Adoption of Innovations and Productivity of Enterprises in French-Speaking Sub-Saharan Africa: Case of Cameroon, Senegal and Ivory Coast

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Bringing Rigour and Evidence to Economic Policy Making in Africa

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Abstract

The productivity of firms is the result of many factors, including their ability to innovate. For most authors, innovation can be diversified into product, process, organization and marketing innovation. The objective of this work is to highlight the impact of the adoption of innovations on firms' productivity in Cameroon, Senegal and Ivory Coast. This work is based on the survey "Determinants of firms' performance in Francophone Sub-Saharan Africa: The case of Cameroon, Ivory Coast and Senegal" conducted among 1,897 companies (639 in Cameroon, 723 in Senegal and 535 in Ivory Coast) in 2014 by the International Development Research Centre (IDRC). This work uses a methodology consisting of two blocks of equations with a repeating structure. By estimating these equations using the bivariate probit and Double Least Squares (DLS) methods, the study finds that technological and non-technological innovations are complementary and have important effects on productivity of firms. This complementarity is proof that technological innovation contributes better to productivity when it is accompanied by non-technological innovation and vice versa. However, the introduction of new products (or services) accompanied by new methods of organization and marketing have a greater effect on the productivity of enterprises.

Key words: Adoption of innovations; Enterprises; Francophone Sub-Saharan Africa; Productivity

JEL classification: Q55; O55 ; P12; J24; D 24; O14

1. Introduction

The new global economic vision and competition from new emerging markets is shifting the focus from production towards more sophisticated products with high technological content. It makes the capacity for innovation the fundamental element of competition. In this new era, economic systems are under increasing pressure, which finds its originality in the complexity of cross-border networks of flows of knowledge, ideas and technologies. Integrating the race for innovation through the appropriation of these flows of technology and knowledge becomes a vital issue for businesses and nations. This innovation, which can be divided into technological innovation (product and process innovation) and non-technological innovation (organizational and marketing innovation), is a key factor in economic growth (Krugman, 1990). This business-level growth can be achieved by putting more inputs to produce or reach higher production levels with the same amount of resources. Innovation does not increase the quantity of these resources but affects growth through the total productivity of factors of production (Mohnen and Hall, 2013). This productivity is an indicator that describes the relationship between production and the factors needed to obtain it. To increase it, the firm will opt in some cases for the launch of radically new products and in other cases for the repositioning of a product in new markets or for the reformulation of a product. This can be either to have the benefit of a change in the cost of inputs or to better adapt it to the needs of its market. If these new activities classified as innovation are mainly adopted, firms will certainly expect productivity growth (Polder et al, 2010). In this regard, attention is given to innovation performance to assess the effect of innovation on firm productivity.

Although many theoretical and empirical studies have shown the importance of innovation in improving business productivity, innovation remains important for firms working in developing countries. This importance is much more pronounced in African countries in general and Francophone Africa in particular in that innovation has an impact on the structural transformation that leads to a dynamism of industrialization and development. One of the problems of these countries is that the economic fabric is both unattractive (Doing Business Ranking between the 147th and the 178th rank over nearly 185 countries for five years) and constituted of small and medium size enterprises (99% in Cameroon, 78% in Senegal, 98% in Ivory Coast) while they aim to become emerging countries (Horizon 2035 for Cameroon, 2035 for Senegal and 2020 for Ivory Coast) with the overall goal of achieving the status of new industrialized countries. To achieve these objectives, businesses, although most of them small and medium enterprises (SMEs), must create wealth, employment and constitute a potential power in the creation of the industrial fabric. To do so, these firms must

have high value-added products that can drive long-term and sustained growth. While it is recognized that innovation is a fundamental factor in business dynamism and economic growth, its consideration in African economic policies is weak.

According to the AfDB (2014), for 70% of African countries, innovation is of fundamental importance for their development, whereas none of them invests 1% of Gross Domestic Product (GDP) in research and development (R&D), which is a source of innovation. The World Bank (2017) argues this finding of the AfDB by showing that Africa must focus on scientific, technological and innovation research to make progress. Although this ambition is displayed by almost all countries taking note of the national strategy, few have succeed in making innovation a driving force for development. Although the level of investment in R&D, technology and innovation has evolved in English-speaking African countries (0.78% in Kenya, 1.06% in Malawi) and North Africa (0.79% in Morocco, 0.68% in Egypt, 0.71% in Tunisia), much remains to be done in French-speaking sub-Saharan African countries (0.34% in Cameroon, 0.51% in Senegal, 0.53% in Ivory Coast). With this low rate of R&D, the high-value-added secondary sector activities contribute little to GDP. This contribution is 28.5% in Cameroon (INS, 2009), 20% in Ivory Coast (PND, 2015) and 24.1% in Senegal (PSE, 2014). The contribution of exports to GDP is significant (50% in Cameroon, 76% in Ivory Coast, 50% in Senegal) but the share of industrial products in these exports is very small (World Bank, 2015). This low contribution to GDP is certainly due to the productivity weakness that is the result of under-utilization of development research results in the case of Cameroon, as nearly 89% of firms do not operate or carry out any research and development activities within their establishments (INS, 2009) while innovation contributes 31% to firms' productivity.

To encourage firms to innovate, a Ministry of Scientific Research and Innovation has been created in these countries (in 2004 in Cameroon) with the mission: the elaboration and the follow-up of implementation of the national innovation policy, the implementation of a regulatory framework favourable to strategic innovation development and innovation transfer. In addition, there are initiatives related to the emergence goals, such as promoting technology in the industrial sector, strengthening the protection of industrial property rights, promoting support structures for technological development; the creation of a support fund for scientific research and technological innovation in Ivory Coast, whose objective is the creation of economic centres through transfer of technology; and the assenting to the African Union (AU) initiative on science and technology, since 2006 (DSCE, 2009). With these initiatives, the current efforts are scattered and the research centres work in isolation. Firms in different countries of this region manage to adopt technological and non-technological innovations developed elsewhere (Zanello et al, 2016). These innovations are adaptive in nature with little chance of reversing the process of creating value. According to the World Bank's "*Enterprise Survey*", the adoption of these innovations developed elsewhere allowed 45% of companies surveyed in Cameroon in 2009 to introduce new or significantly improved products in the market (respectively 43% of those surveyed in Senegal in 2007, 28% of those surveyed in Ivory Coast in 2009). In addition, it also shows that 19% of these

companies surveyed in Cameroon in 2009 use technology under licence (9% of those in Senegal in 2007 and 6% of that of Ivory Coast in 2009). To achieve the ultimate goals of introducing new products and processes (technological innovation) in the market, companies usually combine the different activities leading to innovation. Egbetokum et al (2016) show that the combination of innovation activities in developing countries will outperform those obtained if activities are conducted in isolation. In fact, these innovation activities should be mutually reinforcing and their complementarity should allow companies that combine innovation inputs to achieve better results.

Due to these innovations, firms can move their production possibilities frontier and improve their performance. **This study, therefore, has as its objective to assess the effects of the adoption of innovations on firms' productivity in three countries in French-speaking sub-Saharan Africa (Cameroon, Senegal, and Ivory Coast).** The main contribution of this study is that it performs an econometric analysis of the effect of the separated and joint adoption of different types of innovations on the productivity of labour in firms of the secondary and services sectors in Cameroon, Senegal and Ivory Coast. It draws from recent studies. It classifies activities of innovation into two groups according to the Oslo Manual (2018): technological innovation and non-technological innovation. This approach reveals the heterogeneities present in the adoption of innovation and their effects on productivity between sectors (González-Blanco et al, 2019). It also shows the existing complementarity between innovations and their effect on productivity.

This study is organized in five sections: The second section attempts a review of the literature on innovation and productivity at the firm level. The third section presents the methodology and statistical results while the fourth presents the econometric results. Finally, the fifth section presents the conclusion and offers various avenues for future research.

2. Literature review

From a theoretical point of view, a firm is generally faced with competition in which it should find the best strategies to ensure its survival and sustainability. Faced with this situation, innovation asserts itself as the best guarantee of sustainability because it leads the firm into a dynamic that transforms the production function and puts it in a situation of virtual monopoly (Schumpeter, 1942). Following Schumpeter (1942), numerous works (Griliches, 1979; Crépon et al, 1998; Griffith et al, 2006; Hall, 2011) try to lift the veil on innovation to understand through which channels innovation affects productivity.

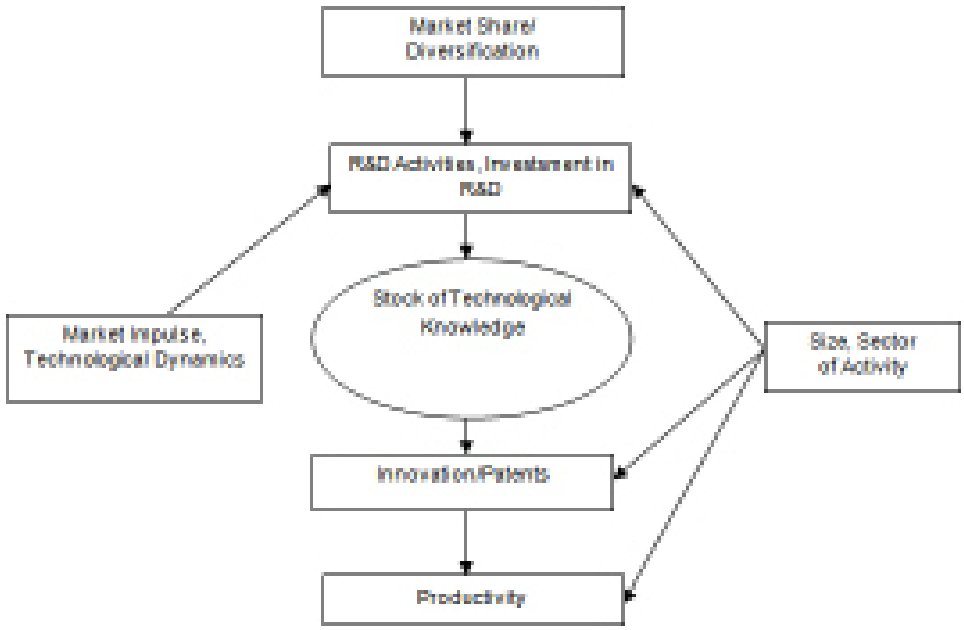
Innovation and firm productivity

Following the equilibrium principle of the neoclassical approach, some authors (Dosi, 1988; Nelson and Winter, 1982) find that this approach does not fit well with the concepts of innovation and productivity growth. They argue that innovation and technical progress occur as a result of information asymmetries and market imperfections, and that the concept of equilibrium can be a poor tool for the co-growth of a firm in a market. This reasoning remains fundamental because if a firm is really in equilibrium, there would be no incentive for research and innovation and productivity would not increase. Following the same idea, Griliches (1979) breaks down the estimates of productivity growth according to various components that had been forgotten. This method of reducing the size of the unaffected residue leads the author to shift the problem to understand the reasons for scientific and technological progress, and to identify the favourable factors that stimulated productivity growth.

To explore the underlying causes of firm productivity, some studies are increasingly interested in firm's research and development (R&D) (Benavente, 2006; Hall et al, 2013; Audretsch and Belitski, 2020). Firms invest in R&D to develop new products and production processes. These R&D expenditures do or do not give rise to new products and processes whose commercialization is not without effect on the productivity of firms. In addition, penetration of the export market can lead to improvement of product quality or specific investments, which can therefore lead to productivity growth (De Loecker, 2013). Crépon, Duguet and Mairesse (1998) show that the launch of a new product on the market creates a new source of demand. This can lead to economies of scale[1] in production or improved productivity. This production requires fewer inputs than the old products and can also benefit from a new production process. New products can obviously compete with old products to the point of moving

them away or replacing them on the market. It is possible that sale of new products in parallel with the old ones may lead to economies of scale in the distribution of goods (services) on the market. Thus, Crépon, Duguet and Mairesse (2000) support that the effect of innovation on production is similar to the term of technical progress, the only difference being that each firm has a term of technical progress that depends on its own strategy. This innovation, which itself originates in an unobservable knowledge capital, which comes from investments in R&D, is presented as shown by the following schematic model by Crépon, Duguet and Mairesse (2000):

Figure 1: Conceptual model of innovation



Source: Crépon, Duguet and Mairesse (2000)

According to Figure 1, the firm's internal (size, sector of activity) and external (market impulse and technology dynamics) attributes determine its R&D activity. The latter stimulates the development of the technological knowledge capital that determines the intensity of innovation. The success of this innovation on the market can have an impact on the firm's productivity. This success may depend not only on the novelty of the product or the production process but also on the quality of the associated marketing or organization of the method of work. Mairesse et al (2005) show that productivity decreases at the beginning of new product launches and improves as the firm shifts the learning curve. This shows that some of these new products launched may be more effective than others because they satisfy an immediate or latent customer need, or because they complement another product or service newly introduced on the market. The concept of technological innovation being composed of product innovation and process innovation, Griffith et al (2006) show

that these two types of innovations have differentiated effects on firm productivity. In fact, the authors show that a process innovation may have a more positive effect on productivity because new processes are often introduced to reduce production costs by saving some of the most expensive inputs (often labour). In spite of these direct effects, innovations can also have indirect effects because when an innovation leads to a reduction in prices which, if the demand is sufficiently price-sensitive, leads to a more proportional increase in sales, then it can create additional productivity. Admittedly, this fall in price depends on the extent of competition in the market, which can itself be a function of important innovations.

Thus, the productivity of a firm may depend on the simultaneous presence of various types of innovations. The summary of the work (Mairesse et al, 2005; Siedschlag et al, 2010) which examined the effect of different types of innovation on productivity presents differentiated results because these forms of innovation are adopted jointly or separately. By evaluating the differentiated effect of product innovation and process innovation, Griffith et al (2006) show that both have insignificant effects when they occur together in the production process. Mairesse and Robin (2009) show in some cases that only product innovation has a significant effect and justify this by the strong measure of product innovation that outweighs process innovation. In the same vein, Hall (2011) shows that product innovations create a market power effect that increases the measurement of production efficiency, while improvements in the efficiency of process innovations may not appear in the turnover. Following these authors and after the extension of the Oslo Manual (2005), some authors (Masso and Vahter, 2008; Hall et al, 2009; Brouillette, 2014; Hajjem et al, 2015) study the complementarity between the different types of innovations.

Innovation complementarity and firms performance

A new product may require a new production process with lighter materials, but also a need for adequate instruments in the manufacture of this new product. We can see that product innovation can be combined with process innovation. Damanpour and Gopalakrishnan (2001) show that the product innovation adoption model is positively associated with the adoption of process innovations. Similarly, they show that new production processes can only increase productivity if they are combined with a new way of organizing work. Thus, the success of a new product or process on the market may depend on the quality of the advertising, the speed of delivery, the efficiency of its distribution and the after-sales service. On the criticism of subjectivity of this point of view, Rouvinen (2002) and Reichstein and Salter (2006), respectively, conclude on the basis of a correlation test, the existence of a complementary relationship between process and product innovation. In exploring the role of product and process innovations in Spanish companies, Martinez-Ros and Labeaga (2009) also show that the complementarity between product and process innovation is important in the decision to innovate in terms of synergies and absorption capabilities of the firm.

The results of the latter are similar to those of Miravete and Pernias (2006) showing the signs of complementarity between product innovation that increases with the process innovation produced the previous year. By showing that this complementarity is limited and stems mainly from unobserved factors, Krzeminska and Eckert (2016) conclude that changes in the organization or other intangible assets (management practice) can unleash the full potential of the combination of product and process innovations.

Although these studies have relevant results, they have focused primarily on product innovations and so-called technological process innovations, thus neglecting the so-called non-technological marketing and organizational innovations, although these are important for the efficiency, growth and performance of the firm. As a result, the study of complementarity has been extended to organizational innovations. Ballot et al (2011) for the United Kingdom and France, and Polder et al (2010) for the Netherlands test the existence of complementarities between product, process and organizational innovations. Although total complementarity is not obtained in these countries, the authors find a complementarity between product and process innovations in the three countries, the complementarity between product and organizational innovations in France and the complementarity between process and organizational innovations in the UK and the Netherlands.

In the same vein, the study of complementarity has been extended to marketing innovations. Unlike these studies, Hall et al (2011) failed to demonstrate complementarity between product, process and organizational innovation in the Italian productivity equation, although they can show that their results are comparable to those of Polder et al (2010) because they used the same inputs. Brouillette (2014) and Hajjem et al (2015) using Canadian and French data, respectively, extend their studies to marketing innovation. They conclude on the positive effect of combining these innovations on productivity. Unlike these authors, Aboal and Tacsir (2017), Fu et al (2018) and González-Blanco et al (2019) rely on a complementarity between technological and non-technological innovation on productivity.

Although these studies show that innovation is the main driver of productivity (Mansury and Love, 2008; Hall et al, 2013), it is clear that innovation capacity is quite low in most African countries, whose economic fabric is characterized by small and medium enterprises. Thus, the ability to adopt innovations from developed countries and adapt them to local specificities will be a crucial step in increasing the productivity of enterprises. Firms in African countries need to establish the link with the outside world that is the main source of technological innovations and the necessary skills to access the pool of existing knowledge. Thus, Wolf (2006) shows that access to technological innovations through imports is likely to increase the technical progress that translates into productivity growth in African countries. Following the same view, Benavente (2006), Chudnovsky et al (2006) and Crespi and Zuniga (2012) show in the case of other developing countries that foreign cooperation increases the propensity to innovate, which leads to improved economic performance of firms. These innovations involve the adoption of new ideas and technologies to boost the productive system

of firms (Fu et al, 2018). Looking at the specific case of 501 manufacturing firms in Ghana, Zanello et al (2016) find that the adoption of innovations has a positive impact on firm productivity.

In light of the literature, the debate on the relationship between innovation and productivity and the presumption of complementarity between different forms of innovation (Benavente, 2006; Hall et al, 2011) remains very lively and mixed. This is generally due either to the method used, to imperfect measurement of innovation or to the quality of data. In addition, most of the existing theoretical and empirical work has been carried out in developed countries (Mansury and Love, 2008; Hall et al, 2013). While a few studies exist on developing countries in general and Sub-Saharan Africa in particular (Chudnovsky et al, 2006; Crespi and Zuniga, 2012; Zanello et al, 2016), they have been limited to the case of English-speaking countries (Fu et al, 2018) and on agriculture (Ntsama and Epo, 2009). As a result, we do not know how innovation affects firm productivity in French-speaking sub-Saharan Africa and even less so in Cameroon, Côte d'Ivoire and Senegal, especially because firms operating in these countries adapt innovations developed elsewhere to their context. Thus, this study fills the gap in the literature on Francophone Africa. In addition, it makes it possible to analyse the specific effect of the adoption of technological and non-technological innovation, and the effect of the simultaneous adoption of these two types of innovations on the productivity of firms.

3. Methodology

To achieve our goal, this study brings in theories of innovation closer to firm productivity. The methodological elements presented in this work deal with data source, model specification and statistical analysis.

Data source

The data used in this work comes from the survey "Determinants of the Performance of Companies in Francophone Sub-Saharan Africa: The case of Cameroon, Ivory Coast and Senegal" conducted in 2014 by the International Development Research Centre (IDRC). The objective of this survey was to identify factors explaining the performance of firms operating in these countries, with the aim of understanding not only if companies can effectively contribute to achieving the objectives of emergence, but also if they can survive the competition if these countries were to ratify the Economic Partnership Agreements (EPAs). Thus, firms were asked about their activities from 2011 to 2013 using the database available at the National Institute of Statistics (NIS) of each country. For example, the survey on Cameroon relied on the business directory resulting from the General Business Census (RGE, 2009) and on the results of the Annual Survey of Enterprises (EAE) as a basis for selecting the firms (Chameni and Fomba, 2015).

From this base, the survey was carried out in three cities in each country. It covered Douala, Yaoundé and Bafoussam in Cameroon; Dakar, Thiès and Saint Louis in Senegal; and Abidjan, San Pedro and Daloa in Ivory Coast. The three cities chosen in each country account for nearly 70% of the total enterprise sample available in these countries (Diene et al, 2015). In Cameroon, for example, 68.132% of all businesses on the sampling frame are located in these three cities (INS, 2009). The survey is stratified to provide an adequate representation of the 70% of all businesses in the sample frame available in these three cities.

In general, the questions did not show information year by year, but on the data of the firm between these three periods (2011 to 2013). These questions were related to the firm, the manager and the employees.

At the end of the data collection, the survey involved 1,897 companies of all types, including 639 in Cameroon, 723 in Senegal and 535 in Ivory Coast, representing a coverage rate of 84%. Table 1 presents some statistics for this sample (28.36% are from the secondary sector and 69.90% from the tertiary sector). The primary sector is under-represented due to the low representativeness of these primary sector companies in the regions selected for the survey. With the primary sector poorly represented in the

selected geographical areas, the number of companies collected respects at least the proportion of 30% of the secondary sector and 70% of the tertiary sector envisaged by the frame (INS, 2009).

Table 1: Sample distribution following the sub-segment

Sector	Cameroon		Senegal		Ivory Coast		Whole	
	Pop.	Freq.	Pop.	Freq.	Pop.	Freq.	Pop.	Freq.
Primary	8	1.25	12	1.66	13	2.43	33	1.74
Secondary	179	28.01	218	30.15	141	26.36	538	28.36
Tertiary	452	70.74	493	68.19	381	71.21	1,326	69.90
Total	639	100.00	723	100.00	535	100.00	1,897	100.00

Note: The primary sector includes agriculture and animal husbandry; the secondary sector includes processing and manufacturing enterprises; the tertiary sector includes trade and service enterprises.

Choice of countries

The choice of these countries was made according to the Global Innovation Index ranking, which ranks these countries ahead of their respective sub-regions (Cameroon is the only country in Central Africa ranked 114th, Ivory Coast ranked 116th and Senegal 98th in 2014) with scores in the interval [25; 30]. According to IDRC, these countries have almost the same structure of the economy and are ranked in the same vein by the "Global Competitiveness Index" with a competitive score that varies between 3.5 and 3.7 in 2014. According to the ranking, this region has seen a significant improvement with almost 50% of "apprentices in the field of innovation". These economies are showing increasing results in terms of innovation as shown in Table 2. This rise is embellished by Ivory Coast, which distinguished itself by winning more than 20 places from 134th in 2012 to 116th in 2014. Regarding Senegal, it is one of the 12 high-income countries and is in the African top 15 on the competitiveness index. Cameroon as a locomotive of the CEMAC zone gains 8 points from 121st in 2012 to 114th in 2014 and ranks in the top five of African governance index. The ranking of these economies shows how innovation is being honored and is essential to transforming economies. The position occupied by these three countries at the African level (Senegal 11th, Cameroon 24th, Ivory Coast 25th) according to their level of innovation shows the need to conduct a study simultaneously on these three economies.

Table 2: Global Innovation Index

Year	**Ranking**			**Score sur 100**		
	Cameroon	Senegal	Ivory Coast	Cameroon	Senegal	Ivory Coast
2011	103	100	117	26.95	27.56	24.08
2012	121	97	134	25.00	28.80	22.60
2013	125	96	136	25.71	30.48	23.42
2014	114	98	116	27.52	30.06	27.02
2015	110	84	116	27.80	30.95	27.16
2016	118	106	108	22.82	26.14	25.80
2017	117	100	112	22.58	27.11	23.96

2018	111	100	123	23.85	26.53	19.96
2019	**115**	**96**	**103**	**23.90**	**26.82**	**25.55**

Source: Extract from Global Innovation Index (GII) 2011-2014

In addition, these countries (Ivory Coast second with US$ 38.496 billion, Cameroon third with US$ 32.625 billion, Senegal fourth with US$ 16.963 billion) top the ranking of French-speaking Sub-Saharan African countries with regard to their budget and are leaders, respectively, in UEMOA and CEMAC (UNIDO, 2011). Cameroon (Africa's 13th largest economy) as one of Africa's most resilient economies (AfDB, 2018) with its strong non-oil GDP growth and economic potential far from being exploited, allows the region (CEMAC) to continue posting positive growth rates (IMF, 2018). The Cameroonian economy is the strongest and most diversified in the CEMAC region with a weight of 31% of GDP (BEAC, 2018). Similarly, Ivory Coast and Senegal, respectively, as the first (33% of GDP) and second (19.55% of GDP) UEMOA economy have a significant economic weight in this sub-region (Foued, 2011).

In addition, out of 17 OAPI (African Intellectual Property Organization) member countries, these three countries register the highest number of patents granted between 2013 and 2018. According to the official IPO bulletins (BOPI) from 2013 to 2018 summarized in Table 3, these three countries received 92.56% (respectively 84.15% for Cameroon, 3.94% for Senegal and 4.37% for Ivory Coast) of all patents granted by OAPI. This shows the importance given to innovation in these countries and the need to carry out a study on the effect of innovation on the economic expansion of these countries.

Table 3: Statistics of invention patents in Africa according to OAPI

Year	Issue of Patents	Number of patents	Cameroon	Senegal	Ivory Coast	Other Countries
2013	15786 to 16215	429	387	3	19	20
2014	16216 to 16815	599	518	26	19	36
2015	16816 to 17341	526	467	14	19	26
2016	17342 to 17701	360	313	12	13	22
2017	17702 to 18085	380	254	35	29	62
2018	18086 to 18125	40	25	2	3	10
Total	15786 to 18125	2,334	1,964	92	102	176

Source: Compiled using official IPO Bulletins from 2013 to 2018

Although innovation was not seen in the past in African countries as a means to achieve development (Martin, 2012), the new emergence-centred vision of development puts innovation and technology at the centre of policy makers' agendas. With the creation of a ministry in charge of promoting and supporting innovation in Cameroon, Ivory Coast and Senegal, innovation culture is still in the gestation phase, with slow social progress and very few people interested in research. Although this organization works in collaboration with other administrations concerned with the promotion and support of innovation, activities remain scattered and have difficulty being felt. This is because the national innovation systems in these countries remain

fragile, with difficulties related to research funding. This calls for firms to adopt and adapt to innovations developed elsewhere as a lever for the transition towards the economic emergence of these countries. Through this study, we seek to show whether the adoption of innovation could guarantee the revitalization of the productive sector and the social progress.

Measure of innovation adoption and enterprise productivity

In the broad sense of the term, innovation as the introduction of new products, processes, organizational and business processes and the invention of new ideas, constitutes the "essential ingredient" of performance of enterprises. The innovations in developing countries are marginal improvements in products and processes, significant adoption of technologies or imitation of foreign novelty. According to Mabah et al (2013), the adoption of innovations refers to the decision to implement new technical proposals in existing production systems and to progressively improve their use. This adoption of innovations depends, as Rogers (2004) shows, on the socio-economic characteristics of the firms, the information they have and the conditions for accessing the necessary resources. It also depends on the structure and nature of the exchanges that firms maintain with their partners and the interactions with the institutions of innovation diffusion (Young, 2011). The characteristics of innovations related to the institutional, technological and economic environment of firms also plays an important role in the adoption of innovations. In this case, the adoption of an innovation is modeled as a choice between adopting or not.

Productivity is the volume ratio of a product in one or more factors of production. The measure of this productivity dates back to the work of Tinbergen (1942) and Solow (1957), who formulated productivity measures of a production function and related them to the analysis of economic growth. Following major contributions, the theory of production presents methods for measuring single factor and multifactor productivity (MFP) or Total Factor Productivity (TFP). This measure provides a profile of the productive use of capital and labour factors combined to generate added value. It reflects the combined effects of technical developments, economies of scale, changes in efficiency and variations in capacity utilization. Thus, based on recent work (Gauzente 2000 ; Louizi, 2011), the productivity indicator used in this work is added value. Since added value[2] is the difference between the turnover and the costs involved in the manufacture of the products or their implementation, it is easier to use it to evaluate productivity because it measures the gross wealth creation of the firm and is according to Mohnen and Hall (2013) and (Mohnen, 2019) the best indicator for evaluating firm productivity.

Econometric model

To specify the empirical model adapted to the environment of African countries, we proceed first to the justification of the choice of this model, then to the detailed presentation of the elements constituting this model.

Choice and justification of the model

To evaluate the effect of the innovation process, the literature proposes several techniques, the basic model of which is that of Crépon et al (1998) known as the CDM model. The basic model is that of Crépon et al (1998; 2000), consisting in correcting selection and endogenous problems linked to innovation. By applying this CDM model, many authors (Mairesse et al, 2005; Loof and Heshmati, 2006) have been able to measure the effect of innovation on productivity. They measure innovation by the number of patents obtained and the intensity of R&D. Because of the positive and negative attributes of these indicators, they show that R&D activity and patent ownership do not fully capture the effect of innovation on productivity. In contrast to those authors who use quantitative measures, Griffith et al (2006) measured innovation output by two dichotomous variables indicating whether the firm made an innovation in product or process. As a result, they used two separate probit models and introduced predicted probabilities of product and process innovation into the production equation to control endogeneity.

With the development of other forms of innovation by the Oslo Manual (OECD, 2005), Polder et al (2010) and Hall et al (2011) adapt the CDM model to their context by incorporating organizational innovation in addition to product and process innovation. In addition, the authors extend the model by including ICT as a catalyst for organizational innovation. Inspired by these, Brouillette (2014) takes into account marketing innovation in addition to product, process and organization innovation. Unlike those who use the binary indicators for innovation, he uses continuous indicators for each type of innovation. With these indicators, he uses a modified three-step CDM model constituting a recursive structured equation system. Like all the rest, he uses Ordinary Least Squares to estimate the productivity equation, where he introduces the predicted values of each type of innovation to control endogeneity. By this method, he succeeds in showing the effect of different types of innovation and their complementarity on firms' productivity. Following the same methodology, Hajjem et al (2015) also study the four types of innovation using qualitative indicators (having or not having introduced an innovation). For this purpose, they use a model composed of three blocks of structural equations, allowing them first of all to correct the selection bias by a generalized Tobit type II, in a second time to evaluate the correlation between the different types of innovations by a multivariate Probit and, thirdly, to correct the endogeneity bias by introducing the predicted values of the different types of innovation into the productivity equation. This technique allowed the authors to measure the impact of the separate and joint adoption of different types

of innovation on productivity using Ordinary Least Squares to which they introduce the predicted probabilities of each type of innovation derived from the multivariate Probit into a first model and then the predicted probabilities of each combination of innovations into a second model.

In contrast to these authors who study individually the effect of each type of innovation on productivity, Aboal and Tacsir (2017) on the case of Uruguay and Fu et al (2018) on the case of Ghana group these different types of innovations into technological innovations (product and process innovation) and non-technological innovations (organization and marketing innovation). For this, they rely on the CDM model by incorporating ICT into the productivity function and also by introducing the predicted probabilities of technological and non-technological innovations from the previously estimated bivariate Probit model. This new method makes it possible to evaluate the causality of technological and non-technological innovations on the productivity of firms by managing the problem of endogeneity.

Building on recent work (Aboal and Tacsir, 2017; Fu et al, 2018; González-Blanco et al, 2019), we can group firms into two innovation groups, such as technological innovation (product and process innovation) and non-technological innovation (organizational and marketing innovation). These innovations can be modeled as follows: lack of innovation, having adopted technological innovation, having adopted non-technological innovation or having adopted both types of innovation (technological and non-technological). This analysis, which makes it possible to highlight two types of innovation can be apprehended, as Robin and Mairesse (2008) show, by a multinomial model. But this approach does not allow interactions between different types of innovation. This is why this work prefers the Bivaried Probit model (Aboal and Tacsir, 2017) which makes it possible to check the interdependence between the different types of innovation. This Probit model will serve us as a basis for having the predicted probabilities of each type of innovation, which will then be introduced into a simple regression estimated by Ordinary Least Squares. To this end, the endogeneity of innovation can be controlled by the instrumentation of innovation inputs while carrying out a heterogeneity control by sector of activity and by country.

Model specification

Based on recent work (Aboal and Tacsir, 2017; Fu et al, 2018), we extend the framework proposed by Crépon et al (2000); Hall, Lotti and Mairesse (2012); Brouillette (2014); and Hajjem et al (2015) to adapt them to the available data in French-speaking sub-Saharan Africa. This work adds some specific points such as the innovation output evaluated is the productivity approximated by the value added; and the innovation output variables are qualitative, that is, whether or not they have a technological or non-technological innovation. Thus, the productivity function proposed by Crépon et al (2000; 1998) where the variable of interest is innovation is enriched by ICT and technological and non-technological innovations. The productivity equation is:

$$\ln\left(VA\right)_i = \alpha_0 + \lambda Innov_i + \beta \ln K_i + \alpha \ln L_i + \delta ICT_i + \varepsilon_i \quad (1)$$

With *VA* as value-added, *K* capital, *L* labour, *ICT* the vector of ICT-related variables (doing online business, use of ICT for production or for marketing); ε_i the term of error supposed distributed according to a normal law; and *Innov* is the innovation vector that results from Equation 2. $\lambda, \beta, \alpha, \delta$ are parameters and α_0 is a constant. Following the approach of the works previously mentioned, this work distinguishes between technological innovations (product and process) and non-technological innovation (organizational or marketing). This distinction is conceptually very relevant since we know that tertiary sector firms have a greater propensity to introduce non-technological innovations than technological innovations in the secondary sector (Aboal and Tacsir, 2017). Thus, companies according to their sector of activity adopt innovations differently and innovation is potentially endogenous because of the simultaneity between productivity and innovation activity. To take into account this notion of endogeneity[3] of innovation ($\text{cov}(Innov; \varepsilon) \neq 0$), we will use the two-step estimation method[4].

Step 1: Given the nature of innovation inputs that are dichotomous (nonlinear variants) and require the use of a qualitative model, we first estimate Equation 2 with a Bivariate Probit. This method makes it possible to obtain the adjusted values (predicted components) of the innovation instrument.

$$Innov \equiv \begin{cases} I\_tech_i = \begin{cases} 1 \text{ if } I\_tech_i^* > 0 \\ O \text{ Else} \end{cases} & \text{with} \quad I\_tech_i^* = X_{1i}\beta_1 + \varepsilon_{1i} \\ I\_Ntech_i = \begin{cases} 1 \text{ if } I\_Ntech_i^* > 0 \\ O \text{ Else} \end{cases} & \text{with} \quad I\_Ntech_i^* = X_{2i}\beta_2 + \varepsilon_{2i} \end{cases} \quad (2)$$

With $i = 1, ..., n$, *Innov* is the innovation instrument, X_{1i} and X_{2i} the vectors of explanatory variables, I_tech_i and I_Ntech_i technological innovation and non-technological innovation, β_1 and β_2 vectors of the parameters to be estimated, and ε_{1i} and ε_{2i} the error terms assumed to be jointly distributed according to a normal distribution. The latent variables of innovation adoption ($I\_tech_i^*$ and $I\_Ntech_i^*$) are explained by the characteristics of the firm (Y), the variables related to the socio-economic environment of the firm (ENV), and the variables related to ICT. The specificity of these equations estimated by a bivariate probit model is to take into account not only the fact that the different types of innovation can be adopted simultaneously, but also the correlation which can exist between the error terms of

these equations.

$$\begin{cases} I\_tech_i^{*} = \alpha_1 Y_{1i} + \gamma_1 ENV_{1i} + \delta_1 ICT_{1i} + \varepsilon_{1i} \\ I\_Ntech_i^{*} = \alpha_2 Y_{2i} + \gamma_2 ENV_{2i} + \delta_2 ICT_{2i} + \varepsilon_{2i} \end{cases} \quad (3)$$

with

$$\begin{cases} \varepsilon_{1i} = \eta_i + \mu_{1i} \\ \varepsilon_{2i} = \eta_i + \mu_{2i} \end{cases} \text{ where } \begin{pmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \end{pmatrix} \rightarrow \text{var}(0, \sum) \quad with \quad \sum = \begin{pmatrix} 1 & \rho_{1,2} \\ \rho_{2,1} & 1 \end{pmatrix}$$

That is, the errors of these two equations consist of a part (η_i) common to both equations and a part unique to each equation (μ_{1i} and μ_{2i}). μ_{1i} and μ_{2i} are assumed to be of zero mean, independent of each other and independent of the explanatory variables of the model, while η_i is an unobserved variable that linearly influences the two dependent variables. Assuming that these errors are normally distributed and that ε_{1i} and ε_{2i} are related to each other, the probability of adoption of innovation is:

$$\begin{cases} \Pr\left(I\_tech_i = 1\right) = \Pr\left(\varepsilon_{1i} > -X_{1i}\beta_1\right) = \Pr\left(\eta_i + \mu_{1i} > -X_{1i}\beta_1\right) \\ \Pr\left(I\_Ntech_i = 1\right) = \Pr\left(\varepsilon_{2i} > -X_{2i}\beta_2\right) = \Pr\left(\eta_i + \mu_{2i} > -X_{2i}\beta_2\right) \end{cases} \quad (4)$$

The two equations being dependent, we have a bivariate normal distribution that hides several simultaneous choices. Thus the decision to adopt innovation depends on four possible observations: $\left(I\_tech_i \ , \ I\_Ntech_i\right) \in \left\{(1,0);(0,1);(1,1);(0,0)\right\}$. As shown in Figure A1 in the Annex, each figure corresponds to one type of innovation, with the following order: technological and non-technological innovation. The terms (1,0) and (0,1) refer respectively to the adoption of technological and non-technological innovation, and (1,1) to the joint adoption of technological and non-technological innovation. According to the same logic, the term (0,0) designates the absence of innovation since it is zero for all firms. The estimation of this bivariate probit model makes it possible to have adjusted innovation instruments (P (*I_tech*), P (*I_Ntech*) and P (*I_tech, I_Ntech*)).

Step 2: The productivity equation is estimated by doubled least squares (DLS) with the predicted values as innovation instrument.

$$\ln\left(VA\right)_i = \alpha_0 + \lambda_1 P(\hat{I\_tech})_i + \lambda_2 P(\hat{I\_Ntech})_i + \lambda_3 P(I\_tech; I\_Ntech)_i + \beta \ln\left(K\right)_i + \alpha \ln L_i + \delta ICT_i + \varepsilon_i \quad (5)$$

The principle of this method is to use an approximation of productivity that

does not correlate with the error term to perform the regression. In the presence of instrumental variables to address the problem of endogeneity, this estimation method is more explicit and gives the effective estimators. Thus, we first regress Equation 2, which allows to obtain the added values of the instrument of innovation, then explicitly making a regression of the productivity equation (Equation 5) in a second step with the adjusted values of the innovation instrument introduced therein.

Finally, a statistical Chow (1960) test is carried out to further show the need to study the three countries. This test makes it possible to check if the coefficients are different or identical in the three countries. With the presence of endogeneity problems, the disturbance distribution is no longer normal. In this case, this Chow test (1960) can be done in a simple way like post-estimation tests. The latter is easily applicable by the *"test"* or *"testparm"* stata[5] command after the estimate.

Descriptives statistics

Table 4 presents some descriptive statistics of firms by sector of activity. Overall, there is less difference in innovation behaviour among firms from one sector to another. But this difference varies depending on the country. On average, overall and regardless of the sector of activity, one in two of the firms adopt a technological innovation (respectively 7 out of 10 in Cameroon, 2 out of 5 in Senegal and 3 out of 5 in Ivory Coast). This ratio is almost the same for those introducing a non-technological innovation (respectively 6 out of 10 in Cameroon, 2 out of 5 in Senegal and 1 out of 2 in Ivory Coast). According to entrepreneurial logic, whatever the country, firms in the industrial sector are more likely than those in the tertiary sector to have introduced new products and new processes or significantly improved, while the opposite is true for the introduction of a novelty or an improvement in the method of organization and marketing.

Industrial companies are more likely to have created links with consumers to develop their innovation project. These firms are usually more available to adopt R&D services and new technologies that enable them to develop their innovation activities. These firms participate more to cooperation initiatives to develop their innovation adoption projects in Cameroon. However, firms in the services sector in Ivory Coast and Senegal better respect quality norms for new initiatives. As concerns ICT, we find that firms in the tertiary sector invest more in ICT for new initiatives. This finding, which is the same in Senegal and the Ivory Coast, is totally contradicted in Cameroon. This low rate of ICT adoption is related to the high cost of internet, the characteristics of the staff and the manager (including the manager's willingness to provide resources for ICT implementation) and the complexity of ICT use (Mughal and Diawara, 2014). Also, firms in the tertiary sector have a higher proportion of qualified personnel. Although the average size of firms in the two sectors is not the same, the industrial sector is more productive.

Table 4 : Statistical description of variables

Variables	Designation	Cameroon		Senegal		Ivory Coast		Whole	
		Secondary	Tertiary	Secondary	Tertiary	Secondary	Tertiary	Secondary	Tertiary
		Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Technological Innovation	I_tech	0.67	0.53	0.49	0.42	0.47	0.504	0.55	0.483
		(0.47)	(0.49)	(0.50)	(0.49)	(0.50)	(0.50)	(0.49	(0.49)
Non-Technological Innovation	I_Ntech	0.70	0.65	0.37	0.44	0.60	0.567	0.544	0.547
		(0.46)	(0.48)	(0.48)	(0.49)	(0.49)	(0.49)	(0.49)	(0.49)
Productivity	VA	1308611	884936	6.02e+08	3.73e+08	1.60e+08	7.09e+07	2.86e+08	1.59e+08
		(9544041)	(7529399)	(4.11e+09)	(3.45e+09)	(1.12e+09)	(8.46e+08)	(2.69e+09)	(2.15e+09)
Size of the Firm	Size	75.81	54.35	29.89	19.38	7.93	9.320	39.41	28.41
		(364.6)	(267.05)	(177.4)	(97.98)	(26.45)	(30.09)	(240.2)	(168.7)
Workers	Qualified	37.73	19.98	18.08	16.83	5.13	6.154	21.22	14.84
		(227.78)	(87.09)	(146.15)	(124.59)	(14.93)	(21.15)	(161.4)	(92.23)
	Unqualified	38.78	35.51	22.72	5.93	3.88	4.545	23.13	15.61
		(156.68)	(229.88)	(176.58)	(19.45)	(14.83)	(17.85)	(144.8)	(135.7)
Legal Form of the Firm	SARL	0.2234	0.141	0.09	0.19	0.88	0.706	0.342	0.3235
		(0.42)	(0.35)	(0.29)	(0.39)	(0.33)	(0.45)	(0.47)	(0.468)
	SA	0.16	0.108	0.11	0.08	0.049	0.199	0.111	0.126
		(0.36)	(0.31)	(0.32)	(0.28)	(0.22)	(0.40)	(0.31)	(0.33)
	EI	0.54	0.67	0.04	0.13	0.02	0.076	0.200	0.298
		(0.50)	(0.47)	(0.19)	(0.33)	(0.14)	(0.26)	(0.40)	(0.46)
Demand Impulse	DEMAND PUL	0.76	0.65	…	…	0.06	0.078	0.271	0.245
		(0.43)	(0.47)			(0.24)	(0.27)	(0.44)	(0.43)
Technological Impulse	TECHNO PUSH	0.17	0.15	0.20	0.24	0.078	0.073	0.158	0.162
		(0.37)	(0.35)	(0.40)	(0.43)	(0.27)	(0.26)	(0.36)	(0.36)
Competition	CONCUR_NAT	0.66	0.55	0.78	0.64	0.51	0.638	0.669	0.610
		(0.47)	(0.49)	(0.41)	(0.48)	(0.50)	(0.48)	(0.47)	(0.49)
	CONCUR_INT	0.42	0.31	0.54	0.34	0.19	0.254	0.412	0.307
		(0.49)	(0.46)	(0.49)	(0.47)	(0.40)	(0.43)	(0.49)	(0.46)
Cooperation	COOP	0.49	0.32	0.142	0.19	0.156	0.049	0.262	0.194
		(0.50)	(0.47)	(0.35)	(0.39)	(0.36)	(0.22)	(0.44)	(0.39)
Respect of Norms of Quality	NORD	0.09	0.05	0.24	0.41	0.127	0.283	0.163	0.250
		(0.29)	(0.21)	(0.43)	(0.49)	(0.33)	(0.45)	(0.37)	(0.43)
ICT	INTERNET	0.31	0.24	0.15	0.24	0.071	0.139	0.184	0.210
		(0.46)	(0.43)	(0.36)	(0.42)	(0.26)	(0.35)	(0.38)	(0.41)
	ICT_MARK	0.246	0.283	0.206	0.326	0.120	0.173	0.197	0.268
		(0.43)	(0.45)	(0.40)	(0.47)	(0.33)	(0.38)	(0.39)	(0.44)
	ICT_PRO	0.346	0.303	0.178	0.320	0.148	0.220	0.227	0.286
		(0.48)	(0.46)	(0.38)	(0.467)	(0.36)	0.415)	(0.412	(0.45)

4. Econometric Results

In this section, the estimation results are presented and analysed. Since it is expected that adoption of innovation may differ from one sector of activity to the other, estimates are made according to the secondary and tertiary sector. For this, we begin by estimating a bivariate Probit model that will not only identify a possible correlation between technological and non-technological innovation, but also have the predicted probabilities of the latter, which will subsequently be introduced into the productivity equation.

Bivariate analysis of technological and non-technological innovation

This sub-section analyses the explanatory factors of technological and non-technological innovations in the secondary and tertiary sectors. According to the results in Table 5 and 6, the size of the firm is relevant to the adoption of innovation. This size indicator is statistically significant at 5% threshold for non-technological innovation in industrial enterprises in Cameroon and Ivory Coast. Thus, skilled labour is the category of employees that embodies a certain level of knowledge. Through their skills and know-how, they play a cross-cutting role by initiating new organizational methods, by forming lasting relationships with other stakeholders in the firm (customers, suppliers, etc). The coefficient for this indicator has a statistically significant effect at 10% threshold on the propensity for non-technological innovation in the secondary sector in Senegal and Ivory Coast, respectively.

The demand impulse (DEMAND_PUL) has a positive effect on the probability of technological and non-technological innovation for firms operating in Cameroon. This statistical significance at 1% threshold for both business sectors is explained by the fact that the proposals and suggestions of customers and suppliers could stimulate studies focusing solely on the point of view of consumers or potential demand. The creation of this novelty stimulated as much as possible can attract new customers and motivate more firms to innovate in this way to meet the expectations of its stakeholders. Similarly, the technological thrust (TECHNO_PUSH) has a positive impact on innovation in all the three countries and according to the sector of activity. This strong significance for technological and non-technological innovation is due to the fact that the technological thrust provides a content for stakeholder interaction on production mechanisms, organization methods and marketing. Thus, demand pull factors and technological push factors are of paramount importance for a creative

dynamic in the firm and according to the sector of activity. As businesses are often compromised between consumer-related operating activities and new technology-based operations, market growth coupled with technological growth can stimulate the development of technological and non-technological innovations that are needed for productivity growth. This result corroborates with those of Pantano and Viassone (2014) and Costantini et al (2015) showing, respectively, in Italy's case that innovation is stimulated by both demand and technological tools.

Table 5: Estimates of the bivariate probit model

Variables	Cameroon		Senegal		Ivory Coast		Whole	
	in_ techno	in_ ntech	in_ techno	in_ ntech	in_ techno	in_ntech	in_ techno	in_ ntech
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
Size	0.125 (0.09)	0.158* (0.09)	-0.016 (0.06)	0.058 (0.06)	0.166** (0.09)	0.211** (0.09)	0.033 (0.04)	0.74* (0.04)
Qualified workers	-0.08 (0.10)	-0.107 (0.12)	0.140 (0.12)	0.098 (0.12)	0.066 (0.15)	-0.027 (0.15)	0.063 (0.06)	0.015 (0.07)
Unqualified workers	-0.06 (0.11)	0.042 (0.12)	-0.025 (0.09)	0.098 (0.09)	-0.187 (0.11)	0.058 (0.12)	-0.083 (0.05)	0.048 (0.06)
Secondary sector	0.229 (0.50)	0.703 (0.53)	0.436 (0.42)	0.029 (0.45)	-0.083 (0.51)	0.712 (0.51)	0.391 (0.26)	0.274 (0.26)
Tertiary sector	-0.104 (0.49)	0.877* (0.53)	0.058 (0.42)	-0.020 (0.45)	0.063 (0.51)	0.612 (0.51)	0.173 (0.25)	0.266 (0.25)
SARL	0.145 (0.28)	0.408 (0.30)	0.324 (0.23)	0.201 (0.24)	0.568 (0.36)	0.050 (0.35)	0.39*** (0.12)	0.42*** (0.12)
SA	0.162 (0.33)	0.138 (0.36)	0.396 (0.28)	0.119 (0.30)	0.543 (0.39)	0.220 (0.38)	0.44*** (0.15)	0.46*** (0.15)
EI	0.46** (0.24)	0.503** (0.23)	-0.066 (0.24)	-0.298 (0.245)	0.204 (0.44)	0.237 (0.43)	0.39*** (0.13)	0.40*** (0.13)
DEMAND _PUL	1.93*** (0.18)	0.971*** (0.17)	…	…	-0.30 (0.23)	-0.311 (0.229)	1.19*** (0.12)	0.7*** (0.11)
TECHNO PUSH	0.525** (0.20)	0.332 (0.22)	0.71*** (0.12)	0.77*** (0.13)	0.467* (0.29)	0.147 (0.29)	0.63*** (0.09)	0.56*** (0.09)
CONCUR_NAT	0.231 (0.17)	0.390** (0.17)	-0.097 (0.12)	-0.020 (0.12)	0.175 (0.13)	0.324** (0.13)	0.146* (0.07)	0.23*** (0.07)
CONCUR_INT	-0.27* (0.14)	-0.06 (0.15)	0.32*** (0.11)	-0.108 (0.12)	0.087 (0.16)	0.097 (0.16)	0.065 (0.07)	-0.064 (0.08)
NORD	-0.012 (0.27)	0.301 (.351)	0.367** (0.21)	0.497** (0.21)	0.047 (0.30)	-0.293 (0.305)	0.30*** (0.11)	0.266** (0.12)
COOP	0.262** (0.13)	0.66*** (0.13)	0.307** (0.16)	0.54*** (0.18)	0.649*** (0.22)	0.558** (0.23)	0.36*** (0.09)	0.64*** (0.09)
INTERNET	-0.014 (0.20)	-0.18 (0.23)	0.219 (0.15)	0.268* (0.16)	0.013 (0.23)	0.118 (0.24)	0.054 (0.10)	0.042 (0.11)
ICT_MARK	0.339 (0.22)	-0.049 (0.23)	0.177 (0.15)	0.215 (0.15)	0.292 (0.23)	0.149 (0.24)	0.23** (0.10)	0.153 (0.11)
ICT_PRO	-0.22 (0.23)	0.251 (0.24)	0.137 (0.16)	0.104 (0.17)	0.136 (0.25)	0.011 (0.25)	-0.009 (0.11)	0.012 (0.11)
CAMEROON							-0.64*** (0.14)	-0.38*** (0.14)

SENEGAL							-0.07 (0.11)	-0.36*** (0.12)
Constant	-1.84*** (0.57)	-2.13*** (0.59)	-0.976 (0.44)	-0.91** (0.47)	-0.905** (0.4059)	-0.93** (0.41)	-1.02*** (0.27)	-0.9*** (0.26)
$\rho_{I\_tech,\, I\_ntech}$	0.65*** (0.06)		0.54*** (0.05)		0.72*** (0.04)		0.64*** (0.03)	
Wald chi^2 Prob > chi^2 Obs	316.6 0.00 639		278.15 0.00 723		74.37 0.00 535		616.9 0.00 1897	

Note: Standard deviations are in brackets. *, ** and *** indicate variables' significance at 10%, 5% and 1%, respectively. I_tech = technological innovation; I_ntech = non technological innovation

The confrontation with a local competitive environment (CONCUR_NAT) positively stimulates the probability of adoption of non-technological innovation in the tertiary sector in Cameroon and Ivory Coast, whereas the external competitive pressure (CONCUR_INT) stimulates the propensity of technological innovation in the secondary sector in Senegal. This shows that the threat of a potential entry into a market stimulates established firms to develop innovative strategies depending on whether they are on the technological frontier or not. This result is in line with the theoretical point of view that the scale of innovation depends on the incentives provided (monopoly rent and competition between firms) in economic structures. According to the marginal effects, the additional entry of a multinational firm into an existing market increases the propensity for technological innovation in the secondary sector in Senegal by 0.0219 points (Table A1 in the Annex). From the point of view of compliance with quality standards (NORD), this indicator has a significant impact on the probability of non-technological innovation in the secondary sector in Senegal and on technological innovation in the same sector in Ivory Coast. This shows that implementation of a quality approach incorporating the different standard practices (customer focus, leadership, staff involvement, continuous improvement, approach of the transversal process) is a source of innovation.

Inter-firm innovation cooperation (COOP) responds favourably to both types of innovation across countries. This evidence of cooperation that is significant for non-technological innovations in Cameroon differs from that of other countries that show the positive effect of cooperation on both types of innovation in the two sectors studied. The lack of significance for the secondary sector in Senegal can be explained simply by a very small proportion of companies in this sector involved in cooperation activities. This can also be explained by the fact that this cooperation could have a long and costly process. This result is in line with that of Giovannetti and Piga (2017) showing that cooperation with various stakeholders of the firm (customers, suppliers, local network) can contribute to the introduction of a process and product innovation system.

With regard to information and communications technology (ICT), the use of the Internet for business is statistically significant only for non-technological innovations in the tertiary sector in Senegal. This shows that e-commerce and the use of high-speed Internet, for example, have a positive effect on the initiation of new (or significantly

improved) methods of organization and marketing. As for the statistically null effect of this indicator in the secondary sector, the use of the Internet for business seems less important, although the Internet has a positive impact on product and process innovation. The use of ICT for production and marketing remains relevant in the secondary sector in general for technological and non-technological innovations. Although the effect of these indicators remains statistically null in Cameroon and Ivory Coast , it is statistically significant at 5% threshold for non-technological innovation in the secondary sector in Senegal. This shows that ICTs facilitate innovative initiatives through processes of rapid dissemination of information, production processes, and use of successful commercial practices. This result corroborates that of Polder et al (2010) in the Netherlands showing that ICT is an important driver of innovation in the industrial and services sector, and that of Cuevas-Vargas et al (2016) in Mexico showing that ICT positively and significantly influences the innovation behaviour of manufacturing firms.

Table 6: Estimates of technological and non-technological innovation equations per sector of activity

Variables	**Cameroon**				**Senegal**				**Ivory Coast**				**Whole**			
	Secondary		Tertiary		Secondary		Tertiary		Secondary		Tertiary		Secondary		Tertiary	
	I_tech	I_ntech	I_tech	I_ntech	I_tech	I_ntech	I_tech	I_ntech	I_tech	I_ntech	I_tech	I_ntech	I_tech	I_ntech	I_tech	I_ntech
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Size	0.248 (0.18)	0.34** (0.18)	0.083 (0.10)	0.008 (0.11)	-0.062 (0.10)	-0.037 (0.11)	0.004 (0.08)	0.124 (0.08)	0.274 (0.18)	0.345** (0.17)	0.226** (0.12)	0.158 (0.12)	-0.024 (0.07)	0.100 (0.07)	0.056 (0.05)	0.063 (0.05
Qualified workers	-0.267 (0.18)	-0.281 (0.20)	0.039 (0.14)	0.004 (0.18)	0.36 (0.29)	0.592* (0.35)	0.140 (0.14)	-0.006 (0.13)	-0.287 (0.39)	0.926* (0.55)	0.086 (0.18)	-0.11 (0.17)	-0.141 (0.12)	0.038 (0.14)	0.158** (0.08)	0.01 (0.08)
Unqualified workers	-0.03 (0.20)	-0.064 (0.23)	-0.087 (0.14)	0.205 (0.16)	-0.01 (0.19)	0.174 (0.22)	-0.06 (0.11)	0.080 (0.11)	-0.493 (0.32)	-0.766** (0.38)	-0.232* (0.13)	0.136 (0.13)	0.086 (0.108)	-0.034 (0.12)	-0.141** (0.06)	0.07 (0.07)
SARL	-0.08 (0.54)	-0.028 (0.57)	0.301 (0.36)	0.560 (0.37)	-0.373 (0.57)	-1.48** (0.64)	0.549** (0.26)	0.456* (0.27)	-0.050 (0.53)	0.278 (0.57)	0.625 (0.52)	-0.161 (0.50)	0.088 (0.25)	0.197 (0.26)	0.56*** (0.14)	0.46*** (0.15)
SA	-0.21 (0.60)	-0.663 (0.69)	0.358 (0.40)	0.365 (0.46)	-0.43 (0.66)	-1.67** (0.73)	0.73** (0.33)	0.409 (0.36)	-0.738 (0.78)	-0.034 (0.98)	0.637 (0.54)	0.013 (0.53)	-0.212 (0.30)	0.051 (0.33)	0.66*** (0.17)	0.57*** (0.18)
EI	0.374 (0.46)	0.358 (0.45)	0.492* (0.29)	0.603** (0.28)	-0.53 (0.65)	-1.37* (0.78)	0.161 (0.27)	-0.099 (0.27)	-0.045 (1.27)	0.490 (1.03)	0.297 (0.57)	0.067 (0.56)	0.317 (0.27)	0.265 (0.28)	0.47*** (0.16)	0.42*** (0.16)
DEMAND PUL	1.8*** (0.36)	0.98*** (0.36)	2.01*** (0.22)	1.03*** (0.20)	…	…	…	…	-0.584 (0.54)	-0.606 (0.56)	-0.307 (0.26)	-0.323 (0.26)	1.30*** (0.23)	0.79*** (0.23)	1.18*** (0.13)	0.74*** (0.13)
TECHNO PUSH	0.69 (0.45)	0.704 (0.48)	0.386* (0.23)	0.206 (0.26)	0.53** (0.24)	1.14*** (0.26)	0.79*** (0.15)	0.63*** (0.15)	-0.478 (0.80)	0.322 (0.92)	0.66** (0.35)	0.192 (0.34)	0.51*** (0.17)	0.75*** (0.19)	0.67*** (0.11)	0.46*** (0.12)
CONCUR_NAT	0.561 (0.36)	0.286 (0.36)	0.111 (0.20)	0.41** (0.25)	-0.63** (0.25)	-0.43* (0.26)	0.098 (0.14)	0.084 (0.14)	0.34 (0.28)	0.610** (0.28)	0.156 (0.15)	0.254* (0.15)	-0.130 (0.14)	0.132 (0.15)	0.21** (0.08)	0.27*** (0.09)
CONCUR_INT	-0.329 (0.30)	0.173 (0.29)	-0.27* (0.17)	-0.194 (0.18)	0.67*** (0.19)	-0.25 (0.22)	0.166 (0.14)	-0.072 (0.15)	0.156 (0.35)	-0.144 (0.37)	0.051 (0.18)	0.189 (0.18)	0.333** (0.13)	-0.068 (0.14)	-0.047 (0.091)	-0.067 (0.09)
NORD	-0.100 (0.46)	0.618 (0.70)	0.334 (0.40)	0.436 (0.50)	0.719 (0.45)	1.87*** (0.53)	0.276 (0.25)	0.253 (0.25)	3.03** (1.33)	1.639 (1.12)	-0.17 (0.34)	-0.363 (0.35)	0.554** (0.24)	0.69*** (0.26)	0.284** (0.13)	0.229* (0.14)
COOP	0.349 (0.25)	0.62** (0.25)	0.233 (0.16)	0.73*** (0.17)	-0.18 (0.44)	0.155 (0.52)	0.47*** (0.19)	0.64*** (0.21)	0.826** (0.33)	0.68** (0.33)	0.753** (0.33)	0.671** (0.34)	0.327** (0.16)	0.57*** (0.16)	0.384*** (0.11)	0.69*** (0.11)
INTERNET	-0.348 (0.42)	-0.15 (0.44)	0.098 (0.24)	-0.17 (0.29)	0.122 (0.36)	-0.03 (0.43)	0.228 (0.18)	0.36** (0.18)	-1.512* (0.88)	-1.66* (0.96)	0.070 (0.26)	0.222 (0.26)	-0.157 (0.22)	-0.262 (0.24)	0.102 (0.12)	0.13 (0.13)
ICT_MARK	0.401 (0.45)	0.350 (0.46)	0.270 (0.27)	-0.19 (0.28)	0.463 (0.35)	0.256 (0.37)	0.040 (0.17)	0.106 (0.17)	-0.677 (0.74)	0.778 (0.69)	0.403 (0.27)	0.122 (0.28)	0.375* (0.22)	0.439** (0.237)	0.172 (0.12)	0.031 (0.12)
ICT_PRO	-0.43 (0.46)	0.242 (0.48)	-0.12 (0.29)	0.222 (0.29)	0.226 (0.45)	0.95** (0.48)	0.145 (0.185)	0.054 (0.19)	0.749 (0.66)	-0.44 (0.77)	0.040 (0.28)	0.062 (0.28)	-0.043 (0.24)	0.106 (0.24)	-0.007 (0.129)	0.013 (0.13)
CAMEROON													-0.566* (0.30)	-0.57* (0.30)	-0.62*** (0.17)	-0.27* (0.16)

SENEGAL													0.003 (0.25)	-0.72*** (0.26)	-0.087 (0.13)	-0.25* (0.13)
Constant	-1.67*** (0.54)	-1.43*** (0.50)	-1.96*** (0.32)	-1.31*** (0.29)	-0.15 (0.25)	-0.52** (0.26)	-1.07*** (0.15)	-1.01*** (0.15)	-0.52 (0.54)	-0.61 (0.58)	-0.88* (0.53)	-0.07 (0.51)	-0.395 (0.25)	-0.322 (0.27)	-0.97*** (0.16)	-0.75*** (0.16)
ρ_{I_tech, I_ntech}	0.744*** (0.09)		0.62*** (0.07)		0.49*** (0.11)		0.57*** (0.06)		0.84*** (0.06)		0.70*** (0.05)		0.679*** (0.05)		0.64*** (0.03)	
Wald chi²	84.06		227.93		84.78		200.04		280.72		520.69		189.91		433.95	
Prob > chi²	0.00		0.00		0.00		0.000		0.00		0.00		0.00		0.00	
Obs	179		452		218		493		141		381		538		1326	

Note : Standard deviations are in brackets. *, ** and *** indicate variables significance at 10%, 5% and 1%, respectively.

In addition, the estimated correlation coefficients[6] ($\rho_{I\_tech,\, I\_ntech}$) between the error terms of the two bivariate probit equations are given at the end of Table 5 and Table 6. These results indicate that the correlation between the two innovation dimensions remains through firms' unobservable specificities, after the joint estimates of these forms of innovation are made. These results not only reject the hypothesis of exogeneity between the two dimensions of innovation, but also strengthen the choice of the bivariate Probit model (Robin and Mairesse, 2008). The correlation between the error terms of technological innovation and non-technological innovation varies between 0.4981 and 0.8465 depending on the country and the sector of activity. The statistical significance at 1% threshold of these coefficients shows that the realization of a new product and the production process leads to new methods of organization and marketing and vice versa. Also, these strong correlations suggest that there is a complementary effect of these two types of innovation on productivity. This result is consistent with that of González-Blanco et al (2019) on Spanish firms and that of Adeyeye et al (2019) on Nigerian firms.

Productivity

Test of instrumental variables

The estimation of the productivity equation relies on the exclusionary restriction to identify the parameters of the innovation equation relative to those of productivity. From the analysis in Tables 5 and 6, the technology impulse approximated by the uptake of licensed technologies, the demand impulse approximated by firm/customer interaction and competition have significant direct effects on technological and non-technological innovation by industry and country. Interaction with customers is a central process for business efficiency. It ranges from information watch to production strategies and enables the firm to avoid certain innovation risks by meeting the potential expectations of stakeholders and to differentiate itself from competitors (Huenteler et al, 2016). Likewise, customers and suppliers, according to their needs and suggestions, could influence the enterprises' decision to adopt or not to adopt innovation. Technology acquisition and the use of licensed technologies trace the dynamics of technology enabling the development of new activities in an environment where firms invest very little in R&D (Battke and Schmidt, 2015; Girod and Woerter, 2017). Given that African firms are not the producers of innovation but the potential adopters, we used these indicators as an exclusionary restriction in our analysis, in the belief that their impact would affect productivity through the adoption of innovations. This is consistent with Metcalfe (1981), who shows that the level of output saturation depends on technology and demand dynamics through the adoption of innovation.

Validation of the exclusion of these variables was confirmed by a falsification test (Khanal et al, 2018; Keele et al, 2019). If a variable is a valid selection instrument, it will have an effect on the adoption of innovations, but not on the productivity of firms

that have not adopted any innovations. Table A2 in the Annex shows that technology push (TECHNO_PUSH), demand push (DEMAND_PULL) and competition (CONCUR) can be considered as valid selection instruments. These instrumental variables are statistically significant factors in the adoption or non-adoption of innovations (model 1; chi^2= 498.94; Prob > chi^2 = 0.00), but not on the productivity of firms that have not adopted any innovation. In addition, it is observed in Table A3 in the Annex that the correlation coefficients between different significant variables at 5% are very low. This suggests that these variables are not related to each other. On the basis of these results, it can be concluded that these explanatory variables of innovation have a significant effect on productivity only through innovation.

The exclusion conditions for these variables are shown in Figure A2 (Annex). The instrumentation of these innovation inputs allows us to introduce the predicted probabilities of technological and non-technological innovation into the productivity equation to control endogeneity. Although there are other endogeneity control methods such as control functions[7] (Baye, 2015; Wooldridge, 2015; Navatte, 2016), the technique used in this work is the one generally used in the field of innovation (Griffith et al, 2006; Robin and Mairesse, 2008; Mairesse and Mohnen, 2010; Polder et al, 2010; Brouillette, 2014; Hajjem et al, 2015; Fu et al, 2018).

Innovation and productivity

According to the results in Table 7, technological and non-technological innovation has more or less significant differentiated effects on business productivity depending on the sector of activity. Technological innovation [P (I_tech)] contributes significantly to high productivity for firms operating in Senegal. This shows that introduction of new and significantly improved products and processes leads to an improvement in the productivity of Senegalese companies. In addition, the optimization of production processes improves the quality of products in-house and its perception among consumers, which contributes to the improvement of sales and market shares and thereby an effective improvement in productivity. This positive result matches that of Fu et al (2018) in Ghana showing the positive impact of technological innovation on firms' productivity. The statistically significant negative effect of technological innovation in the secondary sector in Cameroon may be related to the failure of innovations in the market. A product that is not accepted by the market or simply a new product whose characteristics do not meet the convictions of consumers is doomed to failure. This failure is not without effect on the firm's performance because the initiative of the new product requires huge investments. This negative result is similar to that of Mairesse et al (2005) showing that productivity decreases at the beginning of new product launches and improves as the firm shifts the learning curve.

Similarly, non-technological innovation [P (I_ntech)] positively influences the productivity of tertiary sector enterprises in Cameroon and that of tertiary sector enterprises in Senegal. This statistically significant influence at 5% level, respectively, for the firms in Cameroon and Senegal suggests that the organizational and commercial changes within the firm contribute to increase in productivity. These

changes in operation show a clear improvement in terms of cost reduction and improved production quality, and hence productivity gains. This result corroborates with that of Aboal and Tacsir (2017) showing the positive influence of non-technological innovations on the productivity of service companies.

Table 7 also shows that the combination of technological and non-technological innovation [P (I_tech; I_Ntech)] contributes positively to productivity. But it is striking to note in the case of Cameroon that technological innovation has no positive effect on productivity when done in isolation. This effect becomes positive when combined with non-technological innovation. The same is true for Senegalese firms, because the combination of technological and non-technological innovation has a highly significant effect on firm productivity, while their individual effects are statistically nil. This result is consistent with the theoretical idea of possible complementarities between technological and non-technological innovation. This shows that technological innovation better promotes business performance when accompanied by non-technological innovation. For example, the introduction of new products and the integration of new production models contributes more to productivity when the firm reconciles all processes by extending its initiative to organization and marketing. This result is consistent with that of Brouillette (2014) showing a complementarity effect between technological and non-technological innovations on firm productivity.

The statistically insignificant effect of innovations introduced in isolation in Cameroon and Ivory Coast suggests a constant return to scale. This contradictory result to the literature may be due to the period of evaluation of innovation performance theoretically established between one and three years (OECD, 2005), but also to the relatively small size of firms**.** It is, therefore, clear that the likely effect of innovation is slow to be felt in the very short term. For example, introducing a new product to the market is subject to uncertainty about success, and depends on the relationship between this new product and the market structure. This shows that there is a lag time between the adoption of innovation and its effect on productivity. This result corroborates that of Gordon (2012) showing that the impact of recent innovation is small compared to that of past decades, and depends on the use of current innovation and its likely continuation over the years to come. In addition, since innovation uses new means that are generally very expensive, its effect on productivity in the short run is poorly observable. This effect may also be related to the measurement of real output and thus of productivity growth (the very definition of productivity usually includes sales or earnings) because it is difficult to quantify the contribution of innovations in productivity of goods and services. Some innovations (process innovation, for example) mainly affect costs while others (product innovation) have a major impact on revenue.

The capital coefficient remains positive and statistically significant for firms in Cameroon and Senegal, which indicates that physical capital is relevant to productivity in both sectors of activity. Skilled labour is positively correlated with the productivity of tertiary sector firms in Cameroon and Senegal, suggesting an increase in production following an increase in skilled jobs. Thus, human capital through its transversal

impact on the other stakeholders of the firm is important for the improvement of productivity. The increase in skilled jobs will increase productivity by 0.365, 1.69 and 0.434 points, respectively, for tertiary sector firms operating in Cameroon, Senegal and Ivory Coast. In addition, the coefficient of this indicator, which measures the deviation from constant returns to scale in the productivity equation, is negative and significant for firms in the secondary sector in Cameroon. This indicates a decreasing return on scale in this industry, which may be related to the relatively small size of companies operating at sub-optimal level.

One of the relevant remarks is the use of ICT significantly correlated with productivity for both the secondary and tertiary sectors, depending on the country. The use of the Internet for business is more important for secondary sector firms in Cameroon, as the coefficient for this indicator (3.295) is statistically significant at 5% level. This beneficial effect on productivity comes from the fact that the Internet provides better support for communication (internal and external) and greater sharing of information and better planning within the firm. Also, this may depend on the availability of broadband Internet connection in Cameroon since the installation of new operators in the communications sector (NEXTTEL) and the proliferation of Internet offers by Orange-Cameroon, MTN-Cameroon, CAMTEL and others (Tsambou and Fomba, 2017).

By this indicator comes the improvement of the productive system of the firm, which will certainly result in an increase of productivity through increase of sales, profit, return on investment, and market shares. The statistically insignificant effect of the use of the Internet for other countries is related to the functioning of the market of the Internet connection of these countries (low connection rate, high connection cost, very limited internet offer, etc). In addition, the use of specialized machinery and software for production (ICT_PRO) has a positive impact on the productivity of enterprises in the tertiary sector in Cameroon and that of companies in the secondary sector in Ivory Coast. This shows that the use of ICT tools for production has an intermediate effect induced by specialized software on improving production processes and product quality, and increasing flexibility. Thus, the use of new specialized software for the production of new goods and services is subject to economies of scale for a firm.

Thus, even if studies by Solow (1987) led him to state the „productivity paradox", this result shows that ICTs are a vector for the evolution of the firms's internal performance due to their added value in terms of productivity. But it does not stop the observation of negative or insignificant effect in certain sectors of activity or certain countries. This could be related to the fact that the use of ICT in the enterprise involves the catalysts of productivity increase such as training, staff competence, and organizational changes. Moreover, the statistically zero or negative effect of the use of ICT for advertising (ICT_MARK) is explained by the weak development of e-commerce. This result is in line with Mebarki (2013) and Tsambou and Fomba (2017) showing that certain ICT tools can have positive or negative effects on the firm's performance.

Comparing the Doubled Least Squares (DLS) and the Ordinary Least Squares

(OLS) estimation results (Table A5 in the Annex), we discover that the variance of the Doubled Least Squares estimation results is minimal, showing that estimation of productivity by the instrumental variables method is asymptotically unbiased. This joins the analysis of Angrist et al (1996) showing the relevance of the use of instrumental variables. As for the Chow test, since the residues are not normally distributed because of the problem of endogeneity, we simply apply a post-estimation test by the “test” or “testparm” stata command. This test for each country gives us the Fisher statistics that are above the theoretical values and strongly significant at the 1% level. This makes it possible to reject H0 (the model is unstable). Therefore, the coefficients of the models estimated at the level of each country are statistically different. This confirms the need to simultaneously study the three countries by

making estimates individually for each country.

Table 7: Result estimate of productivity by doubled least squares

Variables	Cameroon			Senegal			Ivory Coast			Whole		
	Secondary	Tertiary	Whole	Secondary	Tertiary	Whole	Secondary	Tertiary	Whole	Secondary	Tertiary	Whole
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
P (I_tech)	-7.946** (30.74)	-7.438 (12.66)	-5.632 (15.70)	-30.10 (29.00)	17.01 (10.94)	21.16* (12.74)	-14.08 (44.22)	-7.652 (23.95)	-7.369 (21.056)	209.59 (147.07)	-37.72 (23.76)	-12.87 (27.56)
P (I_ntech)	-47.21 (35.32)	23.93** (11.86)	14.29 (15.93)	-40.08 (65.98)	30.42** (15.29)	37.44** (19.35)	13.90 (27.20)	-8.976 (13.93)	-5.601 (11.23)	224.02** (115.87)	16.606 (22.26)	32.40 (25.20)
P(I_tech ; I_ntech)	16.62* (9.96)	7.260** (3.583)	4.015* (4.69)	15.07*** (4.045)	24.77*** (8.30)	19.39*** (7.091)	3.089 (7.008)	-1.450 (3.775)	-1.122 (2.893)	43.62** (20.64)	10.82*** (3.95)	11.86*** (4.129)
Capital (KPT)	0.538*** (.127)	0.264*** (0.049)	0.3799*** (0.063)	0.1179 (0.1041)	-0.1096 (0.1196)	-0.126 (0.124)	0.653*** (0.082)	0.220*** (0.054)	0.326*** (0.0455)	-0.265 (0.266)	0.134*** (0.036)	0.131 (0.035)
Cooperation	5.70* (3.36)	-1.797 (1.43)	-0.2122 (1.745)	14.05 (39.04)	-0.014 (4.66)	2.19 (4.405)	-1.807 (1.695)	0.4469 (1.983)	0.107 (1.303)	-1.36 (4.17)	-4.246*** (1.28)	-3.572*** (0.984)
Respect of norms	-0.412 (2.589)	-0.5597 (1.046)	0.2337 (1.301)	2.487 (1.917)	-9.567** (4.485)	-8.943** (4.333)	2.802 (1.874)	1.986* (1.236)	1.625 (1.055)	2.59 (2.43)	-0.865 (0.862)	-0.774 (0.718)
Qualified workers	-0.538** (0.279)	0.365** (0.153)	-0.1821 (0.171)	5.31 (13.02)	1.219 (0.446)	1.69*** (0.597)	-0.5334 (0.428)	0.453* (0.244)	0.434** (0.1980)	1.429 (0.898)	0.311* (0.171)	0.3190** (0.166)
Unqualified workers	0.548 (0.4505)	0.639*** (0.178)	0.251 (0.217)	0.5616 (0.519)	1.126 (0.8734)	1.276 (0.823)	0.763*** (0.287)	0.980*** (0.306)	0.7792*** (0.236)	-0.598 (0.704)	0.313* (0.188)	0.313** (0.159)
INTERNET	3.295** (1.38)	-0.3326 (0.645)	0.5209 (0.772)	-0.725 (1.68)	-0.2226 (2.273)	0.5111 (2.191)	-0.577 (1.337)	-0.226 (0.902)	0.053 (.746)	2.105 (1.892)	-1.373** (0.580)	-0.646 (0.4897)
ICT_MARK	0.583 (1.523)	0.544 (0.691)	0.562 (.829)	-2.992 (1.820)	-5.267** (2.534)	-5.037** (2.249)	-4.546*** (1.157)	0.778 (0.996)	-0.3759 (0.746)	-3.75* (2.19)	-0.113 (0.598)	-0.643 (0.515)
ICT_PRO	0.5665 (2.05)	1.44 (0.9152	1.606 (1.102)	-2.713 (2.258)	-3.228 (2.620)	-3.154 (2.47)	1.577 (1.447)	0.8154 (1.246)	0.934 (0.958)	5.12 (3.73)	-0.294 (0.790)	-0.250 (0.660)
Cameroon										13.92*** (4.44)	5.013*** (0.802)	5.48*** (0.886)

Senegal										25.69*** (5.35)	17.13*** (1.703)	17.79*** (1.502)
Constant	11.52 (9.07)	-3.55 (2.707)	-4.009 (3.749)	17.04* (9.693)	-45.006 (29.213)	-58.06 (34.86)	-1.057 (11.42)	2.780 (4.798)	2.118 (4.178)	-79.72 (42.13)	-6.774 (6.873)	-12.01 (8.090)
F	6.93	43.36	16.06	5.65	3.28	3.68	35.34	24.62	41.41	13.78	108.81	160.16
Prob > F	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	.0000
R-squared	0.280	0.515	0.223	0.079	0,096	0,131	0.750	0.4203	0.4650	0,16	0.507	0.5097
Observation	179	452	639	218	493	723	141	381	535	538	1326	1897

Note: Standard deviations are in brackets. *, ** and *** indicate variables significance at 10%, 5% and 1%, respectively. P(I_tech) = Predicted probability for technological innovation; P (I_ntech) = Predicted probability for non-technological innovation. P(I_tech et I_ntech) = Predicted probability for technological and non-technological innovation

5. Conclusion

The objective of this work was to highlight the impact of the adoption of innovations on the productivity of firms in Cameroon, Senegal and Ivory Coast. For this purpose, we used a two-step methodology method. The first step consisted using the bivariate probit method to obtain adjusted values of innovation instruments and identifiy the existing correlation between technological and non-technological innovation. This correlation allows us to have a presumption of complementarity between these two types of innovation. By instrumentation of the explanatory variables of innovation, we introduced the adjusted values of innovation into the productivity equation. This productivity measured by value added is estimated by double least squares per country and per industry. This method generally used in the literature (Polder et al, 2010; Aboal and Tacsir, 2017; Fu et al, 2018) has allowed us to highlight both the heterogeneity in the adoption of innovations and their effects on productivity, and to show the complementarities between these innovations.In accordance with the literature, we found significant correlations between technological and non-technological innovation in both the secondary and tertiary sectors after controlling for explanatory variables. This correlation enhanced the verification of the effect of joint adoption of technological and non-technological innovation on productivity. Thus, although the adoption of innovations is a complex process involving these two inputs, their adoption in isolation has differential effects on the productivity of the firm according to the sector of activity and the country of establishment. But this effect is much more improved in terms of the level of significance when both types of innovations are introduced together. This shows, for example, that introduction of new products (or services) or new modes of production contributes more to productivity when accompanied by new methods of organization and marketing. In addition, the use of ICT has been necessary for productivity, depending on the sector of activity and the country. Specifically, the use of Internet for business is more prone to economies of scale for Cameroonian and Ivorian firms. Ultimately, since non-technological innovation has a positive and significant impact on productivity, government policies should promote the adoption of new management and marketing methods that could provide countries with another engine of economic growth. Moreover, since the simultaneous adoption of technological and non-technological innovations has a strong effect on productivity, policies to support innovation should take into account the fact that technological and non-technological innovation must be adopted together to move from factor-led to innovation-led growth. This type of study could be extended to all French-speaking sub-Saharan African countries by

assessing not only the effect of innovation adoption on productivity, but also on demand and the structure of the enterprise labour force to place innovation at the centre of development and as an essential ingredient of growth.

Notes

1 We talk about economies of scale if each good produced is less expensive to produce when the quantities produced (economies of scale compared to the cost of production) or sold (economies of scale compared to the cost price) increase. This is a situation in which an increase in the output of a firm results in a decrease in the average unit cost of a product or service.

2 Added value is the concept used to measure the output of an economic agent over a given period of time (usually the term or the year). It is equal to the value of production minus intermediate consumption.

3 According to Wooldridge (2010), endogeneity generally manifests from several sources: Firstly, the omission of variables, i.e. the relationship between the dependent and independent variable is related to the effect of a third factor not introduced in the estimation equation. For this, it would be necessary to add a variable in the model countering this third unobserved factor; secondly, measurement error, that is, some explanatory variables cannot be accurately measured, which causes a bias in the estimation of the coefficient of interest and therefore misleading conclusions; thirdly, simultaneity: It occurs when at least one of the explanatory variables is determined simultaneously with the dependent variable. One of the solutions is to instrument the explanatory variable concerned by another variable not influenced by the dependent variable.

4 In fact, the estimation of an equation system involving a binary equation and a continuous variable is usually done through the Heckman Method (1979). The maximum likelihood method is used in the case of complete information. This involves estimating both equations simultaneously in one step. When the selection variable consists of two binary variables, the full information maximum likelihood method used for the Heckman method is no longer applicable. One can necessarily resort to the method of maximum likelihood in incomplete information; that is to say the estimation of the two equations must be done in two stages.

5 https://www.stata.com/support/faqs/statistics/computing-chow-statistic/

6 The correlation coefficient is a measure that determines the degree to which the movements of two variables are associated. The range of values for the correlation coefficient is [-1,1]. A correlation of [-1,0] indicates a perfect negative correlation, while a correlation of [1,0] indicates a perfect positive correlation.

7 The control function is a variable which, added to a regression, makes the variables of interest suitably exogenous. This method allows us to solve the problems of the endogenous variables in the linear and nonlinear models. Wooldridge (2015) shows that the control function's approach is intricately a method of instrumental variables because the equation of interest (structural equation) contains at least one endogenous explanatory variable or suspected to be endogenous in that it is correlated with the unobservable elements in the equation.

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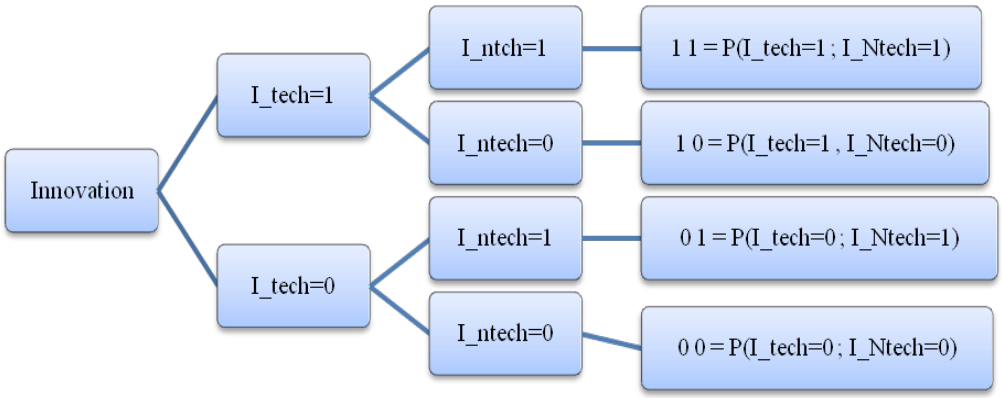
Annex

Figure A1: Tree diagram for the different types of innovations



Note: I_tech = technological innovation ; I_Ntech = non-technological innovation

Figure A2: Principle of instrumental variables

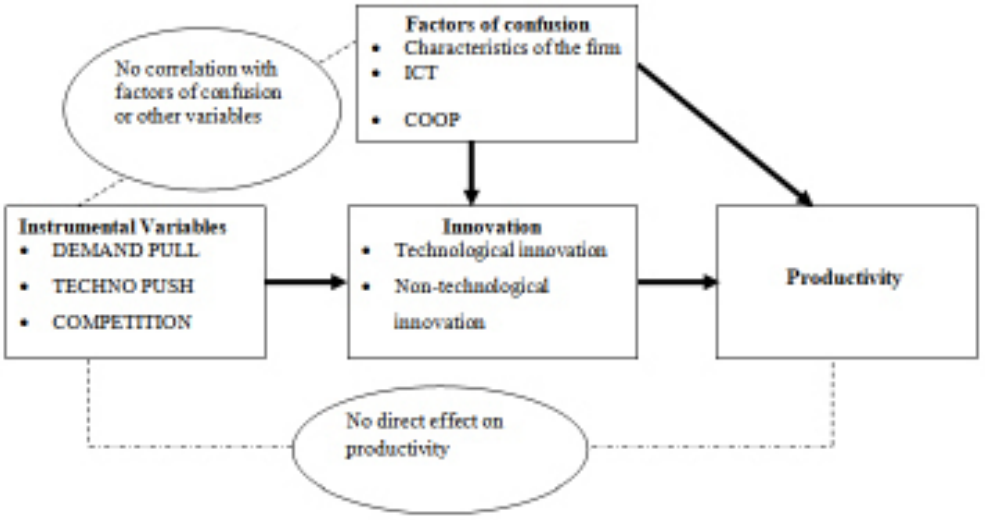


Table A1: Marginal effects

Variables	Cameroon				Senegal				Ivory Coast				Global			
	1 0	0 1	1 1	0 0	1 0	**0 1**	**1 1**	**0 0**	**1 0**	**0 1**	**1 1**	**0 0**	**1 0**	**0 1**	**1 1**	**0 0**
	dy/dx	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**
Size	-0,0054	0,0057	0,0149	-0,0153	-0,0050	0,0069	0,0161	-0,0180	-0,0062	0,0084	0,0181	-0,0203	-0,0055	0,0069	0,0163	-0,0177
	(0,0050)	(0,0083)	(0,0110)	(0,0094)	(0,0079)	(0,0072)	(0,0107)	(0,0123)	(0,0067)	(0,0099)	(0,0130)	(0,0126)	(0,0065)	(0,0083)	(0,0114)	(0,0114)
Skilled labour	0,0044	-0,0098	0,0140	-0,0085	0,0096	-0,0071	0,0117	-0,0143	0,0069	-0,0107	0,0160	-0,0122	0,0071	-0,0090	0,0137	-0,0117
	(0,0082)	(0,0135)	(0,0170)	(0,0148)	(0,0128)	(0,0118)	(0,0165)	(0,0190)	(0,0110)	(0,0162)	(0,0200)	(0,0198)	(0,0107)	(0,0136)	(0,0176)	(0,0177)
Unskilled labour	-0,014**	0,0240**	-0,0104	30,22	-0,023**	0,0202**	-0,0050	0,0078	-0,0190**	0,0283**	-0,0109	0,0016	-0,0187**	0,0238**	-0,0085	0,0034
	(0,0069)	(0,0113)	(0,0147)	(0,0127)	(0,0108)	(0,0099)	(0,0143)	(0,0164)	(0,0093)	(0,0136)	(0,0173)	(0,0170)	(0,0089)	(0,0113)	(0,0152)	(0,0152)
Sector of activity	0,0057	-0,0304	0,1072	-0,0825	0,0315	-0,0145	0,1000	-0,1170	0,0153	-0,0271	0,1253	-0,1135	0,0183	-0,0234	0,10961	-0,1044
	(0,0299)	(0,0503)	(0,0672)	(0,0568)	(0,0481)	(0,0433)	(0,0650)	(0,0749)	(0,0403)	(0,0596)	(0,0786)	(0,0761)	(0,0394)	(0,0501)	(0,0694)	(0,0688)
Tertiary sector	-0,0140	0,0100	0,0643	-0,0603	-0,0078	0,0165	0,0663	-0,0750	-0,0143	0,0182	0,0769	-0,0807	-0,0117	0,0148	0,0686	-0,0716
	(0,0295)	(0,0496)	(0,0664)	(0,0560)	(0,0475)	(0,0428)	(0,06406)	(0,0738)	(0,0398)	(0,0588)	(0,0777)	(0,0752)	(0,0389)	(0,0495)	(0,0685)	(0,0679)
SARL	-0,0116	-0,0055	0,1240***	-0,107***	0,0085	0,0095	0,1223***	-0,14***	-0,0069	0,0047	0,1467***	-0,144***	-0,0026	0,0030	0,1297***	-0,130***
	(0,0145)	(0,0244)	(0,0322)	(0,0273)	(0,0225)	(0,0203)	(0,0302)	(0,0346)	(0,0198)	(0,0293)	(0,0382)	(0,0371)	(0,0188)	(0,0241)	(0,0329)	(0,0326)
SA	-0,0103	-0,0108	0,1395***	-0,118***	0,0138	0,0067	0,1365***	-0,16***	-0,0040	-0,0002	0,1648***	-0,160***	0,0006	-0,0011	0,1455***	-0,145***
	(0,0180)	(0,0299)	(0,0391)	(0,0336)	(0,0277)	(0,0252)	(0,0370)	(0,0425)	(0,0243)	(0,0359)	(0,0463)	(0,0454)	(0,0232)	(0,0296)	(0,0401)	(0,0400)
EI	-0,0086	-0,0104	0,1242***	-0,105***	0,0131	0,0052	0,1214***	-0,14***	-0,0028	-0,0012	0,1467***	-0,143***	0,0012	-0,0018	0,1295***	-0,129***
	(0,0158)	(0,0269)	(0,0356)	(0,0298)	(0,0249)	(0,0224)	(0,0334)	(0,0383)	(0,0216)	(0,0319)	(0,0417)	(0,0404)	(0,0207)	(0,0265)	(0,0363)	(0,0358)
DEMAND_PULL	0,0271**	-0,11***	0,3190***	-0,24***					0,0590***	-0,100***	0,3719***	-0,33***	0,0673***	-0,086***	0,3243***	-0,30***
	(0,0123)	(0,0195)	(0,0256)	(0,0221)					(0,0182)	(0,0283)	(0,0352)	(0,0353)	(0,0173)	(0,0217)	(0,0297)	(0,0299)
TEHNO PUSH	-0,0050	-0,0287	0,1869***	-0,153***	0,0320**	-0,00362	0,1798***	-0,2***	0,0064	-0,0176	0,2200***	-0,208***	0,0123	-0,0160	0,1935***	-0,189***
	(0,0113)	(0,0190)	(0,0251)	(0,0221)	(0,0172)	(0,0157)	(0,0237)	(0,0270)	(0,0153)	(0,0227)	(0,0294)	(0,0294)	(0,0144)	(0,0185)	(0,0255)	(0,0257)
CONCUR_NAT	-0,0128	0,0098	0,0550***	-0,052***	-0,0078	0,0152	0,0570***	-0,06***	-0,0133	0,0170	0,0659***	-0,069***	-0,0110	0,0139	0,0588***	-0,062***
	(0,0088)	(0,0146)	(0,0197)	(0,01677)	(0,0140)	(0,0127)	(0,0191)	(0,0220)	(0,0118)	(0,0174)	(0,0232)	(0,0225)	(0,0115)	(0,0146)	(0,0204)	(0,0202)
CONCUR_INT	0,0136	-0,0230	0,0050	0,0043	0,0219	-0,0199	-0,0001	-0,00186	0,0187	-0,0276	0,0046	0,0043	0,0182	-0,0231	0,0029	0,0019
	(0,0089)	(0,0148)	(0,0198)	(0,0169)	(0,0141)	(0,0129)	(0,0192)	(0,0221)	(0,0120)	(0,0177)	(0,0233)	(0,0228)	(0,0116)	(0,0148)	(0,0205)	(0,0205)
NORD	-0,0014	-0,0153	0,0897***	-0,072***	0,0168	-0,0031	0,0859***	-0,09**	0,0043	-0,0103	0,1055***	-0,099***	0,0071	-0,0092	0,0927***	-0,090***
	(0,0138)	(0,0232)	(0,0308)	(0,0263)	(0,0217)	(0,0196)	(0,0293)	(0,0337)	(0,0184)	(0,0271)	(0,0355)	(0,0348)	(0,0179)	(0,0228)	(0,0315)	(0,0313)
COOP	-0,04***	0,0351**	0,1447***	-0,140***	-0,0294*	0,0482***	0,1520***	-0,17***	-0,043***	0,0562***	0,1738***	-0,187***	-0,036***	0,0461***	0,1557***	-0,165***
	(0,0109)	(0,0171)	(0,0226)	(0,0198)	(0,0169)	(0,0153)	(0,0222)	(0,0258)	(0,0148)	(0,0216)	(0,0278)	(0,0271)	(0,0139)	(0,0173)	(0,0236)	(0,0238)
INTERNET	0,0003	-0,0035	0,0153	-0,0121	0,0037	-0,0013	0,0144	-0,0168	0,0015	-0,0028	0,0179	-0,0166	0,0019	-0,0025	0,0157	-0,0151
	(0,0127)	(0,0211)	(0,0279)	(0,0240)	(0,0201)	(0,0183)	(0,0272)	(0,0312)	(0,0171)	(0,0253)	(0,0329)	(0,0323)	(0,0166)	(0,0212)	(0,0289)	(0,0290)
ICT_MARK	0,0043	-0,0194	0,0622**	-0,0472**	0,0199	-0,0099	0,0577**	-0,067**	0,01031	-0,0178	0,0727**	-0,0651**	0,0119	-0,0153	0,0634**	-0,0601**
	(0,0125)	(0,0210)	(0,0280)	(0,0239)	(0,0199)	(0,0180)	(0,0270)	(0,0310)	(0,0169)	(0,0249)	(0,0328)	(0,0321)	(0,0164)	(0,0209)	(0,0288)	(0,0288)
ICT_PRO	-0,0022	0,0037	-0,0004	-0,0010	-0,0035	0,0032	0,0003	-0,0001	-0,0030	0,0045	-0,0003	-0,0011	-0,00298	0,0037	-0,0001	-0,0006
	(0,0132)	(0,0220)	(0,0294)	(0,0250)	(0,0210)	(0,0190)	(0,0285)	(0,0328)	(0,0178)	(0,0263)	(0,0328)	(0,0337)	(0,0173)	(0,0220)	(0,0304)	(0,0303)

Note: Standard deviations are in brackets, *, ** and *** show significance at the 10%, 5% and 1%, respectively. The terms (1,0) and (0,1), respectively, stand for the adoption of a

technological and non-technological innovation while (1,1) represents the joint adoption of the technological and non-technological innovation. Following this same reasoning, the term (0,0) shows the absence of innovation since it is equal to zero for both forms of innovation.

Table A2 : Validity test estimation parameters for IV instruments

Variables	**Model 1 : Adoption of innovation**		**Model 2: Productivity of firms that have not adopted any innovation**		
	Technological Innovation	Non-technological Innovation	Cameroon	Senegal	Ivory Coast
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
DEMAND_PULL	0,89***	0,89***	0,052		-1,272
	(0,079)	(0,082)	(1,11)		(1,203)
TECHNO_PUSH	0,56***	0,50***	2,64	1,334	-1,856
	(0,089)	(0,092)	(1,364)	(1,524)	(1,711)
CONCUR_NAT	0,19***	0,19***	0,087	5,347	0,069
	(0,070)	(0,071)	(1,356)	(0,784)	(0,568)
CONCUR _INT	0,071	-0,123*	0,034	-1,078	1,191
	(0,072)	(0,074)	(1,324)	(0,716)	(0,904)
NORD	0,62***	0,65***	3,823	3,65***	3,94***
	(0,078)	(0,079)	(2,02)	(0,95)	(0,787)
COOP	0,39***	0,75***	1,805**	6,70***	-0,435
	(0,081)	(0,086)	(0,806)	(1,884)	(1,271)
Constant	-0,67***	-0,53***	3,35***	7,05***	-0,336
	(0,056)	(0,055)	(0,343)	(0,694)	(0,384)
Rho	0,64*** (,027)				
Test de Wald	498,94 ; Prob > chi^2 = 0,00				
Test de Fisher			3,04	11,93	5,96
R^2			0,098	0,098	0,166
Observations	**1,897**		**175**	**317**	**187**

Note: Standard deviations are in brackets, *** p<0,01, ** p<0,05, * p<0,1, parameters of all the other variables are not necessary

Table A3: Correlation coefficients between innovation explanatory variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	Cameroon																
1	1,000																
2	0,743*	1,000															
3	0,914*	0,764	1,000														
4	0,141*	0,080*	0,067	1,000													
5	-0,167*	-0,099*	-0,075	-0,969*	1,000												
6	0,405*	0,267*	0,338*	0,099*	-0,095*	1,000											
7	0,5776*	0,467*	0,597*	0,055	-0,085*	-0,168*	1,000										
8	-0,689*	-0,536*	-0,66*	-0,117*	0,130*	-0,575*	-0,49*	1,000									
9	0,215*	0,146*	0,200*	0,103*	-0,113*	0,061	0,103*	-0,091*	1,000								
10	0,368*	0,283*	0,392*	0,027	-0,025	0,141*	0,232*	-0,287*	0,152*	1,000							
11	0,227*	0,158*	0,210*	0,093*	-0,108*	0,090*	0,120*	-0,136*	0,702*	0,179*	1,000						
12	0,252*	0,172*	0,213*	0,101*	-0,115*	0,093*	0,117*	-0,158*	0,441*	0,195*	0,527*	1,000					
13	0,320*	0,321*	0,320*	0,083*	-0,103*	0,059	0,32 *	-0,255*	0,131*	0,214*	0,165*	0,164*	1,000				
14	0,336*	0,242*	0,293*	0,155*	-0,161*	0,140*	0,19 *	-0,226*	0,180*	0,253*	0,120*	0,127*	0,189*	1,000			
15	0,634*	0,474*	0,611*	0,062	-0,076	0,330*	0,467*	-0,547*	0,163*	0,351*	0,170*	0,169*	0,271*	0,29 *	1,000		
16	0,659*	0,499*	0,644*	-0,044	0,027	0,312*	0,491*	-0,561*	0,195*	0,354*	0,213*	0,209*	0,260*	0,31 *	0,682*	1,000	
17	0,720*	0,550*	0,676*	0,034	-0,059	0,373*	0,504*	-0,607*	0,201*	0,428*	0,231*	0,216*	0,306*	0,312*	0,678*	0,724*	1,000
	Senegal																
1	1,000																
2	0,648*	1,000															
3	0,775*	0,748*	1,000														
4	0,056	-0,014	-0,021	1,000													
5	-0,080*	0,011	0,006	-0,961*	1,000												
6	0,185*	0,099*	0,170*	-0,131*	0,113*	1,000											
7	0,468*	0,466*	0,484*	0,046	-0,044	-0,143*	1,000										
8	-0,003	-0,041	0,029*	-0,132*	0,132*	-0,150*	-0,11*	1,000									

9																	
10	0,148*	0,129*	0,159*	-0,053	0,030	0,066	0,054	-0,037		1,000							
11	-0,048	-0,073*	-0,08*	0,132*	-0,135*	-0,122*	-0,037	-0,214*		0,124*	1,000						
12	0,055	0,073*	0,004	0,182*	-0,186*	-0,035	0,062	-0,148*		0,203*	0,291*	1,000					
13	0,471*	0,393*	0,485*	-0,168*	0,137*	0,509*	0,364*	0,368*		0,096*	-0,221*	-0,078*	1,000				
14	0,423*	0,405*	0,476*	-0,064	0,044	0,275*	0,392*	0,103*		0,120*	-0,086*	-0,027	0,540*	1,000			
15	0,294*	0,275*	0,328*	-0,099*	0,066	0,294*	0,288*	0,086*		0,154*	-0,060	-0,007	0,472*	0,414*	1,000		
16	0,435*	0,397*	0,441*	-0,128*	0,098*	0,289*	0,372*	0,050		0,188*	-0,051	-0,004	0,494*	0,438*	0,551 *	1,000	
17	0,485*	0,447*	0,510*	-0,145*	0,138*	0,353*	0,424*	0,126*		0,185*	-0,152*	-0,034	0,617*	0,465*	0,501 *	0,578*	1,000
	Ivory Coast																
1	1,000																
2	0,661*	1,000															
3	0,796*	0,589*	1,000														
4	-0,002	-0,050	-0,068	1,000													
5	0,033	0,062	0,087*	-0,940*	1,000												
6	-0,167*	-0,133*	-0,16*	0,194*	-0,108*	1,000											
7	0,148*	0,192*	0,223*	-0,174*	0,192*	-0,716*	1,000										
8	0,151*	-0,039	0,038	-0,097*	0,108*	-0,421*	-0,11*	1,0000									
9	-0,114*	-0,076	-0,09*	-0,024	0,023	0,041	-0,023	-0,071	1,000								
10	0,458*	0,447*	0,470*	0,011	0,003	-0,044	0,058	0,050	-0,079*	1,000							
11	0,140*	0,185*	0,180*	-0,106$	0,127*	-0,040	0,045	0,029	0,218*	0,097*	1,000						
12	0,291*	0,288*	0,283*	-0,054	0,063	-0,065	0,040	0,063	0,345*	0,215*	0,367*	1,000					
13	0,728*	0,493*	0,605*	-0,152*	0,177*	-0,217*	0,029	0,398*	-0,157*	0,454*	0,212*	0,321*	1,000				
14	-0,085*	-0,106*	-0,078	0,178*	-0,158*	0,044	0,012	-0,072	-0,055	-0,053	-0,122*	-0,061	-0,159*	1,000			
15	0,451*	0,358*	0,413*	-0,086*	0,104*	-0,097*	0,051	0,152*	-0,103*	0,432*	0,122*	0,245*	0,603*	-0,083	1,000		
16	0,594*	0,530*	0,549*	-0,057	0,078	-0,060	0,073	0,066	-0,102*	0,475*	0,172*	0,294*	0,674*	-0,10*	0,564*	1,000	
17	0,639*	0,543*	0,583*	-0,071	0,095*	-0,131*	0,061	0,153*	-0,104*	0,513*	0,232*	0,288*	0,779*	-0,14*	0,549*	0,633*	1,000
	Whole																
1	1,000																
2	0,692*	1,000															

3	0,848*	0,731*	1,000														
4	0,079*	0,015	0,006	1,000													
5	-0,089*	-0,021*	-0,009	-0,958*	1,000												
6	0,038	0,046*	0,065*	0,021	-0,009	1,000											
7	0,405*	0,387*	0,449*	-0,020	0,010	-0,259*	1,000										
8	-0,197*	-0,182*	-0,18*	-0,094*	0,105*	-0,420*	-0,22*	1,000									
9	0,174*	0,119*	0,202*	0,026	-0,025	-0,118*	0,045*	0,369*	1,000								
10	0,297*	0,232*	0,291*	-0,006	0,001	-0,031	0,098*	-0,113*	0,017*	1,000							
11	0,111	0,068*	0,090*	0,054*	-0,054*	-0,042	0,038	-0,133*	0,245*	0,146*	1,000						
12	0,203*	0,154*	0,149*	0,098*	-0,101*	-0,074*	0,062*	-0,077*	0,211*	0,221*	0,396*	1,000					
13	0,395*	0,326*	0,350*	-0,095*	0,084*	0,135*	0,204*	-0,040	-0,208*	0,209*	0,027*	0,093*	1,000				
14	0,335*	0,276*	0,336*	0,072*	-0,076*	0,013	0,200*	0,081*	0,256*	0,153*	-0,013*	0,048*	0,172*	1,000			
15	0,491*	0,380*	0,479*	-0,032	0,020	0,092*	0,280*	-0,115*	0,115*	0,280*	0,070*	0,125*	0,391*	0,302 *	1,000		
16	0,566*	0,461*	0,541*	-0,076*	0,064*	0,090*	0,316*	-0,160*	0,079*	0,309*	0,104*	0,151*	0,446*	0,300*	0,609*	1,000	
17	0,621*	0,508*	0,596*	-0,060*	0,056*	0,124*	0,339*	-0,130*	0,114*	0,333*	0,087*	0,140*	0,521*	0,303*	0,586*	0,647*	1,000

Note: * significant at 5%, Size of the firm(1), Skilled labour (2), Unskilled labour (3), secondary sector (4), Tertiary sector (5), SARL (6), SA (7), EI (8), DEMAND PULL (9), TECHNO PUSH (10), CONCUR_NAT (11), CONCUR_INT (12), NORD (13), COOP (14), INTERNET (15), TIC_MARK (16), TIC_PRO (17).

Table A4: Description of variables

Variables	**Description of the variables**
Types of innovations	
I_tech	Binary variable that takes the value 1 if the firm adopted a technological innovation and 0 if no
I_Ntech	Binary variable that takes the value 1 if the firm adopted a non-technological innovation and 0 if no
Characteristics of the firm	
SIZE	Total number of employees
Skilled labour	Number of skilled employees: Number of qualified employees: These are employees in middle, senior or senior technical management positions
Unskilled labour	Number of unskilled employees: These are workers and supervisors
Legal structure	1 = limited liability firm (SARL), 2=joint stock firm (SA), 3= sole proprietorship (EI), 4=other.
Sector of activity	1 = primary; 2 = secondary ; 3 = tertiary
Variables related to the socio-economic environment of the firm	
DEMAND PULL	Demand impulse: Binary variable that takes the value 1 if the firm innovates following customer needs (interaction between customers and the firm) and 0 if not
TECHNO PUSH	Technological push: Binary variable 1= yes and 0 if not. This binary variable is constructed from information on the acquisition of R&D services and the acquisition of licensed technologies
NORD	Norms: Binary variable taking value 1 if firm respects production standards and 0 if no
COOP	Cooperation: Binary variable taking value 1 if the firm practices a partnership or cooperation with other companies for innovation activities and 0 if not
CONCUR_NAT	National competition: Binary variable that takes the value 1 if local competition affects decision to innovate and 0 if not
CONCUR_INT	Foreign competiton: Binary variable that takes the value 1 if foreign competition affects decision to innovate and 0 if not
Factors related to ICT	
INTERNET	Binary variable equal to 1 if firm carries out business operations on the internet
ICT_PRO	ICT in the production process: Binary variable taking value 1 if the firm uses ICT in the production process and 0 if no
ICT_MARK	ICT for publicity and the marketing of products: Binary variable taking value 1=yes and 0=no
P (I_tech)	Predicted probability of technological innovation
P_(I_Ntech)	Predicted probability of non-technological innovation
P_(I_tech ; I_Ntech)	**Predicted probability of technological or non-technological innovation**

Table A5: Result estimate of productivity by doubled least squares

Variables	Cameroon			Senegal			**Ivory Coast**			**The three countries**		
	Secondary	Tertiary	Whole	Secondary	Tertiary	Whole	Secondary	Tertiary	Whole	Secondary	Tertiary	Whole
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
Capital (KPT)	.446*** (.0889)	.285*** (.053)	.323*** (.045)	.029 (.082)	-.029 (.043)	-.011 (.036)	.741*** (.082)	.268*** (.051)	.381*** (.042)	.196*** (.046)	.105*** (.026)	.134*** (.022)
P (I_tech)	-24.11*** (7.083)	1.635 (4.847)	-6.445* (3.855)	19.67* (11.89)	28.06*** (8.585)	23.06*** (5.929)	-.658 (15.43)	.961 (18.80)	-8.671 (10.19)	-2.655 (6.443)	9.468*** (4.589)	5.833** (3.391)
P (I_ntech)	2.863 (4.991)	4.595* (2.801)	4.479** (2.389)	35.84** (18.35)	15.48* (8.769)	19.89*** (7.108)	5.271 (9.922)	-5.594 (8.768)	-8.202 (5.370)	7.861 (5.183)	6.974** (2.866)	6.356*** (2.391)
P(I_tech ; I_ntech)	.586 (1.578)	1.633** (.982)	1.779** (.801)	15.223*** (3.642)	10.47*** (2.095)	11.42*** (1.762)	-.525 (2.471)	-.969 (2.323)	-1.766 (1.548)	3.283** (1.515)	3.080*** (.917)	2.909*** (.754)
Qualified workers	-.494** (.189)	-.088 (.147)	-.199* (.114)	.566 (.469)	.781*** (.259)	.647*** (.211)	-.667* (.385)	.0302 (.283)	-.012 (.222)	.072 (.197)	.335*** (.127)	.274*** (.104)
Unqualified workers	.051 (.277)	.081 (.177)	.095 (.143)	-.757 (.579)	-.546 (.346)	-.473* (.276)	.014 (.288)	.622** (.296)	.316 (.228)	-.055 (.246)	.075 (.156)	.053 (.126)
INTERNET	1.853** (.863)	.022 (.585)	.457 (.479)	.136 (1.496)	-1.353 (.849)	-1.084 (.719)	.322 (1.283)	-.0313 (.867)	.176 (.720)	1.427** (.767)	-.568 (.458)	-.144 (.388)
ICT_MARK	.859 (.944)	.567 (.638)	.563 (.509)	-2.91* (1.657)	-1.331 (.834)	-1.700** (.715)	-4.082*** (1.120)	1.104 (.908)	-.125 (.743)	-1.407* (.833)	.437 (.467)	-.0470 (.398)
ICT_PRO	-.582 (.885)	2.287*** (.644)	1.541*** (.5123)	-1.512 (1.863)	.3712 (.834)	-.007 (.741)	3.064*** (1.074)	1.129 (.843)	1.156** (.697)	.768 (.840)	1.346*** (.467)	1.240*** (.402)
Cameroon										2.230*** (.642)	2.852*** (.381)	2.686*** (.322)
Senegal										11.16*** (.775)	9.883*** (.467)	10.09*** (.385)
Constant	2.124 (1.760)	-.148 (.842)	.258 (.751)	1.414 (2.800)	3.313** (1.522)	3.143** (1.270)	-1.187 (3.820)	.751 (3.544)	2.287 (2.014)	-2.339 (1.605)	-3.212*** (.892)	-2.763*** (.743)
F	10.64	19.85	28.41	4.41	8.32	12.43	28.23	15.48	28.28	48.92	103.53	154.30
Prob > F	0.000	0.000	0.000	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.362	0.288	0.289	0.160	0.134	0.136	0.660	0.273	0.326	0.506	0.464	0.474
Adj R-squared	0.328	0.273	0.279	0.124	0.118	0.125	0.636	0.255	0.315	0.495	0.460	0.471
Obs	179	452	639	218	493	723	141	381	535	538	1326	1897

Note: Standard deviations are in brackets. *, ** and *** indicate variables significance at 10%, 5% and 1%, respectively. P(I_tech) = Predicted probability for technological innovation; P (I_ntech) = Predicted probability for non-technological innovation. P(I_tech et I_ntech) = Predicted probability for technological and non-technological innovation

Box: Data representativeness

The survey on the performance of firms operating in Cameroon, Senegal and Ivory Coast focuses on the main indicators describing the economic performance of enterprises, namely: social standards, ICT and innovation within companies. The unit of inquiry is the enterprise, which is an economic unit, legally autonomous, organized to produce goods and services for the market. The sample of the survey is constituted to obtain representative sizes according to the regions selected for the study and is given by the formula:

$$n = \frac{z^2 p(1-p)}{e^2}$$

Where *n* represents the size of the sample to be calculated, Z represents the value of the distribution function of the reduced normal centred law. For a 95% confidence level, $Z = 1,96$. e is the tolerable margin of error or accuracy. P is the estimated proportion of firms with the characteristics studied. The study evaluating several phenomena for which the representativity in the population is unknown, we will retain $P = 50\%$. Setting the margin of error at 4%, we find $n = 600$ firms per country. Given that firms surveys in these countries (RGE, 2009) usually have response rates of around 80%, this survey predicted a response rate of 80%. The *ex-ante* sample was set at a minimum of 750 companies ($n/80\%$) per country. Depending on the sampling frame used in each country (firms directory available at the National Statistical Institution of each country), the three regions selected for the study represent about 70% of firms from these countries. Given this spatial representativeness, the survey took place in Douala, Yaoundé and Bafoussam for Cameroon; Dakar, Saint-Louis and Thiès for Senegal; and Abidjan, San Pedro and Daloa in Ivory Coast. The sampling frame for Cameroon comes from the general census of companies carried out in 2009 by the National Institute of Statistics. That of Senegal comes from the national firms survey and the survey on the monitoring of poverty in Senegal carried out by the National Agency of Statistics and Demography (ANSD) in 2011. That of Ivory Coast comes from the survey base conducted successively in 2012 and 2013 by the National Institute of Statistics.

Of the 750 firms sampled for each country, 639 firms were actually surveyed in Cameroon for a coverage rate of 85.2%; 723 companies were surveyed in Senegal for a coverage rate of 96.4%; 535 companies were surveyed in Ivory Coast for a coverage rate of 71.33%. This shows that the margin of error tolerated is definitely 3.74%, 3.64% and 4.24%, respectively for Cameroon, Senegal and Ivory Coast. This higher margin of error in Ivory Coast is justified by the difficulty of accessing other regions apart from Abidjan because of the aftermath of the 2011 post-election crisis. Overall, the coverage rate was 84.31% for the three countries with a tolerable error of 2.25%. The statistics are presented in the following table:

Table A6: Size of the realized sample

Country	**Sample predicted**	**Sample Realized**	**Response Rate (%)**	**Error tolerated (%)**
Cameroon	750	639	85,2	3,74
Senegal	750	723	96,4	3,64
Ivory Coast	750	535	71,33	4,24
Whole	**2 250**	**1 897**	**84,31**	**2,25**

Comparing with the World Bank's Enterprises Survey data, we find that the differences are quite small, justifying the representativeness of these data. These three agglomerations are the privileged places of business in each country.

Table A7: Sample comparaison of different countries with that of the World Bank's *Enterprises Survey*

Cameroon			Senegal			Ivory Coast		
Region	ES2009 %	IDRC Survey %	Region	ES2007 %	IDRC Survey %	Region	ES2009 %	IDRC Survey %
Douala	59,23	63,1	Dakar	66	46,49	Abidjan	91	62,6
Yaoundé	11,29	25,5	Thiès	10	26,27	San-Pedro	8,37	18,7
Bafoussam	11,29	11,4	Saint-Louis et Kaolack	24	27,24	Daloa	0,63	18,7
Total	**363**	**639**		**506**	**723**		**526**	**535**

Notes: ES = World Bank's *Enterprises Survey*

Mission

To strengthen local capacity for conducting independent, rigorous inquiry into the problems facing the management of economies in sub-Saharan Africa.

The mission rests on two basic premises: that development is more likely to occur where there is sustained sound management of the economy, and that such management is more likely to happen where there is an active, well-informed group of locally based professional economists to conduct policy-relevant research.

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