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Abstract

This study assesses how the mobile phone influences governance to improve information and communication technology (ICT) exports in Sub-Saharan Africa with data from 2000-2012. The empirical evidence is based on Generalised Method of Moments and three main governance concepts are used, namely: (i) institutional (comprising the rule of law and corruption-control); (ii) political (involving political stability/no violence and voice & accountability) and (iii) economic (including regulation quality and government effectiveness) governance. The following findings are established. First, there are positive net effects on ICT goods exports from independent interactions between mobile phones and 'political stability' 'voice and accountability' and corruption-control. Second, significant net effects are not apparent from independent interactions between mobile phones and government effectiveness, regulation quality and the rule of law. Theoretical and practical implications are discussed.

JEL Classification: L59; L98; O10; O30; O55
Keywords: Knowledge Economy; Development; Africa

1. Introduction

It has been widely acknowledged today that the creation and dissemination of knowledge over the past decade has been due to the rapid surge in information and communication technologies (ICTs) which have considerably mitigated the cost of communication and electronic networking. In essence, while the growing affordability of modern ICT has enhanced the efficient diffusion of existing knowledge, it has also facilitated the means by which new knowledge can be created to improve productivity and promote social, business and economic developments (Tchamyou, 2016). This narrative is consistent with the ICT literature on social outcomes (Islama & Meadeb, 2012; Amankwah-Amoah & Sarpong, 2016; Brouwer & Brito, 2012; Amankwah-Amoah, 2015, 2016; Mira & Dangersfield, 2012; Asongu et al., 2017) in both developing (Gupta & Jain, 2012; Sonne, 2012) and developed (Thakar, 2012) countries. However, a drawback to this trend is that countries that are not able to adapt and adjust to the importance of knowledge economy in 21st century development will be left-out in the global transition to knowledge based economies. Unfortunately, this is the case with much of Africa because the continent's overall knowledge index has dropped over the past decade (Tchamyou, 2016).

With the above background in mind, assessing linkages between the mobile phone, governance and technology-driven exports in Sub-Saharan Africa (SSA) is relevant in scholarly and policy-making circles for at least four main reasons, notably: (i) the comparatively high penetration potential of mobile phones in Africa; (iii) the open debate on the relationship between exports and innovation; (iii) apparent gaps in the literature and (iv) the role of governance as a policy tool in stimulating industrialisation and trade.

First, compared to other emerging economies (in Latin America and Asia) and developed countries (in Europe and North America) which are currently experiencing saturation levels in ICT penetration, there is yet a great potential for mobile phone penetration

in SSA (see Penard et al., 2012; Asongu, 2015). Therefore, this represents an opportunity for policy to leverage on the penetration potential of ICT to address development challenges (like the low rate of exports) in the sub-region.

Second, the relationship between exports and innovation is still subject to debate. Whereas a strand in the literature supports the non exogenous association between productivity and exports (Bernard & Jensen, 1999; Melitz, 2003), another view is of the position that prior to exporting, firms enhance their productivity but have post-entry productivity rewards (Aw et al., 2009). Consistent with Harris and Moffat (2011), it is more likely that causality flows to both directions because while 'innovating' affects a firm's decision to export, innovation is also affected by the 'learning to exporting' effect.

Third, contemporary literature has failed to engage the connection between ICT and technology exports in SSA despite the growing relevance of knowledge economy and decreasing importance Africa's global share of trade. Accordingly, despite the strong relationship between investments in ICT and trade, SSA is not being given the scholarly attention it deserves in spite of the established importance of trade in economic prosperity (IMF, 2008; NEPAD , 2008; UNCTAD, 2009) and declining SSA's share in global trade since the 1970s (IMF, 2008; UNCTAD, 2009). Moreover, recent literature on ICT for development purposes has focused on two main streams. The first strand which deals with the use of ICT for entrepreneurial opportunities include: emphasis on entrepreneurs who are continuously innovating because of evolving skills and financial resources (Best, 2015); the discovery and creation of new innovation opportunities (Wan et al., 2015; Hang et al., 2015); technological innovations that are offering new avenues due to road-mapping of patents (Jeong & Yoon, 2015); business opportunities that are associated with an ageing population (Kohlbacher et al., 2015) and growing ecosystems (Overholm, 2015); opportunities for entrepreneurs in scientific fields (Maine et al., 2015) and research collaborations (McKelvey

et al., 2015). The second strand which deals with the employment of ICT for economic development in the developing world is concerned with, *inter alia*: economic prosperity (Qureshi, 2013a; Levendis & Lee, 2013); standards of living (Chavula, 2013); sustainable economic development (Byrne et al., 2011); progress within the financial sector (Kamel, 2005); better life for all (Kivuneki et al., 2011); inclusive development (Asongu & Nwachukwu, 2016a) and externalities in welfare (Qureshi, 2013bc; Carmody, 2013).

Fourth, *inter alia*: corruption (Musila & Sigué, 2010) and absence of good governance (Kayizzi-Mugerwa et al., 2014) are some poor governance policy syndromes[1] that are reducing and/or limiting Africa's share in the global trade. While good governance is considered as the main independent variable of interest, mobile phone penetration is used as a policy variable. In order to improve room for policy implications, three principal governance categories are employed, namely: political governance (involving voice & accountability and political stability/no violence); economic governance (covering regulation quality and government effectiveness) and institutional governance (comprising the rule of law and corruption-control). "*Political governance is defined as the election and replacement of political leaders. Economic governance is the formulation and implementation of rules that enable the delivery of public goods and services. Institutional governance is the respect of the state and citizens of institutions that govern interactions between them*" (Asongu & Nwachukwu, 2016b, p. 2)

In the light of the above, the research question this study aims to address is: how does the mobile phone complement governance in affecting technology-driven exports? In other words, the study seeks to understand how governance can be innovated with the mobile phone

[1] Fosu (2013), defines 'policy syndromes' as situations that are detrimental to growth: 'administered redistribution', 'state breakdown', 'state controls', and 'suboptimal inter temporal resource allocation'. Situations in which such syndromes are not apparent are qualified as 'syndrome-free'. The policy syndromes are thought to have substantially contributed to Africa's poor post-independence growth.

for an export-led (or extensive) development strategy. The rest of the study is organised as follows. Section 2 discusses the theoretical underpinnings while the data and methodology are engaged in Section 3. Section 4 presents results whereas Section 5 concludes with implications and future research directions.

2. Theoretical underpinnings

In accordance with Harris and Moffat (2011), there are two principal theoretical underpinnings in the macroeconomic literature on the relationship between exporting and innovation. In essence, for the most part, the narrative does not make much distinction between research and development (hence R&D) and innovation, essentially because inputs resulting from innovation (e.g. R&D) lead to new commodities and processes. On the one hand, neo-endowment models have fundamentally articulated on specialisation and hence on the competitive advantage with respect to factor endowments such as technology, skilled/unskilled labour and capital. On the other hand, neo-technology models are centred for example on the technology gap theory on trade and the product life cycle theory.

Consistent with Wangwe (1995), some inquiries which are closely associated with long-term economic prosperity have put emphasis on patterns of trade as well as linkages with time-related cross-sector and cross-country tendencies. For the most part, the studies have provided robust results on the impact of innovation in international competiveness and growth. The narrative also borders with neo-technology models that have attempted to endogenize technology processes within the context of open economy equilibrium models (see Spencer, 1981).

An associated strand of the literature is of the position that exports can equally be influenced by innovation. In essence, with respect to this viewpoint on models of endogenous growth (see Aghion & Howitt, 1998; Hobday, 1995), it is vital for corporations

to continuously innovate in view of adapting to constantly growing challenges in foreign markets. Furthermore, a 'learning to export effect' exist which is due to growing exposure to new technology and knowledge. This narrative is in accordance with Spencer (1981) on a learning curve which has consolidated the position of the international trade theory. In more contemporary literature, a dynamic model has been employed by Aw et al. (2009) to emphasise the closed connection between exporting and innovation: "*… each activity alters the future return from undertaking the other activity, thus current R&D directly impacts the probability of exporting and current exporting alters the return to R&D*" (Aw et. al., 2009, p.3). Note should be taken of the fact that productivity is endogenous to a corporation's capacity of innovation.

There is a wealth of empirical literature on the relationship between innovation and exporting. Unfortunately, as maintained by Harris and Moffat (2011), much of this literature has focused on emerging countries without Africa on the one hand and on the other, developed nations. Accordingly, changes in the structure of ICT have been documented to enhance trade in both the emerging countries of Asia (e.g. Singapore, South Korea and Malaysia) and advanced nations (e.g. the United States) (Ngwenyama et al., 2006; Wang, 1999; Avgerou, 1998). There is an established consensus in the underlying literature on a positive nexus between a nation's knowledge accumulation (and/or capacity of innovation) and its exporting capacity (Salim & Bloch, 2009; Leon-Ledesma, 2005; DiPietro & Anoruo, 2006). Some studies have also emphasised the relevance of technology and innovation as key drivers in enhancing export performance, facilitating entry into global markets and consolidating competitiveness. Within this strand, it has been shown by Salim and Bloch (2009) that there is causality flowing from innovation to exports.

With the above insights, the mobile phone can complement or innovate governance in improving trade essentially because ICT has been documented to improve governance

standards. Moreover, from an intuitive standpoint, mobile phones should contribute towards reducing information asymmetry that constraint trade. In the narratives that follow, we first discuss the connection between ICT and governance before stating the main hypotheses to be tested. Consistent with Hellstrom (2008), ICT can be employed to enhance governance because, it *inter alia*, facilitates openness, transparency and the quasi-flow of information between various government departments and institutions. The underpinnings maintain that the decentralisation of information by means of the mobile phone reduces opportunities for bad governance. This narrative is consistent with the bulk of literature on the nexus between governance and ICT (see Suarez, 2006; Boulianne, 2009; Diamond, 2010; Grossman et al., 2014)[2]. In the light of these background and underpinnings, the hypotheses to be tested in the empirical section are as follows.

Hypothesis 1: the mobile phone complements political governance to improve technology exports. Political governance represents appealing conditions in the election and replacement of political leaders.

Hypothesis 2: the mobile phone complements economic governance to enhance technology exports. Economic governance represents the formulation and implementation of policies that deliver public commodities.

Hypothesis 3: the mobile phone complements institutional governance to consolidate technology exports. Institutional governance is the respect by citizens and the State of institutions that govern interactions between them.

[2] It is relevant to balance the narrative with a contending strand of the literaure which argues that ICT can also facilated collective violent action (see Manacorda & Tesei, 2016; Weidmann & Shapiro, 2015; Pierskalla & Hollenbach, 2013; Breuer et al., 2012).

Whereas the testable hypotheses are linked to the theoretical literature, we now engage how the underlying hypotheses steer clear of existing empirical knowledge economy literature. In essence, the positioning of the study deviates from recent literature on knowledge economy which has focused on the importance of ICT in development outcomes, *inter alia* in: financial sector development for financial access (Asongu & Nwachukwu, 2017); electricity consumption and economic growth (Shahbaz et al., 2016); regional economic performance (Ahmed, 2010; Ahmed & Ridzuan, 2013; Kleibrink et al., 2015); financial development (Das et al., 2016); Research and Development (R&D) for business value (Costello & Donnellan, 2016); R&D intensity and economic growth (Sağlam, 2016); university education (public and private) (Nour, 2016); human capital spillovers for knowledge-based economies (Ahmed, 2016; Asongu & Le Roux, 2017) and technical regimes and production networks (Murphy & Carmody, 2015).

3. Data and Methodology

3.1 Data

The study assesses a panel of forty-nine countries in SSA with data from World Development Indicators (WDI) and World Governance Indicators (WGI) of the World Bank for the period 2000-2012. The engaged periodicity is contingent on data availability constraints while the scope of SSA is in accordance with the motivation of the study[3]. Consistent with recent African business literature, ICT good exports is used as a proxy for technology good exports (Asongu & Tchamyou, 2016).

Six governance measurements from three principal categories are used, namely: political governance (involving voice & accountability and political stability/no violence); economic governance (covering regulation quality and government effectiveness) and

[3] Data points for the year 2015 are only available in the 2017 release of World Development Indicators of the World Bank. This is essentially because there is always a two year lag between the most updated year in the data and the publication year of the data. At the time of the study, the most updated year was 2012.

institutional governance (comprising the rule of law and corruption-control). The governance variables which are from Kaufmann et al. (2010) have been used extensively in recent governance literature (Andrés et al., 2015; Yerrabit & Hawkes, 2015; Gani, 2011). The policy or modifying variable is the mobile phone penetration rate (per 100 people).

Four control variables are adopted in accordance with recent African business literature (Tchamyou, 2016), namely: Gross Domestic Product (GDP) growth rate, trade openness, cost of exports and foreign direct investment (FDI). Upon a preliminary empirical assessment, accounting for more than four control variables leads to instrument proliferation or over-identification that substantially biases estimated coefficients. From intuition, we expect GDP growth, trade openness and FDI to positively affect the outcome variable whereas the cost of exports should have the opposite effect. However, the intuition motivating these expected signs should be taken with caution because the relationships are also contingent of economic dynamism and expansion. For instance, if the economy is skewed towards heavy extractive industries and GDP growth is not broad-based but limited to the underlying extractive sectors, the anticipated signs may be counterintuitive.

The definitions of the variables and corresponding sources are provided in Appendix 1 whereas the summary statistics is disclosed in Appendix 2. The correlation matrix which is used to reduce potential concerns about multicollinearity is provided in Appendix 3.

3. 2 Methodology

The study adopts the Generalised Method of Moments (GMM) estimation approach for four main reasons. First, the number of periods per cross section (T=13) is substantially lower than the number of countries or cross-sections (N=49). Second, cross-country differences are not eliminated since the GMM is consistent with panel data analysis. Third, the *system* estimator considers inherent biases in the *difference* estimator. Fourth, the

estimation procedure accounts for endogeneity by controlling for simultaneity in the explanatory variables using an instrumentation process. Furthermore, the employment of time-invariant indicators also improves the bite on endogeneity.

Borrowing from Bond et al. (2001), the system GMM estimator (see Arellano & Bover, 1995; Blundell & Bond, 1998) has better estimation properties when compared to the *difference* estimator (see Arellano & Bond, 1991). The Roodman (2009ab) extension of Arellano and Bover (1995) is preferred because it has been established to limit instrument proliferation and account for cross-sectional dependence (see Love & Zicchino, 2006; Baltagi, 2008; Boateng et al., 2016). Therefore, as opposed to first differences, the extended estimation procedure adopts forward orthogonal deviations. A *two-step* procedure is adopted instead of *one-step* approach because it addresses concerns of heteroscedasticity given that the *one-step* procedure only controls for homoscedasticity.

The following equations in level (1) and first difference (2) summarise the standard *system* GMM estimation procedure.

$$TExp_{i,t} = \sigma_0 + \sigma_1 TExp_{i,t-\tau} + \sigma_2 G_{i,t} + \sigma_3 M_{i,t} + \sigma_4 GM_{i,t} + \sum_{h=1}^{4} \delta_h W_{h,i,t-\tau} + \eta_i + \xi_t + \varepsilon_{i,t} \quad (1)$$

$$TExp_{i,t} - TExp_{i,t-\tau} = \sigma_1 (TExp_{i,t-\tau} - TExp_{i,t-2\tau}) + \sigma_2 (G_{i,t} - G_{i,t-\tau}) + \sigma_3 (M_{i,t} - M_{i,t-\tau}) + \sigma_4 (GM_{i,t} - GM_{i,t-\tau}) + \sum_{h=1}^{4} \delta_h (W_{h,i,t-\tau} - W_{h,i,t-2\tau}) + (\xi_t - \xi_{t-\tau}) + \varepsilon_{i,t-\tau} \quad (2)$$

where, $TExp_{i,t}$ is a technology export indicator in country i at period t, σ_0 is a constant, G is a governance variable (political stability, voice & accountability, regulation quality, government effectiveness, corruption-control and the rule of law), M represents mobile phone penetration, GM is the interaction between a governance variable and mobile phone penetration, W is the vector of control variables (GDP growth, trade openness, cost of

exports and foreign direct investment), τ represents the coefficient of auto-regression, ξ_t is the time-specific constant η_i is the country-specific effect and $\varepsilon_{i,t}$ the error term.

It is important to allocate space to engage exclusion restrictions and identification properties in the GMM regression. All explanatory indicators are considered as predetermined or suspected endogenous and exclusively time-invariant variables or years are considered to be strictly exogenous (also see Boateng et al., 2016; Asongu & Nwachukwu, 2016c). This exclusive restriction is based on the fact that, it is very unlikely for time invariant variables to become endogenous in first difference (Roodman, 2009b)[4].

Given the above, years affect the technology exports outcome indicators exclusively via the suspected endogenous variables. Moreover, the statistical importance of the exclusion restriction is assessed with the Difference in Hansen Test (DHT) for instrument exogeneity. In essence, the null hypothesis of the DHT should not be rejected for the time-invariant indicators to explain the technology exports exclusively via the predetermined variables. Therefore, in the results that are presented in Section 4, the hypothesis of exclusion restriction is confirmed if the null hypothesis of the DHT concerned with the instrumental variables (IV) (year, eq(diff)) is not rejected. This is consistent with the standard IV procedure in which, a rejection of the null hypothesis of the Sargan Overidentifying Restrictions (OIR) test is an indication that the instruments influence the technology export variables beyond the suggested predetermined variable channels (see Beck et al., 2003; Asongu & Nwachukwu, 2016d).

4. Empirical results

4.1 Presentation of results

[4] Hence, the procedure for treating *ivstyle* (years) is 'iv (years, eq(diff))' whereas the *gmmstyle* is employed for predetermined variables.

Whereas Table 1 presents findings related to political stability, voice and accountability and government effectiveness, Table 2 reveals results corresponding to regulation quality, corruption-control and the rule of law. There are two specifications pertaining to each governance variable: one without a conditioning information set and the other with a conditioning information set. For all tables: (i) four information criteria are used to examine the validity of the GMM model with forward orthogonal deviations[5] and (ii) a net effect is computed to assess the effect of mobile phones in governance for technology exports. For example, in Table 1 in the second column, the net effect from the interaction between mobile phones and political stability is 0.046 ([-0.003× 23.379] + 0.117), where: the mean value of mobile phone penetration is 23.379, the unconditional effect of political stability is 0.117 while the conditional effect from the interaction between political stability and mobile phones is -0.003.

The following findings can be established on the linkages between governance, mobile phone penetration and technology exports. First, there are positive net effects on ICT goods exports from independent interaction between mobile phones and 'political stability' 'voice and accountability' and corruption-control. Second, significant net effects are not apparent from the interaction between mobile phones and government effectiveness, regulation quality and the rule of law. Third, most of the control variables are significant. The unexpected negative effects from GDP growth and FDI may be respectively traceable to growth and external investment resources that are skewed towards specific sectors like intensive industries.

[5] "First, the null hypothesis of the second-order Arellano and Bond autocorrelation test (AR (2)) in difference for the absence of autocorrelation in the residuals should not be rejected. Second the Sargan and Hansen over-identification restrictions (OIR) tests should not be significant because their null hypotheses are the positions that instruments are valid or not correlated with the error terms. In essence, while the Sargan OIR test is not robust but not weakened by instruments, the Hansen OIR is robust but weakened by instruments. In order to restrict identification or limit the proliferation of instruments, we have ensured that instruments are lower than the number of cross-sections in most specifications. Third, the Difference in Hansen Test (DHT) for exogeneity of instruments is also employed to assess the validity of results from the Hansen OIR test. Fourth, a Fischer test for the joint validity of estimated coefficients is also provided" (Asongu & De Moor, 2016, p.200).

Table 1: Governance, mobile phones and ICT good exports

	Dependent variable: ICT goods exports					
	Political Stability (PolS)		Voice & Accountability(VA)		Government Effectiveness (GE)	
Constant	0.057	0.373	0.096	0.864	**0.226****	0.563
	(0.398)	(0.638)	(0.476)	(0.210)	**(0.015)**	(0.292)
ICT good exports (-1)	**0.744*****	**0.564*****	**0.796*****	**0.648*****	**0.775*****	**0.631*****
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Mobile phones (Mob)	0.002	**-0.002***	-0.001	-0.001	-0.001	-0.001
	(0.277)	**(0.093)**	(0.478)	(0.616)	(0.434)	(0.699)
Political Stability	**0.117****	**0.097***	---	---	---	---
	(0.048)	**(0.063)**				
Voice & Accountability	---	---	**0.209****	0.119	---	---
			(0.034)	(0.496)		
Government Effectiveness	---	---	---	---	0.218	0.224
					(0.110)	(0.240)
'Political Stability'×Mob	**-0.003***	**-0.001***	---	---	---	---
	(0.082)	**(0.057)**				
'Voice & Accountability' ×Mob	---	---	**-0.002***	-0.0002	---	---
			(0.089)	(0.909)		
'Government Effectiveness'×Mob	---	---	---	---	-0.002	-0.001
					(0.165)	(0.578)
GDP growth	---	**-0.013*****	---	-0.006	---	-0.009
		(0.007)		(0.299)		(0.204)
Trade	---	**0.008*****	---	0.003	---	0.0002
		(0.004)		(0.433)		(0.923)
Cost to export (ln)	---	-0.069	---	-0.113	---	-0.036
		(0.517)		(0.318)		(0.602)
Foreign Direct Investment	---	**-0.008***	---	-0.008	---	-0.006
		(0.074)		(0.315)		(0.344)
Net Effects	0.046	0.073	0.162	na	na	na
AR(1)	**(0.228)**	(0.068)	**(0.253)**	(0.078)	**(0.249)**	(0.075)
AR(2)	**(0.335)**	**(0.965)**	**(0.344)**	**(0.674)**	**(0.342)**	**(0.767)**
Sargan OIR	**(0.877)**	(0.003)	**(0.942)**	(0.022)	**(0.710)**	(0.005)
Hansen OIR	**(0.597)**	**(0.884)**	**(0.566)**	**(0.996)**	**(0.655)**	**(0.994)**
DHT for instruments						
(a)Instruments in levels						
H excluding group	**(0.893)**	**(0.886)**	**(0.709)**	**(0.957)**	**(0.645)**	**(0.972)**
Dif(null, H=exogenous)	**(0.359)**	**(0.718)**	**(0.403)**	**(0.974)**	**(0.532)**	**(0.952)**
(b) IV (years, eq(diff))						
H excluding group	**(0.841)**	**(0.897)**	**(0.182)**	**(0.986)**	**(0.398)**	**(0.946)**
Dif(null, H=exogenous)	**(0.506)**	**(0.533)**	**(0.652)**	**(0.902)**	**(0.635)**	**(0.991)**
Fisher	**1314.29*****	**1676.63*****	**2468.95*****	**17733.72*****	**1672.93*****	**10464.83*****
Instruments	24	37	24	37	24	37
Countries	37	37	37	37	37	37
Observations	305	212	305	212	305	212

*,**,***: significance levels of 10%, 5% and 1% respectively. DHT: Difference in Hansen Test for Exogeneity of Instruments' Subsets. Dif: Difference. OIR: Over-identifying Restrictions Test. The significance of bold values is twofold. 1) The significance of estimated coefficients and the Fisher statistics. 2) The failure to reject the null hypotheses of: a) no autocorrelation in the AR(1) and AR(2) tests and; b) the validity of the instruments in the OIR and DHT tests. na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant. The mean value of mobile phone penetration is 23.379.

Table 2: Governance, mobile phones and ICT good exports

	Dependent variable: ICT goods exports					
	Regulation Quality(RQ)		Corruption-Control (CC)		Rule of Law (RL)	
Constant	0.103	-0.553	-0.041	**1.403***	0.063	-0.814
	(0.184)	(0.574)	(0.621)	**(0.078)**	(0.646)	(0.427)
ICT good exports (-1)	**0.791*****	**0.666*****	**0.752*****	**0.625*****	**0.810*****	**0.639*****
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Mobile phones (Mob)	-0.0002	**-0.006***	0.0003	-0.002	-0.0003	-0.003
	(0.833)	**(0.059)**	(0.747)	(0.288)	(0.832)	(0.424)
Regulation Quality	0.152	**0.337***	---	---	---	---
	(0.241)	**(0.057)**				
Corruption Control	---	---	**0.194****	-0.001	---	---
			(0.017)	(0.992)		
Rule of Law	---	---	---	---	**0.288***	0.329
					(0.054)	(0.171)
'Regulation Quality'×Mob	-0.001	0.0003	---	---	---	---
	(0.270)	(0.886)				
'Corruption Control' ×Mob	---	---	**-0.002****	0.0008	---	---
			(0.027)	(0.592)		
'Rule of Law'×Mob	---	---	---	---	-0.003	-0.002
					(0.115)	(0.381)
GDP growth	---	-0.008	---	**-0.009***	---	**-0.014****
		(0.135)		**(0.077)**		**(0.026)**
Trade	---	**0.014*****	---	**0.004***	---	0.004
		(0.007)		**(0.051)**		(0.333)
Cost to export (ln)	---	0.042	---	-0.184	---	0.123
		(0.744)		(0.104)		(0.367)
Foreign Direct Investment	---	**-0.023****	---	-0.184	---	-0.003
		(0.034)		(0.104)	---	(0.667)
Net Effects	na	na	0.147	na	na	na
AR(1)	**(0.245)**	(0.044)	**(0.214)**	(0.047)	**(0.247)**	(0.088)
AR(2)	**(0.347)**	**(0.588)**	**(0.338)**	**(0.780)**	**(0.346)**	**(0.717)**
Sargan OIR	**(0.782)**	(0.038)	**(0.549)**	(0.001)	**(0.889)**	(0.024)
Hansen OIR	**(0.610)**	**(0.870)**	**(0.606)**	**(0.846)**	**(0.853)**	**(0.975)**
DHT for instruments						
(a)Instruments in levels						
H excluding group	**(0.352)**	**(0.965)**	**(0.472)**	**(0.919)**	**(0.458)**	**(0.914)**
Dif(null, H=exogenous)	**(0.669)**	**(0.608)**	**(0.574)**	**(0.621)**	**(0.891)**	**(0.912)**
(b) IV (years, eq(diff))						
H excluding group	**(0.539)**	**(0.974)**	**(0.284)**	**(0.807)**	**(0.152)**	**(0.946)**
Dif(null, H=exogenous)	**(0.553)**	**(0.247)**	**(0.628)**	**(0.634)**	**(0.941)**	**(0.826)**
Fisher	**1149.94*****	**18084.18*****	**1069.31*****	**2336.47*****	**1040.16*****	**46688.72*****
Instruments	24	37	24	37	24	37
Countries	37	37	37	37	37	37
Observations	305	212	305	212	305	212

*,**,***: significance levels of 10%, 5% and 1% respectively. DHT: Difference in Hansen Test for Exogeneity of Instruments' Subsets. Dif: Difference. OIR: Over-identifying Restrictions Test. The significance of bold values is twofold. 1) The significance of estimated coefficients and the Fisher statistics. 2) The failure to reject the null hypotheses of: a) no autocorrelation in the AR(1) and AR(2) tests and; b) the validity of the instruments in the OIR and DHT tests. na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant. The mean value of mobile phone penetration is 23.379.

4.2 Further discussion of results and implications

In the light of the tested hypotheses, whereas Hypothesis 1 and Hypothesis 3 are valid, Hypothesis 2 is not valid. It follows that in order to boost technology exports, the mobile phone can more conveniently complement political and institutional governance than economic governance. It is important to note that: (i) political governance entails political stability/no violence and voice & accountability; (ii) economic governance embodies government effectiveness and the regulation quality and (iii) institutional governance encompasses the rule of law and corruption-control.

More specifically, the following findings have been established. First, there are positive net effects on ICT goods exports from independent interactions between mobile phones and 'political stability' 'voice and accountability' and corruption-control. Second, significant net effects are not apparent from independent interactions between mobile phones and government effectiveness, regulation quality and the rule of law.

In the light of the above, it is apparent that: (i) not all interactions between the mobile phone and governance significantly affect technology good exports and (ii) the mobile phones could theoretically play a role in reducing information asymmetry or informational rents associated with bad governance that stifle trade. The former and latter respectively constitute practical and theoretical implications which we discuss below. Three main practical implications are apparent from the findings, notably, the need to: (i) create conducive conditions that enhance mobile phone penetration; (ii) improve standards of governance given the negative skew of governance variables and (iii) enhance conditions under which the mobile phone complements governance channels.

First, it is important for policy to leverage on the potential for mobile phone penetration to enhance governance for trade by engaging in reforms that improve the infrastructure needed for ICT and access constraints that limit mobile phone usage. Liberalising the ICT sector, promoting schemes of universal access and favouring low pricing

are other steps toward boosting the usage of mobile phones. This policy recommendation naturally builds on the fact that SSA has one of the highest (lowest) rates of ICT growth (penetration).

Second, given that most governance indicators are left-skewed, good governance policies will have to be enhanced in view of improving the complementary role of mobile phones in facilitating trade. Whereas more action is needed on the governance indicators for which net positive effects have not been apparent (regulation quality, the rule of law and government effectiveness), other governance indicators for which such net positive impacts have been apparent, need to be consolidated.

Third, our results have revealed that governance can be complemented with mobile phones to improve trade. Such complementarity can be boosted by the following measures. On the one hand, tailor the mobile phone to enhance transparency, the free flow of information (especially between various departments of the government) and transparency. On the other hand, consolidate the nexus between governance and mobile services/applications in order to improve information flow between government institutions and technology-driven corporations as well as permit such corporations to participate actively in policy-making on measures that influence ICT-commodity exports.

Given the above practical implications, the mobile phone plays an essential role in acting as an interface of participation between technology corporations and government institutions. Such potential for sharing information to reduce information asymmetry can be further consolidated if the mobile phone is designed to *inter alia*, increase: interaction, access, adoption, cost-effectiveness, efficiency and outreach. This leads us to the theoretical contribution of the study.

Under the intuitive and logical assumption that the mobile phone is a channel of information sharing that mitigates potential information asymmetry between technology

corporations and government institutions, the findings established in this study can be extended to infer that the role of the mobile phone is consistent with the theoretical underpinnings of intermediation efficiency in the banking sector by means of information sharing offices like public credit registries and private credit bureaus. Given the discussed analogy, from the perspective of export promotion and/or efficiency, the findings established in this study are broadly consistent with the theoretical underpinnings of enhancing banking intermediation efficiency through information sharing bureaus.

As far as managerial implications are concerned, the findings show that corporate governance practices need to be aligned with macroeconomic governance conditions to facilitate exports in technology-intensive export commodities. Hence, both fund managers and investors can leverage on the complementarity between the mobile phone and some governance dynamics in respectively taking decisions on portfolio diversification and investment location. Moreover, managers need to be aware of the fact that regardless of how robust their corporate governance structures are, it is not very likely for business to run smoothly if adequate means of ICT are not available. A recent example in an African country is Cameroon where ICT services have been disrupted by the government in the English-speaking South western and North western regions of the country because of calls for better governance through civil disobedience. As a result of the disruption, business operations in many start-ups in the Silicon Mountain (which is the country's main start-up hub) have been grounded (Atabong, 2017).

5. Conclusion, caveats and further research directions

This study has assessed how the mobile phone influences governance to improve information and communication technology (ICT) exports in Sub-Saharan Africa with data from 2000-2012. The empirical evidence is based on Generalised Method of Moments and three main

governance concepts are used, namely: (i) institutional (comprising the rule of law and corruption-control); (ii) political (involving political stability/no violence and voice & accountability) and (iii) economic (including regulation quality and government effectiveness) governance. The following findings have been established. First, there are positive net effects on ICT goods exports from independent interactions between mobile phones and 'political stability' 'voice and accountability' and corruption-control. Second, significant net effects are not apparent from independent interactions between mobile phones and government effectiveness, regulation quality and the rule of law.

The main limitation of the study is that the mobile phone complements only macroeconomic governance in order to improve conditions for technology exports. However, in the real world, technology exports depend on a host of other institutional and macroeconomic factors, some of which are specific to corporations. For instance corporate governance is as important as macroeconomic governance in enhancing corporate operations that drive the export of technology commodities.

Future studies can assess whether the findings in the study are valid within the perspectives of reducing unemployment and promoting entrepreneurship. The future research recommendation essentially builds on evidence that Africa's population is projected to double by 2036 and represent more than twenty per cent of the population in the world by 2050 (UN, 2009). In essence, it has been established in recent literature that only entrepreneurship and jobs from the private sector would accommodate the unemployment associated with the growing population in Africa in the long-term (Asongu, 2013). Furthermore, in the light of the sustainable development agenda, examining how the ICT penetration potential can be leveraged to fight unemployment and promote inclusive development is also worthwhile.

Appendices

Appendix 1: Summary statistics (2000-2012)

	Mean	SD	Minimum	Maximum	Observations
Technology goods exports	0.587	1.741	0.000005	20.944	420
Mobile phone penetration	23.379	28.004	0.000	147.202	572
Educational Quality	43.601	14.529	12.466	100.236	444
Innovation (STJA)	91.231	360.522	0.000	2915.5	480
Internet Penetration	4.152	6.450	0.005	43.605	566
Political Stability	-0.543	0.956	-3.323	1.192	578
Voice & Accountability	-0.646	0.737	-2.233	0.990	578
Government Effectiveness	-0.771	0.620	-2.450	0.934	577
Regulation Quality	-0.715	0.644	-2.665	0.983	578
Corruption-Control	-0.642	0.591	-1.924	1.249	579
Rule of Law	-0.741	0.662	-2.668	1.056	578
GDP growth	4.714	6.322	-47.552	63.379	608
Trade Openness	78.109	36.252	20.964	209.874	592
Cost of exports (ln)	7.374	0.503	6.137	8.683	375
Foreign Direct Investment	5.332	8.737	-6.043	91.007	603

S.D: Standard Deviation.

Appendix 3: Correlation matrix (uniform sample size: 87)

ICT-good-exp	Educ	STJA	Internet	PolS	VA	GE	RQ	CC	RL	GDPg	Trade	Cost of exp	FDI	Mobile	
1.000	-0.188	-0.011	0.165	0.121	0.241	0.268	0.225	0.084	0.314	-0.024	0.399	-0.064	0.128	0.158	ICTgoodexp
	1.000	0.082	-0.407	-0.375	-0.372	-0.376	-0.333	-0.377	-0.402	0.101	-0.349	0.275	-0.125	-0.309	Edu
		1.000	0.095	0.012	0.299	0.368	0.413	0.221	0.159	-0.129	-0.139	-0.049	-0.142	0.543	STJA
			1.000	0.317	0.396	0.480	0.270	0.380	0.449	-0.053	0.406	-0.327	0.040	0.758	Internet
				1.000	0.707	0.691	0.603	0.795	0.823	-0.031	0.480	-0.293	0.096	0.392	PolS
					1.000	0.826	0.796	0.752	0.863	0.002	0.261	-0.339	0.059	0.580	VA
						1.000	0.874	0.870	0.897	0.115	0.305	-0.274	0.061	0.698	GE
							1.000	0.762	0.815	-0.019	0.215	-0.193	-0.033	0.596	RQ
								1.000	0.891	0.062	0.383	-0.263	0.086	0.583	CC
									1.000	0.081	0.410	-0.304	0.069	0.573	RL
										1.000	-0.193	0.155	0.185	-0.167	GDPg
											1.000	-0.396	0.200	0.380	Trade
												1.000	-0.296	-0.314	Cost of exp
													1.000	0.021	FDI
														1.000	Mobile

ICTgoodexp: ICT goods exports. Educ: Quality of primary education. STJA: Scientific & Technical Journal Articles. Internet: Internet penetration. PolS: Political Stability. VA: Voice & Accountability. GE: Government Effectiveness. RQ: Regulation Quality. CC: Corruption-Control. RL: Rule of Law. GDPg: GDP growth. Trade: trade openness. Cost of exp: cost of exports. FDI: Foreign Direct Investment inflows. Mobile: Mobile Phone penetration.

Appendix 3: Definitions of variables

Variables	Signs	Definitions of variables (Measurement)	Sources
ICT good exports	ICTgoodexp	ICT goods exports (% of total goods exports)	World Bank (WDI)
Mobile phones	Mobile	Mobile phone subscriptions (per 100 people)	World Bank (WDI)
Educational Quality	Educ	Pupil teacher ratio in Primary Education	World Bank (WDI)
Innovation	STJA	Scientific and Technical Journal Articles	World Bank (WDI)
Internet	Internet	Internet penetration (per 100 people)	World Bank (WDI)
Political Stability	PolS	"Political stability/no violence (estimate): measured as the perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional and violent means, including domestic violence and terrorism".	World Bank (WDI)
Voice & Accountability	VA	"Voice and accountability (estimate): measures the extent to which a country's citizens are able to participate in selecting their government and to enjoy freedom of expression, freedom of association and a free media"	World Bank (WDI)
Government Effectiveness	GE	"Government effectiveness (estimate): measures the quality of public services, the quality and degree of independence from political pressures of the civil service, the quality of policy formulation and implementation, and the credibility of governments' commitments to such policies".	World Bank (WDI)
Regulation Quality	RQ	"Regulation quality (estimate): measured as the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development".	World Bank (WDI)
Corruption-Control	CC	"Control of corruption (estimate): captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as 'capture' of the state by elites and private interests"	World Bank (WDI)
Rule of Law	RL	"Rule of law (estimate): captures perceptions of the extent to which agents have confidence in and abide by the rules of society and in particular the quality of contract enforcement, property rights, the police, the courts, as well as the likelihood of crime and violence"	World Bank (WDI)
GDP growth	GDPg	Gross Domestic Product (GDP) growth (annual %)	World Bank (WDI)
Trade Openness	Trade	Exports of goods and services (% of GDP)	World Bank (WDI)
Cost of exports (ln)	Cost of exp.	Ln of Costoexport: Cost to export (US$ per container)	World Bank (WDI)
Foreign investment	FDI	Foreign Direct Investment inflows (% of GDP)	World Bank (WDI)

WDI: World Bank Development Indicators.

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