WELFARE IMPLICATIONS OF INFORMATION AND COMMUNICATION TECHNOLOGY DIFFUSION IN SUB-SAHARAN AFRICA

Hammed Adesola Adebowale and Ebere Chuks

Department of Economics, University of Ilorin, Nigeria

ABSTRACT

This study examined the impact of Information and Communication Technology (ICT) on welfare in sub-Saharan Africa (SSA) using a panel data of 34 countries from 2003 to 2017. Welfare was measured using the Index of Sustainable Economic Welfare (ISEW) per capita while ICT was measured using fixed broadband subscription per 100 people and mobile phone penetration per 100 people. Data was analysed using alternative panel estimation techniques including the fixed effect, random effect and dynamic panel regression techniques (difference GMM and system GMM). Fixed broadband subscription was found to have a positive influence on welfare in SSA and the same result was obtained for mobile phone penetration. Therefore, the government of sub-Saharan African countries needs to partner with relevant stakeholders to ensure higher penetration of ICT into the subregion, particularly, fixed broadband subscription and mobile phone penetration.

JEL classification: I31, L86, L96, O30

1. Introduction

The issue of well-being remains dominant in academic discourse. A myriad of articles in economics and the social sciences, in general, have centred on well-

being improvement. It also forms the fulcrum of development programmes for most countries, international organizations and donor agencies. In fact, welfare improvement is at the centre of the United Nation's Sustainable Development Goals (SDGs) and various economic plans of developing countries. In spite of the attention it has received, the challenge of poor well-being is still much present in developing countries, particularly sub-Saharan Africa (SSA). Available statistics show that indices of well-being, such as poverty, unemployment and inequality, are getting worse in most SSA countries. A recent World Bank report indicated that extreme poverty has been on the increase in Africa with Nigeria being the world poverty capital (World Bank, 2018). This is in spite of the fact that most countries of the region have recorded one of the world fastest GDP growths in recent times. The situation shows that an increase in growth may not necessarily translate to welfare improvement.

Similarly, the implication of the above is that even the recommendations of the large volume of research on the issue have failed to remedy the situation by way of improving the well-being of the people, especially the poorest half of the population. Thus, the issue of welfare improvement in developing countries including SSA is very much open to discussion.

Although the last two decades have witnessed an unprecedented promotion of Information and Communication Technology (ICT) facilities in developed economies, the adoption or accessibility is reportedly very low in SSA. Relying on the submissions of a prominent theory in economics, the Solow growth model (Solow, 1956), and its extension, the endogenous growth model (Romer, 1990) and other literature such as Bayoumi and Haacker (2002), who stated that ICT has an impact on welfare as a result of huge benefits from technical advances in ICT which result in decline in the price of digital goods, ICT diffusion ought to have substantially improved the level of well-being in Africa. This is not the case given the poor level of well-being that characterizes the continent.

By increasing technical efficiency (through a reduction in input cost and, by extension, input use relative to output use) and enhancing allocative efficiency, ICT has the potential to increase economic welfare. Allocative efficiency can arise if the ICT penetration improves the buyers' knowledge about market prices which in turn facilitates harmonious competition among product producers or suppliers. The technical efficiency occurs if the ICT reduces the number of employees as well as other input hitherto used in the economic activities. A

study has shown that internet penetration facilitates transactions, especially market transactions in all US industries through a reduction in transaction costs and bounded rationality (OECD, 2013). ICT as a concept may be seen as a type of general-purpose technology because of its link with other technologies or industries (Basu & Fernald, 2007; Lee, Hong & Hwang, 2017). The extent of ICT diffusion is often indicated by the level and quality of internet facilities (measured by fixed broadband subscription) and mobile phone penetration (Asongu & le Roux, 2017; Lee, Hong & Hwang, 2017; Amavilah, Asongu & Andres, 2017).

Though relatively substantial literature exists on the role of ICT in the well-being of people in SSA, they are based on the wrong measure of well-being. In particular, the majority of the studies measure well-being using either GDP per capita (Sepehidoust, 2018; Lee, Levendis, & Guitierrez, 2012) or HDI (Asongu & le Roux, 2016), both of which have been found to be defective measures of welfare (Menegaki, 2018). The situation underscores the urgent need to re-examine the impact of ICT on welfare using a comprehensive and an all-encompassing measure and framework.

From the foregoing, the research questions of the study are: (i) To what extent does mobile phone penetration impact well-being in SSA? (ii) To what extent does fixed broadband penetration impact well-being in SSA? The objectives of the study are to: (i) examine the impact of mobile phone penetration on welfare in SSA and (ii) examine the impact of broadband penetration on well-being in SSA

The rest of the paper is arranged as follows: section 2 presents the literature review, followed by section 3 which contains the methodology and section 4 under which data and variables are described. Section 5 is devoted to the presentation and discussion of results and section 6 presents the summary and conclusion.

2. Theory and Empirical Evidence

The link between ICT and development outcomes in general has been explained by different theories in the literature. Some of the theories link ICT to economic growth. In this league is the Solow growth model (Solow, 1956) which recognized the impact of technology in attaining economic growth. However, the Solow growth model failed to endogenize technology as a key determinant of

growth. The augmented Solow growth model improved on the Solow growth model by not only recognizing the role of technology in promoting economic growth but also made it endogenous while explaining the growth process. New economic development is also situated within the neo-Schumpeterian perspectives of economic development (Asongu & le Roux, 2017). All these theories see technology as a driver of economic growth and development but do not explicitly focus on welfare.

The transaction cost theory can also be used as a theoretical link between ICT and development outcomes, particularly the welfare level. The transaction cost theory originated from Ronald Coase. The transaction cost theory indicates that by reducing the cost of the transaction of an individual economic agent as both the consumer and producer, ICT is capable of influencing aggregate social welfare in a society. The channel through which it influences aggregate welfare is explained using a partial equilibrium analysis with normal demand and supply slopes as presented in figure 1.

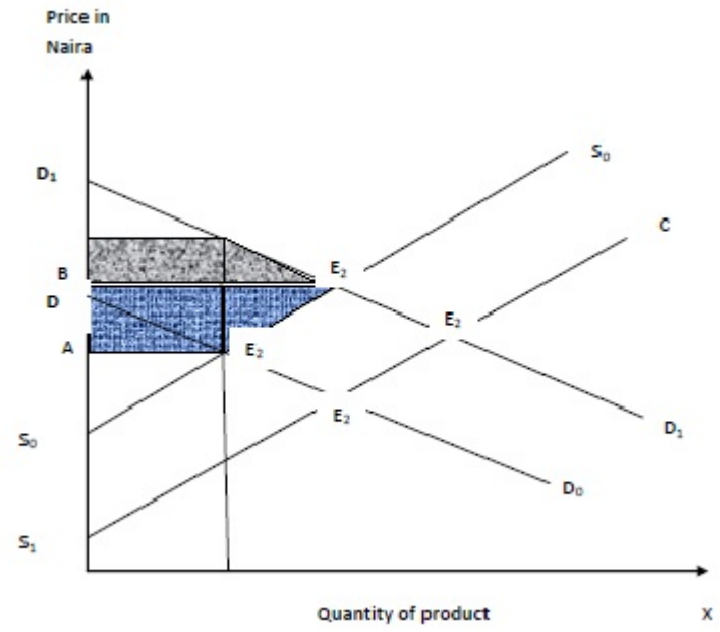

Figure 1. Impact of ICT penetration on Welfare through reduction in transaction costs.

From the figure, the initial demand curve of the consumer is D_0D_0 and that of supplier is S_0S_0. This produces an initial equilibrium at E_0, where the equilibrium price is A. If we assume that a reduction in cost to the consumer is constant for simplicity and that the introduction of ICT brings about a reduction in transaction cost to the consumer, the demand curve shifts from D_0D_0 to D_1D_1 and a new equilibrium point is established at E_1. This increases consumer welfare by consumer surplus represented by the grey shaded portion of the figure. The same will result in an increase in producer welfare represented by the area shaded in blue, which is the measure of producer surplus. If in addition, ICT penetration reduces the transaction cost of the producer such that the supply curve shifts from S_0S_0 to S_1S_1, the new market equilibrium becomes E_2. It can be seen that consumer surplus increases probably as a result of the fact that product prices decline. The producer surplus is also expected to increase if the shift in the supply curve is parallel. However, producer surplus may fall if the supply curve pivots in such a way that the slope of the curve reduces (see Duncan & Tisdell, 1971 for more explanation of this possibility).

Though a reduction in market transaction costs for both the consumer and producer is expected to increase aggregate economic welfare, especially under a static setting, contrary results may be obtained in a dynamic setting. Tobin (1978) and Tisdell (2013) provided the reason for such an outcome. According to them, lack of market frictions may subject markets to destabilization and such prevents a reduction in transaction cost from increasing economic welfare. Thus, ICT may not add to economic welfare since a reduction in transaction cost does not always translate to economic welfare.

The possibility of a negative or insignificant influence of ICT on welfare may also be explained within Jevons paradox which originated from William Stanley Jevons in 1865. Though not originally meant to explain the influence of infrastructure, it has been extended in the literature to explain the possibility of a rebound effect of infrastructure and the link is being extended here to technology. The idea of the concept is that improvement in ICT penetration may reduce the level of sustainable economic welfare through a rebound effect. This may be explained through different channels, one of which is that accessibility to ICT infrastructure may widen the level of inequality in the society and may even reduce the demand for unskilled labour which may eventually reduce the overall level of well-being in the society.

The empirical literature includes several attempts to examine the influence of ICT penetration on development outcomes. These may be grouped based on the outcome variable proxied, techniques of analysis and coverage in terms of developed and developing countries. It may also be grouped in terms of findings.

In terms of findings, many studies have established the positive impact of ICT penetration on development outcomes. Among these is the study by Asongu and le Roux (2017) who reported positive impact of each of the dimensions of ICT on inclusive human development for 45 African countries using the Tobit panel regression. Many other studies have documented different economic outcomes that are components of human welfare such as improved access to health care services by those at the bottom of the income ladder (Kliner Knight, Mamvura, Wright & Walley, 2013); enhancement of business operations, especially small and medium scale (Ondiege, 2010; Mishra & Bashit, 2013; Lee, Kim & Cho, 2010) and efficiency in household management (AlSurikhi, 2012). Others include Islama and Meadeb (2012) and Brouwer and Brito (2012) who found evidence of positive and significant impact of ICT on development outcomes and social change.

Asongu, le Roux and Biekpe (2017), using data from 44 SSA countries between 2000 and 2012, also found that ICT played a significant role in tackling environmental degradation and thus resulted in improvement in inclusive development. They measured ICT with mobile phone penetration and internet penetration, and the GMM method was used as technique of analysis. Their study revealed that ICT can help to dampen the effect of CO2 emission on inclusive human development in SSA. Other empirical findings on the impact of ICT documented in the literature are living standard (Chavula, 2013), economic prosperity (Levendis & Lee, 2013; Qureshi, 2013), and sustainable development (Byrne, Nicholso, Salem, 2011). Venturini (2009) examined the long-run impact of ICT on economic growth for the US and 15 European countries using panel cointegration analysis. The study reported that ICT capital significantly spurs growth over time. Other studies that reported positive impact of ICT on productivity are Dedrick, Gurbaxani and Kraemer (2003), Pilat (2004), and Draca, Sadun and van Reenen (2007) who reported positive impact of ICT on productivity at firm level. They, however, emphasized that strong market rigidity may prevent the benefits gained to appear at aggregate level

since the performance of less efficient enterprises may obscure that of innovative enterprises.

In a study on the impact of ICT on productivity growth, O'Mahony & Vecchi (2005) reported positive and statistically significant impact in the US industries but insignificant results for the UK. Oulton and Srinivasan (2005) reported significant impact in the UK while Marrano, Haskel and Wallis (2009) reported that the information economy made little difference to the macroeconomic performance of the UK. All the findings reported here imply that the nexus between ICT and various development outcomes is still mixed and thus require further empirical test. Thus, it is difficult to make an emphatic statement as to the direction and extent of impact of ICT on development outcomes in general and welfare in particular.

It is clear from the reviewed literature that even though there has been a substantial effort in the literature to examine the influence of ICT on development outcomes which may be seen as components of social and economic welfare, noticeably, none of the studies examined the influence of ICT on aggregate socio-economic welfare. This study is meant to fill this noticeable gap in the existing literature.

3. Model Specification

The model specification for this study is based on a blend of the endogenous growth theory, the transaction cost theory and the partial equilibrium analysis presented in the preceding section. The endogenous growth theory emphasizes the role of technology, of which ICT is a critical component, as one of the determinants of income differences among countries. The partial equilibrium analysis combined with the transaction cost theory reveals how ICT can enhance economic agents' consumption of goods and services and increase producer and consumer surplus.

We used five control variables in order to prevent the problem of variable omission bias which may arise. The variables were selected based on the theoretical link between welfare and development outcomes, empirical review as well as intuition. One of the variables is gross fixed capital formation (GFC) which is a measure of capital and included in the model following insight from the endogenous growth theory. The higher the level of capital in the country, the greater the propensity for people to invest, which may translate to welfare

improvement. Thus, the study expects a positive relationship between GFC and welfare. GFC data was obtained from the WDI database. Another variable is inflation (INF) which is a measure of the level of macro-economic uncertainties. By reducing the purchasing power of the populace and consumption by extension, inflation is capable of reducing individual and social welfare adversely.

Since level of industrialization has been argued to be a key driver of sustainable growth and development (Adebowale, 2018), we also included manufacturing value added (MVA) in the model. A considerable level of openness (TOP) signals less trade barriers which may positively affect the level of welfare. It was argued using partial equilibrium analysis, that openness, which is a signal of the extent of trade barriers, may positively affect the level of welfare (Salvatore, 2013). Therefore, trade openness is also used as a control variable. The last control variable is urbanization (URB) which is an indicator of a country's development. We expect the level of urbanization to be positively related to welfare (WEF) since urbanization is associated with considerable infrastructure development.

From the foregoing, the model of this study, which is an empirical welfare model, is specified as follows:

$$WEF = f(ICT, INF, URB, MVA, OPN, GFC) \quad (1)$$

where

WEF = economic welfare which wemeasure with index of sustainable economic welfare (ISEW per capita)

OPN = trade openness

INF = inflation

ICT = information and communication technology and it would be represented by two different indicators namely; fixed broadband subscription (FBB) and mobile phone penetration (MPP)

MVA = manufacturing value added

URB = urbanization

GFC = gross fixed capital formation

The relation in equation (1) can be expressed in linear equation form as:

$$WEF_{it} = \tau + \vartheta OPN_{it} + \varphi INF_{it} + \omega ICT + it + \gamma MVA_{it} + \pi URB_{it} + + \Psi GFC_{it} + \mu_{it} \quad (2)$$

A major problem associated with panel data model in equation (2) is the endogeneity problem which occurred as a result of the nature of the error term. If the error term in is not white noise due to the presence of unobserved country specific effects which often characterize panel data models, the error term could then be expressed as:

$$\mu_{it} = \rho_i + \varepsilon_{it} \quad (3)$$

If the equation above is true, then equation (2) cannot be estimated using OLS since it will lead to bias and inconsistent estimate, otherwise OLS would have been an appropriate estimation technique. In the presence of unobserved country-specific effect, the model in equation (2) becomes:

$$ISEW_{it} = \tau + \vartheta OPN_{it} + \varphi INF_{it} + \omega ICT + it + \gamma MVA_{it} + \pi URB_{it} + + \Psi GFC_{it} + \rho_i + \varepsilon_{it} \quad (4)$$

where

ε_{it} = error term which is white noise

τ = intercept term that captures changes common to all countries and ρ_i is the unobserved country specific effects which could be either fixed or random. If the ρ_i is fixed, the appropriate estimation technique is the fixed effect model, while random effect model is the appropriate technique if the effect is random.

Among the three models, the baseline static model depends on the result of the F-test (which tests the presence of unobserved country-specific effect with the null of no country-specific effect) and the Hausman test (which is based on the null hypothesis that the random effect is appropriate compared to the fixed effect model).

It may however be possible that the level of welfare at the current period is explained by the welfare in the immediate previous period due partly to the fact that the dependent variable (WEF) is observed over time and thus likely to exhibit persistence (see Cameron & Trivedi, 2009). This thus necessitates the incorporation of dynamics into the model. On the basis of that, we then introduced a dynamic variable into the stated static panel model by specifying equation (3) as an AR(1) model in equation (5):

$$WEF_{it} = \tau + \alpha WEF_{it-1} + \vartheta OPN_{it} + \varphi INF_{it} + \omega ICT + it + \gamma MVA_{it} + \pi URB_{it} + + \Psi GFC_{it} + \rho_i + \varepsilon_{it} \quad (5)$$

Taking first difference of equation (5) to eliminate the country-specific effects produces:

$$WEF_{it} = \tau + \Delta\alpha ISEW_{it-1} + \vartheta\Delta OPN_{it} + \varphi\Delta INF_{it} + \omega\Delta ICT + it + \gamma\Delta MVA_{it} + \pi\Delta URB_{it} + + \Psi\Delta GFC_{it} + \varepsilon_{it} \quad (6)$$

The specification in equation (6) has eliminated the country- specific effect. However, the presence of lag of welfare (WEF_{it-1}) which might be endogenous to the ε_{it} will present the problem of endogeneity. Two options that could be used to overcome the problem are either the instrumental variable (IV) or the generalized method of moments (GMM) estimator (Roodman, 2009). The latter is used here since the IV approach is reported to lead to consistent but not necessarily efficient estimate of the parameters (Baltagi, 1995). Thus, the dynamic model specified in equation (5) is estimated using the two alternative panel GMM, namely difference GMM and Arrellano-Bover/Blundell-Bond (1998) system GMM estimation techniques.

The difference GMM and system GMM are capable of controlling for the endogeneity that may result from an econometric model with a lagged dependent variable as one of the regressors (Roodman, 2009). Though system GMM is the baseline dynamic panel estimation technique adopted in this study, the difference GMM is also estimated to serve as robustness check. The method instruments the first difference lagged dependent variable and other endogenous variables with further lagged levels. This estimation technique has been reported to be

capable of accommodating a dynamic specification and at the same time account for time-invariant country-specific characteristics (Cameron & Trivedi, 2009).

Next is choosing between the one-step system and the two-step system GMM. The two-step GMM has been observed to be asymptotically more efficient than the one-step estimator. It controls for heteroskedasticity, unlike the one-step system which is not heteroskedasticity consistent (see Roodman, 2009).

4. Data and Description of Variables

The data used for the study are secondary in nature and were obtained for 34 SSA countries between 2003 and 2017. The scope was limited by data availability on each of the variables of the study. The data were sourced mainly from the World Development Indicators (WDI). The dependent variable of the study, welfare (WEF), was measured by the Index of Sustainable Economic Welfare (ISEW) which was computed using the method proposed by Menegaki (2018). The ISEW measures welfare from both the economic and social perspectives and has been recognized to be a better representative of aggregate welfare than GDP per capita, human development and others (Menegaki, 2018).

Since the level of industrialization has been argued to be a key driver of sustainable growth and development (Adebowale, 2018), we also included manufacturing value-added in the model. The variable is measured as a percentage of GDP and data for it is sourced from the WDI database. It was argued using partial equilibrium analysis that openness, which is a signal of the extent of trade barriers, may positively affect level of welfare (Salvatore, 2013). The variable is measured as a ratio of trade balance to GDP multiplied by 100 and the data is obtained from the WDI database. Openness (TOP) is used to measure the extent to which countries depend on foreign countries for their survival. It is a measure of economic policies that either restrict or invite trade between countries. A considerable level of openness signals less trade barriers, which may positively affect the level of welfare. The last control variable is urbanization, which is an indicator of a country's development. We expect the level of urbanization to be positively related to welfare (WEF) since urbanization is associated with considerable infrastructure development. The variable is measured as the ratio of urban population to the total population and it is also sourced from the WDI database.

ICT policy variables were measured using mobile phone penetration and fixed broadband subscription per 100 people. The indicators used are consistent with the practice in recent literature (Asongu, 2018; Amavilah, et al., 2017). The data were obtained from the WDI database.

5. Results

The empirical findings of the study are presented in tables 1 and 2. The results for fixed broadband are presented in table 1 while those for mobile phone users are presented in table 2. For each table, the results obtained using both static and dynamic panel regressions are presented.

In table 1, the alternative static panel regression results are in the first three columns. The F-test for the presence of country effect rejects the null hypothesis of no country effect, thus we proceeded to examine if the effect is fixed or random using the Hausman test. The result of the Hausman test rejects the null that the random effect technique is appropriate and on that basis, the static panel result on the effect of fixed broadband subscription on ISEW per capita is interpreted using the fixed effect panel regression technique. The result of the fixed effect is presented in column 1 and it shows that fixed broadband has a positive and significant impact on ISEW per capita (WEF). In addition, other control variables which are significant include manufacturing value-added, gross fixed capital formation, trade openness and inflation. While urbanization had no significant impact on the relationship, all the results obtained here conform to the a priori expectations of this study, except for inflation and urbanization.

The last two columns show the results obtained when dynamics is introduced into the relationship. The two alternative dynamic panel regression techniques namely, the difference GMM and system GMM, are used for the analysis and subjected to post-estimation tests. The results obtained from the difference GMM are presented in column 4 of table 1. The results show that fixed broadband subscription had a positive and statistically significant impact on WEF. It also reveals that besides fixed broadband (FBB), trade openness (TOP) and manufacturing value added (MVA) influenced WEF positively and significantly while urbanization (URB) and gross fixed capital formation (GFC) influenced WEF negatively and significantly.

Table 1. Estimated Panel Regression Results with Fixed Broadband Subscription Proxy

Variables	Static Panel		Dynamic Panel	
	FE	R E	Diff GMM	SYS GMM
L.WEF			0.670109***	0.9257901***
			(0.0740743)	(0.0143924)
FBB	49286.47**	49830.44**	18972.04*	57608.12**
	(24664.63)	(25102.79)	(11292.85)	(27475.99)
INF	611.6052	826.9813	10698.39	22220.36***
	(4862.885)	(4963.991)	(7208.745)	(6187.869)
TOP	891.5322	2541.753	6543.246*	2554.825**
	(3021.151)	(3018.914)	(3889.271)	(1242.51)
URB	-17786.13	13389.83	-63582.65***	5153.114 **
	(18991.11)	(15824.54)	(20995.94)	(2281.479)
GFC	.0000597***	0.000050***	-.0000776 ***	-.0000232***
	(0.0000109)	(0.0000108)	(0.0000212)	(5.87e-06)
MVA	0.0000826***	0.0000929***	0.0003116***	0.0000604***
	(0.0000185)	(0.0000186)	(0.0000412)	(0.0000122)
Constant	2472949***	1047978		-312686***
	(742608.6)	(716217.6)		(110708.7)
Observations	306	306	257	295
R-squared	0.4096	0.4891		
Number of Cid	32	32	31	31
FE	YES	YES		
Hausman Prob	0			
No of Instruments			47	41
AR(1) Prob			0	0
AR(2) Prob			0.417	0.568
Sagar Test (P-value)			0.261	0.131

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1, YES indicates that F-test confirms the presence of country-effect

Source: Authors' computation, 2019.

The AR test results show the presence of autocorrelation of a first order and no autocorrelation of second-order as expected, while the Sagan test of over identifying restrictions accepts the null hypothesis that the instruments used are valid. The results obtained using system GMM are presented in the last column of table 1 and reveal that fixed broadband (FBB) influenced the WEF positively and significantly. Of the control variables, influence of trade openness, inflation, and urbanization were positive and statistically significant while that of gross

fixed capital formation was negative but statistically significant. The AR test indicates the presence of first order autocorrelation but no second-order autocorrelation and the Sargan test accepts the null validity of the instrument used.

The empirical results for mobile phone penetration are presented in table 2. They are also based on the static and dynamic panel technique. The first three columns present the results of the static regression and show the presence of country-specific effect, based on the rejection of the null hypothesis of no country effect by the F-test. The results of the Hausman test show that the effect is fixed as the Hausman test rejects the null hypothesis that the effects are random. Therefore, the results of the fixed effect, which is the baseline static panel technique, show that mobile phone penetration influenced WEF positively and significantly.

From the dynamic panel regression results, the estimated difference GMM coefficient of mobile phone penetration indicates that mobile phone penetration influenced WEF significantly and positively. The results of the AR test, which shows first-order autocorrelation and no second-order autocorrelation, and the Sagan test, which accepts the null hypothesis that instruments are valid, validate the use of either difference or system GMM. The system GMM results in the table also reveal a positive and significant influence of mobile phone penetration on WEF.

Summarily, the results from different estimation techniques show evidence of positive impact of fixed broadband subscription on WEF measured by ISEW per capita and imply that the results are robust to different estimation techniques. Similar results were found for mobile phone penetration in all the estimation techniques used. The implication of the findings of this study is that information and communication technology penetration has a role to play in influencing the level of sustainable welfare in sub-Saharan Africa. Thus, the level of welfare in the region may be increased if the level of ICT penetration (especially fixed broadband and mobile phone) in the continent is enhanced. The findings are similar to the finding by Lee, Hong & Hwang (2017) that ICT has a positive impact on human well-being. The results may be explained by the ability of ICT to reduce transaction costs and information asymmetry in the system. For instance, higher mobile phone access and internet facility ensure that individuals acquire more information at lower cost, thereby allowing them to make rational

choices in their buying and selling activities. The impact may also be attributed to the ability of ICT to bridge the information gap between the potential employer and job seekers thereby improving the living standard of the people. All these translate to positive impact of ICT on welfare.

Table 2. Estimated Panel Regression Results with Mobile Phone Penetration Proxy

Variables	Static Panel		Dynamic Panel	
	FE	RE	Diff GMM	SYS GMM
L.WEF			0.5887282***	0.9514377***
			(0.0694875)	(0.0142189)
MPP	10475.5***	5801.43***	10556.74***	5242.43***
	(1835.013)	(1512.257)	(3067.613)	(1061.878)
INF	-3031.772	-2700.049	17171.34**	13727.44**
	(3363.718)	(3508.907)	(7008.209)	(5946.964)
TOP	289.3625	667.0745	5153.04**	1327.93*
	(1456.905)	(1512.287)	(2138.028)	(750.6752)
URB	-77052.73***	(5577.144)	-196658.1***	8855.819***
	25695.04	17535.53	(35004.65)	(2165.346)
GFC	0.0000487***	0.00042***	-0.0000714***	-0.0000133**
	(9.16e-06)	(9.39e-06)	(0.0000163)	(5.40e-06)
MVA	0.000075***	0.000081***	0.0003064***	0.0000395***
	(0.0000155)	(0.000016)	(0.0000334)	(0.0000112)
Constant	4312615***	1264386*		-149309.8
	(932798.8)	(686598.8)		(99389.89)
Observations	394	394	327	362
R-squared	0.4889	0.5462		
Number of Cid	34	34	32	33
FE	YES	YES		
No of Instruments			37	41
Hausman Prob	0			
AR(1) prob.			0	0
AR(2) Prob.			0.847	0.388
Sagan Test (Prob)			0.176	0.243

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1, YES indicates that F-test confirms the presence of country-effect

Source: Authors' computation, 2019.

6. Summary and Conclusion

Despite the fact that sub-Saharan Africa has experienced some of the fastest growth in the world in recent times, level of welfare remains extremely low and in fact has been reported to be the lowest among the regions of the world (ITU, 2013). This is manifested in the extreme poverty by which the region is characterized. As part of the contribution to the growing debates on welfare improvement strategies, this study examined the impact of ICT penetration on welfare in the region using an unbalanced panel data for a sample of 34 SSA countries between 2003 and 2017. A unique contribution of this study is that unlike previous empirical work on ICT penetration on development outcomes, it measures welfare through a more encompassing measure called the Index of Sustainable Economic Welfare. Both static and dynamic panel regression techniques were applied in the study. The results show that broadband subscription and mobile phone penetration have positive and significant influence on ISEW per capita (WEF). By implication, our findings reveal that a policy initiative designed to boost ICT, notably fixed broad band and mobile phone penetration, is capable of enhancing the level of welfare in the region. Therefore, we recommend that government partner with other relevant stakeholders to, among others, increase the level of fixed broad band subscription and mobile phone penetration in the country. Particularly, governments in SSA countries should pay attention to the availability and affordability of ICT infrastructure in the region. This study also found that level of industrialization, trade openness inflation and gross fixed capital formation play important roles in the design of welfare improvement strategies. In view of this, significant effort must be devoted to the promotion of manufacturing value-added. Sub-Saharan African countries should also be open to trade and capital formation in the countries must be enhanced to improve the level of welfare in the region.

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Appendix 1. Variable Definitions and Data Sources

Variables	Signs	Variable Definitions(Measurement)	Sources
Welfare	WEF	This measures welfare from both economic and social perspective with Index of Sustainable Economic Welfare	Computed by Authors based on the method proposed by Menegaki (2018)
Fixed Broad Band penetration	FBB	This is an indicator of ICT penetration and it is measure as	WDI
Mobile Phone Penetration	MPP	It is an indicator of the extent of ICT penetration measured as Mobile phone subscription (per 100 people)	WDI
Gross Fixed Capital Formation	GFC	(% of GDP)	WDI
Inflation	INF	Consumer Price Index	WDI
Openness	TOP	Trade balance (% of GDP)	WDI
Urbanization	URB	The variable is measured as the ratio of urban population to the total population	WDI
Industrialization	MVA	Manufacturing Value Added (% of GDP)	WDI

WDI: World Development Indicators