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ANALYSIS OF THE DETERMINANTS OF TECHNOLOGICAL INNOVATIONS WITHIN AGRI-FOOD COMPANIES IN MOROCCO

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Abstract

Research background: The commitment of manufacturers in research and development activities (R&D) and the realization of technological innovations have become effective means of stimulating economic growth.
Purpose: The objective of this research is to diagnose R&D activities and innovations within agri-food companies in Morocco that are engaged in the processing of food products by studying the determinants of technological innovations related to product and process within these companies.
Research methodology: A statistical survey was conducted on a sample of 50 agri-food companies, employing a generalized linear model (GLM) with a probit model belonging to the quasi-binomial family.
Results: The econometric analysis of the collected data revealed the presence of complementarity between product innovation and process innovation, as well as differences in the determinants of these

two categories of innovations within the studied companies. The determinants are related to the business environment, R&D activity and partnerships, human resource management in teams, technological infrastructure, and market demand.

Novelty: This research enriches the literature by examining the determinants of technological innovations (both in terms of products and processes) in the agri-food sector in Morocco. Industry professionals can benefit from the results of this research, which will enable them to better understand the levers of innovation in this field. This information can be used to guide their innovation strategies, identify new opportunities and improve their overall performance.

Keywords: Technological innovations, agri-food company, statistical survey, probit, Morocco

JEL classification: C45, O31, Q16

Introduction

Innovation plays a vital role in improving the economy of every country. By introducing new ideas, technologies and processes, innovation drives competitiveness, productivity and economic growth in industrial sectors. Indeed, in Morocco, the agri-food sector as an example plays a very important role in improving the economic fabric of the country. In 2020, it contributed 26.5% to the country's industrial production, representing 21.5% of industrial added value and 12.5% of total exports (Ministry of Industry and Trade and the Foreign Exchange Office of Morocco).

The introduction of technological innovations in products and processes has become a priority for industrial companies to promote their products. Innovation allows the company to increase its market share and profitability (Wamba *et al.*, 2017). It makes it possible to increase the productivity of companies, improve the quality of their products and/or services, and develop key skills (Nonaka, Takeuchi, 1995). On the other hand, the weakness of innovation can explain the gap in productivity between companies.

Many countries have begun the transition from economic growth to green productivity practices. This includes areas such as green finance, green innovation, and many others (Jiakui *et al.*, 2023). To solve an economic problem, companies often resort to using the latest innovations. The innovation can be seen as a solution to many economic problems despite cost constraints and market requirements. Moreover, the question of innovation and its determinants is at the center of the economic debate.

The economic literature has given great importance to studying the determinants of innovations within a company. Mairesse and Mohnen (2003) studied the link between innovation and company growth by focusing on three main areas, namely the determinants of innovations within the company, the analysis of the function of innovation, and evaluation of innovation and research and development efforts on business performance.

Innovation then evolved and became a crucial tool for the success of the company through the rationalization of the activities undertaken by companies. Every company has a given innovation strategy that is seen as a way of organizing ideas within the company. In addition, innovations within companies still encounter several obstacles to development.

Today, we recognize the complexity of innovation; it is no longer a simple question of R&D. Several factors interact and affect the innovative process of a company, namely the acquisition of information and communication technologies, competition, access to markets, and the organization of work and marketing, etc. At this stage, it is important to remember the definition of innovation that has evolved by classifying organizational and marketing innovations alongside product and process innovations (OECD, 2005).

Thus, this work aims to clarify the complexity of the process of technological innovations within the agri-food company in Morocco and to know the correlation between the categories of technological innovations as well as the factors that are necessary to study the determinants of the technological innovations of the product and that of the process.

To achieve the research objectives, we begin with a theoretical and empirical analysis to establish the framework of our study. Next, we outline our methodology, highlighting the econometric model used, estimation technique and the data employed. This approach ensures the robustness of our results. Finally, we present our conclusions, supported by a thorough discussion of theoretical perspectives, economic foundations, and previous studies, thereby illuminating our findings and their implications for future research and practice regarding technological innovations within companies.

1. Literature review

Technological innovations contribute more to increasing the productivity of a company when it is combined with non-technological innovations (Tsambou, Kamga, 2021). Furthermore, the analysis of innovation results and R&D activities is not sufficient to fully understand the process and mechanisms of innovation and R&D. We must go beyond this and look, among other things, for opportunities and internal and external motivations for innovation, as well as a company's ability to innovate. A company that engages in costly and uncertain expenses to carry out R&D activities, so these expenses do not in any way guarantee an increase in the innovation capacity of a company (Dosi, 1997).

Research into the determinants of innovation is generally based on the CDM model (Crépon *et al.*, 2000). This model consists of three equations: The first equation examines the firm's R&D activity, considering internal factors such as size and sector of activity, as well as external factors such as market impulses and technology dynamics. This equation explains the investment decision and the amount of investment in R&D for companies. The second equation explores the relationship between innovation output and R&D activities, using measures such as the number of patents and the proportion of sales from new products in a firm's turnover. These measures provide valuable information about the level of innovation achieved. Lastly, the third equation focuses on explaining the relationship between firm productivity and the output of innovation.

Baldwin and Lin (2002) recognized the hypothesis that insufficient training and lack of competence of employees mainly hinder innovations within a company. Schumpeter (1935) states that large companies are more conducive to innovation. Belonging to a technology-intensive industry has a significant effect on innovation activity. Sadgui (2014) showed that the probability that a company decides to innovate or not is influenced by the characteristics of this company (size, human capital, sector of activity, membership of a group, etc.). Innovation research often overlooks the impact of new entrants and the withdrawal of existing firms from the market. Arora and Gambardella (1990) delve into how large firms in the biotechnology sector integrate and leverage innovations from smaller companies. Their study underscores the importance of inter-entity interactions in driving innovation within specific sectors.

Becheick *et al.* (2009) also underline Schumpeter's idea that size positively influences innovations within a firm. Furthermore, technological change is influenced by the demand expressed in the market. Aghion *et al.* (2004) find that each economy is characterized by some level of education, so this level has a strong impact on the level of technology adopted by companies in that country. Vernon (1966) insists on the presence of the customer component in the life cycle of a product (production phase, product characterization phase, and standardization phase).

Von Hippel (1986) and Moore (2007) point out that part of the customer base is heavily involved in defining new terms for product innovations. Rahmouni and Yildizoglu (2011) point out that market demand determines the life cycles of a product and drives innovation. This demand allows the producer to develop new products that meet market needs. Crampes and Encaoua (2005) argue that market structure and competitive pressure are incentives for innovation. Arrow (1962) advocates that the monopoly business model favors innovation. This position on the market has great power to provide success, develop innovations within a company and perfectly meet the needs of its customers.

Innovation can lead to the establishment of temporary monopolies, allowing companies to enjoy high profits and rapid growth. However, persistent competition puts pressure on these monopolies, gradually reducing their future profits. This process encourages the expansion of innovation throughout the economy. According to Schumpeter (1935), innovation is the source of a monopoly rent, allowing an innovative company to be the sole provider of the desired goods, and to charge a higher price than the marginal cost. This enables them to obtain a temporary monopoly in the market, but competition brings other companies to master the innovation and offer similar products, thereby decreasing the future profits of the innovative company

Several studies have been carried out on individual innovation data using the Crepon-Duguet-Maresse (CDM) model with differences in terms of the choice of endogenous and explanatory variables and estimation methods. These studies used the number of patents and the share of sales of new products to measure innovation output. However, these measures have been widely criticized (Patel, Pavitt, 1994; Hall *et al.*, 2010). Patents only concern radical innovations and it is possible that they can never be introduced on the market. Furthermore, the share of sales of new products cannot be precisely determined. For greater clarity, they have also introduced investment in information and communication technology as well as investment in R&D as innovation inputs.

According to Sarpong *et al.* (2023), the current role of research and development (R&D) is crucial in fostering sustainable innovations, contrasting its significant historical impact since the 1960s. The authors propose a pathway model towards sustainability, highlighting three key elements of R&D: investment, talent, and learning institutions. They argue that aligning R&D investments with talent development and educational infrastructures can catalyze a sustainable innovation system that promotes economic growth. By addressing challenges and opportunities in this realm, the paper provides insights for rethinking R&D investment strategies while bridging sustainability discourses with intellectual traditions in R&D management.

Fishlow and Filho (2020) delve into the dynamics of technological change in Brazil, underscoring the pivotal role of public policy in fostering innovation-driven environments. Through meticulous examination, Fishlow and Vieira Filho explore the intricate interplay between state intervention and private sector initiatives across key sectors of the Brazilian economy, juxtaposing agricultural expansion with advancements in the oil and aviation industries. They assert that modern agriculture thrives on knowledge-intensive practices, crediting public institution-building efforts for its success in Brazil. The authors illustrate how strategic research initiatives have fuelled productivity growth, advocating for innovation policies that transcend individual companies to benefit entire sectors. Caiazza and Stanton (2016) highlight the importance of strategic partnerships in fostering technological innovations. The study reveals that strategic alliances are essential for promoting technological innovations. These partnerships enable the sharing of knowledge, resources, and expertise, thus strengthening the innovation capacity of businesses in the agri-food sector.

The correlation between the location of a company and the dynamics of innovation is weak. Roux (2001) supports this idea by emphasizing the role of the short distance between individuals and companies in the same territory in improving innovation capabilities. Arora and Gambardella (1994) showed the existence of a link and a complementarity between the two internal and external sources and that a single source is not sufficient. The achievement and success of innovation are influenced by internal and external sources of R&D Freeman (1994). The complementarity between knowledge from the internal and external sources of R&D makes it possible to have a strong absorption capacity that is important for a company. Veugelers (1997) points out that the knowledge that comes from external sources limits the R&D expenses carried out internally, in particular, for companies that have an R&D unit or department. Moreover, Veugelers and Cassiman (1999) found that a company, which carries out internal research in an intense way with a strong appropriation of its technology, ignores external sources in R&D activities.

The research of Sancho-Zamora *et al.* (2021) fills a significant gap by highlighting the pivotal role of organizational learning alongside absorptive capacity in driving innovation within companies. Through the quantitative analysis of data from 306 small and medium-sized Spanish firms, it empirically demonstrates that organizational learning is essential for translating absorptive capacity into tangible innovation outcomes. The findings underscore the importance of fostering a culture of continuous learning within organizations to effectively harness external knowledge for innovation purposes.

Bigliardi and Dormio (2009) aim to shed light on the determinants of technological innovation within small to medium-sized enterprises (SMEs) in the Italian food machinery industry. Conducted through a questionnaire survey among 98 firms in the industry, the research framework facilitated a comprehensive understanding of factors influencing innovation and their relative impact on innovation output. Contrary to industry trends, the study reveals a notable emphasis on collaboration with universities and research centers as a significant driver of innovation, while network actors are perceived as being less crucial. Universities, conferences, and scientific papers emerge as valuable sources of information influencing turnover from new products and processes. Financial and informational barriers consistently hinder innovation output, highlighting challenges within the innovation landscape. Furthermore, firms prioritizing market and efficiency-related innovation objectives tend to achieve higher levels of process-related innovation output.

As for Mongo (2013), he studied the impact of innovation factors on innovation capacity as well as on the form of technological or non-technical innovations by making a comparison between the two service and industrial sectors. His work was based on data collected in the framework of community surveys on innovation in 2008 by mobilizing a probit econometric model. The results of this study showed that the capacity for innovation is the same between the two sectors. The difference is visualized only with regard to the form of the innovation.

The examination of the determinants of technological innovations in the agri-food sector studied by Patanakul and Pinto (2021) emphasizes the importance of external factors such as government policies and incentives for innovation. Indeed, support policies for research and development, tax incentives for the adoption of innovative technologies and financial assistance programs have a positive impact on technological innovations. These results underline the crucial role of public policies in promoting innovation in this sector.

2. Methodology

This work aims to study the determinants of innovations within agri-food companies in Morocco. A documentary analysis relating to our subject made it possible to establish the theoretical and empirical foundations of various questions of our research. To affirm or confirm these hypotheses, we conducted an econometric study employing a generalized linear model (GLM) with a probit model belonging to the quasi-binomial family on collected data. The choice of econometric models used was based on the theoretical and empirical framework presented above and was adapted to the Moroccan case in terms of explanatory variables and estimation techniques.

2.1. Study model

To determine the factors of the realization of the technological innovations, we resorted to using two probit models. The first model is interested in the determining factors of the innovation (creation) of the product and the process. The second model is interested in the determinants relating to the innovation (improvement) of the product and the process according to the definition of the categories of innovation established by the OECD (2005). These models are relevant to our case study and give significant results. We, therefore, adapted our two models with the following variables of interest (y):

$$\text{Model 1:}\quad \begin{cases} y_1\left(\text{Creation of a new product}\right)\begin{cases}\text{Yes}=1\\ \text{No}=0\end{cases} \\ y_2\left(\text{Creation of a new process}\right)\begin{cases}\text{Yes}=1\\ \text{No}=0\end{cases}\end{cases}$$

and

$$\text{Model 2:}\quad \begin{cases} y_3\left(\text{Improvement of a product}\right)\begin{cases}\text{Yes}=1\\ \text{No}=0\end{cases} \\ y_4\left(\text{Improvement of a process}\right)\begin{cases}\text{Yes}=1\\ \text{No}=0\end{cases}\end{cases}$$

For the choice of the explanatory variables of these two models, the determinants cited in the literature are numerous. In addition, we focused more on the determinants related to the business environment, recruitment method, human resources management, R&D activities, R&D partnership, market demand, competitive pressure, and technological infrastructure (Table 1).

Therefore, we have four econometric equations to estimate which are written as follows:

$$\text{Model 1:}\quad \begin{cases} y_1 = f\left(T + MRD + DP + WRD + MR + MT + RDP + AT\right) + \varepsilon_1 & (1)\\ y_2 = f\left(T + MRD + DP + WRD + MR + MT + RDP + AT\right) + \varepsilon_2 & (2)\end{cases}$$

and

$$\text{Model 2:}\quad \begin{cases} y_3 = f\left(T + DP + WRD + MR + MT + RDP + AT\right) + \varepsilon_3 & (3)\\ y_4 = f\left(T + DP + WRD + MR + MT + RDP + AT\right) + \varepsilon_4 & (4)\end{cases}$$

Table 1. Explanatory variables of the two models

Model 1		Model 2	
variable	modalities	variable	modalities
Turnover (T)	–	Turnover (T)	–
Mode of R&D (MRD)	Externally (MRD_Ext)	Domain of personnel (DP)	Marketing (DP_Mark)
	Internally (MRD_Int)		Agri-food Sciences (DP_AfS)
	Externally and Internally		In Formulation
Domain of personnel (DP)	Marketing (DP_Mark)	Way of carrying out R&D activities (WRD)	Permanent (WRD_P)
	Agri-food Sciences (DP_AfS)		Sometimes
	In Formulation	Mode of Recruitment(MR)	Seasonal (MR_Seas)
Way of carrying out R&D activities (WRD)	Permanent (WRD_P)		Permanent
	Sometimes	Have a Monitoring Team (MT)	Yes (MT_Yes)
Mode of Recruitment (MR)	Seasonal (MR_Seas)		No
	Permanent	R&D partnership (RDP)	With Suppliers (RDP_Su)
Have a Monitoring Team (MT)	Yes (EV_Yes)		With Experts (RDP_Ex)
	No		With Customers
R&D Partnership (RDP)	with Suppliers (RDP_Su)	Acquisition of Technology (AT)	Yes (AT_Yes)
	With Experts (RDP_Ex)		No
	With Customers		
Acquisition of Technology (AT)	Yes (AT_Yes)		
	No		

Note: () these are the codes of the variables/modalities considered under the R software. The codes of the reference modalities are not mentioned.

Source: own elaboration.

2.2. Estimation technique

We use a generalized linear model (GLM) through a probit regression by exploiting an almost binary link for each category of technological innovations (output of the innovation realized or not). We are interested in this research only in the technological innovations of products and processes within the agri-food company in Morocco according to the definition of innovation by the OECD (2005). Probit regression is widely used in quantitative research, when it comes to testing complex causal models, incorporating several latent variables. It also makes it possible to predict the probability of an event for the study variable. It characterizes and measures the degree of dependence between the qualitative explained variable and the factors that are likely to influence it (explanatory variables). The probability of the occurrence of the event y by a probit model is as follows:

$$P\left(y=1 \mid x\right)=\Phi\left(\beta_0+\beta_1 x_1+\ldots+\beta_k x_k\right) \tag{5}$$

with:

p – Probability of the occurrence of the variable of interest,

x_i – Explanatory variable i,

β_i – Coefficient associated with the explanatory variable i,

k – Number of explanatory variables,

Φ – Standard normal cumulative distribution function defined by:

$$\Phi\left(z\right)=\int_{-\infty}^{z}\left(\frac{1}{2\pi}\right)^{1/2} exp\left(\frac{-u^2}{2}\right)du \tag{6}$$

It should be noted that in binary regression, the interpretation of the estimated coefficients can no longer be performed directly in the same way in linear regression. The sign of the estimated coefficient makes it possible to know only the direction of increase in the probability of occurrence of the event (y = 1) following an increase in the explanatory variable (x). Moreover, recourse to the calculation of the marginal effect is important in the case of a binary regression. The marginal effect is the variation in the probability (y = 1) following an increase in the explanatory variable (x) by one unit (quantitative variable) or a change in the reference modality (qualitative variable). In the case of a GLM probit model, the marginal effect EM_{xk} is calculated as follows:

$$EM_{xk}=\frac{\partial\Phi\left(\beta_0+\beta_1 x_1+\ldots+\beta_k x_k\right)}{\partial x_k}=\beta_k\Phi\left(x_k\right) \tag{7}$$

In our case, it turned out that the use of a quasi-binomial GLM model is adequate in comparison with a binomial GLM. The quasi-binomial model does not fix the dispersion parameter ψ and therefore the resolution of the over-dispersion problem in our case study. This distribution makes it possible to describe an additional variance in the data of a sample of size n that cannot be adjusted by a binomial distribution alone. The probability p of the quasi-binomial distribution is as follows:

$$P\left(X=k\right)=\binom{n}{k}p\left(p+k\psi\right)^{k-1}\left(1-\mathrm{p}-\mathrm{k}\psi\right)\left(1-\mathrm{p}-\mathrm{k}\psi\right)^{n-k} \tag{8}$$

The quasi-binomial distribution is similar to the binomial distribution with an additional parameter ψ conditioned as follows:

$$|\psi| \leq \min\left\{\frac{p}{n}, \frac{1-p}{n}\right\} \tag{9}$$

It is important to note that certain statistical models can exhibit a discrete marginal effect when probability distributions with relatively low variance are used. In such circumstances, the probability of a binary response becomes more sensitive to fluctuations in the value of the explanatory variable, potentially resulting in a discrete marginal effect. Specifically, in a probit model from the quasi-binomial family, when the variance of the quasi-binomial distribution is reduced, the marginal effect of a variable on the binary response can manifest discretely. In other words, the probability of the binary response can change abruptly when the value of the quantitative explanatory variable exceeds a certain threshold or when the category of the qualitative explanatory variable is altered.

2.3. Research data

To conduct this study, we conducted a non-probabilistic statistical survey among 50 agri-food companies in Morocco over a period of three years: 2019, 2020, and 2021, by aggregating them. This choice to aggregate three years is justified by the time required for the implementation of innovations. Based on the theoretical and empirical framework presented previously as well as the Oslo Manual of the OECD (2005) and the Frascati Manual (2015), we established a questionnaire addressed to agri-food companies. This questionnaire contains all the variables of the econometric models recommended in our work (variable of interest, explanatory variables). It should be noted that the correction of non-response was carried out by the various statistical adjustment techniques, namely imputation by the mean, logistic modeling, etc.

It should be noted that in the present research work, we used the R software relying on several packages, which were essential to carry out the data analysis of this study. These packages include **mfx**, **stats** and **car**, developed respectively by Alan Fernihough, R Core Team as well as John Fox and Sanford Weisberg. These packages greatly facilitated our statistical analyzes and graphical visualizations.

3. Results and discussion

3.1. Model validation

The estimated GLM models of the quasi-binomial family were found to be adequate and significant at 5%. The models are globally significant and provide a better fit to the data. The majority of explanatory variables affect the variable of interest. Consistent estimators based on quasi-likelihood were obtained for the coefficients of the four equations considered and are compatible with the economic reality. In addition, these models are intuitively satisfactory and perfectly model the over-dispersion mechanism mentioned in the case of binary probit modeling. The values of the over-dispersions displayed by the said models are low compared to those of binomial models.

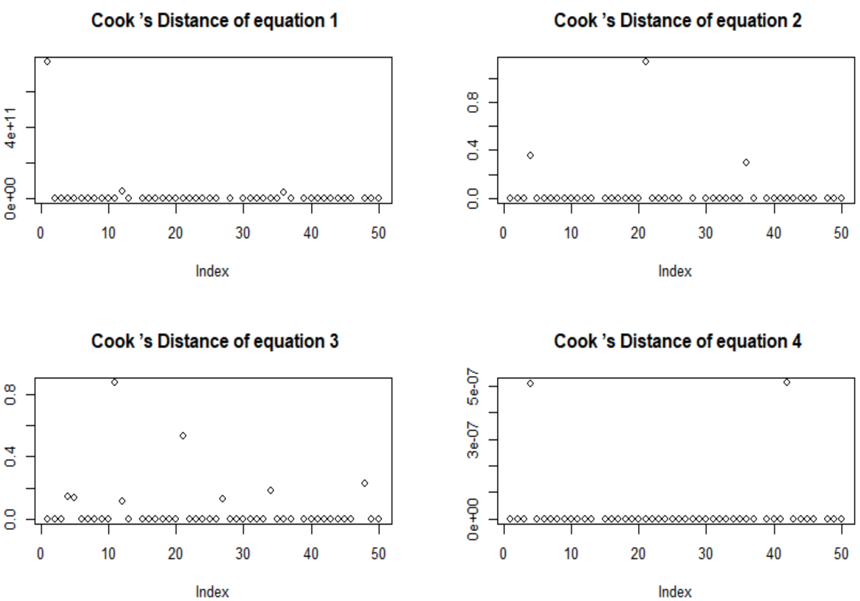

Figure 1. Cook's distance of the models

Source: own elaboration using R.

The estimation of the parameters of our models considered was based on the quasi-likelihood and therefore, it is not possible to reason by the value of the Akaike Information Criterion (AIC) or the log-likelihood to measure the quality of adjustment of the models. The GLM model of the quasi-binomial family consists in establishing a post hoc adjustment of the variance of the binomial distribution. Thus, according to the presentation of Cook's distance, it turns out that the models fit and fit the data object of our work well (Figure 1). Indeed, the analysis of Cook's distance values reveals crucial insights into the fit of our models to the data. Upon examining the distribution of Cook's distance values, we can observe that some observations have values close to zero, while others stand out with higher Cook's distance values, indicating a more pronounced influence on our models.

3.2. Determinants of creation-type product innovation

The results of model 1 show that the determinants of process innovation differ from those of product innovation. This result agrees with that found by Hadhri *et al.* (2016) who showed that innovation is influenced by factors but to different degrees depending on the form of the innovation considered (product, process, organization, etc.). The results of the first equation of the modeling carried out show that most of the variables considered by the model are significant for a margin of error of 5%. The turnover achieved by the company studied, how R&D activities are carried out, internally or externally, the area of personnel in marketing and agri-food sciences, the method of recruitment of seasonal workers, the R&D partnership with suppliers and experts have a significant effect on the achievement of product innovations within the companies studied. On the other hand, the availability of a monitoring team within a company and the acquisition of new technologies are not significant (p-value > 0.05) (Table 2).

The calculation of the marginal effects or the variables significant at 5% makes it possible to distinguish the presence of two types of effects shaped by these (significant) explanatory variables on the realization of the product innovation event. In fact, the turnover, the area of staff training in marketing and agri-food sciences compared to the reference modality (in formulation) and the R&D partnership with the experts compared to the reference situation have an effect almost zero on the achievement of product innovation. Thus, the result relating to turnover does not confirm the hypothesis of Baldwin and Lin (2002) on the fact that only large companies that are more conducive to innovation. Indeed, the agri-food company studied is part of an innovation process and its turnover has no impact on its commitment to R&D activities. This vision was favored by the support presented by the R&D and innovation institutions concerned within the framework of the sectoral strategies undertaken by the country.

On the other hand, the permanent way of carrying out R&D activities, the way of carrying out R&D activities internally or externally, the method of recruiting seasonal workers and the R&D partnership with suppliers decrease the probability of carrying out the innovation of the product within the companies studied. This probability decreased by one percentage point in relation to the reference methods considered by the model. This result confirms, among others, the results of de Veugelers and Cassiman (1999) who found that the company, which carries out internal research in an intense way with a strong appropriation of its technology, ignores external sources in R&D activities. Arora and Gambardella (1994) showed the presence of a correlation and a complementarity between the two internal and external sources and that a single source is not sufficient.

The dynamics of product innovations within the companies studied is strongly oriented by the performance of R&D activities both internally and externally, as well as the recruitment of permanent staff and the development of partnerships with customers, as Von Hippel (1986) and Moore (2007) points out. A part of the clientele participates strongly in defining the new modalities for product innovations.

On the other hand, this category of innovation does not necessarily depend on the profile of the staff recruited and the establishment of a monitoring team, the turnover of the company as well as the acquisition of new technologies. Moreover, the development of human capital within a company favored by the adoption of a new technology is an important ingredient to stimulate innovation and productivity of the agri-food company studied. This result sheds light on the role of human capital in increasing the overall productivity of the factors of production as specified by Dahani *et al.* (2022).

3.3. Determinants of creation type process innovation

Regarding process innovations within the companies under study, the results of the second probit equation indicate that the majority of the variables considered by the model are also significant within a 5% margin of error. Indeed, the area of personnel in agri-food sciences, how R&D activities are carried out, the availability of a monitoring team within a company, and the R&D partnership with experts have a significant effect on the achievement of the process innovation (Table 2).

Thus, the calculation of the marginal effects of the model considered makes it possible to distinguish the presence of two types of effects shaped by these (significant) explanatory variables on the occurrence of the process innovation event. Indeed, the provision of a monitoring team within a company and the R&D partnership with experts about customers increase the probability of the achievement of this category of innovation by one percentage point for each. This result is consistent with the results of Sadgui (2014) who showed that the probability that a company decides to innovate or not is influenced by the characteristics of the size and the human capital of this company. The organization of staff into teams and the establishment of partnerships with experts in the field strongly enhance the innovation of the process within the companies studied.

This result also confirms the idea of Torrès (1999) who advocates that the proximity of a company to other companies and external sources of knowledge (customers for example) is a key factor that promotes the dynamics of innovation. Improving a process requires a dedicated monitoring team for the establishment of a new, more productive process and meets the needs of market demand, which determines the life cycles of a product and boosts innovation as Rahmouni and Yildizoglu (2011) point out. That said there is the presence of complementarity between product innovation and process innovations within the companies studied.

On the other hand, the permanent way of carrying out R&D activities and the area of personnel in agri-food sciences affects the carrying out of process innovation (reduction of the probability of innovation of the process by 1 point compared to the methods of references of these variables). This result can be explained by the fact that process innovation does not require continuous R&D activities over time and that the field of formulation personnel is better in terms of process innovation results compared to agri-food sciences. In addition, for a margin of error of 5%, the turnover achieved by the company studied, the method of carrying out R&D activities and the field of marketing personnel, the method of recruitment and the partnership in R&D with suppliers and the acquisition of new technologies on process innovation.

Table 2. Results of regression – model 1

Variable	Product		Process	
	p-value	discrete marginal effect	*p*-value	discrete marginal effect
Constant	0.0000 ***		0.7716	
T	0.0000 ***	0	0.5918	
MRD_Ext	0.0000 ***	–1	0.3474	
MRD_Int	0.0000 ***	–1	0.9898	
DP_Mark	0.0000 ***	0	0.6228	
DP_AfS	0.0000 ***	0	0.0125 *	–1
WRD_P	0.0000 ***	–1	0.0001 ***	–1
MR_Seas	0.0000 ***	–1	0.1121	
MT_Yes	0.571		0.0000 ***	+1
RDP_Su	0.0000 ***	–1	0.4228	
RDP_Ex	0.0000 ***	0	0.005 *	+1
AT_Yes	0.978		0.4663	

Note: *** significance at $p < 0.001$, ** significance at $p < 0.01$, * significance at $p < 0.05$.

Source: own elaboration using R.

3.4. Determinants of improvement-type product innovation

About product innovation in terms of improvement, according to the results of the third equation of our modelingit turns out that the permanent way in which R&D activities are carried out, the method of recruiting seasonal workers, the partnership in R&D with experts and the acquisition of technology are significant at 5% and influence the probability of the product improvement event within the companies studied. On the other hand, the variables of the turnover achieved, the field of personnel, and the availability of a monitoring team are not significant (Table 3).

Thus, the calculation of the marginal effects of the significant variables showed that the permanent way of carrying out R&D activities and the acquisition of technology positively impact the probability of improving the product by one point in percentage compared to the methods of references considered. The improvement of the product is favored by the presence of an important technology as well as the realization of the activities of the R&D in a continuous way in time making it possible to give exploitable results on the products engaged by the company with a moderate cost. Therefore, the permanent commitment of the company studied in the process of improving the said products was done to meet consumer preferences.

On the other hand, the method of recruiting seasonal workers has almost no impact compared to permanent staff. This result demonstrates that the quality of human resources influences the ability to improve products within the firm under study and aligns with Schumpeter's (1935) hypothesis that innovation is favored in large firms characterized by the large size of its staff. In addition, the R&D partnership with experts negatively affects this probability by one percentage point compared to customers. This result testifies to the strong partnership of the agri-food company with customers versus experts in terms of product improvement.

3.5. Determinants of improvement-type process innovation

As for the innovation of the process in terms of improvement within the companies studied, the results of the 4th equation show that the field of personnel, the method of recruitment, the availability of a monitoring team, the partnership in R&D with suppliers, and the acquisition of new technology are significant at 5%. On the other hand, the turnover achieved by the company, how R&D activities are carried out and the R&D partnership with experts are not significant (Table 3).

More specifically, according to the values of the marginal effects calculated for the significant variables, the provision of a monitoring team positively affects the probability of improving the process by one percentage point (positive effect). This result confirms the observation of Kamien and Zang (2000) who insist on the need to have initial knowledge (monitoring team) to acquire the external knowledge of the experts in our case study. In addition, the fields of personnel training in marketing and agri-food sciences have almost no impact compared to the field of formulation. This means that the probability of improving the process is influenced to the same degree by the three areas of training of the personnel of the company studied. On the other hand, the mode of recruitment of seasonal workers, the R&D partnership with suppliers, and the acquisition of technology negatively affects this probability by one percentage point compared to the reference situations. This result confirms that the process improvement partnership remains oriented toward customers and experts considered being, relevant sources of knowledge and that the acquisition of new technologies is not strongly exploited by the companies studied and constitutes a real obstacle to the agri-food company concerning the improvement of the process.

Table 3. Results of the regression – model 2

Variable	Product		Process	
	p-value	discrete marginal effect	*p*-value	discrete marginal effect
Constant	0.4287		0.0000 ***	
T	0.9855		0.7259	
DP_Mark	0.2636		0.0000 ***	0
DP_AfS	0.8272		0.0121 *	0
WRD_P	0.0000 ***	+1	1.0000	
MR_Seas	0.0069 **	0	0.0000 ***	–1
MT_Yes	0.1578		0.0000 ***	+1
RDP_Su	0.1084		0.0000 ***	–1
RDP_Ex	0.0023 **	–1	0.0572	
AT_Yes	0.0013 **	+1	0.0000 ***	–1

Note: *** significance at $p < 0.001$, ** significance at $p < 0.01$, * significance at $p < 0.05$.

Source: own elaboration using R.

Conclusions

Agri-food companies are repeatedly faced with decisions that determine the future of the company regarding their commitment to R&D activities and capacity for technological innovations. Thus, the results of our study revealed that the determinants vary from one category of innovation to another within the studied companies. The likelihood of product innovation is positively influenced by continuous internal and external R&D activities, permanent employee recruitment, increased partnerships with customers, and adoption of new technologies. On the other hand, the probability of process innovation is positively influenced by the presence of a monitoring team within a company and engagement in R&D activities with customers.

However, our study has certain limitations, such as the non-probabilistic method used for data collection and non-response for variables like R&D expenditure, patent filing, and protection of inventions, which could have influenced their inclusion in the econometric models used. Nevertheless, this study highlights the presence of complementarity between product and process innovation, as well as specifying the determinants of technological innovations within the studied companies. Therefore, it is essential to provide better support for innovation in Moroccan companies, particularly emphasizing R&D activities and thus developing a strategy based on the complementarity between all categories of innovation to capitalize on their benefits. Additionally, aligning training programs with the needs of human capital in businesses is crucial.

This study proposes theoretical and methodological foundations, as well as results, for the determinants of two categories of innovation: product innovation and process innovation. It also suggests the further exploration of other categories of organizational and commercial innovation to understand the synergy between different categories and their impact on the economic growth of Moroccan companies in various industrial sectors.

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