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The role of strategic innovation activities in creating Spanish agriculture companies' innovativeness

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Abstract: The aim of this study is to identify strategic innovation activities that influence the product and process innovativeness of Spanish agriculture companies. From a theoretical perspective, according to the Oslo Manual, strategic innovation activities can be divided into five key groups. Based on a dataset including 874 firms covered by the 2014 edition of the Community Innovation Survey (CIS), we examine the role of different forms of strategic innovation activities used for the introduction of product and process innovations. Using the logit regression model and marginal effects, we found evidence of a relationship between the strategic activities and the product and process innovations in Spanish agriculture companies. The results indicate that only one type of strategic innovation activity, i.e. in-house research and development (R&D) is a common statistically significant factor explaining the product and process innovation. In the case of the other strategic innovation activities, some differences can be found. Thus, external R&D and other activities are significant for product innovation, but not for process innovation. In turn, the acquisition of machinery, equipment, software and buildings and training for innovative activities are significant for process innovation, but not for product innovation.

Keywords: product innovation; process innovation; R&D activities

Innovation is central to improvements in living standards, the economic development and prosperity of a society. Numerous studies suggest that innovation can affect individuals, institutions, entire economic sectors, and countries in multiple ways (OECD and Eurostat 2018). It is also shown that innovation is a fundamental element through which companies can improve their performance and competitive advantage (Mendoza-Silva 2021). Also, research conducted in the agricultural sector suggests that innovation is the key determining factor in adapting to the new global economy paradigm – based on sustainable development and environmental protection for future generations (Jankelová and Joniaková 2021).

However, despite the role that innovation plays in building the competitiveness of various enterprises in the agricultural sector (Materia et al. 2017), the ongoing discussion focuses on a comprehensive approach to the construct of innovation (Berthet et al. 2018; Pigford et al. 2018; Gremmen et al. 2019) and, apart from individual surveys (Goedhuysa and Veugelers 2012), there is a lack of research devoted to assessing the impact of strategic innovation activities on specific types of innovation. It should be noted

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that the identification and assessment of the impact of individual strategic innovative activities on specific types of innovation is important because the determinants of the growth of the enterprises in the individual industries are not innovation as a construct, but specific types of innovation, while sectoral system conditions influence the importance of various innovative activities for the level of the innovation (McCarthy and Aalbers 2016; Materia et al. 2017; Hsu et al. 2021).

The subject of our research is Spanish agricultural sector with 945 024 farms (2016) accounting for 2.88% of the gross domestic product (GDP) (2020) (INEbase 2021). This sector is important and interesting for several reasons. First, Spain's economy is the fourteenth largest in the world in terms of the nominal GDP, and also one of the largest in terms of purchasing power parity. Second, agribusiness accounted for, in 2015, over 15% of all Spanish exports. Third, Spain, although classified by the European Innovation Scoreboard (EIS) as a 'moderate innovator' (Radicic and Balavac 2018), is characterised by a low level of investment in research and development (R&D). The total R&D expenditure fell from 1.35% of the GDP in 2009 to 1.24% of the GDP in 2018. Public R&D investment fell from 0.65% to 0.54% of the GDP in 2009–2018 and was below the European Union (EU) average (0.69%). Private R&D investment fell from 0.73% in 2007 to 0.64% of the GDP in 2016. It has since increased to 0.7% in 2018 but is still low compared to the EU average of 1.41% in 2018 (INEbase 2021).

Therefore, based on the Oslo Manual (OECD and Eurostat 2018) and assuming that, in order to build innovation, companies undertake a number of different strategic activities, the aim of this study was to attempt to identify strategic innovation activities that influence the product and process innovativeness of Spanish agriculture companies.

Literature review and hypothesis development. Considering that innovation activities may either be innovative in themselves or required for the implementation of innovations, to find the strategic innovation, we decided to use the Oslo Manual innovation activities typology based on the following groups: *i*) in-house R&D, *ii*) external R&D, *iii*) acquisition of machinery, equipment, software and buildings, *iv*) training for innovative activities and *v*) other (e.g. feasibility studies, testing, tooling up, industrial engineering, etc.) (OECD and Eurostat 2018).

To investigate the role of the innovative activity in building innovation in agriculture, the systematic literature review method was applied. To obtain the newest comprehensive overview of the literature on the topic, a search was carried out using the Scopus databases and covered the period 2017–2021. The term 'innovation activi*' was used in the title field to identify the relevant studies. The first search returned 655 results. In the next step, we added the following terms 'agri* OR farming OR husbandry OR Oslo OR cis' in the title, abstract and keyword fields. The second search showed 32 results. The following inclusion criteria were applied: *i*) subject area: business, management and accounting and economics, econometrics and finance; *ii*) document type: article; *iii*) source type: journal; *iv*) language: English. This resulted in 22 articles for the analysis.

Scuotto et al. (2017) suggest that in-house R&D plays an important role in fostering innovation due to the high value of the technical skills of the employees. Zhang and Xie (2019) show that in-house R&D activities are the primary source for radical innovation. Wang et al. (2021) note that companies combining in-house R&D and raising capital with technologies perform better on product and process innovation than companies using only one of these innovation strategies. Bianchini et al. (2018) make the observation that R&D should improve the absorption capacity and help meet the challenges of external knowledge and technology acquisition, thus increasing the growth potential of companies that perform external acquisition in conjunction with the R&D. Consequently, we propose the following hypotheses:

H_{1a}: The R&D activities undertaken by Spanish agriculture companies have a positive impact on the introduction of product innovations.

H_{1b}: The R&D activities undertaken by Spanish agriculture companies have a positive impact on the introduction of process innovations.

Carboni and Medda (2021) note that sourcing R&D from external partners positively influences the creation of innovative products, however, as the intensity and complexity of external R&D work increases, companies may incur higher costs of coordination and control. Paula and Da Silva (2018) also indicate that while numerous studies confirm that external R&D plays a key role in the development of innovation, the dependence on partners increases the costs of coordination and monitoring in order to avoid misappropriation. In light of the above, it is possible to formulate the following hypotheses:

H_{2a}: The R&D activities contracted-out by Spanish agriculture companies have a positive impact on the introduction of product innovations.

https://doi.org/10.17221/66/2022-AGRICECON

H_{2b}: The R&D activities contracted-out by Spanish agriculture companies have a positive impact on the introduction of process innovations.

Bianchini et al. (2018) point out the critical importance of challenges associated with external sourcing for product and process innovations. McCarthy and Aalbers (2016) indicate that technology acquisitions not only provide the company with economies of scale but also increase the company's ability to absorb, develop and reconnect knowledge in new ways, which contribute both to the company's short-term innovative results and create a long-term competitive advantage. Rios and Luis Rios (2021) highlight the potential negative consequences – technology acquisitions tend to disrupt the company's technology subsystem and the innovation routine of both the acquiring and acquired companies. Therefore, we suggest the following hypotheses:

H_{3a}: The acquisition of advanced machinery, equipment, software and buildings by Spanish agriculture companies have a positive impact on the introduction of product innovations.

H_{3b}: The acquisition of advanced machinery, equipment, software and buildings by Spanish agriculture companies have a positive impact on the introduction of process innovations.

Odei et al. (2021) show that companies, by investing in training their employees for innovative activities, equip themselves with the necessary knowledge and skills that can help change their ability to offer better goods or services on the market. Børing (2017), indicating that participation in training is beneficial for both participating employees and their employers, sees a positive relationship between the use of employee training and innovative activity. Triguero et al. (2018) indicate that training is a key factor for product and process innovations in low-tech industries. A similar relationship is suggested by the findings Protogerou et al. (2017) showing that training of the workforce becomes less relevant to innovation performance as the degree of innovation increases. Consequently, we propose the following hypotheses:

H_{4a}: In-house or contracted out training for innovative activities by Spanish agriculture companies have a positive impact on the introduction of product innovations.

H_{4b}: In-house or contracted out training for innovative activities by Spanish agriculture companies have a positive impact on the introduction of process innovations.

Also, other in-house innovation activities or innovation activities that are contracted out supporting the implementation of new or significantly improved products and processes are of interest to scientists. Assuming contracts provide a way to manage conflict during knowledge transfer, Charterina et al. (2018) suggest that a high level of contract utilisation enhances the ability to innovate based on the buyer-supplier interaction. Knudsen et al. (2017) point out that the possibilities of accessing inter-organisational relationships and acquiring knowledge through contracts with external R&D providers, both domestic and international, are part of a wide range of organisational possibilities for a company to acquire, create and apply knowledge for product innovation activities. In turn, Yam et al. (2011) suggest the importance of quality and quick feedback from manufacturing to design and engineering and the mechanism for transferring technology from research to product development. Therefore, we pose the following hypotheses:

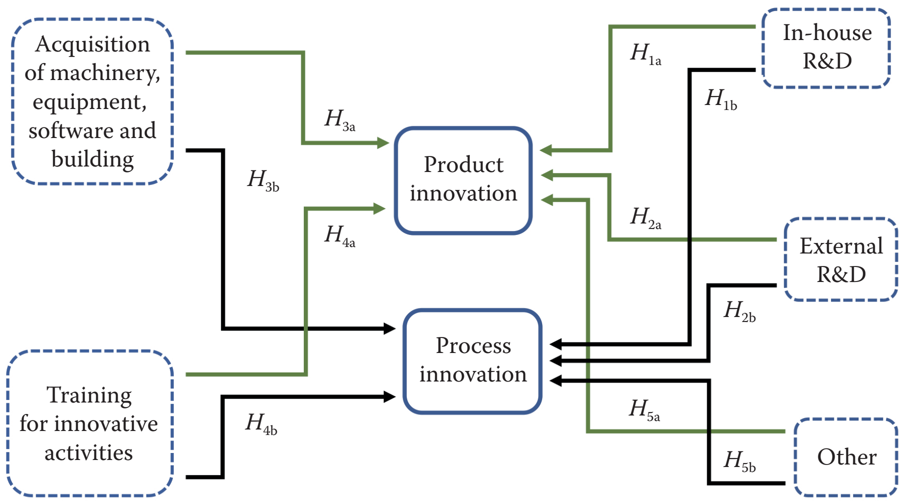

Figure 1. Conceptual model

R&D – research and development

Source: Author's own elaboration

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H_{5a}: Other in-house or contracted out activities by Spanish agriculture companies have a positive impact on the introduction of product innovations.

H_{5b}: Other in-house or contracted out activities by Spanish agriculture companies have a positive impact on the introduction of process innovations.

The above analysis of the research conducted thus far in the field of innovation activities enabled us to formulate the conceptual model presented in Figure 1.

MATERIAL AND METHODS

Data source. We used the microdata from the 2014 wave of Community Innovation Survey (CIS), which is the reference survey on innovation in enterprises. The EU Member States first introduced the survey in 1992 and, since then, it has become a regular biennial data collection source. At present, the survey is carried out in the EU, the European Free Trade Association (EFTA) and the EU candidate countries. The legal framework for CIS, since 2012, is Commission Regulation No. 995/2012 that establishes the quality conditions and identifies the obligatory cross-coverage of economic sectors, size class of enterprises and innovation indicators (EC 2022). In order to comply with the Regulation requirements and also to respond to the needs of various users, Eurostat together with all the countries develops a standard questionnaire for each round – harmonised data collection (HDC). The CIS questionnaires are available on the Communication and Information Resource Centre for Administrations, Businesses and Citizens (CIRCABC) website (Eurostat 2022). The use of CIS microdata has a long history in innovation studies (Jaklič et al. 2014; Martínez-Román et al. 2020). It should be also noted that the CIS survey follows the methodological framework from the Oslo Manual (OECD and Eurostat 2005). The 2014 CIS microdata set covered the 2012–2014 time period and was released by Eurostat on a 3-year lag during 2017.

Sample. The CIS used random sampling and exhaustive surveys, which generated a 60% response rate. The survey respondents were companies that employ more than ten workers. In total, data on 30 333 Spanish companies were analysed. Because the objective of the research was to only analyse data about agriculture companies, the data were filtered and the research sample was reduced to 874 companies belonging to the 01–03 NACE (Statistical Classification of Economic Activities in the European Community) categories. The final dataset is made up of 70.8% small (10–49 employees), 22.4% medium (50–249 employees) and 6.8% large enterprises (over 250 employees).

Variables. The explanatory and control variables were classified into three groups.

The explained variables are the results of innovation activities. In the case of product innovation, we used the following two CIS variables:

– *INPDGD* – goods innovations: new or significantly improved goods (exclude the simple resale of new goods and changes of a solely aesthetic nature) (dichotomous);
– *INPDSV* – service innovations: new or significantly improved services (dichotomous).

As a consequence, the following dummy variable was created:

– Product innovation (y_1) – this variable takes the value 1 if the company introduced a goods or service innovation, or both a goods or service innovation together, and the value 0 if not.

In turn, in the case of process innovation, the following three CIS variables were used:

– *INPSPD* – new or significantly improved methods of manufacturing for producing goods or services (dichotomous);
– *INPSLG* – new or significantly improved logistics, delivery or distribution methods for the company's inputs, goods, or services (dichotomous);
– *INPSSU* – new or significantly improved supporting activities for the company's processes, such as maintenance systems or operations for purchasing, accounting, or computing (dichotomous).

We created the following dummy variable:

– Process innovation (y_2) – this variable takes the value 1 if the company introduced new or significantly improved methods of manufacturing, or improved logistics, delivery, or distribution methods, or supporting activities for the processes, or all those innovations at the same time, and the value 0 if not.

In the area of the explanatory variables, we considered the following five agriculture companies' innovation activities for the product and process innovations. These variables take the value 1 if the company took such action, and the value 0 if not:

– In-house R&D (x_1) – *RRDIN*: R&D activities undertaken by the enterprise to create new knowledge or to solve scientific or technical problems (including software development in-house that meets this requirement);
– External R&D (x_2) – *RRDEX*: the enterprise contracted out R&D to other enterprises (including enterprises in their own group) or to public or private research organisations;

https://doi.org/10.17221/66/2022-AGRICECON

– Acquisition of machinery, equipment, software and buildings (x_3) – *RMAC*: acquisition of advanced machinery, equipment, software and buildings to be used for new or significantly improved products or processes;
– Training for innovative activities (x_4) – *RTR*: in-house or contracted out training for the company's personnel specifically for the development and/or introduction of new or significantly improved products and processes;
– Other (x_5) – *RPRE*: other in-house or contracted out activities to implement new or significantly improved products and processes such as feasibility studies, testing, tooling up, industrial engineering, etc.

We decided also to introduce the following control variable:
– Number of employees (x_6) – *SIZE*: this variable is ordinal and takes the following values: 1 (10–49 employees), 2 (50–249 employees), and 3 (over 250 employees).

The descriptive statistics of all the variables included in the model are presented in Table 1.

Method. In order to analyse the influence of the explanatory variables on the explained dichotomous variables y_1 and y_2, a logistic (logit) regression model was used. The logit regression model can be written as:

$$\operatorname{logit}(p_i) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki} \tag{1}$$

where: logit(p_i) – denoted as $\ln[p_i/(1 - p_i)]$; $\beta_0, \beta_1, \beta_2, \ldots, \beta_k$ – parameters.

$\beta_0, \beta_1, \beta_2, \ldots, \beta_k$ being elements of the vector β, are the subject of the estimation in this model (Greene 2012).

To interpret the results of the model estimation, the marginal effects (dy/dx) were used. The sensitivity of the p_i probability to exogenous variables is a function of both a given model parameter and all explanatory variables in the logit model. The effect of the marginal change of X_j on the value of p_i is:

$$\frac{\partial p_i}{\partial X_{ji}} = \beta_j \lambda\left(x_i'\beta\right) = \beta_j \frac{1}{2\pi}\exp\left(-\frac{\left(x_i'\beta\right)^2}{2}\right) \tag{2}$$

where: $\lambda\left(x_i'\beta\right)$ – destiny function; β_j – parameter for $j = 1, \ldots, k$.

To estimate all the models, the maximum likelihood estimation method and STATA 16.1 software were used.

RESULTS AND DISCUSSION

The final results of the estimations are shown in Table 2. In this table, robust standard errors (SE) are presented. In turn, the marginal effects are shown in Table 3.

In the first step, in order to eliminate the common method variance (CMV) bias, Harman's single factor test was checked. The results showed that a single factor explained 32.3% of the variance, so there is no CMV bias (Podsakoff et al. 2003).

The significances of all the estimated models were verified by the pseudolikelihood ratio test. The results indicate the significance of each of the models (y_1, y_2). In order to additionally confirmation of the quality of fit of the estimated models to the data, the accuracy of forecasting on their basis was prepared. The results are shown in Table 2.

Table 1. Descriptive statistics of variables

Variables		Mean	SD	Variance	Skewness	Kurtosis	Min.	Max.
CIS code	Label							
INPDGD *INPDSV*	y_1	0.083	0.277	0.076	3.010	10.064	0	1
INPSPD *INPSLG* *INPSSU*	y_2	0.167	0.373	0.139	1.785	4.186	0	1
RRDIN	x_1	0.137	0.344	0.118	2.107	5.442	0	1
RRDEX	x_2	0.067	0.251	0.063	3.447	12.885	0	1
RMAC	x_3	0.606	0.238	0.057	3.681	14.555	0	1
RTR	x_4	0.044	0.206	0.042	4.411	20.456	0	1
RPRE	x_5	0.011	0.106	0.011	9.187	85.411	0	1
SIZE	x_6	1.359	0.604	0.365	1.469	4.039	1	3

CIS – Community Innovation Survey; for an explanation of variables, see the Variables chapter in the Material and Methods
Source: Author's own elaboration

https://doi.org/10.17221/66/2022-AGRICECON

Table 2. Logistic regression (n = 874)

Variables	Model 1 (y_1)		Model 2 (y_2)	
	coefficient	SE	coefficient	SE
x_1	1.809***	0.378	2.103***	0.322
x_2	0.886*	0.472	0.093	0.458
x_3	0.618	0.606	3.440***	0.479
x_4	1.006	0.621	2.637***	0.821
x_5	2.063**	0.984	1.417	2.012
x_6	–0.045	0.231	0.467***	0.168
Constant	–3.183***	0.362	–3.248***	0.284
Log pseudolikelihood	–198.937	–	–263.797	–
Wald χ^2 (6)	98.00	–	127.82	–
Probability > χ^2	0.0000	–	0.0000	–
Pseudo R^2	0.2077	–	0.3310	–
Correct predictions (%)	92.11	–	88.79	–

*, **, ***$P \leq 0.10$, $P \leq 0.05$, and $P \leq 0.01$, respectively; SE – robust standard error
Source: Author's own elaboration

It is worth emphasising that only one variable is a common, statistically significant factor, at the confidence level of 0.01, explaining two types of innovation (y_1 and y_2), i.e. the in-house R&D (x_1). So, we cannot reject hypotheses H_{1a} and H_{1b}. In the case of the rest of the variables, some differences can be found. Thus, the variables concerning the external R&D (x_2) and other (x_5) are significant for product innovation [we cannot reject the hypotheses H_{2a} ($P \leq 0.1$) and H_{5a} ($P \leq 0.05$)], but not for process innovation. In turn, the acquisition of machinery, equipment, software and buildings (x_3) and training for innovative activities (x_4) are significant variables for process innovation, but not for product innovation. This, in turn, indicates that we cannot reject the hypotheses H_{3b} ($P \leq 0.01$) and H_{4b} ($P \leq 0.01$). It also is worth underlining the control variables, that is, the size (x_6) turned out to be a statistically significant factor only for process innovation.

Based on the estimation results for the mean values of the explanatory variables (Table 3), *ceteris paribus*, introducing product innovations is 17.5% more likely if the companies undertake in-house R&D, 7% if they undertake external R&D, and 25.7% if they undertake other in-house or contracted out activities. In turn, introducing process innovations is 36.5% more likely if the companies undertake in-house R&D, 67.7% if they undertake the acquisition of machinery, equipment, software and buildings, and 52.2% if they undertake training for innovative activities.

The importance of the in-house R&D demonstrated in our study, both for product and process innovations, is in line with the findings of Catozzella and Vivarelli (2014), suggesting that in-house R&D may not only be a way to gain the internal ability to easily understand and assimilate the discoveries of other innovators but to also represent a key investment in the isolation and use of possible synergies related to the implementation of a variety of innovative activities. The importance of in-house R&D in the agriculture sector is also indicated by the study by Garcia Martinez and Briz (2000), who emphasise that the higher the level of technological autonomy, the greater the probability that the enterprise will be 'truly' innovative. Also, the results of the study by Brewin et al. (2009) relating to the activities of agri-food processors in western Canada suggest that companies that develop new products and in-house processes are better able to capture the added benefits of the discovery process. These companies are also more likely to innovate to keep up with the competition (Brewin et al. 2009).

Our findings support the conclusions of Carboni and Medda (2021), which suggest that external R&D activity positively influences the creation of innovative products. However, it is worth bearing in mind that as the intensity and complexity of external R&D work increases, companies may incur higher costs of coordination and control (Carboni and Medda 2021).

Our results, regarding the link between the acquisition of machinery, equipment, software and buildings and process innovations, do not coincide with the observations of Firlej et al. (2017), suggesting that the product innovations in the Polish food industry mainly include the purchase of new machines, the means

Table 3. Marginal effect

Variables	Model 1 (y_1)		Model 2 (y_2)	
	dy/dx	SE	dy/dx	SE
x_1~	0.175***	0.054	0.365***	0.070
x_2~	0.066*	0.048	0.010	0.052
x_3~	0.041	0.051	0.677***	0.080
x_4~	0.080	0.070	0.522***	0.189
x_5~	0.257*	0.209	0.240	0.463
x_6	–0.002	0.012	–0.050***	0.017

*, **, ***$P \leq 0.10$, $P \leq 0.05$, and $P \leq 0.01$, respectively; (~) dy/dx – discrete change dummy variable from 0 to 1; SE – robust standard error
Source: Author's own elaboration

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of transport or new equipment. Perhaps the observed difference results from the specificity of the Polish and Spanish agricultural sectors, as well as the differences in the level of innovation in the Polish and Spanish economies, although confirmation of this assumption requires future in-depth research.

With regard to training for innovative activities, our findings are consistent with Odei et al. (2021) studies who showed that acquisition of external knowledge and training for innovation activities did not impact product innovations, but training for innovation activities drives the company's innovation because there is a positive relationship between training for innovative activities and process and organisational innovations.

Smith (2005) notes the key importance for innovation of activities that are not directly included in R&D activities, such as product design, trial production runs and tooling up. Czarnitzki and Spielkamp (2003) suggest that the company's innovation capabilities do not depend solely on R&D activities involved; but no less important is the possibility of introducing new or improved products or services to the market and/or using new or improved processes, which depends on such activities as research, market investigation and tooling up.

As observed in our study, the link between the size of enterprises and the process innovation is consistent with the findings of Banterle et al. (2011) who noticed that although innovative activity in the small food business is quite important, especially in relation to investments in product improvement and searching for new markets, though it is not all the steps of the marketing management process that affect the company innovativeness.

CONCLUSION

Using data from the European Commission and Eurostat CIS 2014, collected in the Spanish agricultural sector, this article contributes to the literature on strategic innovation activities that influence the product and process innovativeness. Focusing on Spain allowed us to analyse the case of a country, classified as a 'moderate innovator', showing the limited impact that agriculture has on the creation of the GDP and characterised by a low level of investment in R&D and a low number of innovative companies systematically conducting R&D activity.

Using empirical research and logit regression modelling, we attempted to achieve the goal of identifying strategic innovation activities that influence the product and process innovativeness of Spanish agricultural companies. Our research showed that innovation activities contribute to the possibility of successfully introducing new innovations, although their impact in the case of product and process innovations is diverse. The results suggest that the probability that agriculture companies introduce product innovations is greater in the case of in-house R&D, external R&D and other in-house or contracted out activities. On the other hand, the probability that agriculture companies introduce process innovations is greater in the case of in-house R&D, the acquisition of machinery, equipment, software and buildings and training for innovative activities. The conducted research, although it has shown that all innovation activities are important from the point of view of their impact on innovation, suggests that only the in-house R&D affects both product and process innovations. This is confirmed by the observation of Catozzella and Vivarelli (2014) and Brewin et al. (2009) pointing to the catalysing role of internal R&D, allowing it to generate a higher level of benefits through integration.

The paper has important political and application implications. Although the influence of the agriculture sector on the Spanish GDP is limited, our research suggests that the activity innovation in the Spanish agricultural sector is important and can be used as an effective instrument for building a competitive advantage. Both political decision-makers, by creating appropriate financial incentive programmes, and managers, implementing specific innovative activities in enterprises, should put emphasis on strengthening in-house R&D, which, as our research has shown, is essential for the implementation of innovations.

Our study has some limitations that open the field for further research relating to the impact of innovation activities on product and process innovativeness.

Firstly, in the research procedure, we focused on the impact of innovative activities on the introduction of product and process innovations by companies from the Spanish agricultural sector. In future research, it would be worth referring to other categories of innovation. We also believe that in order to ensure the comparability of data, cross-sectional studies should be carried out and the intensity of the innovative activity of the Spanish agricultural sector should be examined in relation to the activities undertaken in the agricultural sectors of other European countries, with similar variables describing development (in particular GDP, R&D expenditure and the dynamics of the agricultural sector development) to the Spanish economy.

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Secondly, our research relates to innovation activities undertaken in the Spanish agricultural sector in 2014, while the data relating to the innovation of the Spanish economy show that since then, mainly due to the COVID-19 crisis, the level of innovation has decreased. Therefore, it would be worth conducting longitudinal studies that would identify the changes taking place.

Thirdly, the data from the CIS 2014 database used in the study, although obtained from a large number of companies from the Spanish agricultural sector, allow for the formulation of general conclusions, do not sufficiently reflect some activities related to innovative activities (e.g. they omit the issues of acquiring knowledge that is extremely important for innovation). In future research, it would be worth drawing up a questionnaire dedicated to more tailored innovative activities and obtaining other data in the study, important from the point of view of, for example, value creation.

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