Analysing the Relationship between Innovation and Productivity: A Case Study of Senegalese Manufacturing Industries

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Research Paper 542

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Analysing the Relationship between Innovation and Productivity: A Case Study of Senegalese Manufacturing Industries

By

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Abstract

The objective of this study was to profile innovative companies and to examine the link between innovation and productivity in manufacturing firms in Senegal. It took into account the interaction between various forms of innovation. Using a descriptive analysis of variance (ANOVA) approach and multivariate regression, the study found that although Senegal had a satisfactory level of technology adoption, an innovation deficit remained in the industrial sector, notably in research and development (R&D) activities. The study established that larger enterprises and firms that export their products are the most innovative. However, no significant relationship was found between the gender of the manager of the firm and the adoption of various forms of innovation. Furthermore, our results demonstrate that the choice to adopt innovation in an organization is positively related to improved labour productivity. In regard to the other types of innovation, no association was found. Our results suggest the need to develop strategies that integrate innovation in industrial policy in order to facilitate its adoption. They also suggest the need to undertake regular surveys of innovation in firms so as to better understand market trends, identify their strengths and weaknesses and facilitate decision making in terms of innovation.

Key words: Innovation, productivity, industry in Senegal

JEL classification: O31-O41- O25- L6

1. Introduction

Accelerated globalization at the end of the 20th Century and the beginning of the 21st Century contributed to heightened global competition and placed innovation at the core of economic and industrial policies (Paulré, 2016). Indeed, due to international competition that is intensifying in a context of rapid change in the business environment, innovation is becoming vital for firms to maintain or improve their competitive position. Apart from strengthening the competitive position of firms, innovation allows them to increase productivity by improving the quality of products or services and developing competencies.

A study of the relationship between innovation and productivity is of particular interest to economists, especially in developing countries where growth in productivity is one of the major preoccupations. This is evident in Senegal, where the government has placed industrial transformation at the core of its development policy. However, the trend in Senegal's industrial sector, of which 80% is in the agri-business and manufacturing sectors, remains erratic (CEPOD, 2018). Indeed, its contribution to the gross domestic product (GDP) never went above 15% between 2000 and 2017. It followed an overall downward trend. From close to 14% of the GDP in 2000, manufacturing value added dropped to close to 12% in 2017. This weak performance could be explained by the lack of a clear and coherent industrial policy, but also and especially through inefficiency in the manufacturing sector and an innovation deficit. According to the final report of a state-of-the-art survey of industry in Senegal (ANSD, 2017), more than 85% of firms in the industrial sector did not undertake any innovative activity in 2015. For the enterprises that engaged in investments in research and development (R&D), the percentage share of the amount dedicated to the activity out of the total turnover of the firm remained low. Only 8% of the firms channel more than 10% of their turnover towards innovation. Given this situation, this study aimed to contribute towards identifying the drivers that could help in decision making in terms of the application of policies related to industrial innovation in Senegal.

It remains difficult to give a precise definition of innovation. The existing definitions of the term are varied, dependent on the approach used (Djoutsa Wamba et al, 2017). According to the second edition of the Organisation for Economic Co-operation and Development (OECD) Oslo manual: "an innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization

or external relations"(OCDE, 2005, p. 54). On the basis of this definition, there are four forms of innovation: product innovations, process innovations, organizational methods innovations and marketing innovations. Product and process innovations are referred to as technological innovations; organizational and marketing innovations are non-technological innovations.

Theoretically, the role of innovation on growth and employment productivity has been a controversial subject for the various researchers who have handled it. Schumpeter (1942) introduced innovation in the analysis of economic theory. According to Schumpeter (1942), it is thanks to an "innovative entrepreneur" who is the main actor in the process of innovation, that the economic dynamic makes itself felt through quantitative progress (with an increase in the level of production) as well as qualitative progress. In the wake of his studies, the positive impact of innovation on productivity was examined, and demonstrated by several researchers, notably Solow (1957), Romer (1986), Griliches (1995) and Crépon et al (1998).

However, some researchers (such as Sauvy, 1981; Rodrick, 2007; Erixon and Weigel, 2017) state that innovation has a very low impact on labour productivity. They argue that the role of innovation, especially due to the mechanization of the production system, is specifically to destroy jobs. It is the substitution of labour by capital. For example, Rodrick (2007) demonstrated that innovation, through the adoption and diffusion of technology tends to widen the income gap between unskilled workers and highly qualified workers. The more manufacturing activities become automated and in need of highly competent workers, the more developing countries lose their competitive advantage against developed countries. Thus, we are faced with a situation of "premature deindustrialization" that is currently affecting developing countries.

In the context of developing countries, lack of longitudinal data and the fact that for many firms, R&D activities are only a marginal determinant of innovation activities, make it difficult to model innovation and growth. Nevertheless, over the past few years, more empirical studies have examined the role of innovation in firms, in order to examine its impact (Goedhuys, 2007; Egbetokun et al, 2009; Okumu and Buyinza, 2018; El Eljouis and Abassi, 2019; Le Bas and Molou, 2020) Most of these studies focused on product and process innovation and their impact on productivity because they are the only types of innovation that can be examined in a precise manner using quantitative data. From the studies, indicators of innovation and the methodology used varied from one study to the other, and the results are mixed.

Despite the relevance of these studies, most of them do not take into account non-technological innovations (organization and marketing) and the relationship of interdependence that could exist between various forms of innovation. This study intended to fill that gap. The objective of this study was to profile innovative companies and to examine the link between innovation and productivity in manufacturing firms in Senegal. The main contribution of this paper is to take into account the four forms of innovation and their relationships of complementarity.

The rest of the paper is presented as follows: Section 2 gives an overview of the background in terms of trends in industrial policy and the dynamics of innovation in Senegal; Section 3 presents a literature review; and Section 4 introduces the methodology used in data analysis. The results are discussed in Section 5 and Section 6 concludes and provides policy recommendations.

2. Background

In order to have a better understanding of the factors that could explain the innovation capacity of firms in Senegal, it is necessary to understand trends in industrial policy in Senegal. We discuss the place of innovation in various industrial policies. Furthermore, since industrial policy is related to both the socioeconomic context, and the innovation dynamic, all these aspects are covered in this section to illustrate the current situation in the industrial sector.

Innovation in the industrial sector of Senegal

After the country's independence in 1960, Senegal inherited the most advanced manufacturing sector in West Africa. Several industrial policies were put in place to strengthen this heritage. Indeed, from a strategy for industrialization through the substitution of imports (ISI), to an industrial redeployment policy (PRI) and a new industrial policy (NPI), all the industrial policies generally had the same objective: to provide Senegal with a modern, dynamic and competitive industrial sector that would manufacture goods with strong value addition. Despite this willingness, the policies never attained their goals. None of the industrial policies integrated innovation at the core of the industrialization strategy. Senegal's industries are still challenged by some difficulties such as a weakness in the manufacturing tissue, low levels of diversity in the production sector, lack of competitiveness in their goods and services, and insufficient and inadequate distribution channels (PSE, 2014).

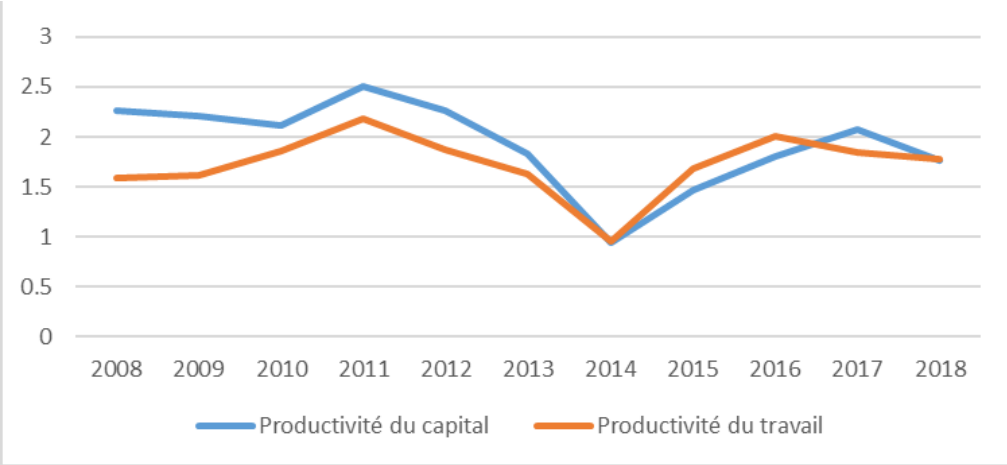
In 2021, in order to implement Senegal's industrial policy through taking into account issues of technological development notably in digital technologies and innovation, the government adopted the New Industrial Policy and Strategy 2021–2035. This policy is based on four priority areas, the fourth stating: "Development of industries with high technological and innovation intensity, including the digital economy, assembly industries and the creative industry" (Ministère du développement industriel et des petites et moyennes industries, 2021:15). This policy is in line with reforms that are the drivers of industrialization, notably strengthening the technical capacities, technologies, marketing and innovation in industrial units. It is still too soon to carry out a definitive evaluation of the industrial policy, however, public authorities are willing to place technological innovation at the centre of industrial development.

Trends in industrial productivity

Data from the National Statistics and Demographics Agency (ANSD) has followed up on industrial activities since 1976 through its Economic and Financial Data Bank (BDEF), allowing us to discern recent trends in the productivity of industries in Senegal. Data from BDEF focus on provisional operational results and statistical and fiscal reports from firms. The data cover a set of firms in the formal sector that have at least on one occasion filed a financial statement with the Centralised Data Collection Centre of Senegal (CUCI). Figure 1 lists the trends in productivity related to labour and capital in the industrial sector from 2008 to 2018.

Capital productivity — a measure of the efficiency with which a firm will use its capital in order to create wealth — dropped over the period 2008–2018. It ranged between 2.26 in 2008 and 1.76 in 2018. It remained above the apparent labour productivity from 2008 to 2011 before experiencing a downward trend, reaching 0.94 in 2014, against 0.95 for labour productivity in the same year. In regard to apparent labour productivity, calculated as a ratio of value added on payroll, capital productivity experienced a drop in 2018, moving to 1.78 from 1.84 in 2017. This drop could be attributed to an increase in the cost of labour in industry.

Figure 1: Trends in apparent labour productivity and capital productivity in the industrial sector



Source: Author using data obtained from Economic and Financial Data Bank (BDEF)

Against a background of a competitive economic environment in transition (globalization, economic crisis and technological advances), Senegal's industry needs now more than ever to uplift its productivity levels in order to be competitive and enact its role as the driver of economic growth.

Dynamics of innovation

The study of innovation in industry focuses on innovation in an entire country. An innovative economy is indeed closely related to an innovative industry (CEPOD, 2018). The Global Innovation Index (GII) is most often used to compare economies on an international scale using their innovation capacities. We benchmarked Senegal in terms of innovation, with reference to countries that are placed high in the index (Singapore, South Korea and China). This allows us to have an idea of the lag Senegal is experiencing in relation to innovative economies of the world. Senegal's performance was also compared with that of other countries at similar levels of development (Côte d'Ivoire, Ghana and Rwanda).

Table 1 shows that Senegal, with a score of 26.83, is ranked 96th out of 130 countries, which is an improvement by 9 places as compared to 2016. These efforts in its innovation capacity have allowed the country to move ahead of Ghana (which dropped from position 102 to 106) and Côte d'Ivoire (103 in 2019), the strongest economy in the West African Economic and Monetary Union (WAEMU). However, the country is outranked by Rwanda, which is placed 94th with a score of 27.38. Asian countries such as Singapore (8th), South Korea (11th), and China (14th) have very high scores, indicating their competitiveness.

Table 1: Classification of countries according to the 2016 and 2019 innovation index[1] (out of 130 countries)

		2016	2019
Singapore	Rank	6	8
	Score	59.16	58.37
South Korea	Rank	11	11
	Score	57.15	56.55
China	Rank	25	14
	Score	50.57	54.82
Côte d'Ivoire	Rank	108	103
	Score	25.80	25.55
Senegal	Rank	106	96
	Score	26.14	26.83
Ghana	Rank	102	106
	Score	26.66	25.27
Rwanda	Rank	83	94
	Score	29.96	27.38

Source: Derived from OMPI Global Innovation Index Report, 2016 and 2019

In relation to the dynamic use of digital technologies in Senegal's industries, we compare Senegal's position to that of countries on a similar trajectory towards industrialization 4.0 (Rwanda, Nigeria, China and India). Industrialization 4.0 is the fourth industrial revolution and is characterized by the adoption of cyber physical systems such as robotics and drones, 3D printing, artificial intelligence (AI), machine learning tools and the Internet of Things in the production process (Cruz et al, 2021).

Figure 2 shows that Senegal is situated at the intersection between the use of traditional production methods and low usage of digital technology in industry. Senegal is behind Rwanda and Nigeria, where the use of digital technology is emergent. The gap between Senegal and China and India which are advanced in terms of the integration of cutting-edge technologies in industry, shows that its industries are experiencing a lag.

Figure 2: Position of Senegal in relation to other countries on the same trajectory towards Industrialization 4.0

NB: The flags are indicative of the position of the country in its trajectory towards industrialization 4.0

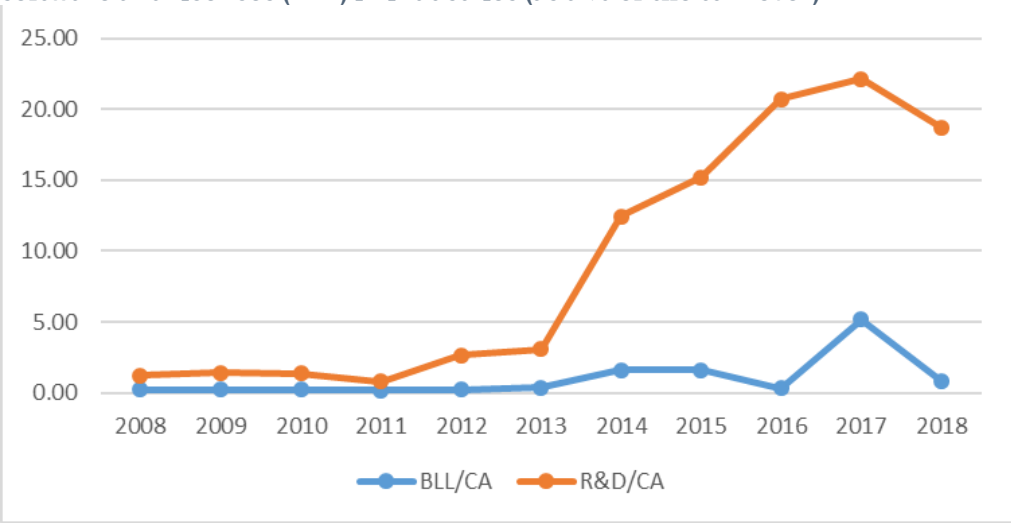
Source: Ministry of Industrial Development and Small and Medium-Sized Industries (2021: 29). .

According to Ciera et al (2021), the most widespread use of technology in Senegal is cloud computing, which is used by less than 5% of firms. Other advanced and more autonomous technologies such as AI, robots and 3D printers for manufacturing and precision agriculture, are used by less than 1% of the country's firms.

Moreover, manufacturing firms in the country show a deficit in investment in R&D activities. Yet, investments in R&D are considered to be a major source of innovation. Indeed, they allow firms to produce new technologies, and acquire knowledge and technical know-how. Expenditure in R&D is a reflection of the financial efforts invested in innovation activities. Figure 3 shows how expenditure on R&D and fees for patents,

licences and software by Senegal's firms follow similar trends. Investment in R&D experienced a sudden increase since 2014, growing to 12.4% of the turnover; it was close to 2% between 2008 and 2013. Over the same period, although expenditure on patents, software and licences in industry did not go above 1% of the turnover, it increased and reached 1.6% of the turnover in 2014. This seems to demonstrate that there is a positive relationship between the costs invested in R&D (considered as any innovation input) and the acquisition of patents in industry.

Figure 3: Progression of expenditure in R&D and the acquisition of patents, software and licences (BLL) in industries (as a % of the turnover)



Source: Author, using data obtained from the Economic and Financial Data Bank (BDEF) and the National Statistics and Demographics Agency. 2018. Available here : https://anads.ansd.sn/index.php/catalog/209

This intensification in R&D activities could be explained by an increase in competition and the emergence of new technologies over the past decade. Nevertheless, a decrease in both R&D fees (3.5 points) and in the acquisition of patents, licences and software (4.2 points), was observed in 2018. Such a situation is worrying, given that an increase in R&D expenditure promotes innovation which has a positive impact on productivity.

This contextual framework demonstrates that Senegal is experiencing a deficit in terms of the adoption of new technologies in industry. Therefore, the country needs to formulate policies for innovation in order to strengthen the capacities of firms and facilitate the adoption of technologies. Empirical data (Hajjem et al, 2015; Benabdelkader, 2021) suggests that an improvement of the management capacities and the organization of firms could have significant and lasting effects on the productivity of firms that have a satisfactory level of the adoption of technologies within the industrial sector.

3. Literature review

According to Schumpeter (1942), it is thanks to an "innovative entrepreneur" who is the main actor in the process of innovation, that the economic dynamic makes itself felt through quantitative progress (with an increase in the level of production) as well as qualitative progress. The author stipulates that innovation is the best strategy for firms to ensure their own survival and continuity. Schumpeter's studies and research topics gave rise to a real interest by economists who were interested in developing on what he had focused upon, leading to the development of the field of economics of innovation.

Determinants of innovation

Studies on the determinants of innovation are abundant. Several researchers in developed countries (Crépon et al, 1998; Gu and Tang, 2003; Griffith et al, 2006; Hajjem et al, 2015), just like in developing countries (Goedhuys et al, 2006; El Eljouis and Abassi, 2019; Le Bas and Molou, 2020) focused on the question using different approaches. They were able to identify several determinants notably the size of the firm, the market structure, exports, demand pull, technology push, financial resources, human resources, sector of activity, institutions and networks.

Among the traditional determinants of innovation, the role of the size of the firm is a controversial subject in the empirical literature since Schumpeter (1942) argued that large firms contribute more to innovation than smaller firms. Other authors (Galbraith, 1956; Soete, 1979; Pavitt et al, 1987), then confirmed Schumpeter's (1942) argument by demonstrating that a large firm is synonymous with innovation due to the means at its disposal. Indeed, firms finance innovation activities using their own income or their capital, which is usually higher in large firms than in smaller ones. Such firms also have easier access to financial resources to carry out costly R&D activities due to their economies of scale and the more favourable position that they occupy in the market. Also, their profits could justify the risks they undertake in R&D activities. Moreover, the studies agree that although expenditure on R&D logically increases with size, the efficiency of that type of expenditure could decrease with size.

However, other empirical studies (notably those undertaken by Dasgupta and Stiglitz, 1980; Kamien and Schwartz, 1982; Gherghina et al, 2020) show that small firms are more innovative than large firms. Kamien and Schwartz (1982) demonstrated

that small firm seems to be more innovative due to the existence of increased costs in bureaucracy for large firms. They argued that a small size would favour a higher capacity for innovation because it allows for a reduction in the cost of replacing old technologies and promotes radical innovations.

Cremer and Sirbu (1978) observed a U relationship between the intensity in R&D and the size of the firm. According to Cremer and Sirbu (1978), the intensity in R&D highly decreases when the size of the firm increases, but starts to grow after a certain threshold is reached. Furthermore, Cohen and Klepper (1996) demonstrated that the impact of the size varies according to the type of innovation. They indicated that the size is related more to innovations of processes than to product innovations.

In Africa, the results on the degree of influence of the size of a firm on innovation, give mixed results. Tsambou and Bibu (2017) undertook a comparative study of the determinants of innovation in Senegal, Côte d'Ivoire and Cameroon, confirming Schumpeter's hypothesis for enterprises in Senegal and Cameroon whereby the size of the firm is a positive and significant variable for the likelihood to invest in innovation activities in the two countries. However, in Côte d'Ivoire, the smaller firms have a higher likelihood to innovate than the larger firms.

Karray and Ghorbel (2014) studied the innovation behaviour of firms in Tunisia, and found that the size of the firm has a significant impact depending on the type of innovation. In regard to firms in Cameroon, Le Bas and Molou (2020) found that the impact of the size of the firm on the likelihood to innovate is statistically insignificant. This result is corroborated by those arrived at by Adeyeye et al (2016) in regard to Nigerian firms. In this paper, our hypothesis is that the size of the firm is associated with the adoption of new technological and non-technological innovations.

In regard to the relationship between exports and innovation, there are two opposing theories. The theory of self-selection (Melitz, 2003; Aw et al, 2011) suggests that firms which have an advantage in terms of innovation tend to self-select in order to export. In other words, firms that have innovative and competitive products or processes would be more likely to enter into the export business than firms that do not have such advantages. Self-selection could explain why innovative firms are more likely to export, since they are already way ahead of their competition. Several studies (Clerides et al, 1998; Dai et al, 2020; Panda and Sharma, 2022; Wang and Wang, 2022) have demonstrated that innovation is an important factor in improving the capacity of firms to export. Other studies have highlighted the learning effect theory (Gaussens and Mohavedi, 2016; Avenyo et al, 2021). According to this theory, the more an enterprise exports, the more experience it acquires in domains such as international trade regulations, quality standards for products and the preferences of foreign clients. Thus, when firms begin to export, they are faced with new challenges and new demands, which force them to conform through adopting them (thus to innovate) and improving their performance. This study assumed that export firms are more innovative.

Moreover, the literature on the gender of the top manager in relation to innovation and performance of a firm has stirred debate. An increasing number of studies (Khan and Vieitto, 2013; Niringiye, 2014; Lage de Sousa et al, 2020) focused on

gender perspectives in relation to innovation activities. Lage de Sousa et al (2020) demonstrated that gender diversity (depicted through both the sex of the employer and the sex of the employees) has a positive impact on marketing innovation and product innovation. However, they showed that gender diversity does not have a significant impact on organizational innovation and innovation of procedures in Brazilian firms. The theory of management diversity argues that diversified management boards are more likely to increase innovation and performance of a firm because they are intrinsically linked to decision making based on the opinions of people with various sociocultural orientations (Smith et al, 2006).

Relationship between innovation and productivity

Empirical literature on relationship innovation and productivity is abundant for developed countries, and less so for developing countries, probably because data are not collected regularly through surveys on innovation. The results obtained are mixed. The absence of a consensus in the results could be explained by the various approaches used, but also from the way in which innovation is understood. Although most studies undertaken in developed countries define innovation through the number of patents lodged or by activities in R&D, in developing countries, innovation is understood through proxy variables.

The pioneer study on the relationship between innovation and productivity is that of Grilliches (1979) who, using an R&D augmented Cobb–Douglas production function, showed that the flow of information which arises from innovation exerts a positive impact on productivity. Crépon et al (1998) were inspired by the works of Grilliches (1979) to develop the Crépon–Duguet–Mairesse (CDM) model, which takes into account yields from innovation. From their study, the internal and external characteristics of the firm determine its R&D activities. Those activities stimulate the development of capital from technological knowledge and innovation intensity that favour the productivity of the firm.

Several empirical studies in developed countries (Crépon-Duguet-Mairesse, 2000; Lööf and Heshmati, 2002; Gu and Tang, 2003; Griffith et al, 2006, Hajjem et al, 2015) agree on the positive impact of innovation on productivity using a CDM[2] model. Lööf and Heshmati (2002), who examined the relationship between innovation and labour productivity in manufacturing firms and the service industry in Sweden, found for the positive effect of innovation on productivity. In the same vein, Gu and Tang (2003) also used R&D as a measurement of innovation, using a sample of 196 firms drawn from 15 Canadian manufacturing industries. They concluded that investment in R&D has an impact on the creation and improvement of new products and procedures.

Furthermore, Griffith et al (2006) studied the role played by innovation on productivity in four European countries — France, Germany, Spain and the United Kingdom. Using a structural CDM model, they measured innovation output using two dichotomous variables indicating whether the firm had made a product of procedural innovation; for this they used two separate Probit models. They concluded that

procedural innovation is only associated with higher productivity in France. In other countries the relationship does not exist. Product innovation is related to a higher productivity in France, Spain and United Kingdom, but not in Germany. Hajjem et al (2015) found that procedural, organizational and marketing innovation, had significant and positive impacts on the productivity of French firms. Furthermore, their results suggest that decisions to undertake R&D and to acquire machines and software depend on the position of the firm among international competitors, from its recourse to means of protecting its ownership, from demand pull and from its size. They also demonstrated that the amounts invested are determined by belonging to a group, technological cooperation, sources of information and public finance. In addition, innovations in product and procedures are more favourable to productivity if they are accompanied by innovations in organization and in marketing, and vice versa.

In developing countries the results are mixed. Using cross-sectional data on manufacturing industries in Argentina, Raffo et al (2008) demonstrated that product innovation does not have a significant impact on labour productivity. Similar studies by Benavente (2006) on firms in Chile concluded that innovation does not have an impact on labour productivity.

Empirical studies on the relationship between innovation and productivity in Africa are relatively fewer. However, there are a few studies (Goedhuys et al, 2006; Fu et al, 2018, Djoutsa Wamba et al, 2017; Okumu and Buyinza 2018; Benabdelkader, 2021) that have taken an interest in the subject (with the exception of Goedhuys et al, 2006; Fu et al, 2018, Djoutsa Wamba et al, 2017; Okumu and Buyinza 2018; Benabdelkader, 2021). For example, Fu et al (2018), studied the performance of firms in Ghana's formal and informal sectors using a revised structural CDM model to analyse data from a survey on innovation on 501 manufacturing firms. Their study revealed that innovation has a positive impact on the labour productivity of firms. Moreover, the impact is significantly higher in the informal sector. The researchers explained the results through the fact that informal firms innovate in order to survive due to difficult market conditions, a lack of financial resources and competencies, and limited support from the government. Benabdelkader (2021), who used a proxy indicator of innovation in the absence of innovation surveys, found a positive relationship between innovation and labour productivity in Morocco's manufacturing sector. Okumu and Buyinza (2018), using data from a World Bank survey carried out in 2013 on enterprises in Uganda, and a technique of estimation per quintile, explained the relationship between labour productivity and innovation within small and medium-sized companies. Their results indicate that the relationship between labour productivity and a firm that engages in a form of innovation is neutral. However, there is proof of the complementarity between product innovation, process innovation, marketing innovation and organizational innovation. More specifically, there is a positive relationship between labour productivity and innovation when a firm engages in the four types of innovation. Even in this case, the impact of complementarity turns out to be slightly positive with occurrences of negative relationships when a combination of innovations inferior to the four types of innovations is used.

Even though the CDM framework was developed such that it would be used with cross-sectional data and repeated panel data (OECD, 2018), its use necessitates the availability of better-quality data. Most of the studies carried out in developed countries use the database of Community Innovation Survey (CIS) from Eurostat or the OECD database on innovation statistics.

The use of these data has allowed for the application of the CDM model (Hajjem et al, 2015; Lööf and Heshmati, 2002; Gu and Tang, 2003) with a unified system of enterprise statistics. This allows us the possibility of using instrumental variables to correct for endogeneity (Hajjem et al, 2015) and to control the simultaneity and endogeneity bias, notably the Heckman two-step method (Heckman, 1979).

In Africa, often the quality of data does not allow for the application of the CDM model proposed by Crépon et al (1998, 2000). For example, Tsambou and Kamga (2021) did not model the three steps of the CDM model, thus not accounting for the fact that the adoption of innovation could determine R&D activities. With their cross-sectional data, they showed their correlation between the simultaneous adoption of technological and non-technological innovation on total productivity. The limitations of cross-sectional data for firms in Uganda forced Okumu and Buyinza (2018) to limit their study to a technique of estimation per quintile, while explaining the relationship between labour productivity and innovation in SMEs.

4. Research methodology and data

Specification of the model

We reiterate that the objective of this study was to profile innovative companies and to examine the link between innovation and productivity in manufacturing firms in Senegal. Thus, we used a descriptive analysis to study the relationship between innovation and productivity. This approach allows us to obtain interesting information, particularly as the analysis is extended to take into account the heterogenous effects.

First, we examined the relationship between innovation and various heterogenous factors likely to be linked to innovation. Indeed, the adoption of innovation refers to the decision to introduce new technical proposals into the existing production systems and to progressively improve their use. This adoption of innovations depends, as demonstrated by Rogers (2004), on socioeconomic characteristics of firms, on the information that they have available and on the conditions of access to the necessary resources. Thus, we studied the relationship between innovation and the size of the firm, exports and the gender of the manager of the firm. Given the dichotomous nature of these variables, we tested their independent relationships using a Pearson Chi-Square correlation test, the Chi-Carré Independence test and the Fisher's exact test. This analysis allowed us to profile the innovative firms.

In the second phase, we used analysis of variance (ANOVA) developed by Fisher (using an assumption of standardization). The ANOVA method is preferred to the simple Student tests for at least two reasons. First, ANOVA allows us to test each factor while controlling the others, making it statistically more powerful (in other words, we need fewer observations in order to find a significant effect) than a simple Student test. The other advantage of ANOVA is that it allows us to detect the interactions between variables, and thus to test more complex hypotheses.

We studied the relationship between productivity and innovation through the ANOVA model without an interaction effect (basic specification) and with an interaction effect:

$$lnP_{ik} = a + Innov_{ik} + CombinInnov_{ik} + \mu_{ik} \quad (1)$$

Ln P_i is the logarithm of labour productivity of firm i (turnover per person employed) having adopted a k innovation form (k=1,2,3,4); a represents the common effect on labour productivity; $Innov_{ik}$ is the specific impact of firms that adopted one of the k innovation forms; μ_{ik} is the disruptive effect linked to productivity; and $CombinInnov_{ik}$ is the specific effect of each combination of innovation which captures the interaction between various types of innovation. In summary, we estimated and compared the overall average of labour productivity with the average of the productivity of firms that have engaged in a form of innovation and the impact of their interactions.

Finally, we conducted multivariate regression analysis using the relevant control variables. This regression analysis that includes interaction terms could help to highlight various potential mechanisms. The model is presented as follows:

$$lnP = a + \beta_1 I_{prod} + \beta_2 I_{proc} + \beta_3 I_{org} + \beta_4 I_{mark} + \beta_5 I_{prodI_{proc}} + \beta_6 I_{prodI_{org}} + \beta_7 I_{prodI_{mark}} + \beta_8 I_{procI_{org}} + \beta_9 I_{procI_{mark}} + \beta_{10} I_{orgI_{mark}} + \gamma_1 Taille + \gamma_2 Genre + \gamma_3 Experience + \gamma_4 Exportation + \gamma_5 TIC + \gamma_6 licence + \gamma_7 Concurrence + \gamma_8 Finbancaire + \gamma_9 Demandpull + \gamma_{10} Formation + \epsilon \quad (2)$$

InP represents the logarithm of labour productivity (defined as the logarithm of turnover per person employed). This choice is dictated by the research objective and the availability of data. It is the most frequently used measurement of productivity in the literature (Schreyer and Pilat, 2001). It provides information on the temporal profile of the use of labour productivity with the view of generating value addition. In this study, it is explained through product innovations, procedural innovations, organizational innovations, marketing innovations and their interaction terms, and a set of explanatory variables that are likely to have an impact on productivity (see Table A1 in Annex for a description of the variables). Indeed, productivity depends on economic, technical and human factors. According to the literature and the limitations related to data, we determined human capital of the firm through the number of years of experience of the manager and the training of the employees. According to Nelson and Winter (1982), the forms of training (individual and collective) lead to incremental innovations from which productivity gains originate. Economic factors were determined by the size of the firm, competition, exports, bank finance and demand pull. Technical factors were determined by access to information and communication technology (ICT) and foreign licences, which is characterized by the use of foreign technologies.

a, β_1 and γ_5 are and the estimated parameters. The variables of interest linked to innovation are measured through dummy variables that take the value of 1 if the firm has introduced new products, new procedures, new organizational changes or new marketing, and 0 if not. Contrary to the two measurement indicators, they provide information that is more complete about innovation outputs.

In this study, the terms introduction of innovation and adoption of innovation are used interchangeably. Indeed, in developing countries, firms consume more new technologies than they create (Tsambou and Bibu, 2017). This justifies the reason why most of them have difficulties emerging into the markets of exports of manufactured goods of medium and high technology in order to fight their competition.

Data

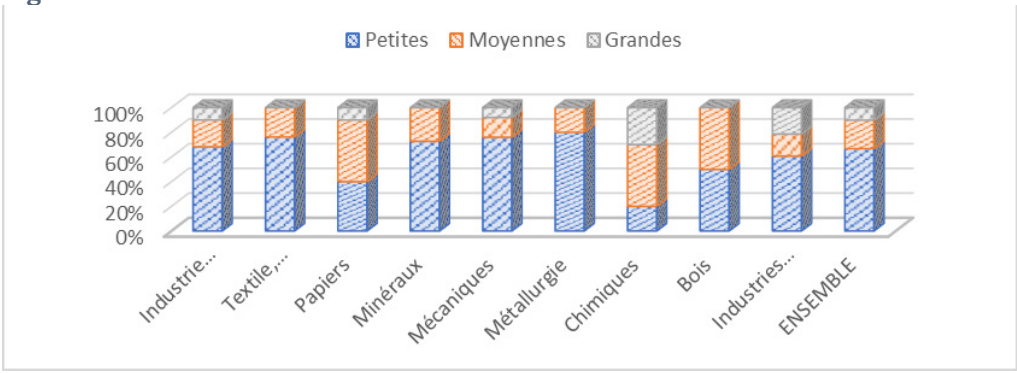
In this study, we used data from the Enterprise Survey (2014) of the World Bank. It is important to specify that it is rare to find survey data on firm innovation in Senegal. Data from the Enterprise Survey (2014) report, which focuses on 601 industrial firms, of which 247 (41.09%) are in the manufacturing sector, allowed us to access information on the sector of activity of the firms, the number of years the firm has been in existence, the size of the firm, the employees, expenditure on R&D, competition, innovation, etc.

The survey used a stratified random sampling technique not only to obtain unbiased estimations on the entire population but also to have various subdivisions of the population with a certain level of precision. Three levels of stratification were used: Industry, size and region. This gave us the benefit of covering all the different sectors/sizes/regions. The sample was representative at the national level. The data were collected over the course of a single year. This therefore indicates that it would not be possible to apply the analysis of panel data. Consequently, we used cross-sectional data.

Descriptive statistics

The data indicated that the 247 manufacturing firms are spread out as follows: food (44.5%), textiles (8.5%), paper (4%), mechanics (20.2%), metal (0.4%), chemical (4%), wood based (0.8%), mining (4.4%) and other industries (16.5%). Small industries represented 66.8% of the manufacturing industries, medium-sized enterprises close to 23.1% and large enterprises represented 10.1%. Firms that carried out R&D activities spend an average of 26,902,165 FCFA (about US$45,000), or 7.5% of their average turnover. Furthermore, 105 out of the 247 manufacturing firms (42.5%) declared that they had innovated a product, 114 firms innovated a procedure (46.1%), 79 firms innovated in organization (32%) and 84 firms innovated in marketing (34%).

Figure 4: Sectoral distribution of the size of firms



Source: Author, using data from the World Bank's Enterprise Survey. Petites=small; moyennes=medium; grandes=large

Figure 4 shows that the small firms are dominant in our sample with almost all sectors except chemical industries (50%) and the paper industry (50%), where most of the firms were medium-sized. The small and medium enterprises comprised almost 90% of the total number of manufacturing firms in our sample.

Table 2 shows that among the firms in our sample from the food industry, 37% innovated a product, 40% introduced new methods or transformed a production or distribution activity (innovation in procedure).

Table 2: Sectoral distribution of firms that innovated (as a percentage)

	Innovation of Pdt	Innovation of Proc	Innovation Org	Innovation of Mark	R&D Activity
Food industries	37.27	40	29.09	31.81	8.8
Textile, clothing	38.09	52.38	28.57	38.09	19.04
Papers	60	70	70	90	10
Minerals	18.18	54.54	0	18.18	9.09
Mechanical	50	50	22	24	2
Metal	60	20	80	20	0
Chemical	50	40	40	60	30
Wood- based	50	0	50	50	0
Various industries	50	57.14	50	35.71	3.57
ALL	42.51	46.15	31.98	34.00	8.09
Observations	105	114	79	84	20

Source: Author derived from World Bank's Enterprise Survey

Only one out of 10 firms in the food industry had carried out activities in R&D. Firms in the paper industry are the most innovative in product innovation (60%), procedural innovation (70%) and marketing innovation (90%), whereas 8 out of 10 firms in the metal industry are innovative in organization. Chemical industries registered the highest percentage (30%) of firms that carry out R&D.

Innovation and the size of the firm

In this subsection, we first present the size of the firms that innovated according to various types of innovation and the size of the firms. Distribution according to size was done based on the number of employees. We defined small firms as those that have between 0 and 19 employees, medium firms with between 20 and 99 workers and large enterprises as those with more than 100 employees.

Table 3: Proportion of firms that have innovated according to their sizes

Innovation types	Small	Medium	Large
Product	32.7	56.1	76
Process	38.2	59.6	68
Organizational	18.8	61.4	52
Marketing	21.8	57.9	60

Source: Author derived from World Bank's Enterprise Survey

Table 3 shows that the proportion of firms that innovate is varied in terms of the size of the firm. More than 50% of large firms innovated using at least one form of innovation (68% innovated in process, 52% innovated in organization, 60% innovated in marketing and 76% innovated in product). Among firms that employ between 20 and 99 workers (medium enterprises), 61.4% of them innovated in organization and 57.9% in marketing. In the small firms, only 3 firms out of 10 innovated, in cases both of technological innovations (product and process) as well as non-technological innovations (organization and marketing). Although these figures provide important information on the relationship between the size of the firm and innovation, one should be cautious in interpreting them, since the sample size was different for each type of enterprise. The large enterprises represent only 10% of the sample, whereas SMEs comprise 90% of the firms.

For a more detailed analysis, we carried out tests of independence to verify whether there is a relationship between the size of the firm and various innovation types. The Chi-square test of independence determines whether there is a relationship between the category variables (in other words whether the variables are independent or apparent). The Chi-square test of independence can only compare category variables. If the probability associated with the test is less at the threshold of significance, we reject the null hypothesis. Consequently, we concluded that there is an association between the two variables. If one of the percentages has an expected number lower or equal to 5, it is recommended to use Fisher's exact test so as to provide a valid result.

Table 4: Test of independence between the adoption of innovations and the size of the firm

Innovation types		Small	Medium	Large
Product	No innovation	78.17	17.61	4.23
	Innovation	51.43	30.48	18.10
Pearson chi²	0.000			

Likelihood-ratio chi²	0.000			
Fisher's exact	0.000			
Process	No innovation	76.69	17.29	6.02
	Innovation	55.26	29.82	14.91
Pearson chi²	0.001			
Likelihood-ratio chi²	0.001			
Fisher's exact	0.001			
Organizational	No innovation	79.76	13.10	7.14
	Innovation	39.24	44.30	16.46
Pearson chi²	0.000			
Likelihood-ratio chi²	0.000			
Fisher 's exact	0.000			
Marketing	No innovation	79.14	14.72	6.13
	Innovation	42.56	39.29	17.86
Pearson chi²	0.000			
Likelihood-ratio chi²	0.000			
Fisher's exact	0.000			

Source: Author

We observed in table 4 that 55.26% of firms that innovated in process were small firms. Small firms also represented 51.43% of firms that innovated in product. Of the sampled firms that innovated in organizational processes, 44.30% were medium sized. Our results show a relationship of dependence that was statistically significant between the size of the firm and the fact that they innovate in product, procedures, organization and marketing. In other words, the size of the firm is significantly linked to its innovation capacity.

This result agrees with Schumpeter's theory, according to which the size of the firm is equal to innovation because of the resources available to larger firms. Indeed, firms finance their innovation activities using their own income or their capital, which is usually then higher in large firms. Such firms also have easier access to financial resources to carry out costly R&D activities due to their economies of scale and the more favourable position that they occupy in the market. Also, the profits gained could justify the risks in R&D activities.

Innovation and exports

Table 5 presents the percentage share of firms that export and the various kinds of innovation that they adopted or failed to adopt. In total, 15.3% of the firms engaged in export activities. Among these, close to 30% adopted non-technological innovations (organization and marketing). In regard to technological innovations, 24.7% of firms that engaged in exporting had innovated in product and 22.8% in procedure. Furthermore, only 10% of the export firms had not innovated, whichever the type of innovation considered.

Table 5: Test of independence exportation-innovation

	I_pdrt	**I_proc**	**I_org**	**I_mark**
No innovation	8.45	9.02	8.33	7.98
Innovation	24.76	22.81	30.38	29.76
Pearson probability test	0.000	0.003	0.000	0.000
Likelihood-ratio probability test	0.000	0.003	0.000	0.000
Fisher's exact probability test	0.001	0.004	0.000	0.000

Source: Author

The test of independence probability tests were all lower than 5%, indicating a significant association between the type of firms that export and the adoption of various innovation types. These results could be explained by the willingness to conform to external demand. Indeed, due to the volatility of the export markets, firms must be capable of responding to the demands of clients by setting up functions that are adapted to those demands, qualities or market conditions, and are different from those that are offered by local producers. This would give rise to changes in production technology and the organizational structure of the firm.

Innovation and gender

We verified whether there was a link between the gender of the manager of the firm and the adoption of new forms of innovation. The results in Table 6 show that female managers of firms were in a minority: nine firms out of 10 were managed by men. Among the firms that innovated, regardless of the form of innovation, less than 10% among them were managed by women.

Table 6: Test of independence innovation and gender of the manager of the firm

	I_pdt	I_proc	I_org	I_mark	I_pdt	I_proc	I_org	I_mark
	Man				Woman			
No innovation	92.25	80.98	92.86	92.02	7.75	9.02	7.14	7.98
Innovative	92.38	93.86	91.14	92.86	7.62	6.14	8.86	7.14
Pearson probability test	0.970	0.397	0.637	0.816	0.970	0.397	0.637	0.816
Probability test Likelihood-ratio	0.970	0.393	0.640	0.815	0.970	0.393	0.640	0.815
Fisher's exact probability test	1.000	0.477	0.618	1.000	1.000	0.477	0.618	1.000

Source: Author

However, there was no significant relationship between the gender of the manager of the firm and the adoption of various forms of innovation. We cannot, therefore, conclude that firms managed by men are more likely to innovate than those managed by women.

5. Results and discussions

A descriptive analysis of the relationship between productivity and innovation according to the types of innovation, gives us an idea of the distribution of the productivity mean of firms that innovated or did not innovate. The firms that adopted non-technological innovations (organization and marketing) reflect the highest averages in labour productivity. In terms of firms that innovated in product, their productivity (15.96) was, on average, slightly higher than those that did not adopt any form of innovation. The result of the regression of parameters using ANOVA without interactions model are presented in Table 7. We observed that the means of productivity in firms that had innovated in organization had a significant impact on the mean of labour productivity. There is, therefore, a significant difference in the averages of productivity in firms that have innovated in organization and those that did not adopt any form of innovation.

However, there was no significant difference in terms of labour productivity between firms that are innovative in product, in procedures and in marketing and those that did not innovate. We cannot, therefore, conclude that there is a relationship between those innovations and productivity. Furthermore, we observed that technological and non-technological innovations account on average, for 10.4% of the labour productivity in firms that innovate.

Table 7: Analysis of the innovation-productivity without interaction

VARIABLES	Productivity	T-statistic
Innovation of Prod	-0.160	-0,65
	(0.245)	
Innovation of Proc	0.144	0.60
	(0.240)	
Organizational innovation	1.259***	4.46
	(0.283)	
Innovation in Mark	-0.291	-1.06
	(0.276)	
Cons	15.438***	111.64
	(0.138)	
Observations	247	
R-squared	0.104	
Prob > F	0.000	

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

Source: Author

In order to take into account the impact of interactions between various types of innovation and labour productivity, we examined the variance in those effects. More specifically, we verified whether the combinations of innovations at those levels are associated with labour productivity. Table 8 presents the results. The results show that labour productivity was explained through the adoption of innovations and their interactions, accounting for 12.1% of the mean of labour productivity. In regard to the interaction between various types of innovation, the significance indicates that no interaction among types of innovation was statistically significant for labour productivity. However, there was a statistically significant difference between firms that are innovative in organization and those that are not innovative in organization. This was a significant observation as it shows that there are other variables that were not taken into account that could explain labour productivity.

Table 8: Analysis of the innovation-productivity with interaction effects

VARIABLES	Productivity	T-statistic
Innovation of Prod	-0.496	-1.25
	(0.398)	
Innovation of Proc	0.453	1.30
	(0.348)	
Organizational innovation	1.366**	2.35
	(0.582)	
Innovation in Mark	-0.419	-0.81
	(0.520)	
Product innovation and innovation in procedure	-0.114	-0.23
	(0.500)	
Product innovation and innovation in organization	0.304	0.47
	(0.646)	
Product innovation and innovation in marketing	0.880	1.43
	(0.616)	
Process innovation and innovation in organization	-0.363	-0.56
	(0.645)	
Process innovation and innovation in marketing	-0.499	-0.82
	(0.606)	
Innovation in organization and innovation in marketing	-0.116	-0.20
	(0.577)	
Cons	15.446***	101.20
	(0.152)	
Observations	247	
R-squared	0.121	
Prob > F	0.000	

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

Source: Author

Table 9 shows the results of a multivariate regression analysis of the association between innovation and labour productivity and the interaction terms include the significant control variables. We observed that there was not much difference between the results from the ANOVA model and the multivariate regression. The adoption of innovation and its interactions were not significantly associated with an improvement in labour productivity. Our results demonstrate that only the choice to adopt innovation in an organization is associated with significantly improved labour productivity.

Table 9: Results of the multivariate regression of innovation and labour productivity

Var dep: Labour productivity		
	Model without interaction	Model with interaction
Innovation of Proc	-0.486	-0.682
	(0.294)	(0.49)
Innovation of Proc	0.178	0.446
	(0.243)	(0.336)
Organizational innovation	0.855***	0.753
	(0.297)	(0.536)
Innovation in Mark	-0.478*	-0.562
	(0.264)	(0.451)
Product innovation and innovation in procedure		-0.078
		(0.527)
Product innovation and innovation in organization		0.375
		(0.713)
Product innovation and innovation in marketing		0.425
		(0.669)
Product innovation and innovation in organization		-0.435
		(0.713)
Product innovation and innovation in marketing		-0.412
		(0.640)
Innovation in organization and innovation in marketing		0.278
		(0.597)
Size	-0.682	0.675***
	(0.163)	(0.171)
Gender	-0.304	-0.294
	(0.294)	(0.305)
Exports	0.12	0.065
	(0.271)	(0.287)
Exp_Manager	0.002	0.001
	(0.009)	(0.009)

Certification	0.558*	0.567
	(0.326)	(0.356)
ICT	0.308	0.341
	(0.212)	(0.221)
Licence	0.181	0.163
	(0.269)	(0.272)
Competition	-0.388**	0.397
	(0.176)	(0.187)
Demandpull	-0.184	-0.196
	(0.301)	(0.316)
Fin_bank	0.108	0.146
	(0.253)	(0.26)
Training	0.452*	0.395
	0.27)	(0.276)
Constant	15.004***	15.045***
	0.452*	(0.474)
R-squared	0.2976	0.3071
Prob > F-test	0.000	0.000
Number of obs	247	247

*** p<0.01; ** p<0.05; * p<0.1

Source: Author

Furthermore, larger firms had a higher level of productivity. This demonstrates that large manufacturing enterprises in Senegal benefit from economies of scale. However, the competition is associated negatively with an improvement in productivity of firms. Indeed, the firms are faced with competition, notably from the informal sector, which makes them lose part of their market share.

These results agree with those from other empirical studies. Our results are also similar to those arrived at by Baldwin and Gu (2004) in Canada, who demonstrated that non-technological innovations, in particular organizational innovation, are likely to be more productive. Raffo et al (2008) also found that product innovation does not have an impact on labour productivity of firms in Latin America.

The lack of an interaction effect of innovations also reflects the results arrived at by Okumu and Buyinza (2008) who found that a combination of two or three innovations had no significant impact on the labour productivity of firms in Uganda. This result is understandable in the context of Senegalese manufacturing industries. Indeed, with manpower that is insufficiently trained in adopting and assimilating new production technologies, the combined changes in production methods, organizational structure and marketing (significant modifications of design, packaging or methods of distribution and sales), could prove to be inefficient in terms of short-term productivity gains. In regard to manufacturing firms in Senegal, our sample showed that only one firm out of 10 (close to 11.3%) provided their employees with training.

Furthermore, the results could be justified through two paradoxes. First, one of

the explanations comes from the "productivity paradox" explained by David (1990). According to David (1990), the effects of technological innovations on productivity take time to become evident. Indeed, the explanation is based on the assumption that technology could considerably increase productivity, but that various obstacles could prevent it reaching its full potential. Among the obstacles is qualified manpower. Efficient use of technology requires manpower capable of exploiting the potential of technology. Thus, poorly trained workers could be an impediment to labour productivity. When such obstacles are done away with, productivity gains arising from the technological innovation will become more evident. In regard to manufacturing firms in Senegal, our sample showed that only one firm out of 10 firms offered training to employees. This could explain the absence of a significant association between innovation and productivity.

Second, the absence of an increase in labour productivity following the adoption of innovation in manufacturing industries of Senegal could be explained through the "innovation paradox" discussed by Cirera and Maloney (2017). In a report published by the World Bank these researchers discuss the coexistence of low levels of investments related to innovation in developing countries, with the spectacularly high returns that would be expected from the adoption of more productive technologies thus closing the gap for developing countries in terms of developing productivity levels. Three factors could explain this paradox. These are lack of: the essential components for investments in innovation necessary to obtain potential high yields; the key capacities of the firm (managerial and organizational practices) necessary to the pursuit and successful marketing of innovation are lacking; and government capacity to put in place innovation policies.

In Senegal, the absence of a National System of Innovation (SNI), bringing together industry, the government and research centres, and leading to the development of managerial and technological capacities of firms, limits innovation firms. Our results suggest the complementarity between investments in innovation, development of managerial and technical capacities of firms, and the capacity of the government to operationalize innovation policies. This would be done through implementing comprehensive and efficient policies in order to grow yields from innovation. Such policies should complement shared efforts in investments on innovation. This requires a rebalancing of policy priorities towards the management of technology, putting in place a national innovation system that highlights the interactions between public firms, private firms, universities and government agencies that facilitate the production of science and technology. The system of innovation should provide the inputs and flow of complementary skills necessary for the creation and/or adoption of technology. It should include all that has an impact on the accumulation of all types of capital (physical, human, knowledge).

6. Conclusion

In summary, this study examined the profile of innovative firms and analysed the relationship between innovation and productivity in manufacturing industries in Senegal. An analysis of background information on innovation in Senegal as compared to other countries allowed us to establish a low level of innovation. Our results show that the size of a firm is significantly linked to its innovation capacity. We also found a significant association between the type of firms that export and the adoption of various innovation types. However, no significant relationship was found between the gender of the manager of the firm and the adoption of various forms of innovation.

In regard to the relationship between innovation and productivity, our results show that firms that adopted non-technological innovations (organization and marketing) reflect the highest averages in labour productivity. We also found a significant difference in the mean of productivity between firms that engaged in organizational innovation and those that did not adopt any form of innovation, using ANOVA without interactions model as well as the ANOVA model with interaction. This demonstrates a positive relationship between organizational innovation and productivity. The adoption of innovation and its interactions are not significantly associated with an improvement in labour productivity. Our results demonstrate that only the choice to adopt innovation in an organization is associated with significantly improved labour productivity. These results could be justified through two paradoxes: the paradox of productivity and the paradox of innovation.

Despite the interest and the significance of the research problem raised in this study, as well as the results obtained, ithere is a caveat. The limits related to the data did not allow us to undertake an in-depth study of the results of this study. Because the data is cross-sectional, it is impossible to have an overview of the dynamics of innovation. The results, therefore, provided a snapshot of innovation in manufacturing industries of Senegal. Consequently, the estimated relationships should not be interpreted as having a cause and effect relationship (in the long term) but more like correlations. It is, therefore, important to carry out regular surveys of innovation in firms. These data on innovation in firms are useful for understanding the market trends, identifying their strengths and weaknesses, encouraging innovation and facilitating decision making in terms of innovation. Despite the constraints, this study provides useful information for a better understanding of how firms carry out their activities related to innovation in Senegal. With data of better quality, this research

could be extended over other research areas, notably on the role of innovation in the creation and elimination of jobs, and for an analysis on the time necessary to achieve the benefits of innovation after the adoption of an innovation, or also an evaluation of the impact of public policy on innovation.

Notes

1 Global Innovation Index 2016
Global Innovation Index 2019

2 This model is extensively addressed in Section 4.

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Appendix

Table A1: Description of variables

Name of variable	Definition
Innov_prod	Binary variable equal to 1 if the firm has introduced an innovation in product over the last three years, 0 if not
Innov_proc	Binary variable equal to 1 if the firm has introduced an innovation in process over the last three years, 0 if not
Innov_org	Binary variable equal to 1 if the firm has introduced an innovation in organization over the last three years, 0 if not
Innov_mark	Binary variable equal to 1 if the firm has introduced an innovation in marketing over the last three years, 0 if not
Productivity	Continuous variable, measured by the logarithm of turnover per person employed
Gender	Binary variable that takes the value of 1 if the firm is managed by a woman, 0 if not
Size	Category variable equal to 1 if the enterprise has a number of employees between 0 and 19, equal to 2 if it is between 20 and 99, and equal to 3 if it has more than 100 employees
Competition	A binary variable which is equal to 1 if the firm is in competition with informal companies, 0 if not
Experience_Manager	Continuous variable measuring the number of years of experience of the manager
Demand-pull	Binary variable that takes the value of 1 if a new product was introduced in the market, 0 if not
Licence	Binary variable that takes the value of 1 if the firm uses a technology for which a foreign firm provides it with a licence
Training	A qualitative variable that takes the value of 1 if the firm has proposed formal training programmes for its permanent and pensionable employees, 0 if not
Certification	Binary variable that takes the value of 1 if the firm has an international certification, 0 if not
Bank financing	Binary variable that takes the value of 1 if the firm has received bank financing, 0 if not
ICT	Binary variable equal to 1 if the firm has a website, 0 if not
Exports	Binary variable equal to 1 if the firm has exports, 0 if not

Source: Author

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