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Is information and communication technology a driver of industrialization process in African countries?

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Abstract

This study investigates how information and communication technology affects industrialization process in 46 African countries over the period 2000-2015. Two information and communication technology indicators (consisting of internet penetration and Mobile phone penetration), and two industrialization indicators (entailing manufacturing value added and employment in industry) are used. The empirical evidence is based on Ordinary Least Squared (OLS), fixed effects (FE) and system Generalized Method of Moments (GMM). The results show that ICT has a positive and significant effect on industrialization in African countries, even if this effect is tiny.

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1. Introduction

Industrialization is one of Africa's long-term economic development paths, and broadening and deepening of the manufacturing sector will help build more resilient economies. Africa is well endowed with vast resources - agricultural, mining and maritime - coupled with a young skilled labour force which, if properly exploited, can drive a resource-based industrialization strategy (ECA and African Union, 2013). Traditionally, industrial development has been the key to sustainable, inclusive and employment-rich development because of the strong productivity growth, labour intensity, productivity spillovers and backward and forward linkages that the industrial sector has with the rest of the economy (UNECA, 2015).

Despite these virtues of industrialization, Africa's history is one of general deindustrialization, with the share of manufacturing in GDP hovering around 10 percent for most countries, while declining in some (Banga and Te Velde, 2018). It appears that African countries have so far failed to take advantage of the opportunities presented by industrialization, particularly in the light of rising labour costs in advanced countries and many emerging Asian economies, especially China. The contrast with East Asia, which is often cited as a development model for Africa, could not be more striking. Manufacturing value added in East Asia and developing Asia is much higher than in Africa (World Bank, 2019).

Nevertheless, a converging point in the literature on economic development is that it imposes significant changes in the industrial structure of economies (De Brauw et al., 2014). In poor countries, the majority of the population lives in rural areas and the labour force is mainly employed in the primary sector (agriculture, livestock, fishing) and in low value-added informal services (Barret et al., 2017). By contrast, in rich countries, the majority of the population is employed in high value-added industries and services, and agriculture uses modern information and communication technologies (ICTs) that significantly improve its performance (McMillan and Headey, 2014).

Therefore, developing countries that wish to make significant progress on the road to development could make major changes to the industrial structure of their economies by using appropriate ICTs in the industrialization process (Horner and Nadvi, 2018). This is certainly the reason for the rapid diffusion of ICTs in Africa since the 2000s. Indeed, the average proportion of individuals with internet access in Sub-Saharan Africa (SSA) has increased from 0.84% of the population in 2000 to more than 17% in 2015 (ITU, 2015). The fastest growing sector is mobile telephony. Far from being a luxury good, the mobile phone is now one of the most consumed on the continent. Between 2000 and 2015, the number of subscriptions to mobile lines increased from 11 million to more than 750 million, a growth rate of 64.33% (ITU, 2015). The rapid growth of the use of mobile phones can also explain that of the internet. Indeed, with smartphones, most telephone operators offer internet access services.

However, this region continues to face a huge lack of ICT infrastructures and a low level of industrialization. Indeed, according to the data from the United Nations Conference on Trade and Development (UNCTAD, 2018), the average rate of industrialization for the period 2002-2016 is 28.2%. This rate is particularly high in the countries rich in natural resources such as the Democratic Republic Congo (70.1%), Gabon (56.1%), Congo (37.8%) and Mauritania (36.3%), and relatively low in countries such as Madagascar (14.2%), Guinea-Bissau (14.6%), Niger (16.2%) and Burundi (16.9%). During the same period, the contribution of manufacturing industry as a percentage of GDP was estimated at 11.26% in Francophone Africa and that of the extractive and mining industries was 12.2%. According to the African Development Bank (AfDB, 2018), African industries generate only $700 per capita GDP, three times less than in Latin America ($2,500) and five times less than in East Asia ($3,400); in addition, Africa exports more low-technology manufactured products.

Theoretically, the diffusion of ICTs in Africa can affect industrialization through a number of channels and mechanisms. The first is the channel of creating new firms. ICT diffusion is always correlated with the emergence of new businesses, in particular in manufacturing and services (Zhou et al., 2019). Start-ups are lunched, generally in the production of useful technologies (using computers and internet). With the introduction of ICT, new services can be offered in the primary sector and affect industrialization via their impact on employment. Beyond efforts to help African manufacturers to better access digital inputs, African Governments can also use digital technologies to enhance public administration's support for industrialization. Digitization can help enhance the efficiency and productivity of services associated with manufacturing (Oulton, 2002), including customs administration, general logistics, etc, thereby enhancing industrial development. In particular, digitization of customs administration can help improve customs efficiency, reduce trade costs and thus promote greater intra-African trade (particularly in the context of the African Continental Free Trade Area (AfCFTA)), which, in turn, would support greater industrial development on the continent. There are a number of digital innovations in customs administration and related trade barriers that can reduce trade costs, including costs of customs clearance and trade document preparation (United Nations, 2017). One such innovation is electronic single windows, which

have proven to be a cost-effective intervention to reduce trade costs in Africa (see African Alliance for Electronic Commerce, 2013).

Several empirical studies have analyzed the effect of ICT on various dimension of economic development, including education (Waverman et al., 2005; Livingstone, 2012), financial inclusion (Kpodar and Andrianaivo, 2011), foreign direct investment (Gholami et al., 2006; Désiré and Melingui bate Adalbert Abraham Ghislain, 2020), trade (Rodríguez-Crespo and Martínez-Zarzoso, 2019), environmental quality (Avom et al., 2020), health outcomes (Dutta et al., 2019), institutions (Avom and Eyike Mbongo, 2020) and more importantly economic growth (Hong, 2017; Niebel, 2018). Despite the growing literature on ICT, little is known about the cross-countries effect of ICT on industrialization, particularly in African countries. The aim of this paper is to fill this gap by assessing how ICTs affect the industrialization process in African countries. To sum up, the results show that ICT is positively associated with industrialization in Africa, even if this effect is very small.

The rest of the paper is organized as follows. Section 2 describes the data and methodology used to capture the link between ICT diffusion and industrialization in the context of African economies. Section 3 discusses our empirical results, while Section 4 concludes.

2. Data and methodology

2.1. Data

We investigate a panel of 46 African countries with data for the period 2000-2015 from World Development Indicators (WDI). The periodicity and countries under investigation are chosen according to data availability constraints. The full description of the data is as follows:

Table I: Summary Statistics

Variable	Observation	Mean	SD	Minimum	Maximum
Employment in industry	720	12.68264	8.879456	1.8	39.1
Manufacturing, value added	601	10.68614	5.552655	0.2370618	26.06944
Internet	728	7.241402	11.15967	.0059021	58.1187
Mobile	729	41.80322	42.06918	.018655	180.4453
Trade openness	690	78.68933	41.09422	20.96405	351.1057
GDP per capita growth	716	2.13479	5.869345	-62.22509	56.88336
Foreign direct investment	699	4.905273	8.227977	-5.977515	89.47596
Foreign aid	697	9.260001	14.0821	-.2602162	192.026
Domestic investment	676	21.90723	11.72864	1.09681	145.746
Financial development	687	34.46611	24.17066	2.857408	151.5489
Human capital	439	43.65474	25.15026	6.0352	108.2675

Source: authors

Table II: Pairwise Correlation

	Empl_va	Manu	Internet	Mobile	GDPPg	FDI	Credit	Educ	ODA	GFCF	Trade
Empl_va	1.0000										
Manu	0.4004	1.0000									
Internet	0.5066	0.2316	1.0000								
Mobile	0.4283	0.0659	0.7802	1.0000							
GDPPg	0.0076	0.0548	0.0006	0.0117	1.0000						
FDI	-0.1241	-0.2099	-0.0903	0.0607	0.1320	1.0000					
Credit	0.6686	0.4780	0.6357	0.4993	0.0605	0.0850	1.0000				
Educ	0.7968	0.3404	0.5983	0.5937	0.0123	-0.1117	0.7118	1.0000			
ODA	-0.5496	-0.2167	-0.3497	-0.2602	-0.0591	0.3580	-0.4044	-0.5475	1.0000		
GFCF	0.0363	0.0046	0.0614	0.2291	0.1146	0.3647	0.0837	-0.0009	-0.0388	1.0000	
Trade	-0.4623	-0.0014	0.1254	0.2380	0.0907	0.3565	0.1947	0.2794	-0.1380	0.3407	1.0000

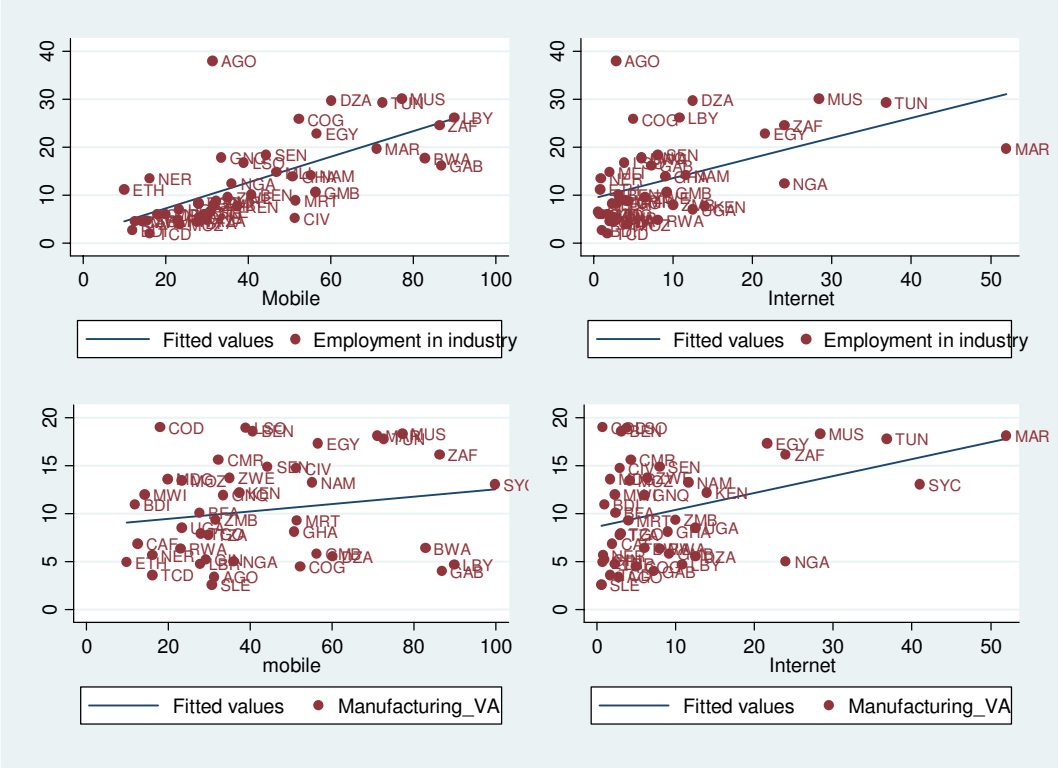
Source: authors

The dependent variable is industrialization measured by two indicators: (i) the value added of the manufacturing sector as a percentage of the GDP and (ii) and the share of employment in the manufacturing sector in total employment. These two indicators of industrialization are increasingly being used in the recent literature (Gui-Diby and Renard, 2015; Nkoa, 2016). The main independent variable is information and

communication technology (ICT). ICT is measured using two different indicators namely, (i) internet penetration rate (per 100 people) and (ii) mobile phone penetration rate (per 100 people). The choice of these two ICT variables is consistent with recent literature (Ali, 2017; Asongu and Le Roux, 2017). To reduce bias that may arise from possible variable omissions, seven control variables are included in this study. They comprise (i) trade openness, (ii) GDP per capita growth (iii) foreign direct investment, (iv) foreign aid, (v) domestic investment, (vi) human capital and, (vii) financial development. A detailed description of variables as well as definition of variables are presented in the appendix. Table I gives the summary statistics of the variables and the pairwise correlation analysis is presented in Table II.

It can be seen from Table II that the three indicators of ICT have a positive and significant association with our two dependent variables. To make sure, we will carry out an empirical verification of these different associations.

Figure 1: ICTs and industrialization



Source: authors

2.2 . Methodology

The purpose of this paper is to investigate the impact of ICT on the industrialization process in African countries. According to the recent literature on industrialization (Gui-Diby and Renard, 2015 and Nkoa, 2016), we formulate the following model:

$$Indus_{it} = \beta_1 Indus_{it-1} + \beta_2 ICT_{it} + \beta_3 X_{it} + \mu_i + v_t + \varepsilon_{it} \quad (1)$$

Where $Indus_{it}$ represents industrialization for country i in the period t, ICT_{it} is information and communication technology (internet penetration rate and mobile phone penetration rate), X_{it} is a vector which includes all control variables, μ_i is an unobserved country-specific effect, v_t is time specific effect, and ε_{it} is the error term. We use different specifications and three estimation techniques to analyses the effect of ICT on industrialization. We first use the Ordinary Least Square (OLS) estimator to estimation Equation (1). However, the OLS model does not account for country fixed-effects, and may suffer from omitted variables bias. To deal with country fixed-effects, we subsequently applied a fixed effect (FE) model. However, when the FE technique is used to estimate this model, the estimated coefficients are inconsistent and likely to be biased since the lagged value of industrialization ($Indus_{it-1}$) is correlated with the error term (Nickell, 1981) raising the problem of endogeneity. To address this endogeneity issue, we apply the System Generalized method of moment (GMM) proposed by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998). GMM is useful for several advantages. First, GMM estimator has been widely used to address the endogeneity problem that appears in panel data estimation (Arellano and Bover, 1995; Blundell and Bond, 1998). Second, GMM

estimator also take into account the biases that appear due to country-specific effects. Third, GMM also avoids simultaneity or reverse causality problems. The consistency of the GMM estimator depends on two things: the validity of the assumption that the error term does not exhibit serial correlation (AR(2)) and the validity of the instruments (Hansen test).

3. Empirical results

The results are presented in the various tables below. Table III presents OLS, FE and System GMM results of the impact of ICTs on industrialization without control variables. Table IV presents the extension of baseline regression with control variables and Table V replicates results presented in Table IV with more control variables. Table VI replicates the results presents in Table IV by using an alternative measure of industrialization. The estimation regressions satisfy mutually the Hansen test of the validity of instruments and the serial correlation test AR (2).

3.1.Baseline results

Table III reports results of the preliminary estimation using OLS, FE and GMM. We start with the simplest version of the model by investigating if ICT affects the industrialization. We use two different ICT variables, namely Mobile phone and Internet penetration. The results in Table III clearly suggest that ICT increase industrialization, ceteris paribus. Both Mobile phone and Internet have a positive coefficients and are highly significant in all cases. Results suggest that countries with more developed ICT sector are experiencing a change in the level of industrialization, even if the latter is still low. For example results in column (1) suggest that a 10 unit increase in Mobile penetration increases the industrialization process by 0.343 unit and in column (2), that a 10 unit increase in Internet penetration increases the industrialization process by 0.844 unit. This result can be explained by the fact that ICT is seen as an important sources of innovation for some countries, improving education and health access, providing African countries access to capital for investment necessary for industrialization (Higón, 2012; Dutta et al., 2019).

However the R^2 of the regression is extremely low, meaning that a number of important variables are missing. The absence of important determinants of the industrialization process could bias the results in the case where the measurement error is correlated with the omitted variables. In order to correct for this attenuation bias, we replicate regression by using System GMM. Results presented in columns (5-6) confirm the positive effect of ICT on industrialization.

Table III: Regression of ICT on industrialization

	Dependent variable : Employment in manufacturing sector					
	OLS		Fixed Effects		System GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
Mobile	0.0343***		0.0121***		0.0161***	
	(0.00296)		(0.00193)		(0.00526)	
Internet		0.0844***		0.0381***		0.0307***
		(0.00747)		(0.00887)		(0.0113)
Lag_dependent					0.981***	0.982***
					(0.00723)	(0.00595)
Constant	10.42***	9.332***	12.46***	12.26***	0.168**	0.141**
	(0.364)	(0.431)	(0.0902)	(0.103)	(0.0635)	(0.0596)
Observations	713	713	713	713	623	625
R-squared	0.159	0.152	0.027	0.056		
Number of countries	45	45	45	45	45	45
AR(1)					0.0055	0.0052
AR(2)					0.517	0.534
Instruments					7	7
Hansen					0.254	0.404

Source: authors, Note: Standard errors reported in parenthesis. ***, **, *, significant at the 1%, 5% and 10% levels respectively.

We additionally carry out the estimation with a number of control variables. As the results using fixed effects and system GMM were qualitatively and quantitatively similar, we report only the results for system GMM estimation in Table IV. Results from the linear specification clearly show that ICT (Mobile phone and internet penetration) have the expected positive coefficients and are highly significant, meaning that ICT contributes to the industrialization of African countries. For example, results in column (2) suggest that a 10 unit increase in Mobile increases industrialization by 0.0179 unit and in column (4), that a 10 unit increase in internet increases

industrialization by 0.0812 unit. Columns 1 and 3 present the non-linear relationship between ICT and industrialization. The non-linear coefficient does not turn out to have any statistical influence on industrialization. The control variables have the expected signs. GDP per capita growth, foreign direct investment and financial development have the expected positive sign.

Table IV: System GMM estimation with control variables

	Dependent variable : Employment in industry			
	(1)	(2)	(3)	(4)
Mobile	0.00256***	0.00179***		
	(0.000904)	(0.000280)		
(Mobile)2	-8.20e-06			
	(5.85e-06)			
Internet			0.00786***	0.00812***
			(0.00107)	(0.00110)
(Internet)2				-1.00e-05
				(2.45e-05)
GDP per capita growth	0.00807***	0.0156***	0.0306***	0.00740***
	(0.000400)	(0.00263)	(0.00278)	(0.000705)
Foreign direct investment	0.00668***	0.0211***	0.0179***	0.00393***
	(0.000629)	(0.00142)	(0.00123)	(0.000503)
Financial development	0.00451***	0.00572***	0.00443***	0.00438***
	(0.000747)	(0.000726)	(0.000902)	(0.000709)
Trade openness	-0.000486	-0.00258***	-0.000125	-0.00215***
	(0.000355)	(0.000445)	(0.000369)	(0.000324)
Lag dependent variable	0.982***	0.984***	0.978***	0.976***
	(0.00238)	(0.00221)	(0.00253)	(0.00173)
Constant	0.0672	0.0845**	0.0277	0.0249
	(0.0466)	(0.0368)	(0.0264)	(0.0191)
Observations	608	608	606	606
Number of country	43	43	43	43
AR(1)	0.0087	0.0079	0.0079	0.0089
AR(2)	0.645	0.607	0.576	0.589
Instruments	40	38	38	41
Hansen OIR	0.776	0.551	0.352	0.321

Note: Standard errors reported in parenthesis. ***, **,*, significant at the 1%, 5% and 10% levels respectively.

3.2. Accounting for other factors that may influence industrialization

We check whether the baseline specification results hold after controlling for the potential determinants of industrialization. For this purpose, we additionally estimated equation (1) with a number of control variables using only system GMM estimation. Table V reports these results, which corroborate the findings shown in Table IV. That is, ICT (both Internet and Mobile) again has the expected positive sign and is highly significant, even if the coefficient is very low.

Looking at mobile phone penetration, column (1) shows that when mobile phone penetration increases by 10-unit, industrialization increases by 0.0150 unit. Column (6) suggests that a 10-unit increase in internet leads to a 0.270 unit increase in industrialization. The coefficient of the independent variable GDP growth per capita has the theoretically expected positive sign and it is highly statistically significant, meaning that economic growth is an industrialization enhancing factor.

Table V: System GMM estimation with more control variables

	Dependent variable : Employment in industry					
	Mobile			Internet		
	(1)	(2)	(3)	(4)	(5)	(6)
Mobile	0.00150***	0.00215***	0.00276***			
	(0.000472)	(0.000408)	(0.000232)			
Internet				0.0211***	0.0274***	0.0270***
				(0.00490)	(0.00226)	(0.00265)
GDP per capita growth	0.00327	0.00801***	0.00601**	0.0489***	0.00759***	0.0126***
	(0.00327)	(0.000917)	(0.00237)	(0.00805)	(0.00150)	(0.00422)
Foreign direct investment	0.00254***	0.00289***	0.00234***	0.0109**	0.0143***	-0.00553***
	(0.000598)	(0.000656)	(0.000755)	(0.00411)	(0.00291)	(0.00125)
Financial development	0.00300***	0.00648***	0.000537	0.0132***	0.0212***	0.0199***
	(0.000692)	(0.00162)	(0.00147)	(0.00317)	(0.00216)	(0.00326)
Trade openness	-0.00689***	-0.000890**	-0.00108***	-0.000908	-0.00178**	-3.33e-05
	(0.000893)	(0.000387)	(0.000294)	(0.00273)	(0.000702)	(0.000863)
Human capital	0.00557***			0.0426***		
	(0.00169)			(0.00726)		
Domestic investment		0.0166***			0.00516	
		(0.00247)			(0.00387)	
Foreign aid			-0.00244***			-0.00426***
			(0.000592)			(0.00125)
Lag dependent variable	0.970***	0.976***	0.988***	0.893***	1.003***	1.008***
	(0.00246)	(0.00317)	(0.00319)	(0.0126)	(0.00338)	(0.00425)
Constant	0.192***	-0.349***	0.0624*	0.861***	0.261***	0.426***
	(0.0680)	(0.0482)	(0.0355)	(0.143)	(0.0438)	(0.0764)
Observations	359	535	563	356	571	603
Number of countries	42	42	43	42	42	43
AR(1)	0.0196	0.0089	0.0083	0.0246	0.0096	0.0103
AR(2)	0.703	0.551	0.631	0.620	0.461	0.547
Instruments	38	37	37	37	37	37
Hansen OIR	0.925	0.264	0.172	0.434	0.245	0.208

Note: Standard errors reported in parenthesis. ***, **,*, significant at the 1%, 5% and 10% levels respectively.

3.3. Robustness checks: alternative measure of industrialization

We also check for robustness of our results by considering alternative measure of industrialization. We use employment in manufacturing sector as a new variable of industrialization. Table VI reports the results based on these alternative measure of industrialization. Once more again, these results confirm the finding of significant positive relationship between ICT and industrialization.

Table VI: System GMM estimation with an alternative measure of industrialization

	Dependent variable :Manufacturing, value added (% of GDP)					
	Mobile			Internet		
	(1)	(2)	(3)	(4)	(5)	(6)
Mobile	0.00456***	0.00227***	0.00284***			
	(0.000996)	(0.000720)	(0.000916)			
Internet				0.00271*	0.00233*	0.00229**
				(0.00139)	(0.00126)	(0.00108)
GDP per capita growth	0.0159***	0.0189***	0.0150***	0.00592***	0.0260***	0.0108***
	(0.00455)	(0.00370)	(0.00428)	(0.00136)	(0.00187)	(0.00272)
Foreign direct investment	0.00998***	0.00943***	0.0142***	0.00921***	0.00902***	0.00846***
	(0.00127)	(0.00253)	(0.00189)	(0.000430)	(0.000870)	(0.00137)
Financial development	0.00700*		0.00215	0.00758***		0.00366**
	(0.00357)		(0.00273)	(0.000685)		(0.00138)
Trade openness		-0.000678	-0.00104		-0.00344***	-0.00168*
		(0.00101)	(0.000938)		(0.000663)	(0.000836)
Lag dependent variable	0.890***	0.902***	0.896***	0.885***	0.900***	0.898***
	(0.00873)	(0.00726)	(0.00820)	(0.00414)	(0.00187)	(0.00461)
Constant	0.976***	1.047***	1.064***	0.835***	0.671***	0.738***
	(0.100)	(0.129)	(0.131)	(0.0517)	(0.0862)	(0.0786)
Observations	517	542	517	514	539	514
Number of countries	42	42	42	42	42	42
AR(1)	0.0658	0.0625	0.0641	0.0729	0.0705	0.0728
AR(2)	0.778	0.768	0.786	0.773	0.775	0.774
Instruments	37	32	38	39	37	34
Hansen OIR	0.393	0.278	0.238	0.378	0.733	0.618

Source: authors, Note: Standard errors reported in parenthesis. ***, **,*, significant at the 1%, 5% and 10% levels respectively.

4. Conclusion

This study complemented existing literature by investigating the impact of information and communication technology (ICT) on the industrialization process in 46 African countries for the period 2000-2015. Two information and communication technology indicators are used, namely: internet penetration rate (per 100 persons) and mobile phone penetration rate (per 100 persons). The empirical evidence is based on OLS, Fixed effects and Generalized Method of Moments (GMM). The results show that improved information and communication technologies are increasing industrialization in Africa. However, the effect of ICT on industrialization is very small regarding the coefficient associated with ICT variables. Despite the record level of mobile penetration in Africa, the impact of mobile telephony in the region remains very early and still needs to be reassessed. For future work, it would be useful to analyze whether the relationship between ICT and industrialization is non-linear by estimating a quadratic form model or to test whether the relationship between ICT and industrialization depends on the level of industrialization using a regression of quantile panel data.

References

African Alliance for Electronic Commerce. 2013 “Guidelines for Single Window Implementation in Africa”. Dakar: African Alliance for Electronic Commerce.

Ali M. S. B. and A. Gasmi (2017) “Does ICT diffusion matter for corruption? An Economic Development Perspective” *Telematics and Informatics*, ***34***(8), 1445-1453.

Arellano, M. and S. Bond (1991) “Some tests of specification for panel data: Monte Carlo evidence and an application to employment equation” *The review of economic studies*, ***58***(2), 277-297.

Arellano, M., and O. Bover (1995) "Another look at the instrumental variable estimation of error-components models" *Journal of econometrics*, ***68***(1), 29-51.

Asongu S. A. and S. Le Roux (2017) "Enhancing ICT for inclusive human development in Sub-Saharan Africa" *Technological Forecasting and Social Change*, ***118***, 44-54.

Avom, D., & Eyike Mbongo, L. D. B. (2020) « La diffusion des TIC ameliore-t-elle qualitativement les institutions politiques en Afrique?». *African Development Review*. (Forthcoming) https://doi.org/10.1111/1467-8268.12449.

Avom, D., Nkengfack, H., Fotio, H. K., & Totouom, A. (2020) "ICT and environmental quality in Sub-Saharan Africa: Effects and transmission channels" *Technological Forecasting and Social Change*, ***155*,** 120028.

Banga and Te Velde (2018) "Digitalization and the future of manufacturing in Africa". Available from https://set.odi.org/wpcontent/uploads/2018/03/SET_Digitalisation-and-future-ofAfricanmanufacturing_Final.pdf. Accessed 14 and 15 January 2019.

Barrett, C. B., Christiaensen, L., Sheahan, M., & Shimeles, A. (2017) "On the structural transformation of rural Africa" *Journal of African Economies*, **26**(suppl_1): i11–i35.

Blundell R. and S. Bond, (1998) "Initial conditions and moment restrictions in dynamic panel data models" *Journal of econometrics*, ***87***(1), 115-143.

De Brauw, A., Mueller, V., & Lee, H. L. (2014) "The role of rural–urban migration in the structural transformation of Sub-Saharan Africa" *World Development*, ***63***, 33-42.

Désiré, A. Melingui bate Adalbert Abraham Ghislain,(2020) "The effect of information and communication technologies on foreign direct investments attractiveness in Africa" *Economics Bulletin*, ***40***(3), 2304-2319.

Dutta, U. P., Gupta, H., & Sengupta, P. P. (2019) "ICT and health outcome nexus in 30 selected Asian countries: Fresh evidence from panel data analysis" *Technology in Society*, ***59*,** 101184.

ECA and African Union (2013) "Making the Most of Africa's Commodities: Industrializing for Growth, Jobs and Economic Transformation Economic Report on Africa 2013" ECA: Addis Ababa.

Gholami, R., Tom Lee, S. Y., & Heshmati, A. (2006) "The causal relationship between information and communication technology and foreign direct investment" *World Economy*, ***29***(1), 43-62.

Gui-Diby, S. L. and M. F. Renard (2015) "Foreign direct investment inflows and the industrialization of African countries" *World Development*, ***74***, 43-57.

Higón, D. A. (2012) "The impact of ICT on innovation activities: Evidence for UK SMEs" *International Small Business Journal*, ***30***(6), 684-699.

Hong, J. P. (2017) "Causal relationship between ICT R&D investment and economic growth in Korea" *Technological Forecasting and Social Change*, ***116***, 70-75.

Horner, R., & Nadvi, K. (2018) "Global value chains and the rise of the Global South: unpacking twenty-first century polycentric trade" *Global Networks*, ***18***(2), 207-237.

ITU (2015). Report, International Telecommunication Union, Geneva, Switzerland

Kpodar, K., & Andrianaivo, M. (2011) "*ICT, financial inclusion, and growth evidence from African countries* (No. 11-73)" International Monetary Fund.

Livingstone, S. (2012) "Critical reflections on the benefits of ICT in education" *Oxford review of education*, ***38***(1), 9-24.

McMillan, M., & Headey, D. (2014) "Introduction–understanding structural transformation in Africa" *World Development*, **63** (2014), pp. 1-10.

Nickell, S. (1981) "Biases in dynamic models with fixed effects" *Econometrica: Journal of the Econometric Society*, 1417-1426.

Niebel T. (2018) "ICT and economic growth–Comparing developing, emerging and developed countries" *World Development*, ***104***, 197-211.

Nkoa, B. E. O. (2016) "Investissements directs étrangers et industrialisation de l'Afrique: un nouveau regard" *Innovations*, (3), 173-196.

Oulton, N. (2002) "ICT and productivity growth in the United Kingdom" *Oxford Review of Economic Policy*, ***18***(3), 363-379.

Rodríguez-Crespo, E., & Martínez-Zarzoso, I. (2019) "The effect of ICT on trade: Does product complexity matter?" *Telematics and Informatics*, ***41***, 182-196.

UNCTAD (2018) "*Trade and Development Report*. Power, Platforms and the Free Trade Delusion" United Nations, New York and Geneva.

UNECA. (2015) "Economic report on Africa 2015: Industrializing through trade" Addis Abeba.

United Nations (2017) "Trade Facilitation and Paperless Trade Implementation Global Report 2017" Available from https://www.unescap.org/sites/default/files/Global%20Report%20Final_26%20O ct%202017.pdf

Waverman, L., Meschi, M., & Fuss, M. (2005) "The impact of telecoms on economic growth in developing countries" *The Vodafone policy paper series*, ***2***(03), 10-24.

World Bank (2019) "World development indicators" World Bank. Washington D.C.
Zhou, Q., Gao, P., & Chimhowu, A. (2019) "ICTs in the transformation of rural enterprises in China: A multi-layer perspective" *Technological Forecasting and Social Change*, ***145***, 12-23.

Appendix

Table A1: List of countries

Algeria	Equatorial Guinea	Mali	South Africa
Angola	Ethiopia	Mauritania	Tanzania
Benin	Gabon	Mauritius	Togo
Botswana	Gambia, The	Morocco	Tunisia
Burkina Faso	Ghana	Mozambique	Uganda
Burundi	Guinea	Namibia	Zambia
Cameroon	Guinea-Bissau	Niger	Zimbabwe
Central African Republic	Kenya	Nigeria	
Chad	Lesotho	Rwanda	
Congo, Dem. Rep.	Liberia	Senegal	
Congo, Rep.	Libya	Seychelles	
Cote d'Ivoire	Madagascar	Sierra Leone	
Egypt, Arab Rep.	Malawi	Somalia	

Table A2: Variable definitions

Variables	Signs	Variables definitions (measurement)	Sources
Manufacturing	Manu	Manufacturing, value added (% of GDP)	World Bank (WDI)
Employment in industry	Empl_va	Employment in industry (% of total employment) (modeled ILO estimate)	World Bank (WDI)
Mobile phones	Mobile	Mobile cellular subscriptions (per 100 people)	World Bank (WDI)
Internet	Internet	Internet penetration rate (per 100 people)	World Bank (WDI)
GDPP per capita growth	GDPPg	Gross Domestic Product (GDP) per capita growth (annual %)	World Bank (WDI)
Foreign direct investment	FDI	Foreign direct investment, net inflows (% of GDP)	World Bank (WDI)
Foreign aid	ODA	Net ODA received (% of GNI)	World Bank (WDI)
Human capital	Educ	School enrollment, secondary (% gross)	World Bank (WDI)
Domestic investment	GFCF	Gross fixed capital formation (% of GDP)	World Bank (WDI)
Financial development	Credit	Broad money (% of GDP)	World Bank (WDI)

Source: authors