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Olive Firms' Interactions and Innovation Efforts in the Regional Innovation System of La Rioja, Argentina

Interacciones y Esfuerzos Innovativos de Las Firmas del Sector Olivícola en el Sistema Regional de La Rioja, Argentina

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Abstract

The present research studies the role of firms' interactions within the Regional Innovation System (RIS) in relation to their innovation efforts for the olive sector in La Rioja, Argentina. Empirical analysis is based on information gained from a survey conducted by the National University of Chilecito in 2012. Quasi-Poisson and Binomial Logistic regressions are built in order to deal with statistical data. The main findings show an association between interactions established by firms and their innovative activities, as well as the relevance of relationships with certain science and technology organizations. However, heterogeneity amongst firms and RIS weaknesses would limit smaller firms' performance.

Keywords: Innovation Efforts, Interactions, Regional Innovation System, Olive Sector.

JEL Codes: D21, O18, O30, R19.

Resumen

La presente investigación aborda el rol de las interacciones de las firmas en el Sistema Regional de Innovación (SRI) sobre sus esfuerzos innovativos para el sector olivícola de La Rioja, Argentina. El análisis empírico *se efectúa en base a una encuesta conducida por la Universidad Nacional de Chilecito en 2012, para cuyo procesamiento se construyen regresiones Quasi-Poisson y Logit Binomial. Los resultados muestran que existe una asociación entre las interacciones que llevan a cabo las firmas y sus actividades innovativas, así como la relevancia de las relaciones con organismos de ciencia y tecnología específicos. Sin embargo, la heterogeneidad entre las firmas y las debilidades del SRI limitan el desempeño de las empresas de menor tamaño.*

Palabras Clave: Esfuerzos Innovativos, Interacciones, Sistema Regional de Innovación, Sector Olivícola.

Códigos JEL: D21, O18, O30, R19

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I. INTRODUCTION

The general purpose of the research is to contribute to the understanding of local innovation processes in developing regions, where heterogeneous actors coexist and small firms are preponderant. In particular, a study of the specificities of innovative processes in the olive sector of La Rioja province, Argentina is conducted. Regional Innovation Systems (RIS) conceptual frame is developed to inquire about the distinctive features that innovation assumes in particular regions. It emphasizes that cooperative relationships between firms and other RIS actors are essential to motivate innovative behaviours.

In this sense, the main hypotheses that guide the research are "Firms' interactions within the Regional Innovation System increase the probabilities to perform innovative activities" and "Firms' interactions within the RIS also increase the probabilities to carry out internal R&D". Empirical analysis is based on statistical information collected through an extensive survey conducted among 91 local olive producers by the National University of Chilecito in 2012. Methodology to analyse the relation between firms' characteristics, cooperation linkages and innovative activities is based on Quasi-Poisson and Binomial Logit regressions, and descriptive statistics.

The study is organized as follows: Section II outlines the theoretical framework and the empirical background; Section III refers to the methodology and data sources; Section IV presents the main results; and finally, Section V develops the discussion and final reflections.

II. Background and Theoretical Framework

II.a.Innovation Systems: interactions, innovative efforts and performance

Under the new techno-economic paradigm of "Knowledge Economy", knowledge creation and its productive application are essential factors to explain different levels of productivity between countries and firms. Evolutionary economics stresses that technological progress plays an essential role on firms' and regions' competitiveness and, therefore, on socio-economic development. Within the evolutionary stream, Innovation Systems (IS) conceptual frames is suitable to inquire about the distinctive features that assume innovation processes in particular regions. This approach studies innovation as an accumulative, multidimensional and territorial phenomenon which includes the analysis of all factors and actors that are involved in the development, diffusion, use and commercialization of innovations, remarking the articulation between them and its interactive nature. Innovation is not the result of isolated firms' actions and efforts, but of a complex scheme of social interactions (Lundvall, 2007; Cassiolato and Lastres, 2005).

This interactive conception of innovation process implies that effective incorporation of new knowledge is not a trivial activity. Firms need to make efforts which require technological and absorptive capacities to identify, select, assimilate, adapt and improve technologies, in order to achieve innovative results which are locally and socially embedded, and depend on firms' linkages within the system. Then, the social, territorial and interactive nature of innovation implies that the Regional Innovation System framework is more adequate to analyse specificities of the regional sphere than the National Innovation System. Regional delimitation might be smaller if there are local administrations, parliaments, autonomous levels of decision, cultural features and particular norms, as well as economic, social and technological heterogeneous dimensions (Cooke et al., 1998; Tödtling et al., 2008).

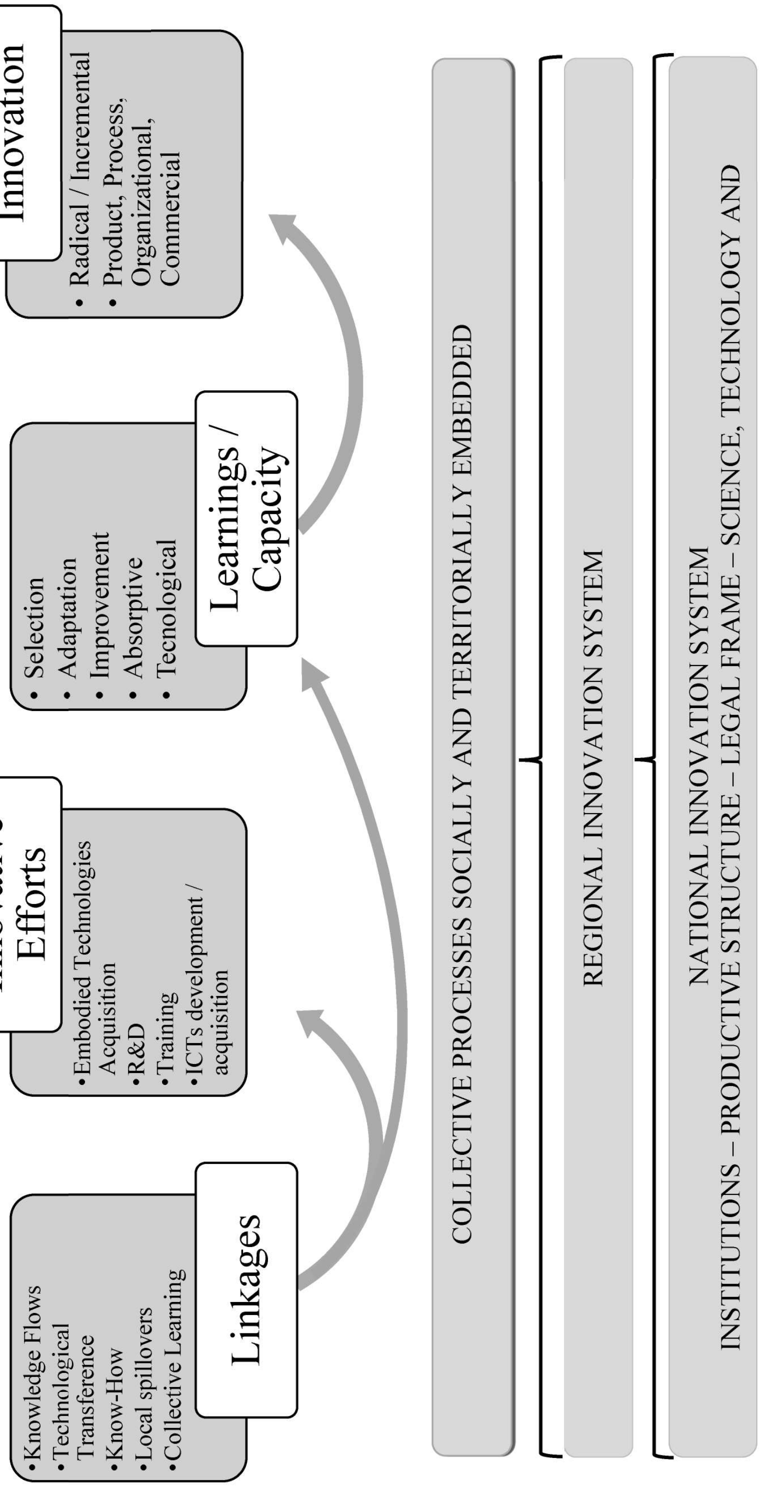
Among the main phenomena that occur in regional systems, collective synergy and efficiency, agglomeration and association economies, learning by interaction, and uncertainty diminish, can be underlined. As knowledge is socially and spatially embedded in a particular environment, construction of technological capacity and innovative results are not only related to firms' behaviour, but to local dynamic (Cooke et al., 1998; Cassiolato and Lastres, 2005).

Interactions between firms, science and technology (S&T) organizations, consumers and suppliers allow for knowledge and information flows that are critical to the innovation process. That is why local conditions, like quantity and type of organizations, translator presence, level of knowledge circulation and appropriation, degree of linkage between actors, science, technology and innovation policies, and cooperation networks, impact on firms' possibilities to perform innovative efforts, build endogenous competences and improve innovative performance (Cooke et al., 1998; Asheim, 2001). In particular, interaction is relevant in terms of collective learning required to incorporate new knowledge, it allows information to flow, increases local spillovers, favours external economies, reduces transaction costs and uncertainty (Tödtling et al., 2008; Krätke, 2010). So that linkages can promote innovative efforts, capacity building, and innovative performance, as presented in Diagram 1.

II.b. The Role of RIS and Interactions over Innovative Performance

Over the last two decades, several academic investigations have approached innovation processes from a regional and systemic perspective. Pioneer works studied the local district and clusters from developed economies and highlight the role of interactions and local synergies on innovative results. For example, Camagni and Capello, (1998), Asheim and Coenen, (2005), Natário et al., (2012), Lavía et al., (2011) explore the dynamic of innovative districts and clusters from Europe, where interpersonal contact, information and knowledge exchange, physical and cultural proximity, uncertainty reduction, and cooperative networks are fundamental to explain technological progress and regional competitiveness. In this sense, the characteristics of the environment are more important than the size of the firm or individual efforts, reinforcing the idea that an innovative process is a collective phenomenon. In all cases, these processes are related to environmental characteristics as tacit knowledge flows, cooperation, articulation with customers and suppliers, common values, and access to scientific knowledge.

Diagram 1: Conceptual Framework: Interactions, Innovative Efforts and Capabilities



Source: prepared by the author.

Also, for developed regions several researches find that interactions with S&T organizations influence over the firm's probability to patent and increase the number of obtained patents, results that are associated to positive and significant statistical coefficients. These results confirm that both internal efforts and cooperative relationships are relevant to innovative performance. In this sense, they present that the number of linkages established by firms are related to their innovative activity (Fritsch and Franke, 2004; Tödtling et al., 2008; Klein and Sauer, 2016; Trippl et al., 2015; Lau and Lo, 2015; Ligenzowska, 2016).

Moreover, other authors, such as Intarakumnerd and Vang (2006) analyse regions from Southeast Asia where firms build technological capabilities and competences throughout a process of imitation, adaptation and improvement of external technology. These investigations conclude that, in developing regions, technology search and selection, learning by doing-interacting-buying, try and fail processes, technical and commercial interactions with firms, customers, suppliers and S&T organizations, and innovative efforts are essential.

Then, Regional Innovation System study is not a wide developed field in Latin America and Argentina. There are few researches that analyse the dynamic and interactive nature of the innovation process in less developed regions. However, there is relevant research from various locations that constitutes useful background. Among their main findings stand out the presence of heterogeneous conditions between regions and within them, the existence of an S&T infrastructure relatively isolated from the productive sector, interactions orientated to services provision and information exchange, technological linkages and capacity concentration in larger firms, and centralization of innovative results in more developed regions (Jiménez et al., 2011; Padilla Pérez, 2013; Zuniga, 2016; Rodríguez and Villarreal Peralta, 2015).

For Argentina it can be mentioned a number of authors such us Gennero de Rearte et al. (1999), Yoguel et al. (2006), Yoguel et al. (2009), Niembro (2017), Borello (2015), Pasciaroni (2015), McDermott et al. (2006), Yoguel and Erbes (2007), and Sanchez and Bisang (2011); who develop exhaustive analyses of innovation processes within regional and local systems. The principal findings highlight RIS' weaknesses as deficient financial resources, low small and medium-sized enterprises (SMEs) articulation, divergence between technological offer and demand, few knowledge interactions, lack of program and local policy coordination and the presence of mainly horizontal promotional policy instruments.

So that Argentine RIS's studies present diverse levels of development among and within them; on the one hand, systems from relative more developed provinces (Buenos Aires, Córdoba, and Santa Fe) constitute synergic environments where interactions and cooperation allow for technological progress, competitiveness increases, capacity consolidation, and SMEs integration. On the other hand, localities with less articulation amongst actors concentrate firms with lower capabilities, innovative efforts and performance. Principally smaller firms establish a fewer number of interactions and face more limitations in order to build technological capacity. However, some common aspects from Argentine regional and local systems can be mentioned, such as insufficient interactions, lack of translation mechanisms between the productive sector and S&T organizations, limited capabilities amongst SMEs, difficulties in getting financial assistance, and scarce knowledge exchange and technological transfer (Yoguel et al., 2009).

III. Methods

The methodology conducted in order to analyse the relation between firms' interactions and innovative efforts is based on a number of Qualitative Response Models (QRM). Binomial Logistic and Quasi-Poisson[1] regression models are built to contrast the relations postulated in the following work hypotheses. These models allow to test the relation between dependent binary variables and count data respectively, with a set of independent regressors which can be both qualitative or quantitative (Greene, 1999). The models are built following the reference literature, as Fritsch and Franke (2004) and Tödtling et al. (2008), who also deal with dichotomous and count data dependent variables through QRM to analyse the relation between firms' linkages and their innovative behaviour. In this sense, given the characteristics of the variables from the survey and that it was only conducted for one period, Binomial Logistic and Quasi-Poisson regression models are a suitable alternative. However, it is relevant to indicate that the number of

1. Quasi-Poisson regression allows to overcome the Poisson regression assumption that the distribution meet the condition *E(x)= Var(x)* for the case of a set of data that presents over or sub-dispersion (Greene 1999).

observations from the sample is limited and there could be potential endogeneity; also cross-analysis could influence the results from maximum likelihood method. That is why the objective of the methodology carried out is not to stablish direct causal effects but to study the presence of relations between the variables analysed and to make the most of the original data provided by the survey.

Particularly, the relation between firms' characteristics, articulations with S&T organizations and their innovative efforts is tested. The main hypotheses that guide the research are:

H1 - Firms' interactions within the Regional Innovation System increase the probabilities to perform innovative activities.

H2 - Firms' interactions within the RIS also increase the probabilities to carry out internal R&D.

Empirical analysis is based on statistical information collected through an extensive survey conducted on 91 olive local producers by the National University of Chilecito in 2012 "Technological Demand for Olive Sector from La Rioja Province". Specifically, the survey contains information about productive and innovative firms' characteristics and about their relationships with other RIS actors. The selection of observations is based on a probabilistic and stratified sample classified by department including 91 producers of different sizes, which allows to make population inferences. It is worth highlighting that in the context of insufficient statistical data for La Rioja province in general, and for firms' behaviour in particular, the information compiled is original and very relevant in order to analyse firms' innovative efforts in a less developed province from Argentina.

III.a. Model specification

In order to build the mentioned regression models a number of variables are constructed based on sample data. Dependent variables are the number of Innovative Activities that firms carry out as a discrete quantitative variable, and a dummy variable that takes value one if firms conduct R&D efforts and zero otherwise. As regards independent variables, a set of variables representing the firms' characteristics and interactions with other RIS actors are taken into account. In the case of factor variables, a reference category is generated and a number of auxiliary variables are constructed, as many as total variables less one, so their interpretation must be done comparatively to base category variables (Chart 1).

Chart 1: Variable Codification

Variable Name	Type	Codification
dep	Factor	1: Chilecito 2: Arauco **3: Capital (base category)**
inv	Dummy	1: National Capital 0: Local Capital
sector	Dummy	1: Secondary Sector 0: Primary Sector
firm_size	Factor	1: Large 2: Medium-sized 3: Small **4: Microenterprise (base category)**
prof_share	Quantitative	N° professionals / Total employees
total_ia	Quantitative	Number of Innovative Activities
R&D	Dummy	1: Perform R&D 0: Do not Perform R&D
interact	Dummy	1: Interact with at least one actor 0: Do not interact
total_interactions	Quantitative	Number of Interactions established
total_organizations	Quantitative	Number of organizations with whom the firm interacts
INTA	Dummy	1: Interact with INTA 0: Do not Interact with INTA
INTI	Dummy	1: Interact with INTI 0: Do not Interact with INTI
Other_S&T_org	Dummy	1: Interact with other S&T organizations 0: Do not Interact with other S&T organizations
Universities	Dummy	1: Interact with Universities 0: Do not Interact with Universities
TA_interaction	Dummy	1: Interact for Technical Assistance 0: Do not Interact for Technical Assistance
R&D_interaction	Dummy	1: Interact for R&D 0: Do not Interact for R&D

Source: prepared by the author.

Models' general specification adopts the following form: Prob (Y=1) = F(x , β) for Binomial Logistic regressions and Prob (Y=y_i) = F(x , β) for Quasi-Poisson regressions. The particular expression for each model is presented below, where the variables are the ones presented in Chart 1, β_i the coefficients to be estimated and ε the random disturbance term for each model.

Quasi-Poisson regression models set out the relation between the firm's probability of performing a greater number of innovative activities and a set of independent variables, including department location, investment origin, firm size, professionals ratio, and sector of activity, as well as different indicators for the characteristics of their interactions. Then taking into account the same explanatory variables a number of Binomial Logistic regressions are built to analyse if any of the independent variables influence the possibility to carry out R&D efforts. Models are ran considering firms which stated that they had carried out, at least, one innovative activity, because the survey gathered information about interaction behaviour only for the firms that make innovation efforts.

Model I Quasi-Poisson:

$$total_{ia} = \beta_0 + \beta_1 (dep) + \beta_2 (inv) + \beta_3 (firm\_size) + \beta_4 (prof\_share) + \beta_5 (sector) + \beta_6 (interact) + \varepsilon$$

Model II Binomial Logistic:

$$R\&D = \beta_0 + \beta_1 (dep) + \beta_2 (inv) + \beta_3 (firm\_size) + \beta_4 (prof\_share) + \beta_5 (sector) + \beta_6 (interact) + \varepsilon$$

Models III and IX Quasi-Poisson:

$$total_{ia} = \beta_0 + \beta_1 (dep) + \beta_2 (inv) + \beta_3 (firm\_size) + \beta_4 (prof\_share) + \beta_5 (sector) + \beta_6 (interactions) + \varepsilon$$

Models IV and X Binomial Logistic:

$$R\&D = \beta_0 + \beta_1 (dep) + \beta_2 (inv) + \beta_3 (firm\_size) + \beta_4 (prof\_share) + \beta_5 (sector) + \beta_6 (interactions) + \varepsilon$$

Models V and VII Quasi-Poisson:

$$total_{ia} = \beta_0 + \beta_1 (dep) + \beta_2 (inv) + \beta_3 (firm\_size) + \beta_4 (prof\_share) + \beta_5 (sector) + \beta_6 (organizations) + \varepsilon$$

Models VI and VIII Binomial Logistic:

$$R\&D = \beta_0 + \beta_1 (dep) + \beta_2 (inv) + \beta_3 (firm\_size) + \beta_4 (prof\_share) + \beta_5 (sector) + \beta_6 (organizations) + \varepsilon$$

For the case of the indicator "Interactions" the following alternatives are tested in different model specifications for each regression: the number of interactions ("total_interactions") and the type of linkage ("R&D_interaction" and "TA_interaction") stablished by the firm. And for the indicator "Organizations" the following alternatives are established: the number of organizations ("total_organizations") and the specific organization ("INTA", "INTI", "Universities" and "Other_S&T_org") with whom the firm interacts.

IV. RESULTS

IV.a. The Olive Sector in La Rioja

The development of the local olive sector is directly associated to the effective implementation of Tax Deferments Law N° 22.021 since 1990s, which promotes agricultural activity in less favourable regions, such as La Rioja, San Juan and Catamarca provinces. Hence, tax benefits allow new olive establishments to set up and important primary and secondary production increases. Particularly, extra-local national capitals establish large and medium-sized enterprises, while local small producers don't have the financial capacity to make new investments. Consequently, its implementation resulted in the reorganization of the olive sector, that implies a large average size of firms, diffusion of new technologies and cultural labours, and better average productivity. However, the olive sector is characterized by the existence of different productive units that operate in heterogeneous conditions, like scale production, technological practices, and yields (Vita Serman and Matías, 2013).

There are around 2000 agricultural establishments growing olives; on the one hand, there are several small traditional producers with less than 50.000 square meter employing family workforce, with a low level of technical development, wide plantation schemes (more than six metres between plants), scarce use of fertilizers and agrochemicals, applying surface flood irrigation, and manual harvesting methods. On the other hand, medium and large firms employ salaried workforce, narrower distance between plants (six to two metres), use drip irrigation systems, intensive practise of cultural labours, and mechanical harvesting, which allows them to achieve mayor yields per 10.000 square metres (Vita Serman and Matías, 2013).

As regards technological developments involved in the production of olives and its by-products, there is a large variety of techniques and knowledge available for the primary sector, manufacturing and commercialization of table olives and oil. In that sense, the local sector faces a technological gap in comparison to the main olive producers as Spain and Italy. This technological gap is present along the value chain, specifically it is related to automatization of cultural labours, irrigation systems, mechanical harvest, equipment and machinery for olive processing, information systems, traceability systems, and residual treatment. However, this gap is not homogeneous within the sector, while medium and large firms which export operate nearer to the technological frontier, small and medium traditional producers face an important technological lag, and they do not have the financial resources nor the capacities to catch up the frontier (Sánches 2013; 2012).

This way, the national and local olive sector has several innovation opportunities from plant genetic, harvest and irrigation technologies, pruning, fertilization, transport, processing, storage, to commercialization. Even though olive production is not a technological complex sector, the implementation of modern techniques is fundamental to reach international competitiveness given the increasing demands for quality, innocuousness and tradability from global food markets. Likewise, its adoption is relevant for the resolution of specific local difficulties, like scarce and inefficient use of water, presence of plagues and diseases, lack of oil classification, and low value added and quality. Thus, specific regional conditions and problems require local adaptation of imported technologies based on endogenous research and innovative efforts (Sánches, 2013; 2012).

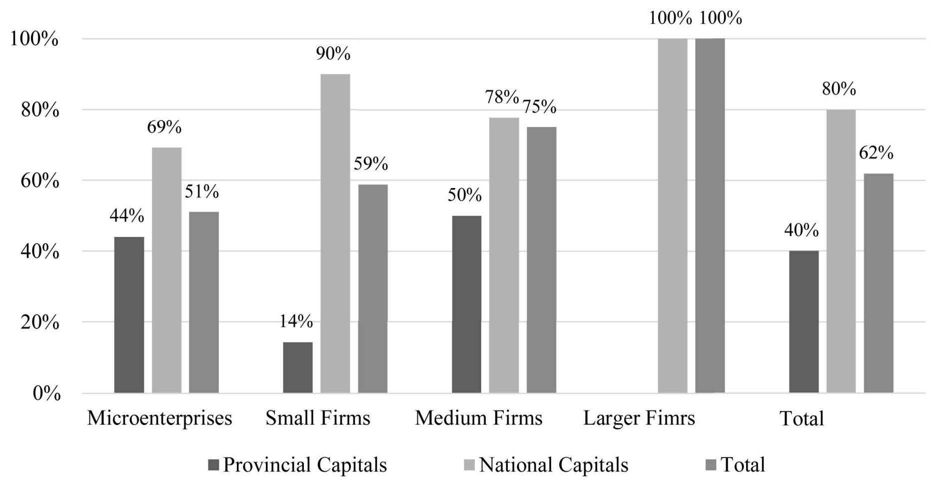
IV.b. Productive and Technological Outline

The survey comprises 91 olive producers distributed in three local departments: Capital (20%), Arauco (37%), and Chilecito (43%), main areas of La Rioja dedicated to olive exploitation. In particular, 66% of them only produce raw material (olives) and 34% are also involved in secondary activities to produce olive oil and table olives.

In relation to the number of workers, microenterprises with less than 6 employees represent 52% of the sample, 15% correspond to small firms between 6 to 10 persons, 25% are medium-sized firms which employ from 11 to 50 people, and only 8% are larger firms with more than 50 employees. As regards its distribution amongst departments, Chilecito and Arauco concentrate a major number of small and micro firms (82% and 71% respectively), while Capital department gathers larger firms (72% are large or medium-sized firms). As a consequence of the Tax Deferment Law there is a strong presence of extra-local investments, which represent 52% of olive producers.

This way, given the heterogeneity amongst local olive firms innovative profile and technological behaviour must be analysed differentially. It can be underlined that 62% of the sample -56 observations- perform at least one innovative activity (IA), and that in the case of larger and extra-local firms, such proportion increases (Figure 1).

Figure 1. Firms which perform IA by size and investment origin (percentage)

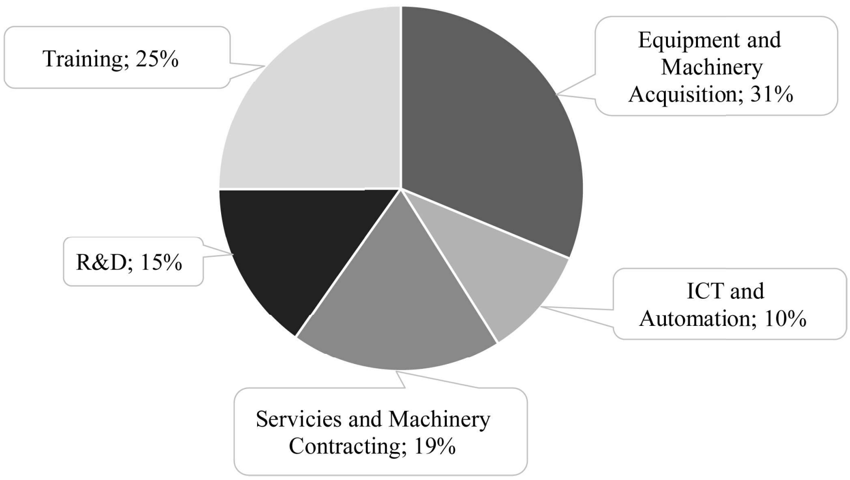


Source: prepared by the author, based on "*Technological Demand for Olive Sector from La Rioja Province*" survey.

Producers which make at least one innovative effort are distributed in the following way: 43% in Chilecito, 36% in Arauco, and 21% in Capital, a similar allocation to the one of the firms surveyed. Within each department the proportion of firms which engage in at least one IA is 61% in Chilecito and Arauco, and 65% in Capital. In relation to the origin of investment, 68% of those firms are from national investment and the other 32% are local. At the same time, those firms operating in the industrial sector are more likely to carry out innovative endeavours.

As regards its composition, taking into account the whole number of activities carried out by olive firms (112 activities), 31% correspond to Equipment and Machinery (E&M) Acquisition, 25% to Human Resources Training, 19% to Services and Machinery Contracting, 15% to Research and Development, and 10% to ICT and Automation Incorporation (Figure 2). Out of those firms which perform IA, 63% acquire E&M, 50% carry out training efforts, 38% hire technological services, 30% conduct R&D activities, and 20% incorporate ICTs and Automation. Although it is not the main activity, 19% of the firms carry out R&D sporadic internal efforts, mainly medium-sized and large manufacturing firms.

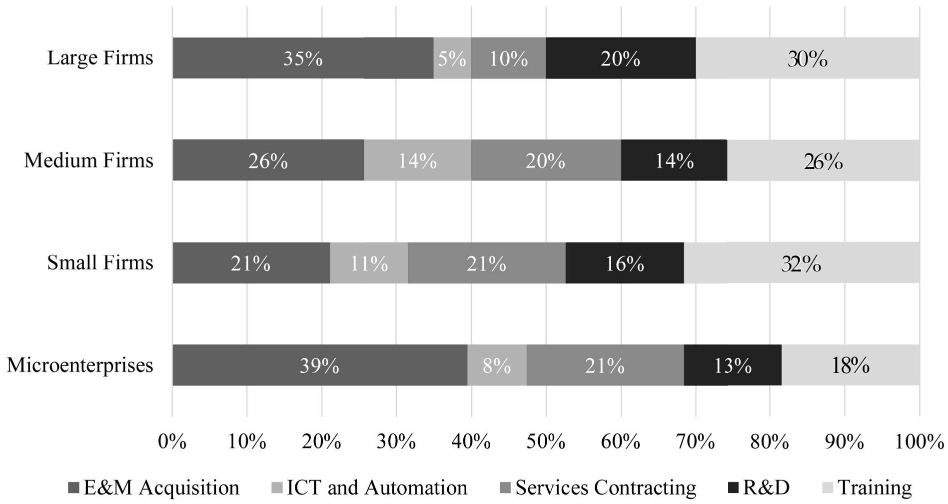
Figure 2. Total innovative activities composition by type



Source: prepared by the author, based on "*Technological Demand for Olive Sector from La Rioja Province*" survey.

Regarding innovative behaviour by firm size, R&D only represents 13% of microenterprises' efforts, while for larger firms account for 20%. E&M acquisition predominate in large and micro firms, and human resources training in small and larger enterprises, while medium-sized ones have a more balanced scheme (Figure 3).

Figure 3. Type of innovative activity by firm size



Source: prepared by the author, based on "*Technological Demand for Olive Sector from La Rioja Province*" survey.

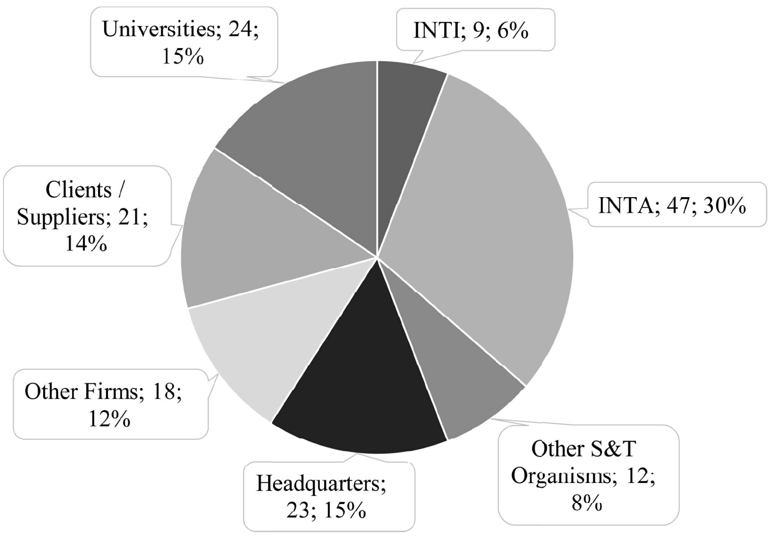
IV.c. Regional System of Innovation and Interactions among actors

Given the systemic, territorial and interactive character of innovation processes, analysing firms' interaction with local organizations is particularly relevant. Out of those firms which make innovative efforts, 66% (37 observations) establish connections with other RIS actors (S&T organizations, Universities, Customers, and Suppliers).

In relation to the distribution of all interactions (154) it can be remarked that 71% correspond to national investment firms, mostly concentrated in Chilecito (51%) and Arauco (39%), while only 10% are established by producers from Capital department. On average, firms maintain four connections, being larger firms the ones with more links. Medium-sized national firms gather 30.5% of total sectors' interactions, followed by provincial microenterprises with 26.6% (which is explained by the assistance of INTA), and extra-local larger firms with 20.8%.

Within the RIS there are S&T organizations such as INTA and INTI regional agencies; the Regional Faculty of National Technological University (NTU); the Science and Technology Federal Council (COFECYT); the Regional Centre of Scientific Research, and the Technological Transference – National Scientific and Technical Research Council (CRILAR-CONICET); the National University of La Rioja; the National University of Chilecito; and the Science and Technology Secretariat – Educational, Science and Technology Ministry. The main actor with whom firms interact is the INTA regional agency, which concentrates 30% of olive sector connections, followed by universities (15%), headquarters (15%), customers and suppliers (14%), and other enterprises (12%). Then, there are less cooperative relationships with INTI's regional agency (6%) and other S&T organizations (8%) (COFECYT, CRILAR, and the S&T Secretariat) (Figure 4).

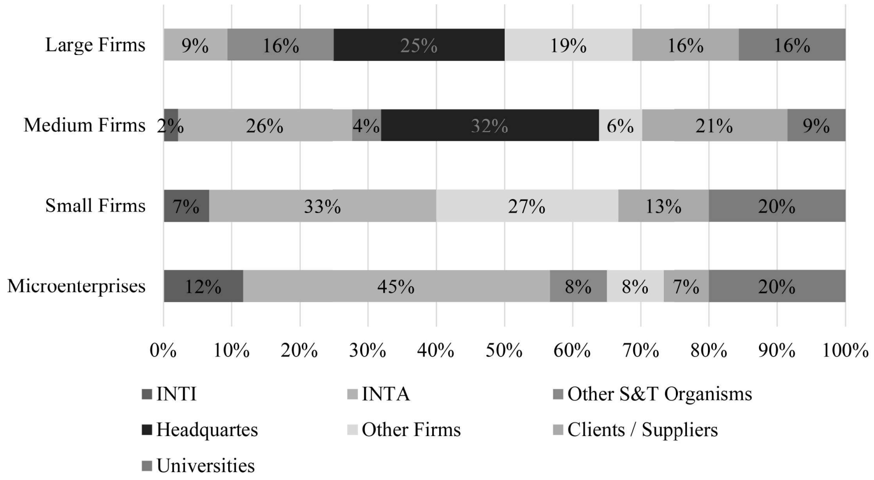
Figure 4. Proportion of interactions by organization



Source: prepared by the author, based on "*Technological Demand for Olive Sector from La Rioja Province*" survey.

In addition, different patterns of interacting are observed. For microenterprises INTA is the principal institution with whom they relate (45% of total connections of that group), followed by universities (20%). However, large firms have more relation with headquarters (25%) and other firms (19%), S&T organisms (16%), universities (16%), customers and suppliers (16%), and the least important is INTA (9%). For medium-sized firms, headquarters (32%), INTA (26%) and clients/suppliers (21%) adopt an important role, while for small ones INTA (33%), other firms (27%) and universities (20%) are the most relevant actors (Figure 5).

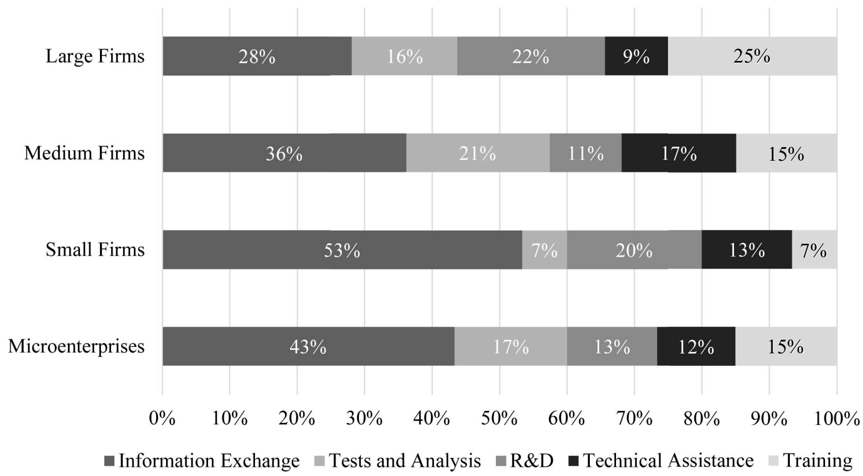
Figure 5. Interactions by firm size and partner



Source: prepared by the author, based on "*Technological Demand for Olive Sector from La Rioja Province*" survey.

Also, less complex interactions prevail amongst smaller firms, for example, information exchange represents 53% of small firms' connections and 43% of microenterprises' ones. Particularly, larger firms have more balanced schemes and carry out R&D and training relationships in a greater proportion. Medium-sized firms tend to interact for Technical Assistance, Test and Analysis while in the case of small ones, R&D has a relative relevance (Fig. 6).

Figure 6. Type of interactions by firm size



Source: prepared by the author, based on "*Technological Demand for Olive Sector from La Rioja Province*" survey.

IV.d. Econometric results

Results from Model I show that Chilecito location, compared to Capital department, positively influences the probability of conducting more innovative activities, as well as belonging to the groups of Large and Medium-sized firms at a 99% confidence level. Other coefficients are not statistically significant. These results show that larger firms have more probabilities to perform a bigger number of innovative efforts. In particular, it can be highlighted that the simple fact of interacting with at least one actor is not a relevant factor. Model II indicates that a greater share of professionals have a positive relation with the probability of performing R&D at a 95% confidence level. With a weaker level of significance (10%) operating in the industrial sector also presents a positive coefficient. Both Models exhibit acceptable levels of goodness of fit (Table 1).

Models III and IV show that a greater number of interactions presents a positive relation with the probability of performing more innovative activities and internal R&D efforts. In both cases, it can be observed that the total interaction coefficient is positive and statistically significant at 5% for the probability of performing a greater number of IAs and only at 10% for the possibility of performing R&D. Pseudo R^2 measures reflect the models' global utility (Table 2).

Models V and VI analyse specifically the relation between the number of organizations with whom firms maintain relationships and the probability of performing a larger number of innovative activities and of conducting R&D respectively. In Table 3 it can be observed that this variable has no statistical significance on the number of innovative efforts. It presents a positive coefficient over the possibility of carrying out R&D, but merely at a 90% level of confidence.

Outcomes from Model VII and VIII show that interacting with other S&T organizations increases the probability of performing more innovative efforts (though with a weak statistical significance of 10%), and having relations with INTI and universities is positively related to the possibilities of carrying out internal R&D (5% statistical significance).

Results from Models IX and X present the influence of different types of interactions on dependent variables. Thus, interacting for R&D

Table 1: Models I and II

Model I Quasi-Poisson:

$$total_{ia} = \beta_0 + \beta_1 (dep) + \beta_2 (inv) + \beta_3 (firm\_size) + \beta_4 (prof\_share) + \beta_5 (sector) + \beta_6 (interact) + \varepsilon$$

Model II Binomial Logistic:

$$R\&D = \beta_0 + \beta_1 (dep) + \beta_2 (inv) + \beta_3 (firm\_size) + \beta_4 (prof\_share) + \beta_5 (sector) + \beta_6 (interact) + \varepsilon$$

	Model I **Probability of performing a greater number of IA**	**Model II** **Probability of performing R&D**
(Intercept)	-0.176	-2.979*
	(0.244)	(1.538)
Chilecito	0.533***	-0.940
	(0.186)	(1.043)
Arauco	0.288	-0.069
	(0.187)	(0.978)
Investment	0.130	-0.709
	(0.167)	(0.933)
Large	0.778***	1.414
	(0.218)	(1.215)
Medium-sized	0.546***	1.260
	(0.184)	(1.040)
Small	0.239	0.708
	(0.198)	(1.126)
Professionals_share	0.013	0.122**
	(0.009)	(0.056)
Sector	-0.028	1.393*
	(0.151)	(0.815)
Interact	0.015	0.664
	(0.144)	(0.844)
Observations	56	56
Pseudo R^2	0.40	0.20
Pseudo R^2_{CN}	0.19	0.22
Pseudo R^2_{N}	0.46	0.31

The results are expressed in terms of the estimated coefficients for each model with its respective standard error below. Significance Levels: (***) p<0.01, (**) p<0.05, (*) p<0.10

Source: prepared by the author

Table 2: Models III and IV

Model III Quasi-Poisson:

$$total_{ia} = \beta_0 + \beta_1\ (dep) + \beta_2\ (inv) + \beta_3\ (firm\_size) + \beta_4\ (prof\_share) + \beta_5\ (sector) + \beta_6\ (interactions) + \varepsilon$$

Model IV Binomial Logistic:

$$R\&D = \beta_0 + \beta_1\ (dep) + \beta_2\ (inv) + \beta_3\ (firm\_size) + \beta_4\ (prof\_share) + \beta_5\ (sector) + \beta_6\ (interactions) + \varepsilon$$

	Model III **Probability of performing a greater number of IA**	**Model IV** **Probability of performing R&D**
(Intercept)	-0.115	-2.836*
	(0.236)	(1.546)
Chilecito	0.365*	-1.611
	(0.185)	(1.154)
Arauco	0.176	-0.440
	(0.181)	(0.995)
Investment	0.100	-0.848
	(0.161)	(0.952)
Large	0.709***	1.390
	(0.212)	(1.230)
Medium-sized	0.487***	1.129
	(0.176)	(1.069)
Small	0.261	0.960
	(0.189)	(1.157)
Professionals_share	0.016*	0.146**
	(0.009)	(0.061)
Sector	-0.125	1.117
	(0.148)	(0.853)
Total_Interactions	0.041**	0.225*
	(0.018)	(0.134)
Observations	56	56
Pseudo R^2	0.46	0.24
Pseudo R^2_{CN}	0.22	0.26
Pseudo R^2_{N}	0.52	0.36

The results are expressed in terms of the estimated coefficients for each model with its respective standard error below. Significance Levels: (***) p<0.01, (**) p<0.05, (*) p<0.10

Source: prepared by the author

Table 3. Models V and VI

Model V Quasi-Poisson:

$$total_{ia} = \beta_0 + \beta_1 (dep) + \beta_2 (inv) + \beta_3 (firm\_size) + \beta_4 (prof\_share) + \beta_5 (sector) + \beta_6 (organizations) + \varepsilon$$

Model VI Binomial Logistic:

$$R\&D = \beta_0 + \beta_1 (dep) + \beta_2 (inv) + \beta_3 (firm\_size) + \beta_4 (prof\_share) + \beta_5 (sector) + \beta_6 (organizations) + \varepsilon$$

	Model V **Probability of performing a greater number of IA**	**Model VI** **Probability of performing R&D**
(Intercept)	-0.144	-2.971*
	(0.242)	(1.584)
Chilecito	0.422**	-1.609
	(0.193)	(1.158)
Arauco	0.217	-0.407
	(0.187)	(1.001)
Investment	0.107	-0.912
	(0.165)	(0.972)
Large	0.753***	1.488
	(0.215)	(1.243)
Medium-sized	0.479**	1.019
	(0.187)	(1.068)
Small	0.243	0.941
	(0.195)	(1.160)
Professionals_share	0.015	0.147**
	(0.009)	(0.062)
Sector	-0.080	1.251
	(0.151)	(0.835)
Total_Organizations	0.066	0.514*
	(0.047)	(0.304)
Observations	56	56
Pseudo R^2	0.42	0.24
Pseudo R^2_{CN}	0.20	0.25
Pseudo R^2_{N}	0.49	0.36

The results are expressed in terms of the estimated coefficients for each model with its respective standard error below. Significance Levels: (***) p<0.01, (**) p<0.05, (*) p<0.10

Source: prepared by the author

Table 4: Models VII and VIII

Model VII Quasi-Poisson:

$$total_{ia} = \beta_0 + \beta_1 (dep) + \beta_2 (inv) + \beta_3 (firm\_size) + \beta_4 (prof\_share) + \beta_5 (sector) + \beta_6 (organizations) + \varepsilon$$

Model VIII Binomial Logistic:

$$R\&D = \beta_0 + \beta_1 (dep) + \beta_2 (inv) + \beta_3 (firm\_size) + \beta_4 (prof\_share) + \beta_5 (sector) + \beta_6 (organizations) + \varepsilon$$

	Model VII	**Model VIII**
	Probability of performing a greater number of IAs	**Probability of performing R&D**
(Intercept)	-0.258	-5.524**
	(0.252)	-2.489
Chilecito	0.624***	-1.089
	(0.189)	-1.390
Arauco	0.379*	1.912
	(0.192)	-1.487
Investment	0.139	-2.865*
	(0.174)	-1.713
Large	0.791***	3.651**
	(0.220)	-1.856
Medium-sized	0.595***	3.625*
	(0.184)	-1.924
Small	0.287	1.556
	(0.195)	-1.642
Professionals_share	0.013	0.296***
	(0.010)	(0.109)
Sector	-0.057	2.383**
	(0.148)	-1.122
INTA	-0.164	-2.099
	(0.147)	-1.300
INTI	0.088	4.357**
	(0.282)	-2.059
Universities	0.062	2.861**
	(0.169)	-1.454
Other_S&T_org	0.454*	-2.401
	(0.242)	-1.650
Observations	56	56
Pseudo R^2	0.46	0.44
Pseudo R^2_{CN}	0.22	0.42
Pseudo R^2_{N}	0.53	0.59

The results are expressed in terms of the estimated coefficients for each model with its respective standard error below. Significance Levels: (***) p<0.01, (**) p<0.05, (*) p<0.10

Source: prepared by the author

Table 5: Models IX and X

Model IX Quasi-Poisson:

$$total_{ia} = \beta_0 + \beta_1 (dep) + \beta_2 (inv) + \beta_3 (firm\_size) + \beta_4 (prof\_share) + \beta_5 (sector) + \beta_6 (interactions) + \varepsilon$$

Model X Binomial Logistic:

$$R\&D = \beta_0 + \beta_1 (dep) + \beta_2 (inv) + \beta_3 (firm\_size) + \beta_4 (prof\_share) + \beta_5 (sector) + \beta_6 (interactions) + \varepsilon$$

	Model IX **Probability of performing a greater number of IAs**	**Model X** **Probability of performing R&D**
(Intercept)	-0.175	-4.170**
	(0.236)	(2.085)
Chilecito	0.432**	-0.564
	(0.174)	(1.258)
Arauco	0.188	-0.135
	(0.179)	(1.261)
Investment	0.131	-1.070
	(0.159)	(1.316)
Large	0.770***	1.620
	(0.208)	(1.589)
Medium-sized	0.466**	1.998
	(0.177)	(1.422)
Small	0.209	0.592
	(0.188)	(1.549)
Professionals_share	0.016*	0.154**
	(0.009)	(0.078)
Sector	-0.112	1.858*
	(0.146)	(1.065)
R&D_interaction	0.142	3.599***
	(0.130)	(1.074)
TA_interaction	0.258*	-0.970
	(0.137)	(1.288)
Observations	56	56
Pseudo R^2	0.47	0.44
Pseudo R^2_{CN}	0.22	0.42
Pseudo R^2_{N}	0.53	0.60

The results are expressed in terms of the estimated coefficients for each model with its respective standard error below. Significance Levels: (***) p<0.01, (**) p<0.05, (*) p<0.10

Source: prepared by the author

common projects improves the probability of conducting R&D internal efforts at 99% level of statistical confidence level, and with a weaker level of confidence (90%) articulations for Technical Assistance show a positive relation with the probability of performing a greater number of innovative activities (Table 5).

Thus, the results present some evidence for the relations proposed in the first hypotheses "Firms' interactions within the Regional Innovation System increase the probabilities to perform innovative activities", but it is not the simple fact of interacting with at least one actor from the RIS. Firms which establish a larger number of relationships presents a better probability to engage in a larger number of IA. Also interacting with S&T organizations, and for more complex activities (TA), are related to higher possibilities but with less level of statistical confidence.

As for the second hypotheses, "Firms' interactions within the RIS also increase the probabilities to carry out internal R&D", evidence also sustained partially this relation. In particular, relating to the INTI and the Universities, as well as interacting for R&D purposes, increase the probability to perform R&D internal efforts. With a lower statistical significance maintaining a greater number of interactions within the RIS show a positive relation with the firms' probability of performing R&D, like keeping relationships with a greater number of organizations.

V. Discussion

Amongst the main findings of the study, it can be highlighted the presence in the olive sector in La Rioja of heterogeneous firms which have diverse innovative behaviour. Thus, small and micro-enterprises, mainly of local capitals, coexist with larger producers that concentrate most planted lands and production with better technological capacities and yield by 10.000 square metres. As regards their innovative efforts, large and medium-sized firms are more likely to make innovative activities. On the contrary, there is a lower proportion of microenterprises that conduct these activities. Thus, larger firms operate closer to the international technological frontier than the smaller ones. As regards innovative activities the most generalised one is machinery and equipment acquisition while internal R&D is sporadic and focused on adapting and improving imported technology.

In this sense, empirical evidence suggests that firms' size (larger and medium-sized firms) is related to better probabilities of performing a greater number of innovative activities as well as having bigger share of qualified human resources and being located in Chilecito. Thus, within the local olive sector the size of the firms presents a relation with innovative behaviour. So the presence of heterogeneous actors which do not have the same possibilities to face innovative activities stands out. Medium and large producers who implement modern production models are prone to carry out innovative efforts, while microenterprises and small firms don't have the minimal competences to encourage them with more intensity. Similar findings are presented by other authors as Yoguel et al. (2006), Borello (2015), Pasciaroni (2015) and Yoguel and Erbes (2007).

In particular, within the Regional Innovation System it is shown for olive firms that a greater number of interactions and more complex linkages with specific organizations are associated to the possibilities of carrying out innovative efforts. A relevant result, in accordance to the presented backgrounds (Fritsch and Franke, 2004; Tödtling et al., 2008; Klein and Sauer, 2016; Trippl et al., 2015; Lau and Lo, 2015; Ligenzowska, 2016), is the positive link between the number of interactions established and the probability to perform a lager quantity of innovative activities. Even though the simple fact of articulating with at least one actor do not present a statistically significant coefficient, maintaining a larger number of relationships does. Thus, the evidence supports to some extent the relation between interactions within the RIS and innovative efforts conducted by firms.

In addition, it is observed that specific connections present a relation with better probabilities to engage in more activities, for example nexus with other S&T organizations and for Technical Assistance, but with a weak level of statistical confidence. For the case of R&D efforts the empirical evidence shows that the likelihood to perform internal R&D is also related to the specific interactions, such as connections with the INTI and Universities, as well as for R&D projects. In this case a higher number of articulations presents a significant coefficient but only at a 90% level of confidence.

As regards microenterprises, they mainly interact with the INTA to exchange information, while the importance of those interactions diminishes along with the size of the firm. Thus, larger firms have more balanced schemes in terms of actors and type of link diversity. For large firms, R&D and training interactions are preponderant, and amongst medium-sized Technical Assistance and Test and Analysis linkages prevail. Also, it can be underlined that R&D cooperation predominates between firms and other S&T public organisms. These findings agree with the ones obtained by Lavía et al. (2011), Fritsch and Franke (2004), Tödtling et al. (2008), Yoguel et al. (2006), McDermott et al. (2006), Pasciaroni (2015) and Sanchez and Bisang (2011), about the relevance of interacting with S&T organizations and involving in more complex connections, in addition to the divergent relational behaviour amongst firms of different size.

Outcomes that associate the size of the firm with the probability of performing a greater number of activities, indicate that even though interactions within RIS are important, its development is not enough to make smaller firms overcome their own limitations. This situation is comparable to that found by Lavía et al. (2011), Jimenez et al. (2011), Yoguel et al. (2006), Borello (2015), Pasciaroni (2015), and Yoguel and Erbes (2007), where a relation between size firms and their innovative efforts, capacity and performance prevails.

So empirical results support to some extent the relations proposed in the hypotheses, descriptive analyses and econometric models present evidence in favour to the role of interactions within the RIS to influence over firms' possibilities to engage in more innovative activities and R&D efforts. This way, the study shows that a greater number of interactions and complex articulations with S&T are connected to innovative efforts carried out by olive firms. Specifically, it is not the mere fact of interacting with at least one actor but establishing a greater number of interactions which influence the probability to carry out more innovative activities, and specific relationships are related to the possibility of performing R&D efforts. Nonetheless, outcomes that associate firm size to the number of efforts performed by the firms, indicate that even though interactions within RIS are relevant, they are not extensive to the whole sector.

Regional Innovation System approach proposes that innovative efforts are not spontaneous nor trivial, and are the result of complex social relations. In that sense, a greater number of interactions, which can stimulate knowledge and technology exchange, generate local spillovers, and reduce uncertainty, along with capacity building, may set off accumulative learning processes that allow to reduce technological gap and to achieve endogenous innovations improving local productivity and competitiveness. So that promoting a greater number of linkages within the RIS for the olive sector and identifying organizations and type of interactions which are particularly useful represent a policy challenge. In order to accomplish those objectives, implementation of specifically designed instruments addressing sectorial and local specificities is required. Local actors' involvement in policy planning is fundamental to aim at particular problems such as funding technology acquisition, qualify resources incorporation, R&D promotion, and the improvement and the adaptation of imported technology.

The work represents an original study for a narrowly explored case, inquiring at a firm level the interactions stablished with other actors within La Rioja's RIS for the olive firms and its relation to their innovative behaviour. Relevant evidence is constructed on the base of processing original information provided by the specific survey to shed light about the relation between olive firms' innovative efforts and their links with different organizations.

However, it is worth noting the limitations of the analysis. In the first place, as specified in the methodology, the size of the sample is limited for maximum likelihood method and there could be potential endogeneity, so statistical results should be taken mainly as correlations and not as causal effects. The scope of the sample also restrains the possibility to include interactions between variables which could be useful to extend the study. In the second place, as the survey was conducted only for one period provides cross-section data and there are not time series available to go in depth with statistical analysis. Nevertheless, given the relevance and originality of the information from the survey the study conducted presents interesting results about the proposed relations and the analysed phenomena.

Finally, it can be highlighted that this work is part of a wider research framework that approaches the study of La Rioja's RIS features, dynamic and evolution, so that the findings developed represent a valuable contribution in that sense. Further research topics can be outlined, detailed studies of obstacles as well as firm's characteristics which limit interactions between firms and S&T organizations and RIS weaknesses can be useful to understand the difficulties that local firms face and to promote cooperative linkages, especially amongst smaller firms. Also, in depth inquiry of RIS's broad dimensions, its evolution and history, additionally to other sectorial studies and specific cases analysis are relevant subjects which require further research.

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