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Firm-Level Innovation and Business Obstacles in Sub-Saharan Africa: A cross-country analysis

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Contents

ACRONYMS

GVC	Global Value Chain
R&D	Research and Development
SOE	State Owned Enteprises
WBES	World Bank's Enterprise Surveys

Abstract

This study explores the concept of firm level innovation, and how it has developed over time. It also conducts descriptive and econometric analysis on the patterns and drivers of innovations among firms of different categories from nine African countries such as Cameroon, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Rwanda, Senegal, Zambia and Zimbabwe. Key emphasis is given to an approach that assesses innovation from the perspectives of intention, invention and protection resulting in six innovation indicators: Investing in Research and Development (R&D), Process Innovation, Product Innovation, Organizational Innovation, Marketing Innovation and Protection of Intellectual Property Rights. Overall, despite significant variations across the different indicators and countries, most African firms display limited levels of innovation. However, firms in Kenya, Ghana and Zimbabwe were found to be more innovative than others, with over 50% of firms in these countries engaging in at least three of the six innovation indicators. High levels of engagement by firms in R&D investments , though declining over several years, is evident across all firm types and countries. Large firms and publicly listed firms were found to be more innovative than smaller and unlisted firms. Contrary to our expectations, the econometric results suggests that firms that were affected by power outages were more likely to innovate. The same applies to those that consider access to finance as a major obstacle. These findings indicate that firms in Africa are innovating as a strategy to cope with business obstacles, rather than to enhance competitiveness.

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1 INTRODUCTION

For any given economy, innovation is important at both micro and macro levels. Indeed, innovation plays a role in explaining the differences in economic performance among countries (Fagerberg, et al, 2010). For example, Fagerberg and Verspagen (2002) found that the rapid growth of Asian economies in the 1970s and 1980s was largely due to extensive innovation in those countries. According to Bloom et al (2019), durable and sustainable productivity growth is only guaranteed in economies that expend significant resources on innovation. For African economies, extensive innovation can play a central role in enhancing their ability to catch-up with – and perhaps leapfrog – other emerging and developed economies.

At the micro level, innovation is beneficial for consumers as the returns to innovation may also accrue to them in the form of low prices and better-quality products (Simanis & Hart, 2011). Innovation can also facilitate the introduction of more products, enhancing variety (Fagerberg, 2006). At firm level, innovation outcomes are expected to affect firm performance in different ways. First, successful innovations are likely to increase firm-level productivity by improving the capacity to transform factors of production into more and better products, and by more efficiently creating products of higher value. Second, the increase in productivity is expected to increase the marginal productivity of labor, and as a result, improve the quality of jobs, i.e., allow for more productive jobs. Third, more productive firms are expected to push less productive firms out of the market, thereby increasing the overall efficiency of the economy.

However, despite encouraging trends, most African firms still lag behind in terms of competitiveness and innovativeness. Moreover, African firms face many challenges including regulatory challenges, infrastructural problems (e.g., inefficient electricity and water supply), credit constraints, challenges in getting business permits, problematic tax administration systems, customs and trade regulations, among others. These challenges create a difficult environment for the firms, and ultimately lead to low profitability and stifled growth.

Scholars in emerging economies, and specifically in Africa, tend to agree on the need for more empirical work to understand the patterns, trends and obstacles of firm-level innovation (Cerera, 2015). This call is based on the fact that the continent, which is further behind in the development frontier, possesses unique characteristics such as high rates of urbanization, a growing labour force, a high proportion of young people in the population structure, a growing domestic market, an expanding middle class, decreases in the severity of internal political confrontations, attenuation of inter-country armed conflicts, and the development of digital technologies (Ledeneva, et al., 2020). Maximizing this opportunity, however, can only be guided by the availability of consistent and comprehensive evidence on the extent of innovation in the continent and the identification of prevailing challenges to innovation.

This study therefore seeks to investigate the patterns and drivers of innovation in selected African countries using the World Bank Enterprise Surveys. More specifically, it uses a sample of firms from nine African countries and a mixed methods approach (a conceptual analysis followed by a less rigorous empirical proof) to achieve its objectives. The study describes innovation patterns across countries, industries, time and type of firm. The study intends to establish the extent of firm-level innovation in Africa, when using a broader definition of innovation that takes into account the probability of firms' innovativeness (product, process, marketing and organizational), intention or desire to innovate (directing and using investments in R&D) and protection of intellectual property rights.

In terms of innovation drivers, it specifically seeks to investigate whether the business environment obstacles (in the form of access to energy, finance and markets) affect the level of innovative activity within firms. This is important given the argument by Fagerberg (2006, pp. 19) who states that, "…a firm does not innovate in isolation, but depends on extensive interaction with its environment". If African firms find themselves in a difficult environment, to what extent does this affect their ability to innovate? How do they cope with or address these business environment challenges?

The rest of this paper is organized as follows: the next section explores contemporary understandings of the concept of firm-level innovation and its drivers. This is then followed by the data section which describes the sources and coverage of the data used to measure firm-level innovation and its drivers. The empirical estimation strategy section introduces the indicators used to measure innovation and methods used to estimate the effects of business obstacles on firm-level innovation. This is then followed, by the results and discussion sections, which presents the econometric results as well as the patterns of innovation. The conclusion summarizes major findings and provides strategic options for improving innovation among African firms.

2 Conceptual Framework

This section presents a synthesis of the existing literature on: 1) the concept of firm-level innovation from both the narrow and broad perspectives, and 2) the drivers of firm-level innovation.

2.1 The concept of firm-level innovation

Scholars generally agree on the ability of firm level innovation to boost individual firm's productivity and competitiveness as well as promote general economic growth. This is despite the dynamics around the concept whose meaning has evolved considerably over the years (Hussen & Çokgezen 2020; Younas & Rehman 2020, González et al, 2016, Dohnert et al, 2017; Regasa et al 2020). There is general agreement that in the past, both the definition and measure of the term were quite narrow (Trigo, 2013; O'Brien, 2016; Husssen & Cokgezen 2020). For years, policy and academic research on firm level innovation narrowly focused on R&D driven modes of innovation (Trigo, 2013), and were also biased towards high-capability technological innovations (O'Brien, 2016). This approach not only overlooked non-technological innovations and the role played by non-R&D activities in innovative outcomes, but it also limited the understanding of innovative performance, especially among firms in the low-technology sectors (Trigo, 2013; O'Brien, 2016).

According to O'Brien (2016), the bias towards high-capability technological innovation undermines other potentially significant impacts that could arise from low-capability innovations like novel products or processes, as well as those from organizational or marketing innovations. Furthermore, this narrow conceptualization limited research on firm level innovation to mostly the developed world (Husssen & Cokgezen 2019; Younas & Rehman 2020). Since innovation was largely understood as the introduction of a new product and was measured by the amount of R&D expenditure, the initial research on firm level innovation primarily focused on the countries which had significant financial resources to direct towards R&D activities. However as pointed out by Younas & Rehman (2020), the technological advances of firms in most developing countries fall outside these formal R&D models.

In recent years however, there has been a shift away from this narrow conceptualization to a broader perspective which emphasizes the importance of other initiatives beyond R&D through which firms achieve innovation (González et al, 2016, Trigo, 2013; Husssen & Cokgezen 2020). This shift has been deemed significant especially when assessing firm level innovation in developing countries where imitation of pre–existing products and processes are vital for innovation and growth (Husssen & Cokgezen 2020). Over time therefore, the conceptualization of firm level innovation has expanded and now captures the importance of imitation in these countries, representing innovations which could be new to a firm but not necessarily new in the market.

Furthermore, contrary to past perceptions that associated firm level innovation with the manufacturing sector, current scholarship also acknowledges that innovation occurs across many industries beyond manufacturing (O'Brien, 2016; Trigo, 2013). During the last decade, this perspective has for example highlighted the importance of understanding innovation in services due to the substantial growth of this sector (Trigo, 2013).

Additionally, the broadened understanding of firm-level innovation has also shifted from its narrow focus on only product innovation to include other types of innovation such as processes, marketing and organizational methods (Hussen & Çokgezen 2020). This expansion has also made it possible

to extend firm level innovation research to developing countries.

Given the varied perspectives on the concept of innovation, it is evident that distinctions should be made on how the concept applies to economies at different levels of growth and development. As developed countries and emerging economies are at the edge or close to the edge of the technology frontier, innovation in these contexts would mainly be radical, resulting in innovation outputs that are new to international markets. For developing countries which are often affected by resource constraints, innovation should be viewed from an incremental basis since firms in such economies lean more towards adoption, adaptation, or imitation of existing innovations (Fagerberg et al., 2010). Faced with limited resources, firms in these countries need to make efficient decisions in their innovation processes, especially around the allocation of available resources. This process is critical as deployment of innovation inputs and choice of innovation activities play a vital role in determining the innovation outcomes of the firm (Cirera, 2015). The current study focuses on innovation in the context of developing countries and therefore emphasizes the concepts of incremental innovation as well as the need to incorporate innovation inputs as a key element in measuring firm-level innovation.

2.2 Drivers of firm-level innovation

Traditionally, literature on the drivers of firm level innovation mainly focused on firms' characteristics (Hussen & Çokgezen 2020; Regasa et al 2020). Consequently, firm size has been considered to be one of the most important drivers of innovation at this level. According to Hussen & Çokgezen (2019), larger firms are regarded as more innovative compared to their smaller counterparts as they benefit from economies of scale. Similarly, it has been assumed that with an increase in firm size, there is a greater tendency to finance R&D and other complementary activities whose trickle-down effects are an increase in the innovative performance of a firm. Critics have however pointed out that although this may be true in some cases, smaller firms may be more efficient than large firms due to their higher levels of flexibility and reduced bureaucracy among other factors (ibid).

A firm's age is another factor that has been argued to drive firm level innovation. Firms are thought to develop their experience, knowledge and entrepreneurial flexibility over time and this should propel them to take risks and make decisions to innovate (Hussen & Çokgezen, 2020). This is particularly evident in the case of incremental innovation. Some studies, however, argue that younger firms tend to be more innovative as they enter the market with new technologies and engage in exploratory R&D, often resulting in radical innovations (Akcigit & Kerr, 2018).

For a long time also, the ownership structure of a firm has been considered a driving force for firm level innovation (Lööf, 2009). While some scholars believe that it is easier for government-owned firms to engage in innovative activities due to their access to resources, others argue that the lack of incentives among managers in these firms could prevent them from engaging in innovative activities.

In the recent past, there has been a shift in the conceptualization of the determinants of firm level innovations which focus beyond firm characteristics. Current literature on firm level innovation emphasizes the need to also focus on the environment within which the firm is operating. These external factors arguably determine firm level innovations especially in the context of developing countries (Dohnert et al, 2017, Hussen & Çokgezen 2020; Regasa et al 2020). Key among these factors is the access to finance. There is a general consensus among researchers that access to finance is important for funding innovation (ibid). According to these studies, access to finance influences not just the decision to innovate but also the ability to sustainably pay for the innovation activities.

Additionally, current debates have identified market structure as a driver of firm level innovations (Hussen & Çokgezen 2020). Firm level innovations may be determined by the structure of the market from which the firm acquires its inputs and to which it sells its outputs (ibid). Specifically, the level and type of competition is highlighted as an important factor when assessing the role of market structure in driving firm-level innovation.

Furthermore, the role played by the institutional structure of the economy - both formal and informal - is also noted as yet another driver of firm level innovations (Hussen & Çokgezen , 2020, Barasa et al , 2016). According to these scholars, such structures influence both the internal and external factors affecting innovations, and consequently, influence firms' decisions to engage in innovative activities. It is therefore more likely for a firm surrounded by supportive institutional structures to invest in R&D, access finance easily

and enhance their human capital through training as opposed to one which lacks such structures.

Contemporary scholarship also identifies human capital as a key driver of firm level innovation (González et al, 2016; Dohnert et al 2017; Mohan, Strobl & Watson, 2018; Khatiwada & Arao, 2020). The relevance of human capital endowment is emphasized even in cases where a firm is engaged in imitating or implementing technologies and products that already exist elsewhere (Khatiwada & Arao, 2020). The acquisition of human capital is usually through formal education, within-firm training and the development of experience among workers in the firm. The study by González et al (2016), for example, shows that simultaneously engaging in R&D and worker training significantly increases the likelihood for innovation. Similarly, Dohnert et al (2017) highlight the importance of human capital in driving innovation in their study which shows that an increase in the proportion of skilled workers increases the likelihood of both process and product innovation.

Firm openness which addresses how firms engage with different sources of information and knowledge on innovation has also been identified as a determinant of firms' innovativeness. Indicators such as the importing of inputs, exporting outputs, competition and foreign ownership of firms are used to measure the openness of the firm. Empirical studies on the influence of openness on firm innovation show varied results with some demonstrating a positive relationship while others indicate a negative relationship (Almeida & Fernandes, 2008; Ayalew et al., 2019).

3 DATA

The data for this study is extracted from the World Bank's Enterprise Surveys (WBES, 2020). The Enterprise Surveys are a standardized and globally comparable database, providing establishment-level data that is representative of the non-agricultural production, private sector economy. As such, they cover clearly defined economic sectors in manufacturing and services, following a stratified survey design and can be interpreted using survey weights to account for the varied probability of selection of each establishment. The surveys provide a widely comparable data source for most developing economies and constitute the best approximation for aggregate employment dynamics.

The WBES collects a vast array of qualitative and quantitative data through interviews with firm managers and other relevant stakeholders concerning the performance of the firm and the business environment. The survey questions cover a variety of factors including infrastructure, trade, finance, regulations, taxes and business licensing, corruption, crime and informality, innovation, labor, and perceptions about obstacles to doing business.

A stratified sampling methodology is employed in the Enterprise Survey. Three levels of stratification are used: sector of activity (industry), firm size and region. To limit the survey to only firms in the formal sector, however, the sample frame includes only firms with at least 5 employees. Firms with 5 to 19 employees are categorized as small, while those with 20 to 99 employees are medium and those with at least 100 employees are classified as large. The locations or regions selected for the survey in each country are usually the main urban centers, where most of the non-agricultural activity is concentrated.

This study utilizes Enterprise Survey data from nine Sub-Saharan Africa countries representing Eastern, Southern, and Western Africa respectively. Ethiopia, Kenya and Rwanda represent Eastern Africa, Zambia and Zimbabwe stand in for Southern Africa while Cameroon, Côte d'Ivoire, Ghana and Senegal represent West Africa. The countries were purposively sampled to represent the four regions of Sub-Saharan Africa. The survey data cuts across different phases between 2006 and 2019. The intervals between phases differ between and within countries, with some countries having longer survey intervals than others, and crucially, some phases being shorter than others within the same country. Given the varied nature of the countries' panels, an overall pseudo-panel dataset comprising of 11,085 firms from 9 countries is constructed (Table 1). Though the data is a pseudo-panel, we used it as a pooled cross-sectional dataset as the number of observations varies greatly across years and countries. More importantly, some of the variables are not uniform across years and countries. Thus, the number of observations used for actual estimation varies greatly across the type of analysis. For the descriptive analysis section, a more inclusive and larger number of observations is used. But for the econometric section, fewer observations are used due to missing values for some of the dependent and independent variables. A clean and full dataset for econometric analysis was obtained for only 5,500 firms out of the 11,085 total number of firms.

Table 1: *List of countries by survey year*

Country	Year of WBES* data collection	No. of firms
Cameroon	2006, 2009, 2016	856 (153, 359, 344)
Côte d'Ivoire	2009, 2016	877 (524, 353)
Ethiopia	2011, 2015	1,482 (634, 848)
Ghana	2007, 2013	1,205 (494, 711)
Kenya	20017, 2013, 2018	2,405 (656, 757, 992)
Rwanda	2006, 2011, 2019	811 (212, 239, 360)
Senegal	2007, 2014	1,083 (506, 577)
Zambia	2007, 2013	1,196 (483, 713)
Zimbabwe	2011, 2016	1,170 (583, 587)
Total		11,085

Source: Authors' estimation based on WBES (2020). The numbers in the brackets include the number of sample firms in each year and the number ouside of the bracket is the total number of samples.

The distribution of firms by size in each of the survey countries is presented in Table 2. The sample covers a wide range of industries, which were stratified into seven categories as illustrated in Table 3.

Table 2: *Firm distribution by size and country*

Country/Firm size	Small	Medium	Large	Total
Ghana	834	281	90	1,205
Ethiopia	717	455	310	1482
Cameroon	459	242	155	856
Rwanda	461	254	96	811
Zambia	733	347	116	1,196
Senegal	825	188	70	1,083
Côte d'Ivoire	551	230	96	877
Kenya	1,044	847	514	2,405
Zimbabwe	558	375	237	1,170
Total	6,182	3,219	1,684	11,085

Source: Authors' estimation based on WBES (2020)

Table 3: *Firm distribution by size and industrySource: Authors' estimation based on WBES (2020)*

Industry	Firm size			
	Small	Medium	Large	Total
Food processing	649	507	369	1,525
Non-food manufacturing	1832	1,238	793	3,863
Construction	159	128	78	365
Trade (retail and wholesale)	2,061	655	163	2,879
Transport & Communication	207	142	122	472
Hospitality (hotel, restaurants)	696	369	95	1160
Other services including IT	586	175	60	821
Total	6,190	3,214	1,680	11,085

Source: Authors' estimation based on WBES (2020)

The firms are further grouped into age categories based on the time of the survey. An individual firms' age is calculated by subtracting the variable 'the year a firm began operations' from the survey year. For firms with no data on 'when operations began' but with data on 'when the firm was formally registered', their age is calculated based on the latter information. The study adopts three age-categories: Start-ups (≤ 5 years), Emerging stage (6 -15 years), and Maturity stage (> 15 years). Distribution of sample firms by age and country is shown in Table 4.

Table 4: *Distribution of firms by age-category in each countryEMPIRICAL ESTIMATION STRATEGY*

Country	Age Category			
	Start-up firms	Emerging firms	Mature firms	Total
Ghana	224	576	405	1,205
Ethiopia	371	718	393	1,482
Cameroon	94	331	430	856
Rwanda	282	350	179	811
Zambia	258	576	362	1,196
Senegal	213	513	357	1,083
Côte d'Ivoire	262	350	265	877
Kenya	367	800	1,238	2,405
Zimbabwe	118	217	835	1,170
Total	2,189	4,431	4,464	11,085

Source: Authors' estimation based on WBES (2020)

4 EMPIRICAL ESTIMATION STRATEGY

4.1 Measuring firm level innovation

To analyze the patterns and trends of firm innovations, the study generates six innovation indicators based on firms' intention (innovation inputs), invention and protection of innovations (Table 5). The four types of inventions such as product, process, organizational and marketing innovations are intertwined with one intention indicator such as investment in R&D, and protection of intellectual property rights.

The first indicator represents the firm's intention to innovate as evidenced by the firm's engagement in innovative activities by employing inputs and knowledge for innovation. These activities are broadly categorized as: R&D source and expenditure; capacity building of human resources; purchase or licensing of inventions and other knowledge forms; and application of patents, trademarks and other intellectual property (Cirera 2015). Key innovative activities in the data are captured using a number of questions enquiring about the firm's response to questions related to the soft or intangible R&D inputs. However, the study also makes the assumption that acquisition of tangible assets is an expression of a firm's willingness and commitment to innovate. A variable for expenditure on equipment and machinery for the last fiscal year is therefore included (Table 5).

The other four indicators (from 2 to 5) measure a firm's ability to invent and represent innovation outcomes in the form of new or significantly improved products and services, processes, organizational and marketing approaches that are new to the firm or market. The sixth indicator measures other innovation outcomes including Intellectual Property (IP). Legal protections in the form of registered patents, trademarks, designs and copyrights are incorporated into this variable. This is guided by the fact that such IPs would cut across product and process innovation and represent the final product of the innovation process (on approval and conclusion of the applications process). These protections show the firm's determination to safeguard the property rights of the innovations developed.

The last column of Table 5 presents data for estimating the value of the indicators which are captured from the Enterprise Survey questions that measure various metrics. The data on R&D investments, product innovation and process innovation indicators are directly captured in "Section H – Innovation: introduction of product or process innovation, R&D" of the WBES questionnaire. Section H has been the principal focus in most innovation studies. However, in this study, the six innovation indicators are measured more broadly using multiple questions/ metrics (see Table 5). A general binary variable is constructed for each indicator, such that it takes a value of '1' if a firm responded positively to a given metric, and '0' if otherwise.

Table 5: A broader definition of innovation indicators and their metrics Source: Authors

Innovation indicators	Description	Metrics used to construct the values of the indicators
Investment in R&D	Firm's intention to innovate and willingness to invest in innovating new products	• Expenditure on equipment and machinery • Incentive to employees (time) to conduct R&D • Formal R&D expenditure • Different types of trainings
Product innovation	New, and/or significantly improved products or services	• Development of new or significantly improved products • Development of products or services that are new to the firm's main market
Process innovation	New and/or significant improvements in production and delivery methods	• Any new or significantly improved processes, logistical improvements on business processes or logistical improvements on distribution processes, • Any new or significantly improved methods of manufacturing goods or offering services
Organizational innovation	New organizational method in business practices, workplace organization, or external relations.	• Structural changes seen in organizational structure, responsibilities or line of command • Changes in procedures, such as routines, processes, and operations
Marketing innovation	Changes aimed at strengthening firm's competitive edge	• New or improved marketing methods
Protecting Intellectual property right	Firm's investment towards legal protections including design and product patents, trademarks and copyright licences	• Patent registered • Patent license • Industrial design license • Trademark license • Copyright license

Source: Authors

4.2 Estimating drivers of innovation

In this study we aim to identify critical drivers of firm-level innovation with special emphasis on business environment related factors such as access to energy, markets and finance. We also assess how such obstacles affect the likelihood to innovate. We use the following model to estimate the relationship between these obstacles and the likelihood to innovate while controlling for firm characteristics:

$$Innovation_i = \beta_0 + \beta_1 Medium + \beta_2 Large + \beta_3 ManagerExperience + \beta_4 Quality\ Certification + \beta_5 Exports + \beta_6 SOE + \beta_7 ForeignOwned + \beta_8 Employment + \beta_9 Legally\ Incorporated + \beta_{10} Gvt\ Intervention/Obstacle + \varepsilon_i$$

The variable $Innovation_i$ captures the different innovation indicators, for firm *i*, that are used in the study i.e., product innovation, process innovation, and research and development as defined in Table 6. The definition of innovation indicators in Table 6 is narrower than the one presented in Table 5 as the broader definition of innovation doesn't allow for adequate variability among firms. Table 6 also shows all variables used in the model. Since the innovation variables are binary, we estimated the above model using the probit regression model for each innovationvariable separately.

In this study we focus on business obstacles as a major driver of firm-level innovation in African contexts. Two sets of business enabling environment

indicators are identified (Table 6). The first group includes business operation obstacles related to power outages, electricity and access to finance. The second group includes government support for firms to access secured markets such as contracts for inputs or outputs. The variables measuring electricity constraints (i.e., power outages, number of power outages, power outage duration, and electricity as a major obstacle) are used as alternative measures. They are therefore entered separately into the regression models. Table 6 shows the definition of these business environment variables. In addition to these policy variables, control variables related to firm characteristics are included in the estimation (See Table 6).

There is a possibility of reverse causality in the sense that innovation may drive the variation in some of the independent variables. For example, innovation may drive firm size as firms expand following innovation. More innovative firms are also likely to be more profitable and to have access to finance. This means that innovation may drive access to finance. These problems of endogeneity are difficult to address using cross section data. Results from this study must therefore be cautiously interpreted.

Table 6: *Variable Definitions*

Variable	Definition
Innovation variables / Narrow definition	
Product innovation	Dummy variable taking a value of '1' if firm introduced a new or improved product/service in the last 3 years, '0' if otherwise
Process innovation	Dummy variable taking a value of '1' if firm introduced a new or improved process during the last 3 years, '0' if otherwise
Research and development	Dummy variable taking a value of '1' if firm spent on research and development during the last 3 years, '0' if otherwise
Core innovation index	Dummy variable taking a value of '1' if firm introduced a new product or a new process in the past 3 years, '0' if otherwise
Firm characteristics	
Age of the firm	The age of the firm measured from year of establishment to survey year
Firm's participation in GVC	Dummy variable taking a value of '1' if firm exports some of it goods, '0' if otherwise
Firm's number of employees	Number of employees at 3 years prior to the survey
Foreign ownership	Dummy variable taking a value of '1' if part of the firm is foreign owned, '0' if otherwise
Small enterprise	Dummy variable taking a value of '1' if the firm has less than 20 employees, '0' if otherwise
Medium enterprise	Dummy variable taking a value of '1' if the firm has between 20 to 100 employees (inclusively), '0' if otherwise.
Large enterprise	Dummy variable taking a value of '1' if the firm has 100 or more employees, '0' if otherwise
Legal incorporation	A dummy variable taking a value of '1' if firm is legally incorporated, '0' if otherwise
Manager's years of experience	Top manager's years of experience working in the same the sector
Quality certification	Dummy variable taking a value of '1' if firm has an international recognized quality certification (ISO 9000, 14 000, or HACCP) , '0' if otherwise
State-owned enterprise (SOE)	State-owned enterprise dummy taking a value of '1' if part of the firm is government owned, '0' if otherwise

Variable	Definition
Business obstacles	
Power outages	Dummy variable taking a value of '1' if the firm experienced electricity outages in the past fiscal year
Number of power outages	Number of power outages in a typical month
Power outage duration in hours	Average duration of electricity outages in a typical month
Electricity as a major obstacle	Dummy variable taking a value of '1' if firm considers electricity to be a major or severe obstacle, '0' if otherwise
Secured/Attempted to secure Government Contract	Dummy variable taking a value of '1' if the firm secured a government contract a year prior to the survey, '0' if otherwise
Finance as obstacle	Dummy variable taking a value of '1' if firm considers access to finance to be a major or severe obstacle, '0' if otherwise

Source: Authors

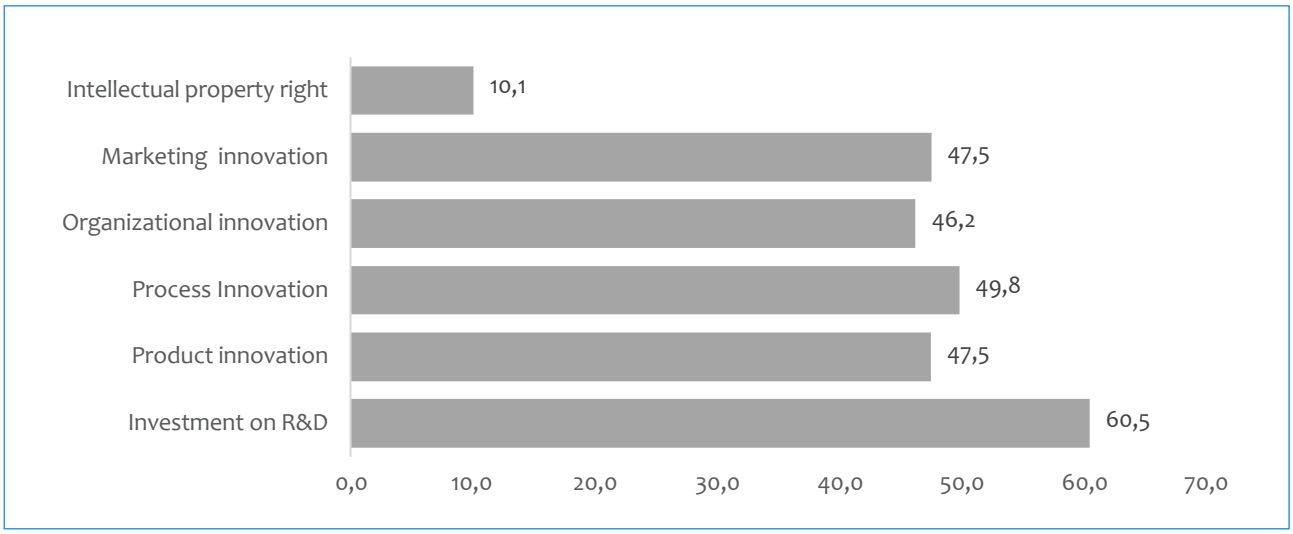
5 RESULTS AND DISCUSSION

5.1 Innovativeness of African firms

Based on the sample of 11,085 firms from the nine countries, the study estimated the percentage of firms engaged in the six innovation indicators listed in Table 5 (Figure 1). As mentioned earlier, the first one indicates the firm's readiness and willingness to innovate by investing in research and development. Overall, 60% of the sample firms are invested in R&D either through allocating funds for R&D or by providing training and incentives for their employees.

With regards to the actual level of innovation (2-5 in Table 5), less than 50% of the firms are involved in either of the four types of innovations. Close to 50% of firms are involved in process innovation, while only 46% of the firms are involved in organizational innovation. The number of firms which have tried to protect intellectual property, a sign of the firm's aspiration for innovation, is very low. Only 10% of the firms from Kenya and Cameroon reported their efforts to protect intellectual property rights (Figure 1). It appears that a majority of African firms are in the initial stages of investing in R&D and only a few have reached the level of investing in property rights protection or patenting. This might be because of the broader definition of R&D investment. Majority of the firms engage in staff training and purchase of equipment and machinery, which we included as part of the R&D indicator besides the formal spending on research and development of products. Roughly only 13% of African firms formally invest in R&D.

Figure 1: *Percentage (%) of firms innovating by different types of innovation in Africa*



Source: Authors' estimation based on WBES (2020)

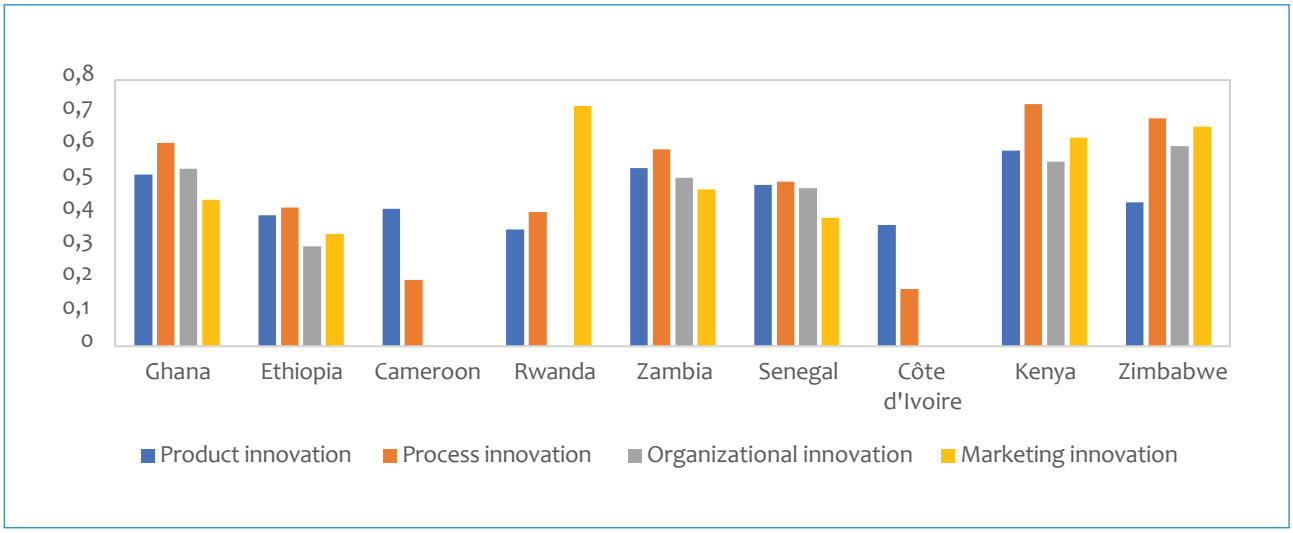
5.2 Firm innovativeness across countries

Figure 2 presents the type of innovation and the percentage of firms innovating in selected African countries. Overall, firms in Ghana, Kenya and Zimbabwe appear to be more innovative than others. More than 50% of firms in these countries reported at least three types of innovations. For example, about 73% of the firms in Kenya have reported process

innovation, while 61% and 68% of firms in Ghana and Zimbabwe respectively, reported the same type of innovation.

Firms in Ethiopia, Senegal and Zambia reported all four types of innovations, but less than 50% of the firms are able to innovate. In other countries such as Cameroon and Côte d'Ivoire, firms reported only on the two core innovations (product and process innovations). These countries have the lowest number of firms engaged in core innovations. Firms in Rwanda reported organizational innovation besides the core innovations, and the percentage of firms there engaged in organizational innovation is higher than in most of the other countries.

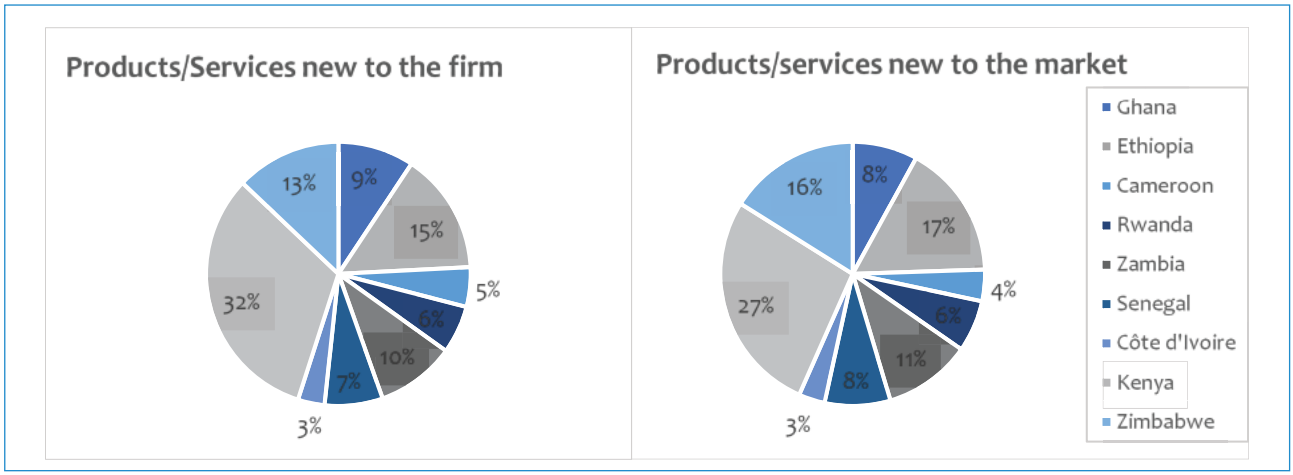
Figure 2: *Share of firms with innovation across African countries*



Source: Authors' estimation based on WBES (2020)

As mentioned before, product innovation is measured as a dummy variable indicating whether a firm developed its own product (new to the market) or adopted an already existing product in the market (new to the firm). To distinguish whether firms are actually inventing new products or imitating existing ones, each product innovation indicator is assessed separately, and firms with inventions that are also new to the market are deemed more innovative than their counterparts with inventions only new to the firm. Figure 3 shows the distribution of firms innovating products/services that are new to the firm and to the market respectively, in the sample countries. Firms in Ethiopia, Senegal, Zambia and Zimbabwe show a higher level of innovation with more firms developing products and services that are new to the market, while many firms in Kenya and the other sample countries mainly engage in copying or adopting already existing innovations.

Figure 3: *Share of firms inventing and imitating*

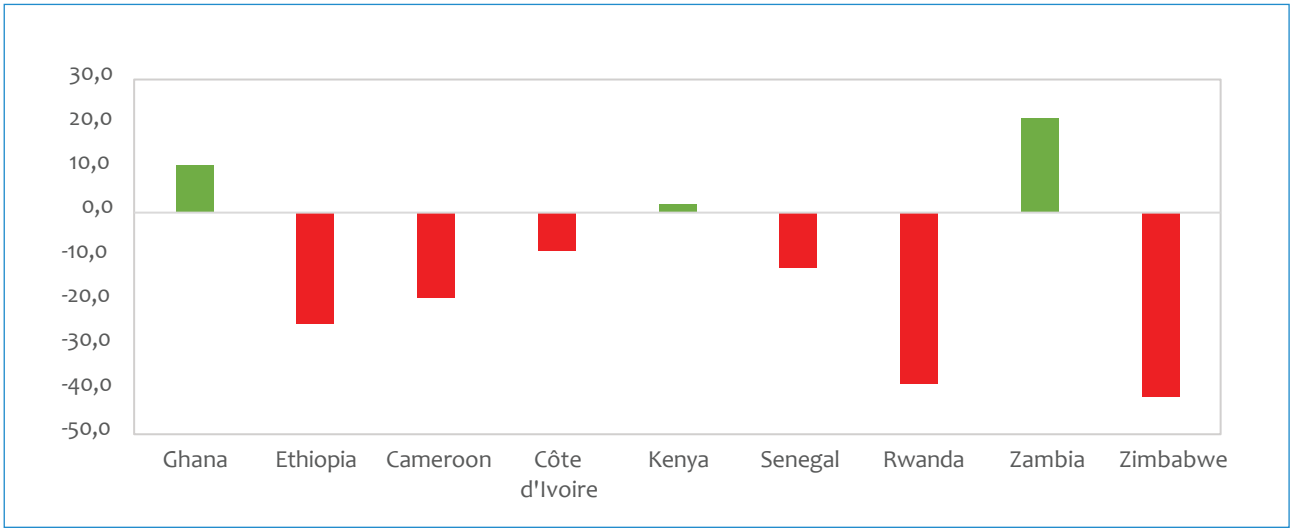


Source: Authors' estimation based on WBES (2020)

5.3 Firm innovativeness over time

We assessed the number of firms investing in R&D over the most recent surveys per country to examine the trends around the firms' desire to innovate and induce competitiveness. Surprisingly, the percentage of firms investing in R&D has declined in six countries (Cameroon, Côte d'Ivoire, Ethiopia, Rwanda, Senegal, and Zimbabwe) over the two consecutive surveys (Figure 4). This is an important concern that requires closer examination from both research and policy perspectives. Only three countries, namely Ghana, Kenya and Zambia, had firms that were able to increase investing in R&D over the two survey periods.

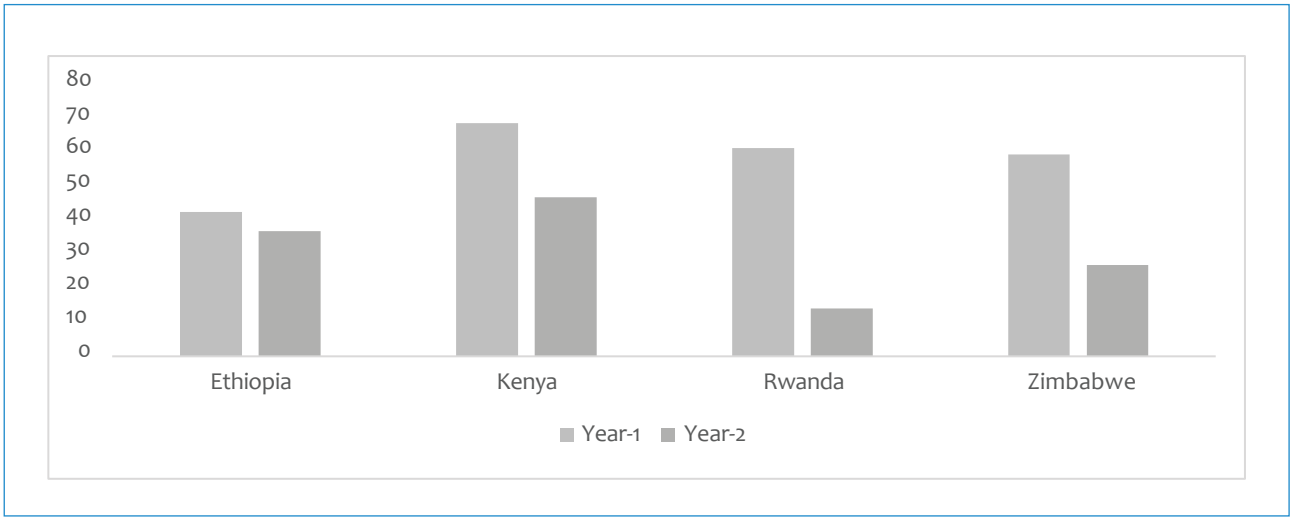
Figure 4: *Changes in percentage points of firms investing in R&D between the two recent surveys*



Source: Authors' estimation based on WBES (2020)

Unfortunately, the reduction in the extent of innovation is more widespread than the reduction in investing in R&D. Figure 5 presents the percentage of firms inventing product innovations in two consecutive survey years for four countries for which data was sufficient. In all four countries, the probability of firm invention has declined. This has happened even for Kenya whose probability of investing in R&D had showed a slight increase over time (Figure 4). This means that the reductions of investment in R&D has translated into reductions in invention of technologies.

Figure. 5. *The percentage of firms innovating over years (Product innovation)*

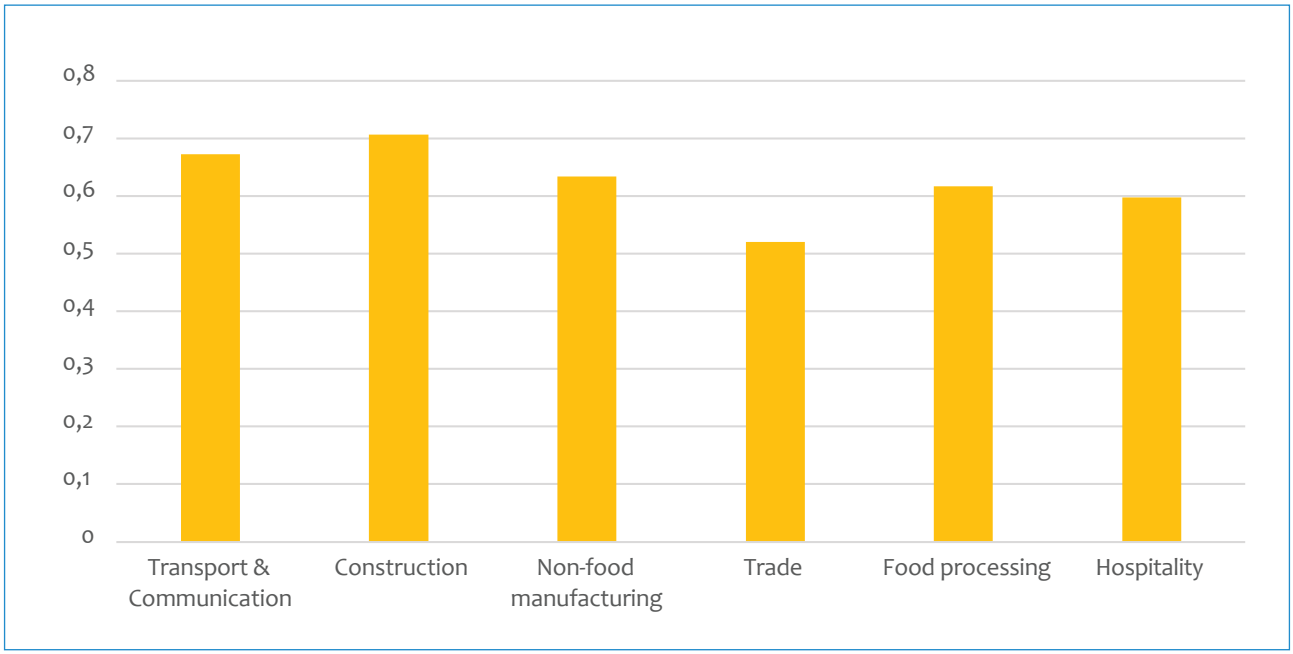


Source: Authors' estimation based on WBES (2020)

5.4 Firm innovation across industries

Figure 6 shows the frequency of firms investing in R&D across broadly classified industries. Firms in transport and communication as well as construction appear to be more willing to innovate than firms in other industries. Quite a significant number of firms (61-63%) in the manufacturing sector (both food and non-food) are also investing in R&D to acquire knowledge that would lead to innovation. However, there is no significant difference across industries especially with regards to investment in R&D. Given the emerging demand for more processed and higher quality products in Africa, manufacturing industries should have been better prepared to meet these demands. However, advances to meet this expectation were not clearly seen in the data.

Figure 6. *Proportion of firms investing in R&D by industry*



Source: Authors' estimation based on WBES (2020)

We further assessed the actual differences in innovation differences across industries and countries using the probability of a firm adopting a process innovation which is a more widely reported innovation indicator than others. The purpose of this was to examine the type of industries which are innovative in each country. However, as seen in Table 6, no industries emerged as dominantly innovative in any of the countries. While many Kenyan firms are inventing, these firms are close to equally distributed across all sectors. The transport and communication industry has a relatively higher number of innovative firms. While the food processing sector is more innovative in Cameroon, Ethiopia and Zimbabwe, non-food manufacturing industries are more innovative in Senegal.

Table 7: *The proportion of firms adopting process innovation across countries and industries*

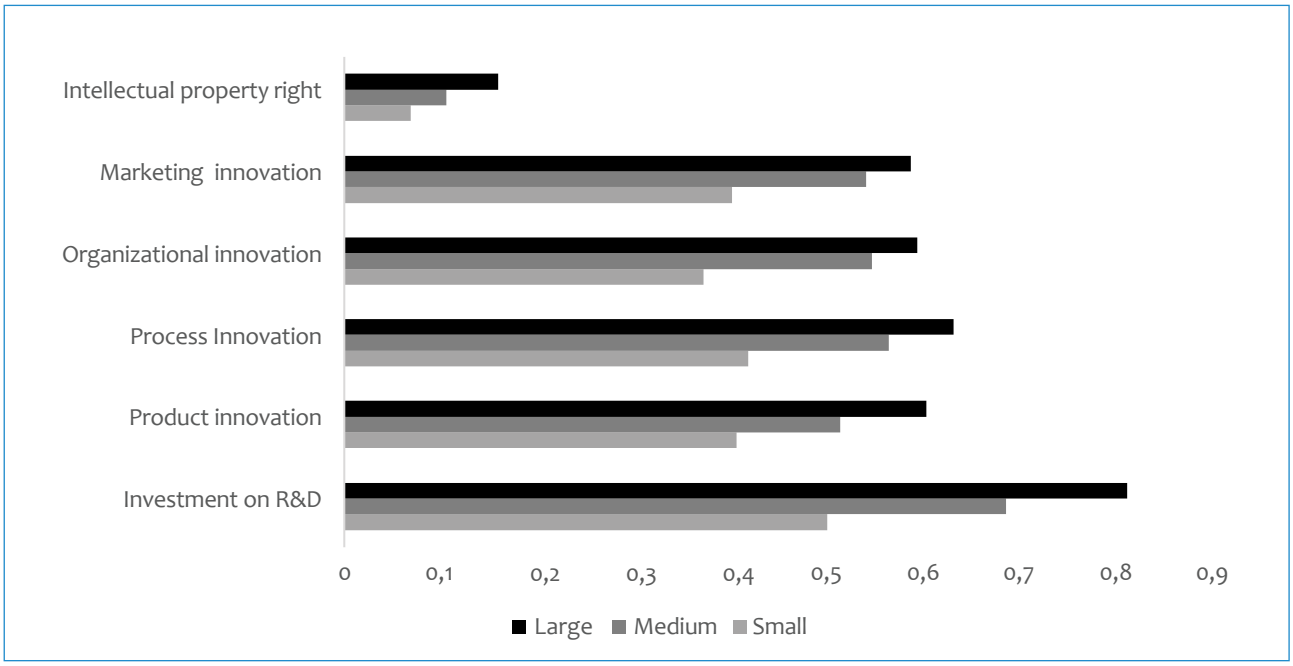
Industry	Cameroon	Côte d'Ivoire	Ethiopia	Ghana	Kenya	Rwanda	Senegal	Zambia	Zimbabwe
Food processing	0.32	0.14	0.55	0.61	0.78	0.30	0.52	0.62	0.83
Non-food manufacturing	0.27	0.21	0.50	0.65	0.73	0.51	0.59	0.65	0.66
Construction	0.06	0.11	0.29	0.67	0.83	0.63	0.44	0.53	0.57
Trade (retail and wholesale)	0.11	0.14	0.30	0.55	0.66	0.36	0.39	0.55	0.61
Transport & Communication	0.13	0.25	0.30	0.33	0.85	0.63	0.52	0.71	0.78
Hospitality	0.24	0.33	0.46	0.71	0.77	0.36	0.50	0.49	0.70
Other services	0.13	0.13	0.41	0.56	0.66	0.34	0.56	0.55	0.68

Source: Authors' estimation based on WBES (2020)

5.5 Innovation by firm size

The firms in the sample are distributed as follows: small- and micro-enterprises (55.8%), medium-sized firms (29%), and large firms (15.2%). As seen in Figure 7, large firms are more likely to innovate than small- and medium-sized firms. This pattern is consistent across all innovation indicators and can be attributed to larger firms having grown over time, thereby accumulating sufficient resources to cover the high fixed costs and investment required for invention of new products and services. Furthermore, large firms are more likely to have access to external sources of funds that enable them to engage in diverse projects that are likely to yield innovative outputs.

Figure 7. *Proportion of firms innovating by size*



Source: Authors' estimation based on WBES (2020)

5.6 Innovation by type of enterprises

Based on the legal status of the firms, five categories are identified: publicly listed companies, limited liability companies, sole proprietorship, general partnership, limited partnership, and other firms. Although the distribution of innovation indicators among the different types of firms does not follow a distinct pattern, it is clear that innovation ranks lower in sole proprietorship firms (Table 8). The low engagement of sole proprietorships in innovation could be attributed to resource constraints as the majority (73.9%) also fall within the category of small-firms. Public enterprises and limited partnerships seem to be more innovative than others. Public enterprises show higher probability for innovation in four of the eight indicators. Similarly, limited partnerships show higher probability for innovation in three of the eight indicators (Table 8).

Table 8: *Percentage of firms innovating across enterprise types*

Innovation indicators	Publicly Listed	Limited Liability	Partnership	Limited Partnership	Sole Proprietorship
Investment in R&D	74.79	67.90	62.36	73.90	50.15
Product innovation	49.45	53.87	46.38	60.27	38.99
Process innovation	44.99	54.82	54.13	68.11	40.38
Marketing innovation	68.48	59.07	45.72	58.30	38.07
Organizational innovation	75.00	64.21	41.90	56.62	35.34
Intellectual property	18.92	9.57	10.43	8.31	10.51

Source: Authors' estimation based on WBES (2020)

5.7 The extent of business obstacles in Africa

Table 9 presents the proportion of firms facing obstacles in the form of emergencies and financial access in their business operations across the sample countries. At 0.91, Cameroon had the largest proportion of firms stating that they had power outages in the previous month, and Rwanda, at 0.39, had the smallest proportion of firms stating that they had power outages in the previous month. Ethiopia and Zimbabwe, at 15.23 and 6.50 respectively, had the largest and smallest average number of power outages in a typical month. In terms of constraints imposed by the electricity problems, we found that Côte d'Ivoire and Rwanda, at 0.62 and 0.08 respectively, had the largest and smallest proportion of firms that stated that they consider electricity to be a major obstacle. Regarding the securing of government contracts, we found that Cameroon (0.18) and Ethiopia (0.32) had the smallest and largest proportion of firms that attempted to secure a government contract.

Table 9: *Proportion of firms facing business obstacles and innovating in sample countries*

Variables	Côte d'Ivoire	Kenya	Zambia	Zimbabwe	Senegal	Rwanda	Ghana	Ethiopia	Cameroon
Power outages	0.825	0.886	0.825	0.783	0.825	0.389	0.900	0.869	0.908
Number of power outages	6.617	6.731	14.326	6.495	6.617	10.867	11.070	15.230	10.136
Power outage duration in hours	6.784	7.895	8.351	5.489	6.784	1.770	0.629	8.050	11.063
Electricity as major obstacle	0.618	0.248	0.574	0.245	0.618	0.081	0.220	0.424	0.487
Finance as major obstacle	0.609	0.239	0.384	0.518	0.609	0.151	0.617	0.293	0.463
Attempt to secure market	0.203	0.238	0.227	0.190	0.203	0.225		0.320	0.177
Secured market		0.160	0.467	0.579		0.409			
Product innovation	0.365	0.468	0.333	0.269	0.142	0.476	0.515	0.370	0.407
Process innovation	0.177	0.263	0.138	0.148	0.081	0.351	0.385	0.206	0.149
Investing in R&D	0.102	0.193	0.119	0.134	0.053	0.072	0.222	0.081	0.105

Source: Authors' estimation based on WBES (2020)

Table 9 also presents descriptive statistics on innovation by country. About 47% of firms in Kenya stated that they had introduced a new product, 26% stated that they had improved processes and about 20% had invested in research and development. At 0.51, Ghana had the largest proportion of firms that had introduced a new product while Rwanda, at 0.14, had the smallest proportion. Table 6 presents the descriptive statistics for the control variables.

5.8 The effects of business obstacles on firm innovation

Table 10 presents the summary of the main regression results from the study. The results show the effects of government assistance or obstacles to business operations on the likelihood to innovate using three main innovation measures: product innovation, process innovation and investing in research and development. The full estimates for each innovation variable are recorded in the Annexes (Annex 1a-1c). Given that the policy variables (both business operation obstacles and government support) may be highly correlated, they are entered into the regressions separately.

The results show that when using the introduction of a new product as an innovation measure, firms that were affected by power outages were more likely to innovate. Those that found electricity to be a major obstacle were also more likely to innovate. The same applies to those that considered access to finance as a major obstacle. Securing a government contract was also found to positively influence the likelihood to innovate. The number and duration of power outages were found to be insignificant drivers of innovation.

The fact that firms which experience power outages are more likely to innovate suggests that they are probably being forced to innovate in self-generation of electricity. It is also possible that such firms are being induced to introduce new processes to cater for power outages or any other obstacles that they

may face. More generally, firms in Africa seem to be innovating to cope with the challenges emanating from the various obstacles they face, rather than for competitiveness, which undermines the economy-wide benefits of firm innovation. The result is consistent with the impact of innovation on labor productivity being negative as presented in Section 4.

The positive and significant effects of secure markets (through government contracts) on innovation suggests that firms may be encouraged to introduce new processes or products to cater for government requirements and utilize the markets created. Securing government contracts may also avail resources required for innovation. This finding however contradicts the puzzling positive relationship between financial constraints and (product and process) innovation.

Table 10. *The effect of business obstacles (energy, finance and market) on the likelihood of firms to innovate* [1]

VARIABLES	Product innovation	Process innovation	Investment in R&D
Business obstacles			
Power outages, past year	0.486***	0.381***	0.303***
	(0.054)	(0.061)	(0.078)
Number of power outages	0.002	0.000	0.002
	(0.002)	(0.002)	(0.002)
Power outage duration	0.001	0.001	-0.004
	(0.001)	(0.001)	(0.003)
Electricity as a major obstacle	0.241***	0.247***	0.196***
	(0.040)	(0.043)	(0.056)
Finance as a major obstacle	0.067*	0.118***	0.036
	(0.040)	(0.043)	(0.056)
Secured government contract	0.319***	0.292***	0.374***
	(0.047)	(0.049)	(0.063)
Control variables			
Medium enterprise (0=small)	0.000	-0.199***	0.002
	(0.044)	(0.056)	(0.064)
Large enterprise (0=small)	0.047	-0.060	0.179**
	(0.062)	(0.073)	(0.082)
Manger's years of experience	0.004**	0.001	-0.000
	(0.002)	(0.002)	(0.003)
Quality certification	0.153**	0.336***	0.538***
	(0.065)	(0.077)	(0.075)
Participation in GVC	0.161***	0.059	0.116
	(0.060)	(0.073)	(0.077)
Number of employees	0.000**	0.000	0.000
	(0.000)	(0.000)	(0.000)
State-owned enterprise (SOE)	-0.250	-0.307	0.297
	(0.189)	(0.259)	(0.210)
Foreign ownership	0.017	-0.032	-0.073
	(0.056)	(0.070)	(0.074)
Legal incorporation	-0.018	0.139**	0.147**
	(0.050)	(0.060)	(0.063)

1 Please note that to save space the variables measuring business obstacles were entered separately in each innovation regression model. All of them were therefore not entered simultaneously.

Constant	-0.825***	-1.086***	-1.497***
	(0.060)	(0.066)	(0.085)
Observations	4,377	4,373	3,393
Log-Likelihood Full Model	-2851	-2336	-1336
Chi-square test	139.2	102.8	129.7
Pseudo R-squared	0.0238	0.0215	0.0463

Source: Authors' estimation based on WBES (2020): Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1;

When it comes to the control variables, we found that the top manager's years of experience, quality certification and direct exports were positively related to the likelihood to innovate. This suggest that increased years of experience, through learning by doing can enhance human capital which helps stimulate innovation. Firms that export may also learn by doing as they compete with other international players.

Similar to previous studies (e.g Ayyagari et al, (2011)), larger firms were found to be more likely to innovate compared to small firms. This indicates that size is important when it comes to innovation. For example, larger firms may have more market power than smaller firms (which may yield higher profit levels), economies of scale and more resources, all of which can encourage such firms to innovate.

6 CONCLUSION AND RECOMMENDATIONS

This study explores the concept of firm level innovation and its development over time. The study team undertakes descriptive analysis on the patterns and trends of innovation among firms of different categories. Key emphasis is given to an approach that assesses innovation from the perspectives of intention, invention and protection resulting in six innovation indicators. Overall, the study finds that the firms in Kenya, Ghana and Zimbabwe are more innovative than others, with over 50% of firms in each of these countries engaged in at least three innovation indicators. Information searching and investment in R&D are more prevalent among the sampled firms.

High levels of firm engagement in adoption of process technologies, and investment in R&D is evident across all firm types and countries. Adoption of process technologies, which indicates the readiness of firms to innovate by adopting, adapting, and imitating emerging technologies through information searching is considered a resource-light endeavor and is therefore being embraced by a large number of firms. With the increasing mobile phone and internet connectivity in Sub-Saharan Africa, more opportunities for firms to adopt process technologies still exist. More strategic attention should be focused on guiding and supporting such firms to maximize on these lower-cost investments to increase returns and boost innovation opportunities.

Although a generally high probability of firm investment in R&D is observed across all countries, a declining trend is observed in the recent surveys for six countries, indicating a further decline in innovation outputs. This trend calls for interventions that will stimulate firm investment in R&D. These may include tax incentives, and direct grants to firms as well as redesigning higher education systems so as to incorporate more technical, and problem-solving-oriented approaches. Whereas the former incentives will create an enabling environment for firms to invest in R &D, the latter will cushion the firms from high investments in employee training.

The levels of product and process innovations by firms are lower than expected across all countries and firm categories. These two indicators which signify intensity and novelty of the innovations by firms need to be boosted within the region. Approaches such as collaboration with R&D institutions, establishment of strategic alliances, co-creation and co-development, could be adopted so as to increase the level and uniqueness of innovations among firms in the region. This will in turn increase their chances of competing in the global market through introduction of products and services that are new in international markets, an aspect that is currently very low among African firms.

Low likelihood for innovation is observed among sole proprietorships, small firms, and medium-sized firms, an outcome that could be associated with the resource constraints characteristic of smaller firms. Large firms, and publicly listed firms are however, found to be more innovative. These firm categories indicate higher probabilities of investing in R&D and adoption of process technologies as well as engaging in marketing, organizational, product and process innovations. They however rank low in technology transfer, and protection of intellectual property. This group can be seen to represent the top innovators in the region, and interventions aimed at increasing and speeding up innovation in the region should

be more targeted to these firms. As seen in the study, numerous prospects surrounding firm level innovation exist in the region, calling for strategic policy directions such as interventions that support small, young and individually owned enterprises in the region. With the majority of firms in the region falling under these categories, tailor-made interventions will create an enabling environment to tap and harness the existing potential of these firms. This will further boost their level of innovativeness and ultimately the region's economic growth and development.

The study also assesses the effects of business obstacles (in the form access to electricity, finance and government contracts) on the likelihood to innovate using three main innovation measures: product innovation, process innovation and investing in research and development. The results suggest that firms which were affected by power outages were more likely to innovate. Those that found electricity to be a major obstacle were also found to be more likely to innovate. The same applies to those that considered access to finance to be a major obstacle. Securing a government contract was also found to positively influence the likelihood to innovate.

The fact that we find a positive relationship between obstacles and innovation indicates that firms in Africa seem to be innovating to manage the challenges emerging from the obstacles. Is it a positive outcome if African firms are innovating in order to provide their own infrastructural services (e.g., electricity, water, etc.)? This may not necessarily be so if one considers that such firms may be forced to spend their resources on non-core business activities. Furthermore, in most economies, electricity and water are provided by government regulated natural monopolies which may provide them at cheaper rates, with such benefits accruing to the firms. As such, the policy implication may not necessarily be that governments should provide less infrastructure. In fact, the opposite is true, African governments must provide reliable electricity, water and other infrastructural services so that African firms can focus on their core business activities.

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Annex 1a: Likelihood of Innovation when using New Product as the Innovation variable

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Medium	0.000	-0.044	-0.039	0.028	-0.000	0.071	0.022
	(0.044)	(0.051)	(0.055)	(0.044)	(0.044)	(0.068)	(0.044)
Large	0.047	-0.039	-0.032	0.080	0.049	0.194**	0.081
	(0.062)	(0.069)	(0.074)	(0.061)	(0.061)	(0.092)	(0.062)
manageryearofexperience	0.004**	0.004**	0.004	0.004**	0.005***	0.008***	0.005***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
qualitycertification	0.153**	0.193***	0.129	0.175***	0.175***	0.204**	0.175***
	(0.065)	(0.074)	(0.079)	(0.066)	(0.066)	(0.089)	(0.066)
directexportsdummy	0.161***	0.199***	0.232***	0.154**	0.157***	0.194**	0.149**
	(0.060)	(0.069)	(0.075)	(0.060)	(0.060)	(0.081)	(0.060)
emplattimet_2	0.000**	0.000**	0.000*	0.000**	0.000**	0.000	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
SOE	-0.250	-0.060	-0.058	-0.286	-0.344*	-0.641*	-0.292
	(0.189)	(0.224)	(0.243)	(0.188)	(0.190)	(0.353)	(0.189)
Foreignowned	0.017	0.031	0.010	0.005	0.026	-0.024	0.018
	(0.056)	(0.064)	(0.068)	(0.056)	(0.056)	(0.081)	(0.056)
legallyincorporated	-0.018	-0.051	-0.021	-0.015	-0.057	-0.042	-0.027
	(0.050)	(0.057)	(0.062)	(0.050)	(0.050)	(0.071)	(0.050)
any_power_outages_pastyr	0.486***						
	(0.054)						
number_of_poweroutages1		0.002					
		(0.002)					
power_outagedurationinhours			0.001				
			(0.001)				
electricity_major_obstacle				0.241***			
				(0.040)			
secured_attempted_gvt_contract					0.319***		
					(0.047)		
secured_gvt_contract						0.052	
						(0.065)	
finance_obstacle							0.067*
							(0.040)
Constant	-0.825***	-0.339***	-0.300***	-0.540***	-0.503***	-0.620***	-0.482***
	(0.060)	(0.051)	(0.053)	(0.044)	(0.042)	(0.065)	(0.045)
Observations	4,377	3,159	2,713	4,375	4,374	1,880	4,342
Log-Likelihood Full Model	-2851	-2130	-1836	-2872	-2866	-1210	-2867
Chi-square test	139.2	38	29.10	86.63	97.27	48.45	53.63
Pseudo R-squared	0.0238	0.00971	0.00847	0.0161	0.0176	0.0210	0.0104

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Annex 1b: Likelihood of Innovation when using Process Innovation as the Innovation variable

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Medium	-0.148***	-0.199***	-0.225***	-0.125***	-0.155***	-0.044	-0.121**
	(0.049)	(0.056)	(0.061)	(0.049)	(0.049)	(0.078)	(0.049)
Large	-0.014	-0.060	-0.086	0.010	-0.029	0.055	0.025
	(0.065)	(0.073)	(0.079)	(0.065)	(0.065)	(0.103)	(0.066)
manageryearofexperience	0.001	0.001	-0.000	0.001	0.002	0.005	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
qualitycertification	0.307***	0.336***	0.310***	0.321***	0.316***	0.399***	0.324***
	(0.068)	(0.077)	(0.082)	(0.069)	(0.068)	(0.093)	(0.068)
directexportsdummy	0.079	0.059	0.114	0.080	0.085	0.080	0.065
	(0.064)	(0.073)	(0.080)	(0.064)	(0.064)	(0.089)	(0.064)
emplattimet_2	0.000*	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
SOE	-0.381*	-0.307	-0.315	-0.403*	-0.474**	-0.405	-0.420*
	(0.211)	(0.259)	(0.279)	(0.220)	(0.217)	(0.401)	(0.219)
foreignowned	-0.023	-0.032	-0.016	-0.040	-0.016	-0.211**	-0.020
	(0.060)	(0.070)	(0.074)	(0.061)	(0.061)	(0.095)	(0.061)
legallyincorporated	0.101*	0.139**	0.179***	0.112**	0.073	0.274***	0.105**
	(0.053)	(0.060)	(0.065)	(0.053)	(0.053)	(0.077)	(0.053)
any_power_outages_pastyr	0.381***						
	(0.061)						
number_of_poweroutages1		0.000					
		(0.002)					
power_outagedurationinhours			0.001				
			(0.001)				
electricity_major_obstacle				0.247***			
				(0.043)			
secured_attempted_gvt_contract					0.292***		
					(0.049)		
secured_gvt_contract						-0.011	
						(0.073)	
finance_obstacle							0.118***
							(0.043)
Constant	-1.086***	-0.696***	-0.673***	-0.882***	-0.838***	-1.065***	-0.842***
	(0.066)	(0.055)	(0.057)	(0.047)	(0.045)	(0.073)	(0.049)
Observations	4,373	3,155	2,706	4,370	4,370	1,881	4,338
Log-Likelihood Full Model	-2336	-1753	-1511	-2340	-2334	-902.7	-2339
Chi-square test	102.8	49.94	50.46	87.21	90.82	56.33	63.54
Pseudo R-squared	0.0215	0.0151	0.0173	0.0195	0.0198	0.0321	0.0144

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Annex 1c: Likelihood of Innovation when using Research and Development as the Innovation variable

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
medium	0.002	0.036	0.027	0.016	-0.006	0.004	0.016
	(0.064)	(0.072)	(0.078)	(0.063)	(0.063)	(0.085)	(0.063)
large	0.179**	0.159*	0.195**	0.190**	0.174**	0.185*	0.194**
	(0.082)	(0.091)	(0.099)	(0.080)	(0.080)	(0.106)	(0.080)
manageryearofexperience	-0.000	-0.002	-0.003	-0.000	0.000	0.004	0.001
	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)
qualitycertification	0.538***	0.550***	0.496***	0.567***	0.567***	0.538***	0.559***
	(0.075)	(0.086)	(0.094)	(0.076)	(0.077)	(0.096)	(0.076)
directexportsdummy	0.116	0.175**	0.242**	0.117	0.115	0.121	0.107
	(0.077)	(0.086)	(0.094)	(0.076)	(0.077)	(0.094)	(0.076)
emplattimet_2	0.000	0.000*	0.000	0.000*	0.000**	0.000	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
SOE	0.297	0.095	0.208	0.259	0.184	-0.157	0.255
	(0.210)	(0.273)	(0.284)	(0.212)	(0.221)	(0.369)	(0.214)
foreignowned	-0.073	-0.138	-0.206**	-0.086	-0.069	-0.044	-0.080
	(0.074)	(0.086)	(0.093)	(0.075)	(0.075)	(0.097)	(0.074)
legallyincorporated	0.147**	0.173**	0.223***	0.152**	0.103	0.125	0.136**
	(0.063)	(0.072)	(0.077)	(0.063)	(0.064)	(0.082)	(0.063)
any_power_outages_pastyr	0.303***						
	(0.078)						
number_of_poweroutages1		0.002					
		(0.002)					
power_outagedurationinhours			-0.004				
			(0.003)				
electricity_major_obstacle				0.196***			
				(0.056)			
secured_attempted_gvt_contract					0.374***		
					(0.063)		
secured_gvt_contract						0.206***	
						(0.077)	
finance_obstacle							0.036
							(0.056)
Constant	-1.497***	-1.206***	-1.133***	-1.333***	-1.333***	-1.359***	-1.269***
	(0.085)	(0.069)	(0.078)	(0.060)	(0.058)	(0.080)	(0.062)
Observations	3,393	2,490	2,116	3,389	3,392	1,876	3,365
Log-Likelihood Full Model	-1336	-1032	-875.4	-1339	-1325	-764.8	-1341
Chi-square test	129.7	97.02	89.27	132.9	156.4	74.35	118.7
Pseudo R-squared	0.0463	0.0425	0.0478	0.0451	0.0530	0.0452	0.0407

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

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