



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

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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 considered 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. Regarding the other types of innovation, no association was found. Our results suggest the need to develop strategies that integrate innovation in industrial policy to facilitate its adoption. They also suggest the need to undertake regular surveys of innovation in firms to better understand market trends, identify their strengths and weaknesses and facilitate decision making in terms of innovation.

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. Based on 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; the 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 that have handled it. Schumpeter (1942) introduced innovation in the analysis of economic theory. According to him 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, an increasing number of 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 consider 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 consider the four forms of innovation and their relationships of complementarity.

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 socio-economic context, and the innovation dynamic, all these aspects are covered in this section to illustrate the current situation in the industrial sector.

The place of innovation in the industrial sector of Senegal

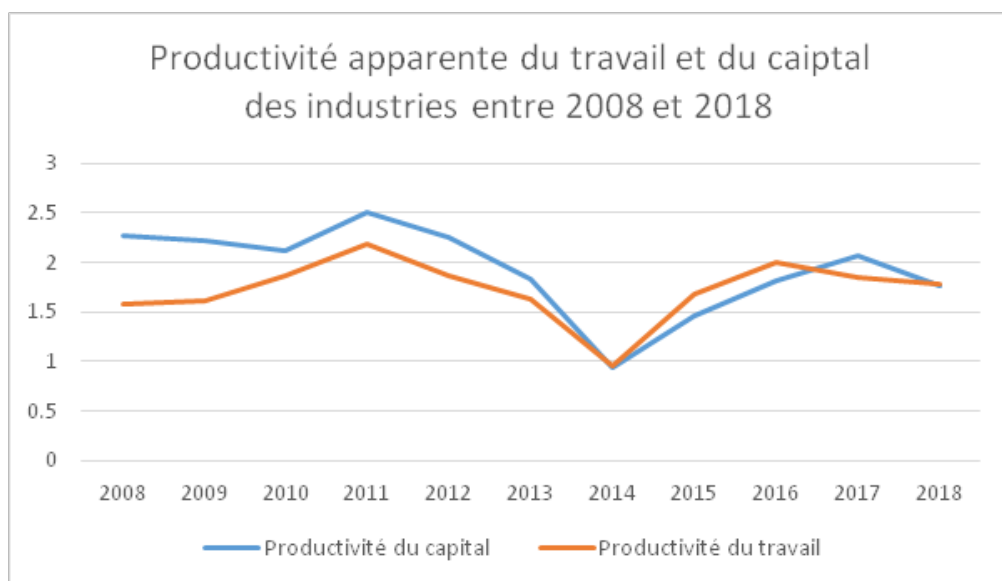
After the country's independence in 1960, Senegal inherited the most advanced manufacturing sector in West Africa. Several industrial policies were put in place to strengthen this heritage. Indeed, from a strategy for industrialization through the substitution of imports (ISI), to an industrial redeployment 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, to implement Senegal's industrial policy through considering 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". 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.

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 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. Regarding 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 to be competitive and enact its role as the driver of economic growth.

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 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). 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.

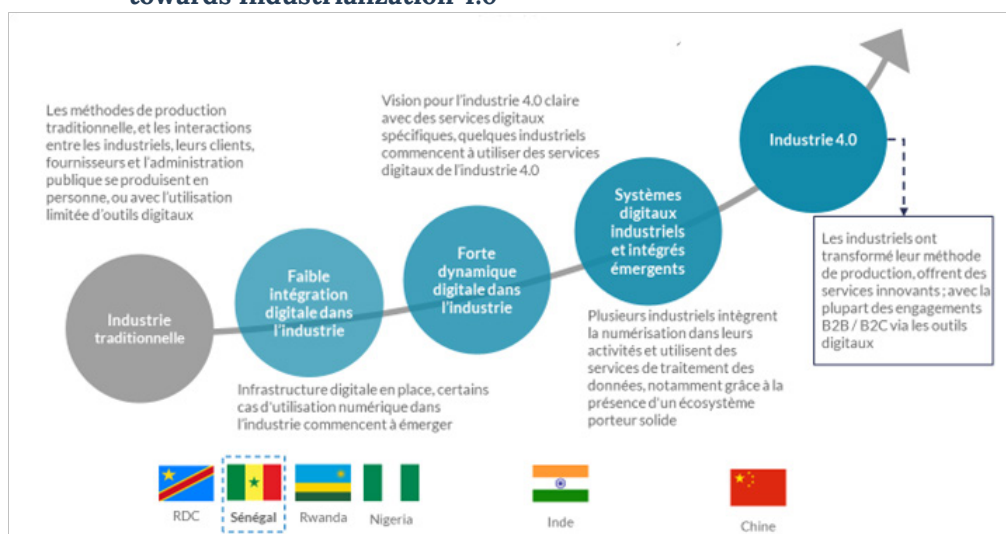
In relation to the dynamic use of digital technologies in Senegal's industries, we compare Senegal's position to that of countries on a similar trajectory towards industrialization 4.0 (Rwanda, Nigeria, China, and India). Industrialization 4.0 is the fourth industrial revolution and is characterized 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.

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 a major source of innovation. Indeed, they allow firms to produce new technologies, and acquire knowledge and technical know-how. Expenditure in R&D reflects 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.

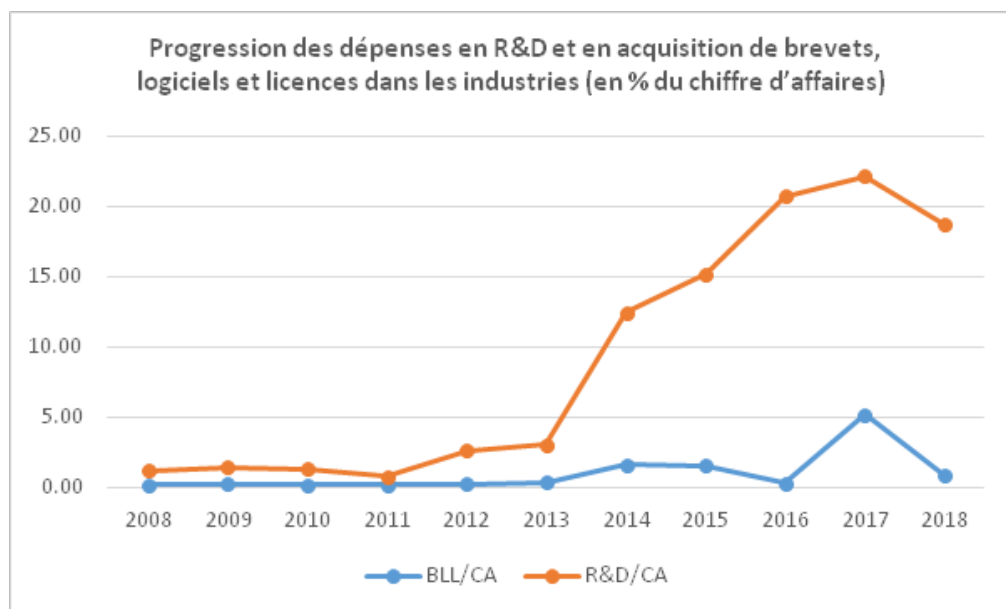
Figure 2: Position of Senegal in relation to other countries on the same trajectory towards Industrialization 4.0



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) . .

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 (2019)

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 to strengthen the capacities of firms and facilitate the adoption of technologies. Empirical data 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.

Data sources

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 consider 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 socio-economic 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 to find for 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.

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.

Regarding 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, it is important to raise 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 better understanding 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.

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