

Despite its important implications, this study has three limitations. First, we grouped the countries based on only two levels of human development: high and medium. The low human development group was omitted due to limited data availability for Asia-Pacific countries that fall under this group. Therefore, future investigation into the low human development group, with a larger scope of study, can enrich existing evidence on the relationship between ICT, electricity access, governance, and the human development of countries. Second, ICT in this study was measured only by mobile cellular subscriptions and Internet users. Future research should include more advanced forms of technology such as access to computers and fixed broadband to assess whether these new technologies offer the same favourable impact on human development. Third, this study used only one indicator of governance, which was government effectiveness. Future researchers should consider delving into impacts of other governance indicators, such as regulatory quality and rule of law.

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