Technology absorption capacity and firm growth in Africa

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Abstract: Technology absorption has become an important driving force for firm competition, strategy and survival. Consequently, the capacity of African firms to absorb the right technology has dominated the contemporary discourse on the performance of African firms. Drawing on the Resource-Based View (RBV) theory, we investigated the impact of three critical resources namely human capital development, access to credit, and access to electricity on the technology absorption capacity of African firms. Employing a quantitative strategy based on ordinary least squares regression, data for our empirical inquiry comes from three main sources. Technology absorption and human capital index being an outcome and explanatory variable respectively, are sourced from the Global Entrepreneurship Index (2017) for 40 African countries. Two other explanatory variables namely access to electricity and access to credit is also sourced from the World Bank's Doing Business Report for 40 African countries (World Bank, 2017). Our data evidence suggests that technology absorption in practice has the potential to increase performance. Nevertheless, a broad access to credit, electricity, and effective human capital development, we argue, accounts for the differential performance of African firms in developing technology absorption capacity. Whiles education quality in promoting technology absorption in Africa is essential, governance structures do not seem to support the same. We conclude by delineating some relevant implications of our study for policy and practice of technology absorption in Africa.

Keywords: *Africa, credit; electricity; human capital; technology absorption*

1. Introduction

Technology absorption has become the vehicle for organisational growth, competitiveness, meeting excessive demand and reducing the operational cost of firms (Narayanan and Chen, 2012; Kim, 2016). Consequently, research on the phenomenon in Africa has been on the increase over the past decade. In this regard, several technology experts have expounded on the extensive benefits from technology absorption particularly for small firms which are stagnated with poor and obsolete technologies (Lin and Chang, 2015). Indeed, research regarding technology lifecycle, discontinuity, diffusion, absorption, and the emergence of dominant technology designs are of concern to the African growth and development agenda (Narayanan and Chen, 2012; Pehrsson, 2016). However, technology absorption has opportunities and threats (Yencken, 2008). Hence, the ability of firms to assess such threats and anticipated benefits before undertaking an absorption process is an essential consideration (Du Preeza and Pistorius, 2002).

Research evidence suggests that African firms do not possess the kind of technological capacity which is needed to produce goods and services in meeting the current demand in the continent. This has affected Africa's ability to participate fully in the global market with other economies such as India and China. Subsequently, several government interventions in promoting technology absorption for domestic firms have been initiated in Africa (Soofi, 2017). In this age and era where technology has become an important driving force for firm competition, strategy and even survival, firms in Africa cannot afford not to catch up with absorbing the right technology needed to drive development (Du Preeza and Pistorius, 2002). In the same vein, Li *et al*. (2017) emphasised the need for technology transfers and diffusion to Africa which is expected to drive economic development and competitive advantage for African firms. Even though it has costs associated with its coordination, integration and communication, adopting a broad technology base provides the firm with an opportunity to combine and integrate different technological tools to create innovative products and services. A firm's technological diversity and performance is therefore linked to its absorptive capacity and environmental dynamism (Lin and Chang, 2015).

The nature and direction of technology absorption could have a direct impact on the developmental goals of Africa. Soofi (2017) indicates that one of the prerequisites of an innovative economy which has growth potential is to have advanced technological capabilities which drive industrial development. Several factors are noted to affect technology absorption

capacity of African firms. Khayyat and Lee (2015) noted that a firm's innovation ability and capacity, industry networks, the availability of innovation-friendly environments, the presence of intellectual property rights, the nature of state support and global economic systems plays a major role in the technology absorption of firms in a country. Lema and Lema (2016) also indicate the presence of research and development (R&D) and strategic alliances as pre-requisites for technology absorption in Africa. This is particularly essential for ‘‘technological learning and catching up" (Lema and Lema,2016:223).

2. Background

Driving competitiveness through technology absorption in Africa

Technology absorption is an important element in the growth trajectory of all countries. Rogers (1983) refers to technology as a design consisting of both hardware and software components which are intended to bring an instrumental action to reduce uncertainty in achieving the desired result. Technology also refers to the application of knowledge or pieces of knowledge to industrial or commercial use to gain competitiveness (Li *et al*., 2017). Acs *et al*. (2017) argue that countries should be able to absorb current and user-friendly technology, especially in digital forms to innovate and grow. Indeed, technological innovation is considered as one of the most important determinants of productivity, economic growth and global presence without which no country can be globally competitive (Krammer, 2015). However, even though Africa is endowed with several resources, the continent lacks the kind of technological advancement that is needed to drive economic development. Research evidence indicates that there is currently a technological divide between Africa and the rest of the world in terms of technology utilisation, availability of platforms for e-commerce and effective virtual collaborations (Oluwatobi *et al*. 2015; Pick and Nishida, 2015).

Institutional variables in a country play a pivotal role in technology absorption and innovation. This is because, as argued by Krammer (2015), institutional factors could create both barriers and opportunities for technology absorption in a country. Thus, the legal structure in a country, firm staffing, institutional void, information asymmetry, funding opportunities for small firms, governmental support, and inter-firm alliances are critical issues which need to be considered (Oluwatobi *et al*. 2015; Atiase and Dzansi, 2020). According to Pick and Nishida (2015), other factors such as the level of foreign direct investment inflows, geographical proximity to an advanced technological source, the nature of higher education in a country and societal openness towards technology absorption contributes to technological development in a

country. Therefore, the encouragement of technological innovation by African governments to foster entrepreneurial development in support of local firms is an important factor worth considering (Littlewood and Kiyumbu, 2017; Pick and Nishida, 2015).

However, Botchie *et al*. (2017) caution of the acceptance of inferior and low-cost technology from emerging economies which might be detrimental to Africa eventually. The acceptance of these low-cost technologies in Africa is driven mainly by low profitability of African firms as well as the unavailability of perfect information about the existence of suitable technologies to address Africa's technological challenges. Similarly, Feige and Vonortas (2017) also caution that it is important for developing countries to critically consider technologies which could be developed internally to suit environmental conditions versus those that could be sourced externally. Narayanan and Chen (2012) refer to these environmental conditions as technological standard. Technological standard states the specifics associated with technology absorption which complies with products, processes, formats, procedures, utility, technical possibilities and its functional parameters. This is a concern in Africa.

Resource considerations for technology absorption in Africa

Globally, knowledge has been recognised as the most powerful intangible resource and determinant of firm performance and competitive advantage (Li, Clark, and Sillince, 2017). A higher stock of human capital is noted to enhance technology absorption, diffusion and advancement in countries (Rahman and Zaman, 2016). Asongu and Roux (2017) in their research argue that knowledge-based societies are more likely to successfully confront organisational challenges which threaten performance. In line with various growth models, advancement in technology in a country is the outcome of direct investment into the mobilisation of critical resources that has a bearing on human capital development (Asongu and Roux, 2017). Similarly, Danquah and Amankwah-Amoah (2017) argue that human capital remains a single most important determinant for technology absorption and innovation leading to firm performance. This perspective suggests that the level of education, training received as well as the experience gained in previous work activities of employees could enhance technology absorption and advancement in a firm.

Access to financial resources remains one of the drawbacks to technological innovations and advancement in Africa. Soofi (2017) noted that poor financial development and fiscal policies regarding technological advancement has been the main bane of Africa's poor technological development. Although access to credit is a global challenge, the magnitude of the challenge

in Africa is greater, which hinders the development of innovations and other entrepreneurial pursuits (Bowen et al., 2009; Klyton and Rutabayiro-Ngoga, 2017; Atiase et al., 2018).

Efficient energy combined with other inputs such as financial capital and labour is considered an important factor to drive technology absorption and advancement. As an energy source, electricity is an important input for economic growth in any country which is determined to build its competitiveness on the absorption of the right technology and innovation (Winkler *et al.*, 2011). Davidson and Mwakasonda (2004) noted that the lack of accessible and reliable source of electricity to drive technology absorption prevents most African countries from achieving their economic and technological goals. The Sub-Saharan African countries, for instance, have not lived up to expectation when it comes to electricity generation to drive economic growth (Onyeji *et al.*, 2012). The discussions above so far point to two main contributions. Firstly, this study aims at contributing to the technological inclusiveness literature by highlighting the importance of financial resources, human capital and access to electricity in developing technology absorption capacity in Africa (Klyton and Rutabayiro-Ngoga, 2017; Soofi, 2017). Secondly, this study also deepens the understanding of the role of various institutions that provide these critical resources for technology absorption in Africa (North, 1990; Scott,1992). This study is organised into seven sections including the introduction. Whiles section 2 presents the background to the study, section 3 discusses the theoretical framework and the presentation of hypotheses. Section 4 presents the research context and methodology for this study. Whiles sections 5 and 6 present the results and discusses the results respectively, section 7 concludes the study.

Empirical Model specification

To test the hypotheses relating to the technology absorption capacity of African firms, we employ an empirical model based on its relationship with access to credit, access to electricity, human capital development, governance quality and educational quality as indicated below:

$$\text{Technology Absorption} = \alpha + \beta_1 GQ + \beta_2 EQ + \beta_3 AC + \beta_4 AE + \beta_5 HCD + \varepsilon$$

Where: α is the constant term, β_1 to β_5 = regression coefficients, GQ = governance quality, EQ= educational quality, AC = access to credit, AE = Access to electricity, HCD = human capital development, ε =error term

3. Theory and hypotheses development

The availability of firm resources is known to contribute to competitiveness and growth. Barney (1991) introduced the Resource-Based View (RBV) theory to argue that organisations achieve a competitive advantage based on their internal characteristics and resources which are Valuable, Rare, Inimitable, and Non-substitutable (VRIN). Thus, if a firm possesses and continuously exploit resources and capabilities that meet the VRIN criteria, it will achieve a competitive advantage as well as an above-average performance. These resources include the internal resources of the firm which are heterogeneous such as human capital, physical assets, capabilities, organisational processes, firm attributes, information, financial resources, and knowledge which are all controlled by the firm. By these resources, the firm can conceive and implement strategies to achieve firm objectives and competitiveness (Talaja, 2012). The variation in firm performance is therefore attributed to the possession of specialised human capabilities and assets which are unique.

In the achievement of technological competitiveness in Africa firms, it is expected that critical resources such as specialised skill (knowledge economy), funding opportunities for technology transfers and diffusion as well as efficient energy sources should be at the reach of firms without much difficulty. Lin and Chang (2015) indicate that resource difficulties and structural divisibility particularly of small businesses hinder their ability to absorb current and suitable technologies to increase productivity. Crucially therefore, the availability of specialised knowledge which comes in the form of education, experience, and skills to support the kind of technological advancement that is needed in Africa is a necessary input (Rauch *et al*. 2005). This, Li *et al.* (2017:1) argue that in promoting effective technology absorption in Africa, the development of indigenous ‘‘core competency’’ and ‘‘technological know-how’’ as opposed to transferring of technical information and equipment from abroad need to be reconsidered. Thus, technological advancement and innovation in Africa can only be possible through the presence of the available scientists, engineers and the professional workforce (Pick and Nishida, 2015). This implies that there is the need for financial resources such as foreign direct investment inflows which will support firms to develop, adapt, absorb and advance the necessary technology for firm performance in Africa (Salim *et al*., 2017). Based on the resource-based view theory as discussed above, the following hypotheses are developed.

The quality of human capital and technology absorption in Africa

Many studies in the field of entrepreneurship highlight the importance of human capital in the performance of the firm. The concept of refers to the knowledge, skills and problem-solving abilities that come through education, training and experience of the employees in a firm which enhances firm performance (Becker, 1993; Davidsson and Honig, 2003). Chen and Thompson (2016) refer to human capital as both the cognitive and non-cognitive skills of the members of a firm acquired through education and experience which contributes to the performance of the firm. Again, the concept posits that the availability of adequate human capital in the firm enhances performance in terms of the achievement of its economic and social goals (Mahmood and Rosli, 2013; Simpson *et al*., 2012). In a similar vein, Aggestam (2014) argues that skilled human labour generates higher positive externalities and has a higher impact on the firm processes and performance than the unskilled ones. A skilled workforce also leads to a competitive advantage as well as innovation in the firm (Johnston *et al*., 2010; Laforet, 2011).

Madsen *et al*. (2008) indicate that education and experience acquired by firm employees could either be specific or general. It is general if it does not relate to any specific business sector or entrepreneurial activity. On the other hand, it is specific if it relates to a particular type of firm activity. In terms of skill acquisition for venture performance, Chell (2013) suggested that such skills could be technical, conceptual, human management and networking skills. In a similar vein, Kirschenhofer and Lechner (2012) distinguish among general, industry-specific and firm-specific human capital development.

However, Barney (1991) argues that for such knowledge, skills, and experiences of organisational members to bring a competitive advantage to the firm, it should be inimitable and non-substitutable. Such knowledge according to Li *et al*. (2017) consists of particular technological expertise, production techniques, the experience of past experiments, managerial methods and know-how of complex business processes. Thus, the concept emphasises investment in education, training and gaining work-related experience which explains performance differentials and entrepreneurial success among firms (Gabrielsson and Diamanto, 2012; Hashi and Krasniqi, 2011). This implies that the stock of skilled human capital present in a country provides the necessary platform for technological innovation and absorption (Danquah and Amankwah-Amoah, 2017). The impact of technological knowledge accumulation on technology absorption is well recognised in the literature. However, due to the weak knowledge base of most African countries, they only benefit from imitation and

knowledge spill-over from developed countries (Rahman and Zaman, 2016). It is therefore important for firms in Africa to identify and develop various internal capability needs which are necessary for technology absorption (Feige and Vonortas, 2017). More so, complementary knowledge such as in product design and manufacturing and building of various enterprise infrastructure are helpful in technology absorption in a country (Chen *et al*., 2017). Based on the above discussion and evidence in the literature, the study hypothesised as follows:

H_1: *The quality of human capital is positively related to technology absorption in Africa*

Access to financial capital and technology absorption in Africa

The African continent is noted to have one of the lowest financial penetration globally. Apart from South Africa which is considered to be the most financially penetrated country in Africa, the bankable population in Africa remains as low as 20% (Popoola, 2009). Usually, financial capital which is considered as one of the most important factors of production remains a challenge to African firms in absorbing modern technology which would increase their performance as much as production is concerned (Bastiéa *et al.*, 2016; Kuzilwa, 2005). The availability of financial capital in the form of loans to acquire modern technology, to support various kinds of innovations in boosting various sectors of the Africa economy is extremely limited if not unavailable (Andrianova *et al.*, 2008; Fatoki and Odeyemi, 2010). This is particularly true for nascent African firms which lacks the necessary financial strength to drive the kind of technological innovation which is needed in Africa (Asiedu *et al.*, 2013; Mbonyane and Ladzani, 2011). More so, most new firms in Africa do not have the necessary credit history and the required collateral to support any debt acquisition process (Kuzilwa, 2005; Mahmood *et al.*, 2014). Therefore, many small and new firms turn to depend on informal sources to finance their operations such as from family and friends which might not be sustainable in financing technological innovations in the firm (Ahmed and Nwankwo, 2013). The above discussion points to the fact that general financial resources to support technology absorption in Africa is limited and, in most cases, unavailable. Therefore based on the general findings in the literature, the following hypothesis is proposed:

H_2*: Access to financial capital is positively related to technology absorption in Africa*

Access to electricity and technology absorption in Africa

Access to a reliable and cheap source of energy such as electricity to support technology absorption remains a challenge to many African firms. Research evidence point to the fact that approximately two-thirds of the total population in Africa live without adequate electricity (IEA, 2014). Averagely, general access to electricity in Africa is 25%. With only Mauritius having access rate of 94%, other countries such as Chad, Somalia, Uganda, Sierra Leone and Rwanda have access rates of 5% (Brew-Hammond, 2010). Similarly, Mauritania, Ghana and South Africa have electricity access rate of over 50% for its population (Brew-Hammond, 2010). It has been observed that the North African countries including Morocco and Tunisia have done tremendously well in providing electricity to their citizens at the access rate of 96% which is remarkable (Onyeji *et al.*, 2012). The discussion on access to a reliable, efficient, and cheap source of electricity to drive technology absorption is an important factor which is worth considering in improving technology usage and absorption in Africa (Sihag *et al.*, 2004; Worch *et al*.2012).

Several reasons have been attributed to this shortfall in electricity generation in Africa. Among some of these reasons includes poor infrastructure in the generation, distribution and transmission of electricity coupled with a limited capital investment in the energy (D'Amelio *et al.*, 2016; Suberu *et al.*, 2013). More so, Africa suffers from weak institutional and structural support to improve the energy sector adequately (Madubansi and Shackleton, 2006; Onyeji *et al.*, 2012). Most African countries continuously depend on bilateral and multilateral donors in generating their energy systems. This over-dependence on donors to support the energy sector makes the continent vulnerable and unable to support any meaningful growth in the generation of adequate and reliable energy sources (Murphy, 2001).

The African continent, therefore, needs adequate institutional reforms, capital investment as well as the development of the requisite technical knowledge in the production of electricity to meet the technological needs of firms. It is also that Africa can also leapfrog its energy systems by adopting other renewable energy technologies (RETs) such as solar, wind and other organic energy resources which may seem more promising and reliable compared to the traditional non-renewable energy systems. Based on the discussion above and the findings in the literature, the following hypothesis is proposed:

H_3: *Access to electricity is positively related to technology absorption in Africa.*

Based on the above discussion and considering the major findings from the literature, the following conceptual framework as shown in Figure 1 below is proposed for this study in relation to the hypotheses stated above.

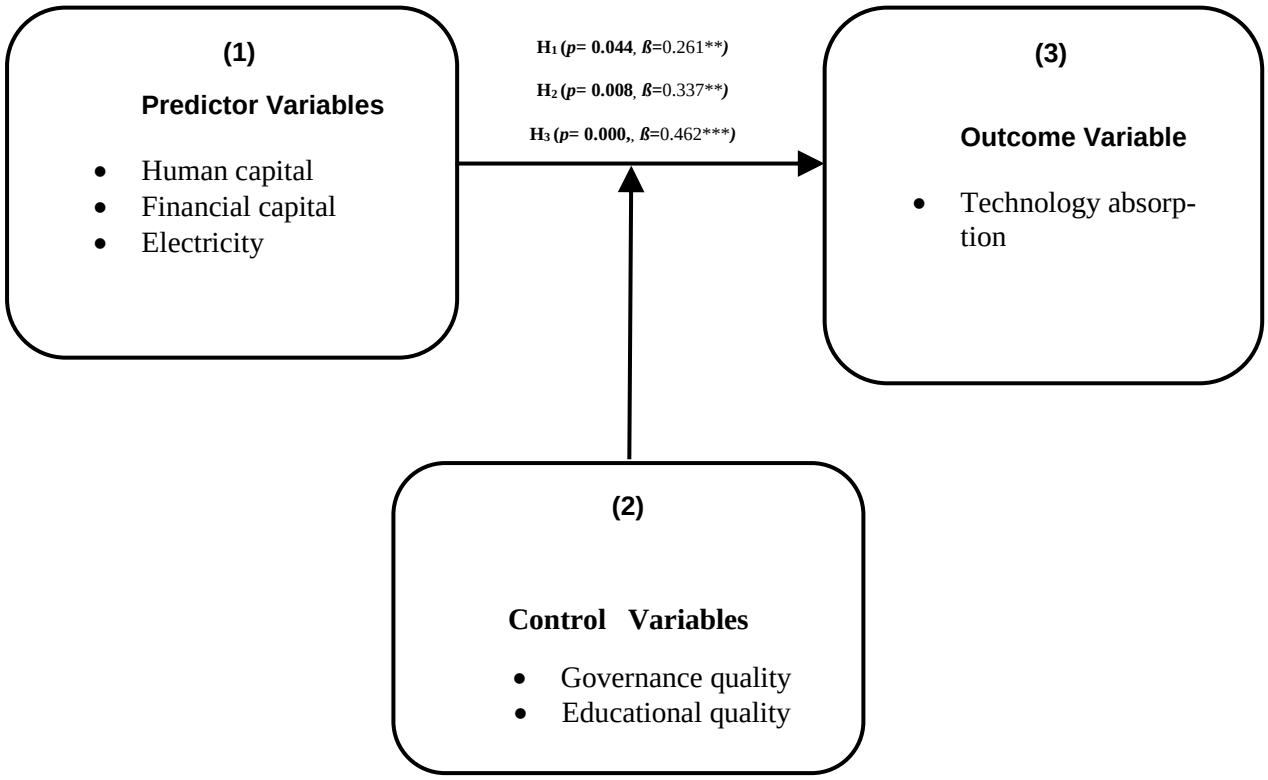

Figure I: A hypothesised model of critical resources for technology absorption in Africa

4. Research context and methodology

Sample and sources of data

This study has used three sets of secondary aggregated data in the form of index. First, the sample for this study consists of data for 40 African countries that were covered by the Global Entrepreneurship and Index (GEI) in the 2017 survey. Broadly, the GEI involved 508,009 individuals from 137 countries which were engaged in the GEI survey. This study has used the seventh pillar of the GEI known as technology absorption (TA) for the 40 African countries as the outcome variable. Technology absorption is defined as the measure of a country's capacity and technology intensity of firms to adopt useful technology (GEDI, 2017). Second, three explanatory variables were used to explain technology absorption in Africa. The human capital

variable measuring the quality of the available human capital in Africa which is measured by the *educational level of participants, labour market efficiency, staff training provided and general labour freedom* across the 40 African countries. The access to credit variable which is measured by the *collateral laws* and *information on credit systems* in each country and the access to electricity variable which is measured by the *procedures, time and cost* to connect electricity to businesses were taken from the World Bank's Doing Business Report (World Bank, 2017). The study used two (2) main control variables namely the quality of political governance in Africa from the Ibrahim Index of African Governance (Mo Ibrahim Foundation, 2016), and the quality of education index which measures access to only mathematics and science education across the 40 African countries (UNESCO, 2015). All the data used in this study are aggregate in nature. Table IV (see Appendix) describes each of the variables in detail. Table I below provides a summary of the sources and types of data that were used in this study.

Table I: Summary of data sources and variables

Indicator	**Unit**	**Data sources**
Technology absorption	Index	GEDI, 2017
Human capital	Index	GEDI, 2017
Access to electricity	Index	World Bank, 2017
Access to credit	Index	World Bank, 2017
Education quality	Index	UNESCO, 2015*
Governance	Index	IIAG,2016

***These are the most recent data available**

Constructs and measures

Dependent variable

The diffusion of new technology and the capacity to absorb it is a pre-requisite for innovative firms with high growth potential (Acs *et al*. 2017). The dependent variable, technology absorption which is the seventh pillar of the GEDI 2017, is based on aggregate data captured by two main variables namely *technology level*, and *technology absorption (*adopted from the Global Entrepreneurship Monitor survey). The technology absorption variable indicating the country and firm-level capacity for technology diffusion, intensity and absorption are measured on a seven-point Likert scale anchored by (1 = not able to absorb new technology, 7 =

aggressive in absorbing new technology). The technology level variable also measures the percentage of the Total Early-phased Entrepreneurial Activity (TEA) businesses that are active in the technology sectors of the respective countries (Acs *et al*. 2017). The technology absorption index is, therefore, the average of the two normalised variable scores. The score ranks African countries in terms of country and firm-level technology adoption. The GEM data collection procedure is briefly described below.

The GEM Adult Population Survey (APS) uses a questionnaire with a binary scale (yes/no) to survey both entrepreneurs and owner-managers of African businesses. These individuals are randomly selected from these African countries and are aged between 18 and 64 years (Sambharya and Musteen, 2014). To ensure international data comparability in the GEM survey process, primary data were collected using three main data collection methods: *Adult Population Survey (APS), National Expert Survey (NES) and National Expert Interviews (NEI)* (Reynolds *et al*., 2005). The APS, which is a representative population survey, was conducted either through the telephone or face-to-face, The NES involves the use of standardised questionnaires to investigate the national framework for entrepreneurship development in each country. The NEI is used to obtain a deeper understanding of strengths, weaknesses, the major issues and challenges that each country faces in terms of entrepreneurship development.

The data collection instrument has five main sections which are indicated below. Respondents answer questions on the following areas: section 1 (screening items concerning the entrepreneurial activity of respondents), section 2 (questions for respondents who are currently trying to start a new business), section 3 (questions for owner-managers of existing businesses, irrespective of the company's age), section 4 (questions for people who work as informal investors) and section 5 (questions for people who gave up or quit the business in the last twelve months). Cronbach's alpha was used to check the internal consistency of the variables. Technology absorption scores being part of the *ability* pillars has a score of 0.91 which is greater than the threshold of 0.7, indicating a strong internal consistency. The Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity were also conducted. The Kaiser-Meyer-Olkin measure was 0.94 for the original pillar values and 0.96 for the adjusted pillars, which is above the normal threshold of 0.50. The Bartlett's test which was conducted to test the strength of the correlation between the variables was significant at the 0.000 level indicating a high confidence level of the variables involved in this study.

Independent variables

This study employed three explanatory variables (indexes): human capital, access to credit, and access to electricity as predictors of technology absorption in Africa. While the human capital variable is sourced from the GEI (2017), the access to credit and electricity were sourced from the World Bank's Doing Business Report (World Bank, 2017). These three explanatory variables represent the critical resources which are needed to revamp technology absorption in Africa. They were chosen because these critical resources still hinder technology absorption entrepreneurship development in Africa (Davidson and Mwakasonda, 2004). The World Bank's Doing Business Report (2017) investigates country regulations, laws and administrative requirements that promote or constrain business activity. The report presents quantitative data on 11 business areas, including access to credit and electricity. The report covers 190 countries, including the 40 African countries that were used in this study. The methodology for measuring each variable is discussed below.

The availability of high-quality human capital is vital for technology absorption and innovation. This requires an educated, experienced and a healthy workforce (Davidsson and Honig, 2003). The human capital index sourced from the GEI (2017) is measured by four variables namely the *level of education, labour market, level of investment in staff training and labour freedom* in Africa. The index focuses on aggregating the percentage of start-ups by individuals with higher than secondary education with the propensity of firms to train employees combined with the labour freedom in respective countries (Acs *et al*. 2017). The educational level captured by above-secondary school education of entrepreneurs measures the quality of entrepreneurs in Africa. The labour market comprises two components: labour freedom (measures the freedom of labour from the regulatory perspective) and staff training (measures the level of investment in staff training to increase staff quality).

The access to credit variable, which measures the collateral laws and information on credit systems, is measured by two main constructs: *availability of movable collateral laws and availability of credit information systems.* Data were collected for 133 countries, all of which have populations of 1.5 million or greater. Four variables (strength of legal rights, depth of credit information, credit bureau coverage and credit registry coverage) are used to measure access to credit.

The access to electricity index, which captures the procedures, time and cost to connect a business to electricity is measured by five main constructs namely: *procedures for connection, time*

spent on connection procedures, cost of supply, the reliability of electricity supply and transparency of tariffs (World Bank, 2017). Data were collected from utility distribution firms, independent professionals such as electricians, electrical engineers and construction companies in each country. The index covers 183 economies (47 high income, 50 upper middle-income, 54 middle-income and 32 low-income economies). The index covers 46 economies in sub-Saharan Africa and 4 in North Africa. The data is constructed using responses from more than 12,500 respondents. A standardised case study of small and medium-sized enterprises that seek electricity connections is used across 183 countries to ensure data comparability. The primary utility distribution company serving enterprises is also interviewed to ascertain the time and cost of obtaining such a service. The procedure is further verified through email and telephone interviews (Geginat and Ramalho, 2015).

Description of control variables

The quality of education and political governance has a bearing on a country's technological innovativeness (Oluwatobi *et al*, 2015). This study controlled for country-specific variables namely the quality of governance and education. These control variables were included in the analysis because these factors have been observed to affect entrepreneurship development and technology innovation in Africa (Ahmed and Nwankwo, 2013; Onyeji *et al.*, 2012; Winkler *et al.*, 2011). The quality of education index measures accesses to maths and science education among African countries measured on a seven-point Likert scale anchored by [1 = extremely poor – among the worst in the world; 7 = excellent – among the best in the world]. The governance index captures the political, social and economic provisions that citizens have a right to expect from the state and that the state has a responsibility to provide to its citizens. Four constructs measure the index: safety and rule of law, participation and human rights, human development and sustainable economic opportunity. In total, 166 variables from 34 data sources combine to form 95 indicators and 14 constructs that measure governance concepts. The governance index provides data for the 40 countries that were used in this study. The variables are measured on a five-point Likert scale to capture the views of respondents in each country. Although these factors were not used as predictor variables in this study, understanding their impact on technology absorption in Africa is important.

5. Results

Table II presents the descriptive statistics (i.e. means and standard deviations of the dependent and independent variables, minimum and maximum values, skewness, and Kurtosis of the variables). The results of the regression analysis for the technology absorption and the explanatory and control variables appear in Table III. The model was used to examine the impact of credit supply, access to electricity, and human capital on technology absorption in Africa. A restricted model (Model 1) that comprised only the control variables (i.e. governance quality and education quality) was executed. The independent variables were then added to Model 1 to assess the overall fitness of the model. In the full regression model (Model 2), human capital (p = 0.008, β = 0.337) is statistically significant at 5% level. A unit increase in human capital, therefore, has a corresponding increase in technology absorption in Africa by 33.7%. Thus, the hypothesis regarding the impact of human capital on technology absorption is accepted. Secondly, access to electricity (p = 0.000, β = 0.462) is statistically significant at 1% level. Accordingly, a unit increase in access to electricity increases technology absorption in Africa by 46.2%. Finally, access to credit (p = 0.044, β = 0.261) is statistically significant at 5% level. A unit increase in access to credit increases technology absorption in Africa by 26.1% Thus; the hypothesis regarding the impact of electricity and credit on technology absorption in Africa is accepted.

The results for the control variables are as follows: governance quality (p = 0.365, β = -0.110), quality of education (p = 0.049, β = 0.254. The results indicate that whiles the current quality of political governance in Africa is non-significant and therefore does not support technology absorption, the quality of education is statistically significant at 5%. The R^2 indicates the overall fitness of the regression model. From the full regression model, the R^2 value is 0.516, and its adjusted value is 0.445, thereby indicating that the full regression model explains 44.5 percent of the variance in technology absorption. Tables II and III below presents the descriptive statistics and results of the regression analysis respectively.

Table II: Descriptive statistics and correlations

	Variable	Mean	SD	Min	Max	Skewness	Kurtosis	(1)	(2)	(3)	(4)	(5)	(6)
(1)	Technology absorption	0.174	0.062	0.050	0.310	-0.184	0.014	1.00					
(2)	Human capital	0.225	0.172	0.030	0.900	2.322	6.221	0.375**	1.00				
(3)	Access to electricity	0.391	0.122	0.145	0.606	0.086	-0.954	0.434**	-.018	1.00			
(4)	Access to credit	0.296	0.095	0.050	0.500	-0.110	1.085	0.364**	.110	.000	1.00		
(5)	Governance quality	0.339	0.092	0.110	0.592	0.307	0.728	-0.103	-.014	.057	0.00	1.00	
(6)	Education quality	0.750	0.121	0.535	0.966	0.042	-1.042	0.327**	.063	-.060	.022**	-.081	1.00
	Valid N (list-wise):40												

Note: ***p*<0.1, ****p*<0.05, *****p*<0.01

Table III: Regression analysis of technology absorption and critical resources

Technology absorption

	Model 1						**Model 2**					
Variable	Unstandardized Coefficients ***(ß)***	Std. Error	Standardized Coefficients (Beta)	t	Sig.(p)	VIF	Unstandardized Coefficients (***(ß)***	Std. Error	Standardized Coefficients (Beta)	t	Sig.(p)	VIF
Human capital							0.121**	0.043	0.337	2.808	0.008	1.014
Access to electricity							0.234***	0.061	0.462	3.859	0.000	1.007
Access to credit							0.170**	0.081	0.261	2.091	0.044	1.091
Governance quality	-0.052	0.104	-0.078	-0.499	0.621	1.007	-0.074	0.080	-0.110	-.918	0.365	1.012
Education quality	0.163**	0.079	0.321	2.065	0.046	1.017	0.129**	0.064	0.254	2.038	0.049	1.092
R	0.336						0.719					
R2	0.113						0.516					
Adjusted R^2	0.065						0.445					
ANOVA *F*	2.354						7.260					
Sig. F Change	0.109						0.000					
N	40						40					

Note: *p<0.1, **p<0.05, ***p<0.01

6. Discussion

Table II shows the results of the regression analysis regarding the impact of human capital, access to credit and access to electricity on technology absorption in Africa. First, as indicated in Table IV (see Appendix), access to credit was measured by considering the legal rights of borrowers and lenders with respect to secured transactions and reports of credit information through credit reporting service providers such as credit bureaus or credit registries. The results indicate that access to credit significantly explains technology absorption in Africa. This implies that access to credit by firms in Africa would increase their technology absorption capacity significantly. This is because access to such financial resources would influence the firm's strategic decisions as much as technology absorption and innovation are concerned (Bastiéa *et al.*, (2016). More importantly, Africa needs a variety of financial sources. The availability of different forms of financial capital to entrepreneurs in Africa will increase the ability of firms to absorb new technologies to support economic growth (Fatoki and Odeyemi, 2010). It is therefore expected that firms in Africa will continually be provided with all forms of financial capital such as loans, trade credit, foreign direct investments to boost their technology base (Andrianova *et al.*, 2008).

Secondly, the availability of qualified human capital in Africa has a significant impact on technology absorption. The results indicate that human capital significantly explains technology absorption in Africa. Technology advancement mostly depends on the quality of the human capital which is present in a country. A skilled human labour has a direct impact on a firm’s technological competitiveness and advancement (Aggestam, 2014; Johnston *et al*., 2010). It is expected that firms in Africa should continue to invest in staff training particularly in technical and engineering fields which can support technology development. Also, a specific focus on technical, mathematical and science education provides considerable leverage for African firms to have the needed human resources to drive technology absorption and innovation (Johnston *et al*., 2010; Laforet, 2011).

Finally, access to an efficient, reliable, and cheap source of electricity is an important step towards technology absorption in Africa (Sihag *et al*., 2004). From the result, access to electricity significantly explains technology absorption in Africa. This result was to be expected because most African governments currently acknowledge the importance of energy for enterprise and technology development. For instance, Kenya has streamlined access to electricity by using a geographic information system to eliminate the need for site visits and

thereby reducing the time that businesses require to access electricity. Similarly, Senegal and Ghana have computerised electricity connection processes, making the application process less time consuming (World Bank, 2017). Also, the access rate to electricity by the North African countries such as Morocco and Tunisia has reached 96% which propels technology absorption and adoption (Onyeji *et al*., 2012). However, it is expected that African Governments should continue to improve their service delivery in terms of electricity access to firms particularly those located in rural areas where small and micro businesses abound.

In summary, the findings from this study imply that there has been a considerable improvement in access to electricity, access to credit and human capital development across Africa. However, for Africa to experience a far richer experience in technology absorption, access to these resources need to improve. African governments need to have the political will and devote a chunk of their budgets to ensure African firms have access to these critical resources.

7. Conclusion

The research context in this study provides a unique environment for the study of technology absorption and the critical factors which affect it. The African continent does not seem to be doing well as far as technology usage is concerned. This paper investigates the impact of three critical resources (human capital, access to credit and access to electricity) on technology absorption in Africa. The findings indicate that the current level of human capital, access to credit, and electricity availability in Africa supports technology absorption. However, there is much to be done to see real technology absorption taking place among indigenous African firms particularly when these effects are not seen to be taking place.

Contribution to Knowledge

This study has been built on previous studies on the technology absorption literature focusing on Africa. Even though critical research on technology absorption in the West abounds, not much has been written about this phenomenon in the African context. The current study has two main contributions to offer. First, this study contributes to the technology inclusiveness literature by highlighting the critical factors that are needed to drive technology absorption in Africa (Botchie *et al*. ,2017; Narayanan and Chen, 2012; Pehrsson, 2016). It is important that these critical resources are available and developed to the highest level to support technology absorption in Africa. The readiness of Africa indigenous businesses to absorb technologies particularly from emerging economies such as China is critical. Second, this study contributes to the understanding of the Resource-Based View Theory and how it applies to African

indigenous businesses to remain competitive (Barney, 1991). The availability of the critical resources investigated in this study will make African businesses competitive on the global scale with other continents.

Implications for policy and practice

This study has implications for policy and practice. First, African governments need to provide a sound institutional environment that guarantees access to credit, affordable electricity supply and the development of a quality workforce. Second, African governments should consider embracing alternative renewable energy technologies (RETs) such as biomass, biogas or using solar, wind and other organic resources which are considered as a more promising alternative to the conventional non-renewable energy systems to supplement electricity provision in locations where supply is still insufficient (Murphy, 2001). Practically, indigenous African firms should endeavour to train their workforce to the highest level of expertise since this a critical element for all technology absorption strategies. Particularly, technical expertise is needed to maintain and improve absorbed technologies in Africa.

Research Limitations

There are a few limitations to this study. First, a lack of GEI data for all 54 African countries limited this study to 40 African countries (36 in sub-Saharan Africa and 4 in North Africa). Therefore, generalisations of our findings to the whole of Africa might be limited. Secondly, the model used in this study is parsimonious in the sense that much more explanatory variables could have been explored as against technology absorption.

Future research direction

The findings from this study highlight some further research areas which future research could be focused. Firstly, future research could focus on various other driving forces of technology absorption such as cost, the impact of various institutions and the general entrepreneurial ecosystem and its support on technology absorption. Secondly, future research could also be conducted from the supply side particularly on emerging economies to determine what the driving forces are in supplying technology to Africa.

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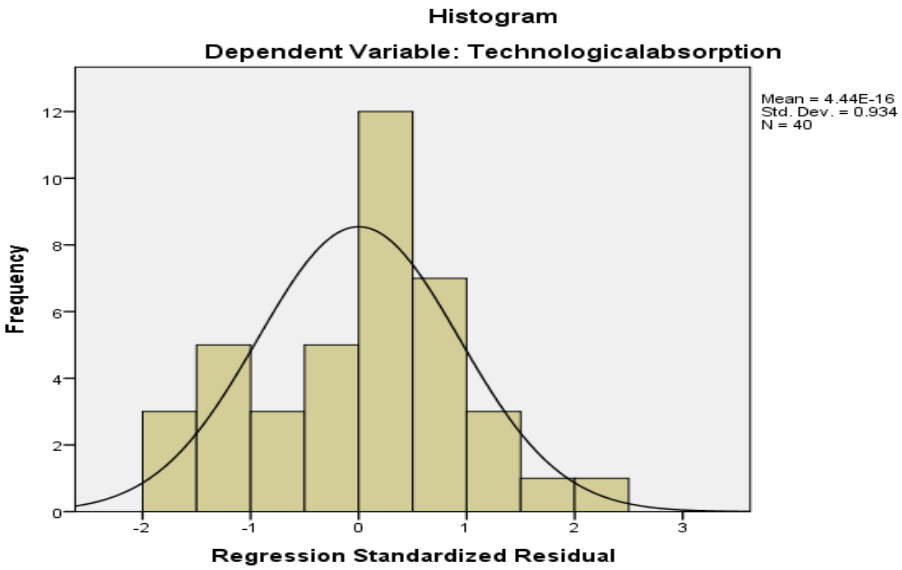
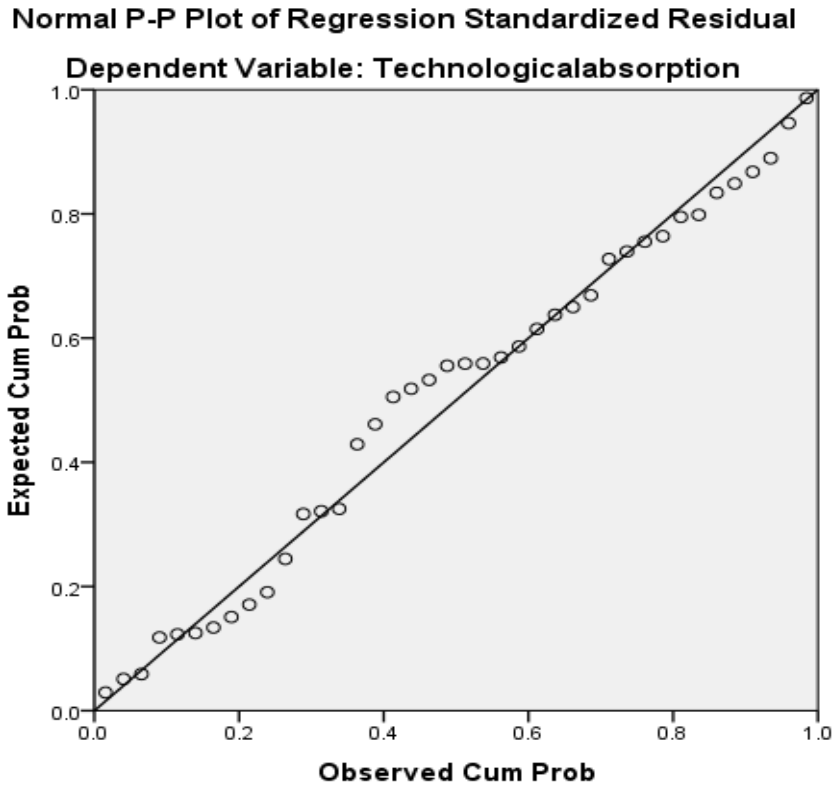
Appendix 1

Table IV: Description of variables

Construct	Description	Variables Used
Technology Absorption	This pillar reflects technology-intensity of start-up activity combined with a capacity for firm-level technology absorption in a country	Technology level, technology absorption
Human Capital	Focus on quality of entrepreneurs as weighing percent of start-ups by individuals with higher than secondary education with a qualitative measure of the propensity of firms in a country to train staff combined with freedom of labour market	Educational level, labour market (staff training, labour freedom)
Access to credit	Measures legal rights of borrowers and lenders with respect to secure transactions and reporting of credit information through credit reporting service providers such as credit bureau or credit registries	The strength of legal rights, depth of credit information, credit bureau coverage, credit registry coverage
Access to electricity	All procedures necessary for a business to obtain a permanent electricity connection and supply for a standardised warehouse. These procedures include applications and contracts with electricity utilities, all necessary inspections and clearances from distribution utility and other agencies, external and final connection works	Procedures to obtain electricity, the time required to complete each procedure, the cost required to complete each procedure, the reliability of supply and transparent tariff, the price of electricity
Quality of politics and governance	Provision of political, social, and economic goods that citizens have rights to expect from the state, and a state has a responsibility to deliver to citizens	Safety and rule of law, participation and human rights, human development, sustainable economic opportunity
Education quality	Access to mathematics and science education in a country	Tertiary education, quality of education

Appendix II


Histogram
Dependent Variable: Technologicalabsorption
Mean = 4.44E-16
Std. Dev. = 0.934
N = 40
Frequency
Regression Standardized Residual


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Technologicalabsorption
Expected Cum Prob
Observed Cum Prob

Appendix III: Model Summary and ANNOVA table

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.719[a]	.516	.445	.046248	.516	7.260	5	34	.000	1.927

a. Predictors: (Constant), Education, Electricity, Human capital, Governance, Credit

b. Dependent Variable: Technology absorption

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.078	5	.016	7.260	.000[b]
	Residual	.073	34	.002		
	Total	.150	39			

a. Dependent Variable: Technology absorption

b. Predictors: (Constant), Education, Electricity, Human capital, Governance, Credit