# Nexus between technology absorption and firm growth in Africa: A resource-based perspective

**ABSTRACT**

By drawing upon the Resource-Based View (RBV) theory, this study investigates the effects of human capital, credit, and electricity on technology absorption among firms in Africa. The technological absorption index for 40 African countries was used to measure technological diffusion and the capacity to absorb new technology among African firms. Secondly, the World Bank's data on access to credit and electricity for 40 African countries was also employed as explanatory variables. The findings indicate that to support technological absorption and diffusion among African firms, a broad access to credit, electricity and effective human capital development is imperative. Access to credit, electricity and human capital were significant in explaining variances in technological absorption. More so, whiles education quality is significant, African governance structures are insignificant in driving technological absorption.

**Keywords:** Africa, Credit; Electricity; Quantitative approach; Technological absorption

## Introduction

Research on technological development particularly for developing and emerging economies such as Africa has been on increase over the past decade. It is the vehicle for organisational growth in terms of meeting excessive demands and cutting down operational cost (Narayanan and Chen, 2012). Indeed, several technological experts have expounded on the extensive benefits which are derived from technological absorption particularly for small firms in developing countries which are stagnated with poor and obsolete technologies (Lin and Chang, 2015). More importantly, technological absorption has opportunities and threats. Therefore, the ability of the firm to assess such threats and anticipated benefits before the absorption is an essential consideration (Du Preeza and Pistorius, 2002). Indeed, research regarding technological lifecycle, technological discontinuity, technological diffusion and absorption and the emergence of dominant technological designs are of concern to the African growth and development agenda (Narayanan and Chen, 2012; Pehrsson, 2016).

Institutional variables play a pivotal role in technological absorption and innovation. However, Krammer (2015) opines that institutional factors could create both barriers and opportunities for technological absorption in a country. 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 support technological absorption in a country (Oluwatobi *et al*. 2015). According to Pick and Nishida (2015), other factors such as foreign direct investments, geographical proximity to an advanced technological source, the nature of higher education and societal openness towards technological absorption have been noted to have contributed to technological development among countries. Another important factor worth considering is the type of encouragement from African governments to local firms to absorb technology which aims at fostering entrepreneurial development (Pick and Nishida, 2015; Littlewood and Kiyumbu, 2017).

However, Botchie *et al*. (2017) caution of the acceptance of inferior and low-cost technologies from emerging economies which might be detrimental to Africa eventually. The acceptance of these low-cost technologies is driven mainly by low levels of income as well as unavailability of perfect information about the existence of suitable technologies to address Africa's technological challenges. Simarly, 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 this as technological standard which is the specifics associated with technological absorption that complies with products, processes, formats, procedures, utility, technical possibilities and its functional parameters for the African environment.

## Resource considerations for technological 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 technological absorption, diffusion and advancement among countries (Rahman and Zaman, 2016). Asongu and Roux (2017) in their research also 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 is the outcome of a direct investment into the mobilisation of critical resources that has a bearing on human capital development (Asongu and Roux, 2017). Danquah and Amankwah-Amoah (2017) argue that human capital remains a single important determinant for technological 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 in a firm could enhance technological absorption and advancement.

Access to financial resources remains one of the drawbacks of 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).

Efficient energy combined with other inputs such as financial capital and labour are considered important factors in driving technological absorption and advancement. As an energy source, electricity is an important input for the growth of any economy which is poised to build its competitiveness on the adoption of the right technology and innovation (Winkler *et al.*, 2011). Davidson and Mwakasonda (2004) noted that the lack of an accessible and reliable source of electricity to drive technological advancement prevents most African countries from achieving their economic and technological goals. Particularly, the Sub-Saharan African countries have not lived up to expectation when it comes to electricity generation to drive economic growth (Onyeji *et al.*, 2012). About two-thirds of the African population lives without electricity (IEA, 2014). However, North African countries such as Morocco and Tunisia have increased the rate of access to electricity from 30% in 1996 to more than 96% of the population in 2009 (Onyeji *et al.*, 2012). On the average, general electricity access in Africa is 25% compared to other jurisdictions such as Latin America (93%), Middle East (89%) and Asia (81%) (Brew-Hammond, 2010; Atiase et al., 2017).

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 electricity in developing technological absorption in Africa (Klyton and Rutabayiro-Ngoga, 2017; Soofi, 2017). Secondly, this study also deepens the understanding of resource features which meet the Valuable, Rare, Inimitable, and Non-substitutable (VRIN) criteria which is necessary for technological absorption in Africa (Barney, 1991). The rest of the paper is organised as follows. The first section considers the theoretical perspectives on critical resource needs for technological absorption This sections also presents the various hypothesis underlying this study. The second section presents the research context and methodology for this study. The third and fourth sections present the results and discuss the results respectively. Section five concludes the study.

## 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 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 all the internal resources of the firm which are heterogeneous in nature and in various forms such as human capital, all 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 (Talaja, 2012). The variations in firm performance, therefore, are attributed to the possession of specialised human capabilities and assets which are unique in nature.

In the achievement of technological competitiveness among firms in Africa, it is expected that critical resources such as specialised skill (knowledge economy), funding opportunities for technological 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 the suitable technologies. Crucially, the availability of specialised knowledge which comes in the form of education, experience, and skills to support the kind of technological advancement that is absent in Africa is a necessary input (Rauch *et al*. 2005). This, Li *et al.* ( 2017:1) argue that in promoting effective technological 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 considered. 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). Pick and Nishida (2015) again argues that capital investment into technological advancement is important to derive the right results. This implies that there is the need for financial resources such as foreign direct investments which will support firms developing, adopting, absorbing and advancing 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 technological absorption in Africa**

Many studies in the field of entrepreneurship highlight the importance of the human capital theory to underpin the 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 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. 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) intimate 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 an 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) intimates 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 a particular technological expertise, production techniques, experience of past experiments, managerial methods and know-how of complex business processes. Thus, the concept emphasises an investment in education, training and gaining work related experience which explains performance differentials and entrepreneurial success among firms (Hashi and Krasniqi, 2011; Gabrielsson and Diamanto, 2012). This implies that the stock of skilled human capital present in a country provides the necessary platform for technological innovation and advancement (Danquah and Amankwah-Amoah, 2017). The impact of technological knowledge accumulation on technological absorption is well recognised in literature. However due to the weak knowledge base of most African countries, they only benefit from imitation and knowledge spill-over from developing 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 technological 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 technological absorption in a country (Chen *et al*., 2017). Based on the above discussion and evidence in the literature, the study hypothesised as follows:

***H₁***: *The quality of human capital is positively related to technological absorption in Africa*

**Access to financial capital and technological absorption in Africa**

Africa has one of the lowest financial penetration of any region in the world. Thus, excluding South Africa, the percentage of the bankable Africans remains less than 20% of the population (Popoola, 2009). Financial capital which is usually treated as a factor of production in terms of capital investment influences a firm's decisions regarding technology adoption and absorption as well as other financial goals (Kuzilwa, 2005; Bastiéa *et al.*, 2016). It is a widely accepted phenomenon that financial capital in the form of loans, trade credit or suppliers credit can support economic growth and the adoption of technological innovations particularly in developing countries where access to such facilities are extremely limited (Andrianova *et al.*, 2008; Fatoki and Odeyemi, 2010). However, evidence shows that firms in African particularly nascent ones lack the necessary financial capital to drive innovations and technological advancement (Mbonyane and Ladzani, 2011; Asiedu *et al.*, 2013).

This financial challenge of firms is mainly attributed to lack of collateral by firm's particularly new ones to support loan applications among other information asymmetry and moral hazard issues (Kuzilwa, 2005; Mahmood *et al.*, 2014). Evidence has therefore shown that many firms, particularly the small ones, depend on informal sources of credit such as from family and friends which might not be a sustainable source of financing for technological innovation and advancement (Ahmed and Nwankwo, 2013). Therefore, general financial resources for technological absorption and advancement is limited in Africa. Based on the above discussion and the general findings in the literature, the following hypothesis is proposed:

***H₂****: Access to financial capital is positively related to technological absorption in Africa*

**Access to electricity and technological absorption in Africa**

Access to cheap and reliable electricity for technological absorption and advancement is generally a challenge in Africa. Approximately two-thirds of the African population lives without electricity (IEA, 2014). On the average, general electricity access in Africa is 25%. Thus; apart from Mauritius with an electricity access rate of 94% Chad, Somalia, Uganda, Sierra Leone and Rwanda have access rates of 5%. Other countries such as Mauritania, Ghana and South Africa have electricity access of 50% to its population (Brew-Hammond, 2010). However, the North African countries such as Morocco and Tunisia have enjoyed tremendous success in terms of the rate of access to affordable electricity, which rose from less than 30% in 1996 to more than 96% of the population in 2009 (Onyeji *et al.*, 2012). Therefore, access to an efficient, reliable and cheap source of electricity to drive technological advancement in Africa is an important condition worth considering (Sihag *et al.*, 2004; Worch *et al.*2012).

Some reasons have been attributed to this shortfall in electricity generation in Africa. Infrastructural difficulties in the production, distribution and transmission of electricity coupled with limited capital investment and weak technological knowledge are top on the list (Suberu *et al.*, 2013; D'Amelio *et al.*, 2016). More importantly, Africa suffers from weak institutional and structural reforms to improve the energy sector (Madubansi and Shackleton, 2006; Onyeji *et al.*, 2012). One issue which is more worrying is that Africa still depends on bilateral and multilateral donors in generating its energy for industrial and technological growth (Murphy, 2001). This makes Africa vulnerable to producing its own energy systems.
Africa, therefore, needs institutional reforms, capital investment as well as the technical knowledge in the production of electricity to meet technological needs of the continent. Murphy (2001) also recommended leapfrogging the African energy system into other renewable energy technologies (RETs) using solar, wind and other organic resources which are considered as a more promising alternative to the conventional non-renewable energy systems.

Based on the above discussion and the general findings in the literature, the following hypothesis is proposed:

***$H_3$***: *Access to electricity is positively related to technological 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 is proposed for this study in relation to the hypotheses stated above.

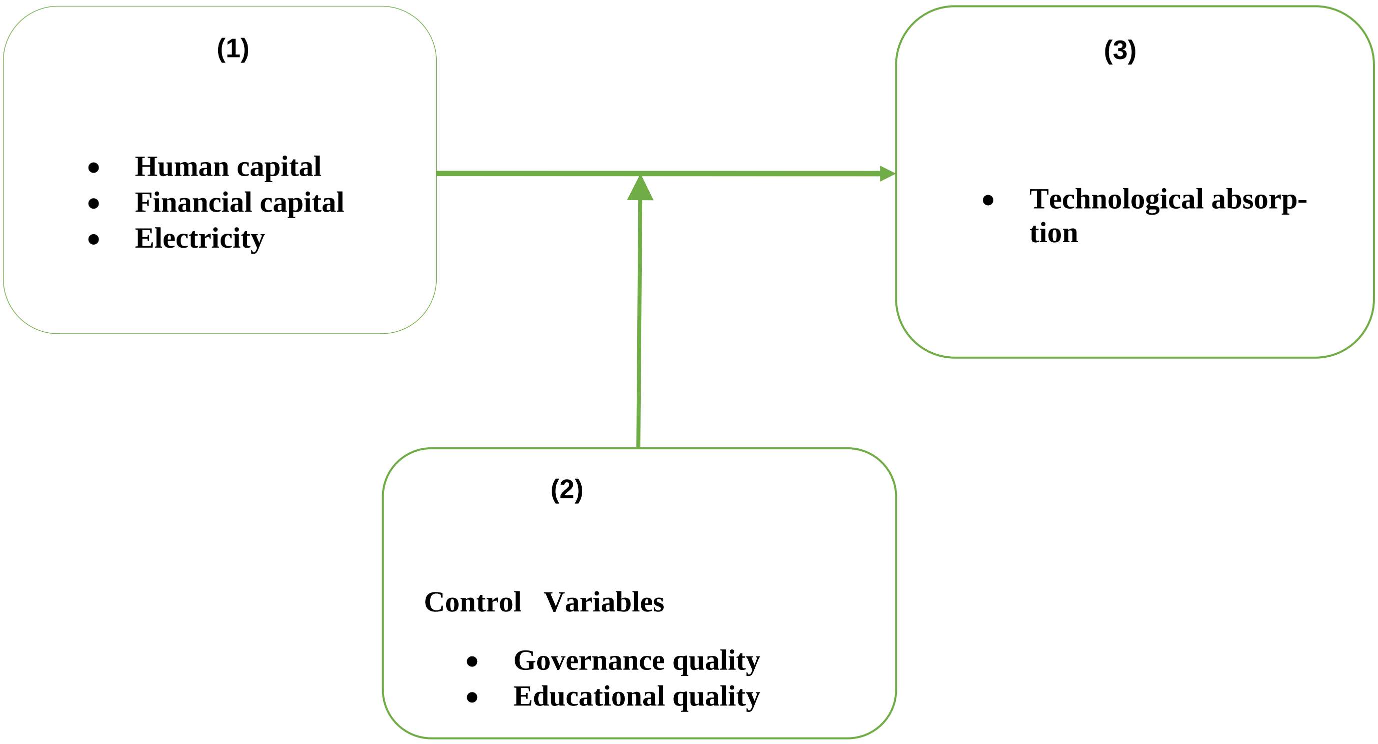



**Figure I:** A hypothesised model of critical resources for technological absorption in Africa

## Research context and methodology

Sample and sources of data

The study used three sets of secondary data in the form of an index. First, the sample for this study consists of data for 40 African countries that are covered by the Global Entrepreneurship and Index (GEI). In total, the GEI covers 508,009 individuals from 137 countries. This study has used the seventh pillar of the GEI known as technological absorption (TA) for the 40 African countries as the dependent variable. Technological absorption is a measure of a country's capacity and technology intensity for firm-level technological adoption (GEDI, 2017). Second, three explanatory variables were considered. Human capital (GEDI, 2017) measuring the quality of human capital (Educational level, labour market, staff training and labour freedom) across the 40 African countries, access to credit (collateral laws and information on credit systems) and access to electricity (procedures, time and cost to connect to electricity services) from the World Bank's Doing Business Report also measuring access to both resources across the 40 African countries (World Bank, 2017). Finally, the study used country-specific data measuring the quality of political governance in Africa known as Ibrahim Index of African Governance (Mo Ibrahim Foundation, 2016), and the quality of education measured across the 40 African countries as control variables (UNESCO, 2015). All data used are aggregate in nature. Table IV (see Appendix) describes each of the variables. Table I below summarises the sources and types of data that were used in this study.

**Table I: Summary of data sources and variables**

| Indicator | Unit | Data sources |
|---|---|---|
| Technological 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, technological 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 technological diffusion, intensity and absorption, measured by 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 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 technological 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, GEM collects primary data using three principal 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, is conducted as either a telephone or a face-to-face survey, while the NES involves the use of standardised questionnaires to investigate the national framework for entrepreneurship development. The NEI is conducted to ascertain a deeper understanding of strengths, weaknesses, and other major issues regarding entrepreneurship in each country. The data collection instrument has five principal sections. Respondents answer questions on the following areas: section 1 (screening items concerning 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 a business in the last twelve months).

Cronbach's alpha was used to check the internal consistency of the variables. Technological absorption scores which form part of the *ability* pillars has a score of 0.91 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 conducted. The Kaiser-Meyer-Olkin measure was 0.94 for the original pillar values and 0.96 for the adjusted pillars, which was well above the threshold of 0.50. The Bartlett's test was significant at the 0.000 level indicating a high confidence level of the variables.

**Independent variables**

This study employed three explanatory variables (indexes): human capital, access to credit, and access to electricity as predictors of technological absorption in Africa. While the human capital variable is sourced from the GEDI,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 technological absorption in Africa. They were chosen because these critical resources still hinder technological 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 businesses 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 prevalence of high-quality human capital is vital for technological absorption and innovation. This requires an educated workforce, experienced as a healthy workforce (Davidsson and Honig, 2003). The human capital index sourced from the GEDI, 2017 is measured by two variables (level of education, labour market, level of investment into 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 of 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 a credit index, which captures the collateral laws and information on credit systems, is measured by two 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 to electricity services, is measured by five constructs: procedures for connection, time spent on connection procedures, cost of supply, the reliability of electricity supply and transparency of tariffs (World Bank, 2017). Data are 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 are 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 on 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 technological innovativeness in Africa (Winkler *et al.*, 2011; Onyeji *et al.*, 2012; Ahmed and Nwankwo,2013). 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 measures capture 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 entrepreneurship development in Africa is important.

**Statistical analysis and 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 technological 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 technological absorption in Africa. A restricted model (Model 1) that comprised only the control variables (i.e. governance quality and education quality) was built. 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, $\beta$ = 0.337) is statistically significant at the 5% level. A unit increase in human capital, therefore, has a corresponding increase in technological absorption in Africa by 33.7%. Thus, the hypothesis regarding the impact of human capital on technological absorption is accepted. Secondly, access to electricity ($p$ = 0.000, $\beta$ = 0.462) is statistically significant 1% level. Accordingly, a unit increase in access to electricity increases technological absorption in Africa by 46.2%. Finally, access to credit ($p$ = 0.044, $\beta$ = 0.261) is statistically significant at 5% level. A unit increase in access to credit increases technological absorption in Africa by 26.1% Thus; the hypotheses regarding the impact of electricity and credit on technological absorption in Africa is accepted.

The results for the control variables were as follows: governance quality ($p$ = 0.365, $\beta$ = -0.110), quality of education ($p$ = 0.049, $\beta$ = 0.254. The results indicate that whiles the current quality of political governance in Africa is non-significant and therefore does not support technological 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 model explains 44.5 percent of the variance in technological 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)** | Technological 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 technological absorption and critical resources**

**Technological 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**

## Discussion of empirical results

*Access to credit is an important resource in technological absorption in Africa*

Table II shows the results of the regression analysis regarding the impact of some critical resources such as human capital, credit and electricity which are needed to drive technological 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 technological absorption in Africa ($p = 0.044$, $\beta = 0.261$). As noted by Bastiéa *et al.*, (2016) access to such financial resources influences a firm's strategic decisions as much as technology adoption and absorption is concerned. The availability of different forms of financial capital to entrepreneurs in Africa promotes the ability of firms to be able to absorb new technologies which support economic growth (Fatoki and Odeyemi, 2010). It is therefore expected that entrepreneurial firms in Africa will continually be provided with all forms of financial capital such as loans, trade credit, foreign direct investments to boost the technological base of indigenous African firms (Andrianova *et al.*, 2008).

*The availability of skilled human capital promotes technological absorption in Africa*

Secondly, the results also indicate that human capital significantly explains technological absorption in Africa ($p = 0.008$, $\beta = 0.337$). Human capital was measured by the effectiveness of the labour market, labour freedom and investment into staff training in Africa. Technological 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 firm’s technological competitiveness and advancement (Johnston *et al*., 2010; Aggestam,2014). It is expected that firms in Africa should continue to invest in staff training particularly in technical and engineering fields which has the capacity to support technological development. Also, a specific focus on technical, mathematical and science education provides a considerable leverage for African firms to have the needed human resources to drive technological absorption and innovation (Johnston *et al*., 2010; Laforet, 2011).

*Access to adequate and efficient electricity promotes technological absorption in Africa*

Finally, access to an efficient, reliable, and cheap source of electricity is an important step towards technological absorption in Africa (Sihag *et al*., 2004). From the result, access to electricity significantly explains technological absorption in Africa ($p = 0.000$, $\beta = 0.462$). This result was to be expected because most African governments currently acknowledge the importance of energy for enterprise and technological development. For instance, Kenya has streamlined access to electricity by using a geographic information system to eliminate the need for site visits and thereby reduce the time that businesses require to access electricity. Similarly, Senegal and Ghana have computerised electricity connection processes, making the application process less time to consume (World Bank, 2017). Also, access rate to electricity by the North African countries such as Morocco and Tunisia has reached 96% which propels technological 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 electricity, access to credit and human capital development across Africa. However, for Africa to experience a far richer experience in technological absorption, access to these resources need to improve. African governments need to have the political will to support firms in accessing these resources.

## Conclusion

This paper investigates the effect of human capital, credit and electricity on technological absorption in Africa. The findings indicate that the current level of human capital, access to credit, and electricity in Africa supports technological absorption. This study contributes to the African technological inclusiveness literature by investigating the critical resources that are needed to drive technological absorption in Africa. Technology absorption among firms in Africa has the potential to drive industrialisation. This study highlights the need for access to critical resources such as credit, electricity and human capital which are essential ingredients for technology diffusion and absorption in Africa. Effective technological absorption and diffusion depend on these critical factors. Therefore, various institutional infrastructure which supports the delivery of these various resources is important for technological development in Africa.

## Research implications for policy in Africa

This study has implications for 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).

## Research limitations

A lack of technological absorption data for all the 54 African countries limited this study to only 40 African countries: 36 in sub-Saharan Africa and 4 in North Africa. Therefore, the generalisability of this study’s findings to the whole of Africa might be limited. Secondly, this study depended on indexes for this study. Therefore, any inconsistencies in the index aggregation if any could not be authenticated. This study has practical implications for technological absorption in Africa. Public and private institutions that are responsible for credit delivery, human capital development and the provision of utility services such as electricity are crucial for technological absorption in Africa.

**References**


IEA. (2011), ‘‘*World Energy Outlook’’.* Paris, France: OECD/IEA.

Acs, J., Szerb, L., Autio, E., and Lloyd, A. (2017), ‘‘ *Global Entrepreneurship Index’’,*Washington, D.C.: The Global Entrepreneurship and Development Institute.

Aggestam, M. (2014), ‘‘Conceptualizing entrepreneurial capital in the context of institutional change’’. *International Entrepreneurship and Management Journal,* Vol. 10 No.1, pp.165–18.

Atiase, Y. V., Mahmood, S., Wang, Y., & Botchie, D. (2017). Developing entrepreneurship in Africa: investigating critical resource challenges. *Journal of Small Business and Enterprise Development*.

Ahmed, A., and Nwankwo, S. (2013), ‘‘Entrepreneurship development in Africa: an overview’’. *World Journal of Entrepreneurship Management and Sustainable Development,* Vol. 9 No.2, pp. 82-86.

Andrianova, S., Demetriades, P., and Shortland, A. (2008), ‘‘Government ownership of banks, institutions, and financial development’’. *Journal of Development Economics,* Vol. 85, pp.218–252.

Asiedu, E., Kalonda-Kanyama, I., Ndikumana, L., and Nti-Addae, A. (2013), ‘‘Access to Credit by Firms in Sub-Saharan Africa: How Relevant is Gender?’’ *American Economic Review: Papers and Proceedings,* Vol.103 No.3, pp.293–297.

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

Barney, J. B. (1991), ‘‘Firm resources and sustainable competitive advantage’’. *Journal of Management,* Vol.17, pp. 99-120.

Bastiéa, F., Cussya, P., and Nadant, L. A.L. (2016), ‘‘Network or Independent Business? Entrepreneurs’ Human, Social and Financial Capital as Determinants of Mode of Entry’’ *Managerial and Decision Economics,*Vol. 37 No.3, pp. 167–181.

Becker, G. (1993), *Human Capital, a Theoretical and Empirical Analysis with Special Reference to Education* (3rd ed.). Chicago, IL.: University of Chicago Press.

Botchie, D., Sarpong, D., and Bi, J. (2017), ‘‘Technological inclusiveness: Northern versus Chinese induced technologies in the garment industry’’. *Technological Forecasting and Social Change,* Vol.119, pp. 310–322.

Bowen, M., Morara, M., and Mureithi, S. (2009), ‘‘Management of Business Challenges among Small and Medium Enterprises in Nairobi-Kenya’’ *KCA Journal of Business Management,* Vol. 2 No.1, pp.16-31.

Brew-Hammond, A. (2010), ‘‘Energy access in Africa: Challenges ahead. *Energy Policy,* Vol.38 No.5, pp.2291–2301.

Chell, E. (2013), ‘‘Review of skill and the entrepreneurial process’’, *International Journal of Entrepreneurial Behaviour and Research,* Vol. 19 No.1.pp. 6-31

Chen, L.-W., and Thompson, P. (2016), ‘‘Skill Balance and Entrepreneurship Evidence from Online Career Histories’’, *Entrepreneurship Theory and Practice,* Vol. 40 No.2, pp.289–305.

Chen, T., Qian, L., and Narayanan, V. (2017), ‘‘Battle on the Wrong Field? Entrant Type, Dominant Designs, and Technology Exit’’. *Strategic Management Journal,* Vol.38, pp.2579–2598.

D'amelio, M., Garrone, P., and Lucia, P. (2016 ), ‘‘Can Multinational Enterprises Light up Developing Countries? Evidence from the Access to Electricity in sub-Saharan Africa’’, *World Development,* Vol.88, pp. 12–32.

Danquah, M., and Amankwah-Amoah, J. (2017), ‘‘Assessing the relationships between human capital, innovation and technology adoption: Evidence from sub-Saharan Africa’’, *Technological Forecasting and Social Change,* Vol.122, pp.24–33.

Davidson, O., and Mwakasonda, A. S. (2004), ‘‘Electricity access for the poor: a study of South Africa and Zimbabwe’’, *Energy for Sustainable Development,* Vol. 8 No.41, pp.26-40.

Davidsson, P., and Honig, B. (2003), ‘‘The role of social and human capital among nascent entrepreneurs’’, *Journal of Business Venturing,* Vol.18 No.3, pp.301–331.

Du Preeza, G. T., and Pistorius, W. C. (2002), ‘‘Analyzing technological threats and opportunities in wireless data services’’, *Technological Forecasting and Social Change,* Vol.70, pp. 1–20.

Fatoki, O., and Odeyemi, A. (2010), ‘‘The determinants of access to trade credit by new SMEs in South Africa’’, *African Journal of Business Management,* Vol.4 No.13, pp. 2763-2770.

Feige, D., and Vonortas, S. N. (2017), ‘‘Context appropriate technologies for development: Choosing for the future’’, *Technological Forecasting and Social Change,* Vol.119, pp.219–226.

Gabrielsson, J., and Diamanto, P. (2012), ‘‘Work experience and the generation of new business ideas among entrepreneurs’’, *International Journal of Entrepreneurial Behaviour and Research,* Vol.18 No.1, pp.48-74.

Geginat, C., and Ramalho, R. (2015), *Electricity Connections and Firm Performance in 183 Countries.* Washington: World Bank. Available: http://documents.worldbank.org/curated/en/622221468190154401/pdf/WPS7460.pdf(Accessed 17 January 2018)

Hashi, I., and Krasniqi, A. B. ( 2011), ‘‘Entrepreneurship and SME growth: evidence from advanced and laggard transition economies’’, *International Journal of Entrepreneurial Behaviour and Research,* Vol.17 No.5, pp.456-487.

Johnston, L., Robinson, S., and Lockett, N. (2010), ‘‘Recognising "open innovation" in HEI-industry interaction for knowledge transfer and exchange’’, *International Journal of Entrepreneurial Behaviour and Research,* Vol. 16 No.6, pp.540-560.

Khayyat, T. N., and Lee, J.D. (2015), ‘‘A measure of technological capabilities for developing countries’’, *Technological Forecasting and Social Change,* Vol.92, pp. 210–223.

Kirschenhofer, F., and Lechner, C. (2012), ‘‘Performance drivers for serial entrepreneurs’’, *International Journal of Entrepreneurial Behaviour and Research, 18*(2), pp.305-329.

Klyton, v. A., and Rutabayiro-Ngoga, S. (2017), ‘‘SME finance and the construction of value in Rwanda’’, *Journal of Small Business and Enterprise Development*.Available: https://doi.org/10.1108/ JSBED-02-2017-0046

Krammer, M. S. (2015), ‘‘ Do good institutions enhance the effect of technological spillovers on productivity? Comparative evidence from developed and transition economies’’, *Technological Forecasting and Social Change,* Vol. 94, pp.133–154.

Kuzilwa, A. J. (2005), ‘‘The Role of Credit for Small Business Success: A Study of the National Entrepreneurship Development Fund in Tanzania. *The Journal of Entrepreneurship,* Vol.14 No.2, pp.131-161.

Laforet, S. (2011), ‘‘A framework of organisational innovation and outcomes in SMEs’’, *International Journal of Entrepreneurial Behaviour and Research,* Vol.17 No.4, pp.380-408.

Lema, A., and Lema, R. (2016), ‘‘Low-carbon innovation and technology transfer in latecomer countries Insights from solar PV in the clean development mechanism, *Technological Forecasting and Social Change,* Vol.104, pp.223–236.

Li, S., Clark, T., and Sillince, J. (2017), ‘‘Constructing a strategy on the creation of core competencies for African companies’’, *Technological Forecasting and Social Change*, pp.1-10. Available: https://doi.org/10.1016/j.techfore.2017.08.008

Lin, C., and Chang, C.C. (2015), ‘‘The effect of technological diversification on organizational performance: An empirical study of S&P 500 manufacturing firms’’, *Technological Forecasting and Social Change*, Vol.90, pp.575–586.

Littlewood, C. D., and. Kiyumbu, L. (2017), "Hub" organisations in Kenya: What are they? What do they do? And what is their potential?’’, *Technological Forecasting and Social Change*, pp.1-10.Available: https://doi.org/10.1016/j.techfore.2017.09.031

Madsen, H., Neergaard, H., and Ulhøi, P. J. (2008). Factors influencing the establishment of knowledge-intensive ventures. *International Journal of Entrepreneurial Behaviour and Research,* Vol.14 No.2, pp. 70-84.

Madubansi, M., and Shackleton, C. (2006), ‘‘Changing energy profiles and consumption patterns following electrification in five rural villages, South Africa’’, *Energy Policy,* Vol.34 No.18, pp.4081–4092.

Mahmood, R., and Rosli, M. M. (2013), ‘‘Microcredit position in micro and small enterprise performance: the Malaysian case’’, *Management Research Review,* Vol.36 No.5, pp. 436-453.

Mbonyane, B., and Ladzani, W. (2011), ‘‘Factors that hinder the growth of small businesses in South African townships’’, *European Business Review*, Vol.23 No.6, 550-560.

Mahmood, S., Hussain, J., and Matlay, Z. (2014), ‘‘Optimal microfinance loan size and poverty reduction amongst female entrepreneurs in Pakistan’’, *Journal of Small Business and Enterprise Development,* Vol.21 No.2, pp.231-249.

Mo Ibrahim Foundation. (2016). *A decade of African Governance 2006-2015*. Available: http://s.mo.ibrahim.foundation/u/2016/10/01184917/2016-Index-

Report.pdf?_ga=2.91950362.1661060765.1497914380-1221281049.1482841462(Accessed 17 January 2018)

Murphy, T. J. (2001), ‘‘Making the energy transition in rural East Africa: Is leapfrogging an alternative?’’, *Technological Forecasting and Social Change,* Vol. 68, pp.173–193.

Narayanan, V., and Chen, T. (2012), ‘‘ Research on technology standards: Accomplishment and challenges’’, *Research Policy,* Vol.41 No.8, pp.1375-1406.

North, D. (1990). *Institutions, Institutional Change, and Economic Performance.* Cambridge: Cambridge University Press.

Oluwatobi, S., Efobi, U., Olurinola, I., and Alege, P. (2015), ‘‘Innovations in Africa: Why Institutions Matter?’’, *South African Journal of Economics,* Vol. 83 No.3, pp.390-410.

Onyeji, I., Bazilian, M., and Nussbaumer, P. (2012), ‘‘Contextualizing electricity access in sub-Saharan Africa. *Energy for Sustainable Development,* Vol.16 No.4, pp.520–527.

Pick, B., and Nishida, T. (2015), ‘‘Digital divide in the world and its regions: A spatial and multivariate analysis of technological utilization’’, *Technological Forecasting and Social Change,* Vol.91, pp.1–17.

Popoola, B. A. (2009), ‘‘Will Credit Bureau Infrastructure Enhance Access to Finance for Small Business in Africa?’’ *ICSB World Conference Proceedings,* pp.1-10.

Pehrsson, T. (2016), **‘‘**Is innovation research contingent on competitive context?’’, A systematic review of research in the agriculture and forest industry’’, *European Business Review,* Vol 28 No.2, pp.225-247.

Rahman, A. M., and Zaman, M. (2016), ‘‘Human Capital and Technological Catch-up of Developing Countries in search of a technological leader’’,. The Journal of Developing Areas, Vol. 50 No. 1, pp. 158-174.

Rauch, A., Frese, M., and Utsch, A. (2005), ‘‘ Effects of Human of Capital and Long-Term Human Resources Development and Utilization on Employment Growth of Small-Scale Businesses: A Causal Analysis’’ *Entrepreneurship Theory and Practice,* Vol.29 No.2, pp.681-698.

Reynolds, P., Bosma, N., Autio, E., Hunt, S., De Bono, N., and Servaias, I. (2005), ‘‘Global Entrepreneurship Monitor: Data collection design and implementation 1998–2003’’, *Small Business Economics,* Vol. 24, No.24, pp. 205–231.

Rogers, M. E. (1983), *Diffusion of Innovation*, The Free Press, New York

Salim, A., Razavi, R. M., and Afshari-Mofrad, M. (2017), ‘‘Foreign direct investment and technology spillover in Iran: The role of technological capabilities of subsidiaries’’, *Technological Forecasting and Social Change,* Vol.122, pp.207–214.

Sambharya, R., and Musteen, M. (2014), ‘‘Institutional environment and entrepreneurship:An empirical study across countries’’, *Journal of International Entrepreneurship* , Vol.12 No.4, pp.314–330.

Sihag, A., Misra, N., and Sharma, V. (2004), ''Impact of power sector reform on the poor: case-studies of South and South-East Asia'', *Energy for Sustainable Development,* Vol.VIII No.41, pp.54-73.

Simpson, M., Padmore, J., and Newman, N. (2012), ''Towards a new model of success and performance in SMEs'', *International Journal of Entrepreneurial Behaviour and Research,* Vol. 18 No.3, pp.264-285.

Soofi, S. A. (2017), ''A comparative study of Chinese and Iranian Science and Technology, and techno-industrial development policies'', *Technological Forecasting and Social Change,* Vol.122, pp.107–118.

Scott, W. (1992), *Organizations: Rational, natural, and open systems,* Englewood Cliffs, New York

Suberu, Y. M., Mustafa, W. M., Bashir, N., Muhamad, A. N., and Mokhtar, S. A. (2013),' 'Power sector renewable energy integration for expanding access to electricity in sub-Saharan Africa''. *Renewable and Sustainable Energy Reviews,* Vol.25, pp.630 - 642.

Talaja, A. (2012). Testing VRIN Framework: Resource Value and Rareness as sources of competitive advantage and above average performance. *Journal of Contemporary Management Issues,* Vol. 17 No.2, pp. 51-64.

UNESCO. (2015). *The Education for All Development.Available:*http://www.unesco.org/fileadmin/MULTIMEDIA/HQ/ED/pdf/gmr2012-report-edi.pdf(Accessed 17 January 2018).

Winkler, H., Felipe Simo˜, A., Rovere, L. B., Alam, M., Rahman, A., and Mwakasonda, S. (2011), ''Access and Affordability of Electricity in Developing Countries. *World Development,* Vol. 39 No.6, pp. 1037–1050.

WorldBank. (2017). *Doing Business: Equal Opportunity for All,* World Bank, Washington DC.

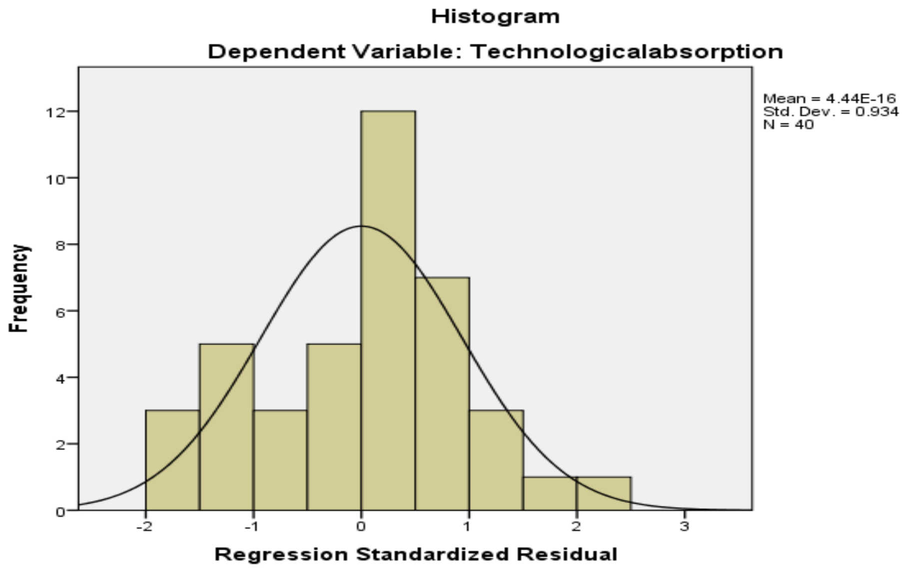
Worch, H., Kabinga, M., Eberhard, A., and Truffer, B. (2012), ''Strategic renewal and the change of capabilities in utility firms. *European Business Review,* Vol.24 No.5, pp.444-464.

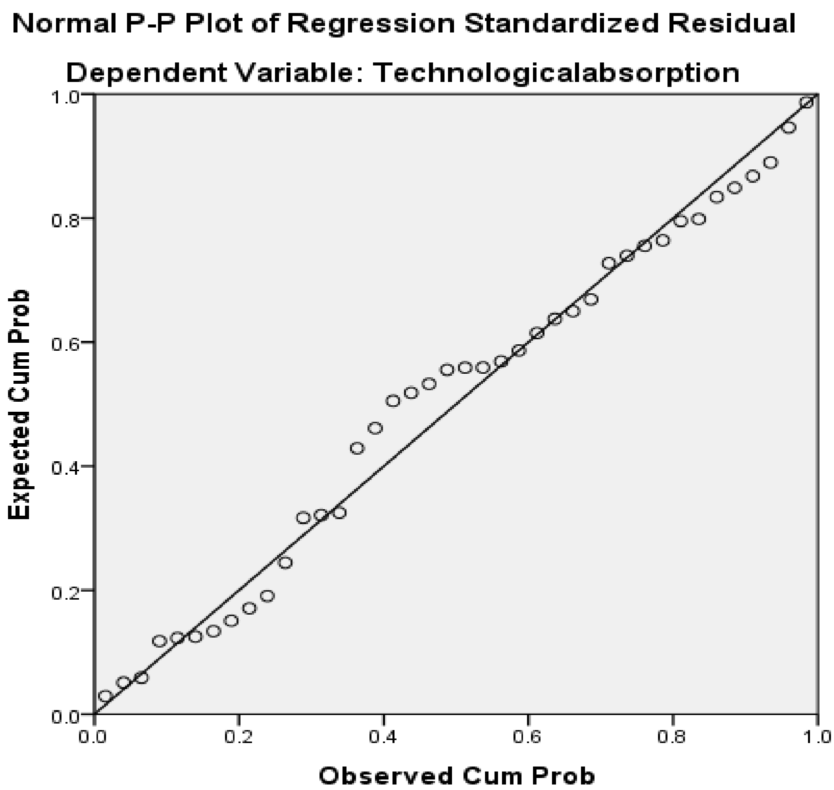
**Appendix 1**

**Table IV: Description of variables**

| **Construct** | **Description** | **Variables Used** |
|---|---|---|
| Technology Absorption | This pillar reflects technology-intensity of start-up activity combined with capacity for firm-level technology absorption in a country | Technology level,<br>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 propensity of firms in a country to train staff combined with freedom of labour market | Educational level,<br>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 | Strength of legal rights, depth of credit information,<br>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, time required to complete each procedure, cost required to complete each procedure, reliability of supply and transparent tariff, price of electricity |
| Quality of politics and governance | Provision of political, social, and economic goods that citizens have rights to expect from state, and a state has 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: Technological 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: Technological absorption

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