Networks, knowledge flows and innovation in the Chilean meat sector

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Abstract: This paper contributes to the debate on innovation in the agro-food industry by presenting the results of a study of the impact of knowledge flows on firm’s innovation in the Chilean meat sector. Most literature agrees that innovation is the result of complex systemic interactions among many different players including other firms, universities and government institutions. In order to test this hypothesis, we apply social network analysis (SNA) and logistic regression to assess whether there is a significant relationship between firms' position in the network and their innovation performance. The empirical test of this hypothesis is based on secondary data and on primary data collected through firm-level questionnaires and interviews to the population of slaughtering and processing plants in six Chilean regions.

Keywords: innovation; knowledge flows; business networks; social network analysis; SNA; food sector; meat sector; Chile.


Biographical notes: Sara Gorgoni is a Postdoctoral Research Fellow at the Department of Economics and Quantitative Methods at the University of Piemonte Orientale. She obtained her PhD in Development Economics from the University of Roma Tre and her Master’s in Political Economy from the University of Essex. Her main research topics include innovation and upgrading in developing countries, knowledge networks, clusters and global value chains in the agri-business sector.
1 Introduction

1.1 Rationale for the study

The agro-food industry is experiencing rapid transformations: it is becoming increasingly technology intensive and is facing changes in consumers’ preferences with important repercussions throughout the entire chain. Innovation is at the basis of competition between firms in order to enter global value chains and access demanding markets. The meat sector is no exception (World Bank, 2007; Reardon and Timmer, 2007; Regmi and Gehlhar, 2005).

Knowledge creation, adoption and diffusion have therefore become key elements of competitiveness. Knowledge, however, is not a factor that can be localised within a firm’s borders, making competitiveness strongly depend on the firm’s relationships with external actors. The process of interaction allows knowledge flows and learning processes that are essential for innovation (UNIDO 2008, 2003/2002; Lall and Pietrobelli, 2005; Etzkowitz and Leydesdorff, 2000; Edquist et al., 1997; Freeman, 1995, 1991; Nelson, 1993; Grabher, 1993; Lundvall, 1992).

In addition, over the last decade, the meat sector has experienced repeated disease outbreaks, with a consequent rise in buyers concerns and therefore, higher demand for quality and safety assurance. The adoption, on one hand, of sanitary standards imposed by governments as a consequence of the spread of infectious diseases and on the other hand, of technical and quality standards imposed by giant supermarkets as part of their strategy to reduce costs and differentiate products, has called for higher coordination between firms participating in the same value chain and for higher collaboration between firms and external business and scientific partners.

In spite of not being a livestock country, Chile is an interesting case study because, by exploiting the initial advantage of being freed (because of geographical isolation) from cattle, pork and poultry diseases, it has been able to develop a meat exporting sector and to service high value meat to demanding markets that are instead closed to exports from traditional livestock producers. The universe of firms making up the sector is however very heterogeneous even within sub-sectors: dynamic successful firms coexist with laggards. Understanding what originates such differences is of paramount importance for the survival and competitiveness of firms, for the sector as a whole and for the country’s export strategy.
1.2 Research question and hypotheses

In this paper we explore to what extent differences in innovation performances of firms in the Chilean meat sector are explained by the relationships developed with external partners. This is our main research question.

From this research question, a main hypothesis is drawn: there is a positive and strong relationship between firms’ innovation performance and their connections to other firms in the sector, as well as to universities and government agencies active in the sector (Etzcowitz and Leydesdorff, 2000; Lundvall, 1992; Granovetter, 2003; Salman and Saives, 2005). This is because linkages can act as conduits for knowledge transfers that are essential for the innovation process and the network of relations that a firm develops can either create opportunities to learn and innovate or work as constraints.

Acknowledging the importance of understanding the social context within which firms are embedded, this paper looks at the structure of knowledge flows within the Chilean meat sector (Fleming and Juda, 2004; Grabher, 1993).

This paper does not take into account linkages firms develop with suppliers and customers, like for example in Pietrobelli and Rabellotti, (2007). Rather, it focuses on horizontal relationships among national competing firms and with supporting institutions. Although the limitations of a national focus in today’s globalised world have been noted (Nelson, 1993), a preliminary overview of the sector and discussion with key informants made immediately clear that, as long as horizontal relations are concerned, the international realm is still distant.

1.3 The methodology

The empirical test of the hypothesis is based on secondary data and on primary data collected through firm-level questionnaires and interviews to the population of slaughtering houses in six regions in Chile (RM, 6, 7, 8, 9 and 10).

Firms were identified on the basis of official sources and industry associations’ databases. A questionnaire was designed to gather both attribute and relational data. The relational part of the questionnaire aims at identifying the flows of knowledge among actors and was designed to collect data that could allow social network analysis (SNA) with Ucinet 6 (Borgatti et al., 2002).

Degree centrality, one of the most common elements of network structure and eigenvector centrality were computed from the matrix built from the interviewees’ responses to test the hypothesis. Degree centrality is a count of ties connecting actors and it is used in the literature as a proxy for actor’s direct access to the resources of the network. Eigenvector centrality is an indirect measure of actor’s access to these resources. Centrality was then used as explanatory variable in a logistic model aiming at explaining firms’ probability to innovate.

SNA offers many advantages for the study of knowledge flows and innovation. The graphical analysis allows immediate identification of important aspects of the network structure, while the mathematical analysis helps to make sense of data that, given their (relational) nature, cannot be analysed through standard statistical tools, while at the same time providing more robustness to what would otherwise be a simple qualitative analysis (Wasserman and Faust, 1994).
1.4 Contributions, limitations and structure of the paper

Few studies have applied SNA to the study of the relationship between knowledge flows and innovation in the agro-food sector. In particular, to the best of our knowledge, no study has done so in the meat sector. This is surprising, given that the sector is undergoing rapid transformations, becoming increasingly technology intensive and strongly competitive, thus requiring firms to constantly innovate. In addition, the meat sector constitutes for some middle and developing countries an important source of income. A better understanding of the process of innovation in this sector is therefore important.

The paper is organised as follows: the next section defines the theoretical framework of the study, as well as the main research question and hypothesis. A brief description of the empirical context of this study follows. The fourth section describes the methodology of the study in detail. The fifth section provides empirical evidence by also showing why SNA is a valuable tool in order to analyse innovation in the agro-food sector. The last section concludes.

2 Theoretical framework and context of the study

2.1 Theoretical framework

In the effort to understand what explains heterogeneous performance of firms, several studies have emphasised the external environment of firms and have indicated that the position of firms in inter-organisational networks influences firms’ behaviour and outcomes (among others, Granovetter, 1985; Powell, 1996; Walker et al., 1997).

In the industrial organisation and management field, numerous studies show that networks may serve as loci of innovation because they provide favourable access to knowledge and resources that are otherwise unobtainable, which can then be recombined into innovation.

Ties between actors can provide access to knowledge, as well as serving as information conduits through which news of innovations, discoveries and successful (or failed) approaches and insights to problems travel within the firm or from one firm to another.

In a study of the biotechnology industry, Powell (1996) attempts to test empirically the claim that when the knowledge of an industry is broadly distributed and rapidly changing, the locus of innovation will be found in inter-organisational networks of learning, rather than in individual firms.

Indeed, one important characteristic of technology is that it is systemic. Although often introduced by private firms, innovation is the product of a system of institutions that are closely linked together by economic and social relationships. One important consequence of conceiving technology as the result of a system is that we have to look beyond the single firm. Innovative firms often do not have all the necessary knowledge to introduce new products and processes and need to interact with other institutions such as competing firms, suppliers, customers, universities, government agencies or laboratories, business associations and so on. If some of the relevant institutions are missing or cannot communicate properly, then the innovation process could be jeopardised.
The systemic approach poses the accent on the interaction between heterogeneous actors, rather than on their attributes. Therefore, network analysis is a useful analytical tool to account for the systemic approach, since it focuses on the relations connecting pairs of agents into larger relational systems, where the relations are not the property of agents, but of systems of agents (Scott, 2000).

In SNA, the observed attributes of social actors (such as innovation, or access to resources) are interpreted as a function of their location in the network. Therefore, network position, which is an outcome of the relationships between actors, is considered a key variable, since it could be considered as an intangible strategic resource (Wasserman and Faust, 1994).

Following Coleman (1988), it is possible to argue that dense sub-groups are a source of social capital. A group of highly inter-connected agents generates trust, common languages and problem solving, social disapprobation for opportunistic behaviour and so on. This is the approach taken by some empirical studies (among others, Gulati and Nickerson, 2008; Dyer and Nobeoka, 2000; Gulati and Gargiulo, 1999; Powell, 1996).

According to Cowan and Jonard (2006), when an industry is young, technologies are being explored and many different avenues of advance are potentially fruitful. Here, it is important to have rapid access to ‘distant’ (both in geographical and technological space) information. Thus redundant ties are less valuable than ties that connect to different parts of the network. However, in a more mature industry, there are fewer technological surprises, so exploitation is more common. Here, a dense core of agents addressing similar issues creates the critical mass that is necessary to make further progress along the chosen path. Although its international competitiveness is a recent phenomenon and goal, the Chilean meat sector is not a young industry. This is why this paper builds on Coleman’s approach, rather than on the competing view of Burt (1992) based on structural holes.

Centrality refers to how well connected a node is within its local environment. Degree centrality (Freeman, 1979) is the most straightforward way to measure local centrality, since it considers the number of other nodes to which a node is adjacent. Bonacich (1972), however, argues that the centrality of a particular node cannot be assessed in isolation from the centrality of all the other nodes to which it is connected, since “a point that is connected to central points, has its centrality boosted” [Scott (2000), p.87]. Bonacich’s approach to centrality calls for an alternative measure which uses weighted scores instead of the raw scores of degree.

2.2 The context

The empirical study of this paper focuses on the Chilean meat industry. In the last decade, meat consumption has dramatically changed: Global demand has risen as a consequence of income per-capita increases in some of the mostly densely populated countries of the world. In the developed world, market preferences have shifted from quantity to quality, opening the path to market niches for premium quality products. In addition, in both developing and developed countries, governments and consumers concern for food safety has increased dramatically as a result of repeated animal disease outbreaks, some of which can be fatal to humans.

On the production side, there is a clear tendency towards vertical integration and concentration of buyers, and technology and techniques have undergone processes of increased codification of knowledge. This has allowed countries that were not traditional...
livestock countries to emerge as exporters, servicing highly demanding markets such as the USA, Japan and the EU. Chile is an example of this pattern.

In spite of not being a livestock country, Chile has been able to exploit the initial advantage of being freed – thanks to geographical isolation – from cattle, pork and poultry diseases and to develop a meat exporting sector.

The farming sector in Chile represents only 1.8% of the total GDP. This includes different types of livestock (sheep, poultry, pigs, etc.) among which cattle represents 25% of the total. The current size of the cattle meat sector is very small compared to the country’s neighbours. Nevertheless, this sector is significant in terms of hand labour employed, especially in the south of the country (regions 6 to 10) (Maino et al., 2007).

In the beef sector, Chile adopts an import-to-export strategy, that is, it imports low value meat for the domestic market in order to export its meat to high value markets, where consumers’ concerns on quality and safety assurance are particularly high, as is their availability to pay higher prices. Quality is, however, becoming increasingly important also for the Chilean consumer, as the average income grows.

The Chilean pork sector provides a successful example of sectors that, after a structured and focused effort, were able to jump ahead in productivity and in the development of exports. The annual number of slaughtered heads had passed from 302,674 in 1950, to 671,646 in 1970 (Ponce Vergara, 2006).

During the 80s has soared, passing from 697,497 in 1980 to 1,666,679 in 1990. In 2004, it was 3,860,149 (Ponce Vergara, 2006). When the pork production saturated the domestic market during the 90s, the industry looked for new markets and began to export (Agosin and Bravo-Ortega, 2009). Pork exports gained significance in 1998, when the country was recognised as freed from any animal disease. The perfect sanitary condition produced a spectacular export increase in the following years, which passed from 10,098 tons in 1997 to 78,797 in 2004 (Ponce Vergara, 2006).

Quality and safety are two distinct characteristics. Safety could be seen as a quality of meat (the fact that it is freed from pathogens). It is however useful to differentiate the two, since safety concerns are usually addressed by governments, while quality is a complex concept made up of different dimensions, which also include producers’ and retailers’ efforts to differentiate their product.

Building on a very effective role of the government in addressing safety concerns and in trying to develop the sector, many Chilean firms have been able to modernise and become dynamic innovative firms. However, the universe of firms making up the sector is very heterogeneous. Understanding what originates differences in innovative performance is of paramount importance for the survival of the specific firms, for the sector as a whole, and for the country’s export strategy.

This study is based on data collected in six Chilean regions (RM, 6, 7, 8, 9, 10), where, due to natural conditions, the meat production is concentrated. Firms are not evenly distributed in this territory; most of the bovine meat is produced and slaughtered in Regions 9 and 10, while most of the pork and poultry meat is produced closer to the Metropolitan Region (RM), where Santiago is located.2

There are important differences in the production costs and processes of these two different type of meat, as well as in the social relations involved, the pork sector being characterised by far less actors at all stages of the chain and being far more technology intensive. The two sectors were nevertheless considered in conjunction, because the focal points are the slaughtering plants where the modernisation process of the sector has started, and some of these produce both types of meat.
3 Data and analysis of the Chilean meat knowledge network

3.1 The data

While the unit of analysis included in non-network analysis tends to be the result of independent probability sampling, in network studies they tend instead to include all of the actors who interact within some (usually naturally defined) boundary. In this work, we consider the population of slaughtering and processing plants located in the six Chilean regions considered (RM, 6, 7, 8, 9, 10). On the basis of official sources and industry associations’ databases, a list of firms was created.

A number of pilot interviews indicated that firm’s managers are the best informants about the history and current characteristics of the firm. More importantly, within the firm, they are also most in charge of the firm’s formal and informal external networking. Managers participate in fairs, they design and actively participate in collaboration projects with universities and other firms, they attend meetings and ‘learning expeditions’ organised by the specialised government agencies or industry associations and they are responsible for developing and maintaining the relationship with clients and suppliers. For these reasons, the questionnaire was administered to them in face to face semi-structured interviews.

The face to face interviews gave access to information far beyond what can be collected through an electronic questionnaire and allowed both the collection of qualitative and quantitative data. The former was used to complement the quantitative analysis through a better understanding of the context and the sector’s idiosyncrasies.

The questionnaire was built to gather both attribute and relational data. Relational data were collected through a ‘roster recall’ method (Wasserman and Faust, 1994). Each firm was presented with a complete list (roster) of other firms, universities and government agencies operating in the sector and was asked to indicate the presence/absence of a relationship.

In the questionnaire-based interview, each firm was presented with a complete list (roster) of the other firms, universities and government agencies and they were asked the following question:

*Question: reception of technical knowledge*

Could you name, among the actors included in the roster, those that over the last two years have transferred relevant technical or business knowledge to this firm?

‘Knowledge transfer’ refers to flows between firms and other private and public organisations with the objective to exchange knowledge. The fact that the question is specifically about knowledge-transfer creates a direct correspondence between ties and knowledge flows. ‘Technical’ knowledge transfer often takes the form of a suggestion on how to solve specific problems, such as, for instance, the high levels of pH in the meat, while ‘business’ refers, for example, to knowledge about final market characteristics. Both of these are meant to go beyond the mere transfer of information, the access to which can be easily obtained through other channels, such as trade fairs, the internet or specialised reviews (Giuliani, 2005). ‘Relevant’ refers to the fact that these flows involve some effort in producing improvements and change within the economic activity of a
firm and are likely to improve products and processes in ways to be reflected in higher profits.

Besides the firms, we have included government agencies and universities, both private and public, involved with the sector.

The population under analysis is therefore composed of 49 nodes (or actors), including 36 firms \((F = 1\ldots, 36)\), seven government agencies \((A = 1\ldots, 7)\) active in the food sector and providing support to firms, and six universities \((U = 1\ldots, 6)\). This defines the universe of players in the specific sector, which gives us an asymmetric (directed) matrix of \((N*\text{N}-1) = (49*48) = 2,352\) observations.

### 3.2 Chilean meat knowledge network

NetDraw allows some interesting graphical analysis. Figure 1 shows the knowledge flows between the actors of the network. The circles represent the firms, the triangles the universities and the squares the government agencies. Flows are expressed by the directed edges between the nodes.

**Figure 1** Knowledge transfer network

![Knowledge transfer network](image)

Circles = firms  Squares = government agencies  Triangles = universities

Source: Authors own data

The relationships amongst government agencies and those amongst universities, as well as the relationships between these two categories, are not shown, as a natural consequence of how knowledge transfer has been defined in the previous section.

The original matrix has been transposed, so that the arrows from one actor to another mean that knowledge has been transferred from the former to the latter.

There are seven isolates in the study population. These isolates must have had a circle of local contacts but they were not cited by any of the other nodes (Burt, 2004).
The graphical analysis provides both a crude first examination of patterns in the data, and a useful descriptive tool, especially if used in combination with the mathematical/statistical analysis made possible with the Ucinet software.

Figure 2 shows the knowledge transfers among firms only. It appears that there are essentially three main poles of interaction occupying respectively the top, the left and the right-hand side of the figure, with some firms (F5, F8, F9, F21, F22, F24, F32) bridging in the middle. Actors are positioned in the network according to their relative degree-centrality, thus, firms located in the middle are also those who have more linkages. These firms are exposed to a higher degree of knowledge flows and could play a strategic role, either diffusing or blocking the knowledge created in one pole of the network.

Figure 2  Knowledge transfer across firms only

Source: Authors’ own data

The right part of the figure appears particularly dense in linkages. Most of the firms occupying this position in the network are located in the same region (the 10), hinting at a special role played by the territorial dimension in terms of enhancing informal interactions. If we turn to Figure 1, we can see that one of the most central positions is occupied by A1, a government agency called Pro Chile that is in charge promoting Chilean exports. Its presence here is clearly due to prestige: It is seen as a reference point by many firms who have named it as a source of knowledge. The role it plays is therefore fundamental both as a source of knowledge and in terms of connecting the two halves of the network. This agency also has regional offices and this may partly explain its popularity. All the other non-firm organisations occupy a marginal role, being connected to only few nodes (two on average), with the exception of U3 and U5, which are the two most important universities in Santiago. Thus, a picture of the network immediately reveals that universities and government agencies do not play an important role in the knowledge exchange, except for the three main ones mentioned.
The marginal involvement of universities can be explained as a result of the little R&D performed in the sector, as well as by the concentration of key activities in the very few larger universities in Santiago. The minimal participation of government agencies is somehow more surprising; given the role that government intervention needs to play in developing countries as a consequence of widespread market failures. However, the minimal involvement of government agencies makes sense given the history of the country and the cultural idiosyncrasies. Indeed, the private sector suffers a diffused lack of trust towards the government, which is perhaps the legacy of the years of neo-liberal ideology under the Pinochet dictatorship and that it is still so deeply embedded in the country’s culture (Chile Innova, 2005, Pietrobelli, 1998). In the light of this, what surprises then is not the reduced interaction of government agencies with the firms, but rather the central role that ProChile (A1), managed to gain in terms of recognition. Given that the role played by this organisation is essentially in the marketing area, its network position also reveals how central this function is for the firms in the meat sector. This confirms the strategic importance of information on importers’ preferences and requirements in a market shaped by the recent changes in consumers’ tastes and demands in the food industry today.

From a policy perspective, the graphical analysis suggests that A1 is the government agency that has most chances to reach the firms and therefore the preferred channel the government should use to provide directions to the sector. Although an inter-temporal analysis of the network is not possible with our dataset, by using secondary data we may argue that the position occupied today by A1 was probably once occupied by another government agency with a specific mandate to promote new and emerging areas of business.4 This also suggests that networks and organisations co-evolve over time and may change the pattern of linkages accordingly (Nelson, 1994).

4 The relationship between knowledge flows and innovation

4.1 The model

Following previous studies, in this paper, we use binary logistic regression to analyse the relationship between network degree centrality and innovation. Christiensen et al. (2000) use a logistic regression model to analyse the impact of collaboration between manufacturing firms and knowledge institutions on product development in Australia, Denmark, Austria, Norway and Spain. Silva and Leitão (2007) apply a logistic model to the study of cooperation in innovation practices among Portuguese firms to find a positive effect of relationships on product innovation. Other studies apply similar techniques: Warren-Rodrigues (2008) uses firm-level data and logit regression analysis to identify factors associated with firms’ decision to engage in technology-upgrading efforts in the Mozambican manufacturing sector. Giuliani (2006) applies probit and ordered probit models to the study of the relationship between network structure and innovation in the wine sector in Chile.

Binary logistic regression is a form of regression that is used when the dependent is a dichotomy and the independents are of any type. Logistic regression applies maximum likelihood estimation after transforming the dependent into a logit variable (the natural log of the odds of the dependent occurring or not). In this way, logistic regression
estimates the odds of a certain event occurring. Unlike logit regression, however, there can be only one dependent variable.

$$\text{logit}(Y) = \ln(\pi/(1-\pi)) = \alpha + \beta X$$  \hspace{1cm} (1)

$$\pi = \left[ \frac{e^{\alpha + \beta X}}{1 + e^{\alpha + \beta X}} \right]$$  \hspace{1cm} (2)

The impact of predictor variables is usually explained in terms of odds ratios, where $\pi$ is the probability of the outcome of interest or ‘event’, $\alpha$ is the $Y$ intercept, $\beta$ is the regression coefficient and $e = 2.71828$ is the base of the system of natural logarithms. $X$ is a vector of independent variables, which can be categorical or continuous, but $Y$ is always categorical. According to equation (1), the relationship between logit ($Y$) and $X$ is linear.

Yet, according to equation (2), the relationship between the probability of $Y$ and $X$ is non-linear. For this reason, the natural log transformation of the odds in equation 1 is necessary to make the relationship between a categorical outcome variable and its predictor(s) linear. The value of the coefficient $\beta$ determines the direction of the relationship between $X$ and the logit of $Y$. When $\beta$ is greater than zero, larger (or smaller) $X$ values are associated with larger (or smaller) logits of $Y$. Conversely, if $\beta$ is less than zero, larger (or smaller) $X$ values are associated with smaller (or larger) logits of $Y$.

Note that logistic regression calculates changes in the log odds of the dependent, not changes in the dependent itself as OLS regression does (Campbell, 2006). Logistic regression, however, has many analogies to OLS regression: logit coefficients correspond to b coefficients, the standardised logit coefficients correspond to beta weights and a pseudo $R^2$ statistic is available to summarise the strength of the relationship. Unlike OLS regression, however, logistic regression does not assume linearity of relationship between the independent variables and the dependent, does not require normally distributed variables, does not assume homoskedasticity and in general has less stringent requirements. It does, however, require observations to be independent and the independent variables to be linearly related to the logit of the dependent.

### Table 1 Definition of variables

<table>
<thead>
<tr>
<th>Innovation performance</th>
<th>$INNOV$ = Dichotomous. Introduction of new products or processes in the last three years that had positive economic impact in terms of higher profits.</th>
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<tbody>
<tr>
<td>Knowledge inflows</td>
<td>$C_{IND}$ = Number of incoming ties $In_{Eigen}$ = Sum of connections to other nodes, weighted by the centrality of each of these other points</td>
</tr>
<tr>
<td>Presence of internal technological capabilities (TC)</td>
<td>$SKILLS$ = % employees w/technical, university degree</td>
</tr>
<tr>
<td>Age of the firm</td>
<td>$AGE$ = Number of years the firm has been operating</td>
</tr>
<tr>
<td>Firm size</td>
<td>$SIZE$ = Number of employees</td>
</tr>
<tr>
<td>Exposure to international competition</td>
<td>$EXPORT$ = Dichotomous: It is 0 when the firm does not export and 1 when it does.</td>
</tr>
</tbody>
</table>
4.2 Model specification

This section deals with the definition of the variables included in the model and with how they are measured. Innovation performance is the dependent, incoming knowledge flows is the key explanatory variable in our hypothesis, while age, firm size, export orientation and TC are used as control variables. Table 1 provides a list of the variables considered with their conceptual and operational definition.

4.2.1 The dependent variable

In dealing with innovation in a middle-income country like Chile and with an industry still at its early stage of development, innovation cannot be confined to (and measured by) mere investments in R&D. This study acknowledges the necessity to define innovation in incremental terms and as not solely R&D based.

Community innovation surveys (CIS) based on the Oslo Manual tend to focus on the inventive efforts (R&D) leaving aside adoption efforts. That is, the innovative firm is understood as the one that has performed R&D. Following a Schumpeterian approach to innovation, where only radical innovative attempts count, firms that successfully adopt innovations but which do not carry out their own R&D are left aside. This is a reductive view of innovation, especially in developing countries, where minor innovations, adaptive and improvement efforts are an important part of the process of accumulation of TC (RICYT, 2001).

Another shortcoming of these innovation surveys is the exclusive focus on technological innovations. Non-technological innovations are also relevant for the firm performance and therefore should be taken into account (Lugones and Peirano, 2004). One of the most distinctive features of the attempts to use innovation surveys in developing countries (like the Bogotá Manual of 2001) is the effort to consider a broader category of innovation activities, which goes beyond R&D expenditures in order to capture real technological efforts of firms. The measurement suggested to also capture non-R&D based innovations takes into account innovation efforts in the form of design, installation of new machinery, acquisition of embodied technology, organisational modernisation and marketing (RICYT, 2001).

Most firms in developing countries do not have an R&D department and only in some cases they would consider product development as requiring R&D rather than, for instance, an empowered marketing division. If only technologically-based innovations were considered, a proportion of innovation efforts made by some firms would be left out.

A final problem with the definition and measurement of innovation deals with its economic relevance. Ultimately, firms’ innovation performance matters as long as it improves the firms’ competitiveness and therefore the economic relevance of the innovations introduced is essential. Cases of firms that have introduced innovations that did not turn out to be profitable are not considered in this study. This work only considers those innovations that were commercialised and had an impact in terms of higher profits.

Our dependent variable, INNOV, is dichotomous, meaning it can only assume the value 0 (the firm does not innovate) or 1 (the firm innovates). Only product and process innovation are considered.
4.2.2 The explanatory variable

The conclusion of many studies that apply social network to innovation is that, regardless of which ties are analysed, network position is to be considered as an intangible strategic resource. The idea behind this is that actors that are more centrally located accumulate greater knowledge and thus, are in a better position to convert this knowledge into further innovations.

Centrality refers to the position of an individual actor in the network and represents the extent to which the focal actor occupies a strategic position in the network. There are different centrality measures, each of which captures different aspects of being an actor involved in many ties.

Two centrality measures are calculated in this paper: degree centrality and eigenvector centrality. Degree centrality (Freeman, 1979), one of the measures most often used, provides a count of the number of ties an actor has, meaning the number of organisations the actor is in contact with. The actor with the most connections, i.e., the highest degree, is the most central. Degree centrality also represents the number of alternatives available to an actor. Since more alternatives are usually better than fewer (Brass and Burkhardt, 1992), more ties are usually considered to be better.

Degree centrality, however, does not take into account the relative centrality of the nodes a node is linked to. That is, it does not differentiate between connections to nodes that are in turn involved in many knowledge exchanges and nodes that are not. The eigenvector centrality (In_Eigen) (Bonacich, 1972), instead, accounts for this. A node that has a high eigenvector score is one that is adjacent to nodes that are themselves central.

Ties here are treated as asymmetric and therefore, the computation returns two different measures, one for in-coming ties and one for out-going ties. Only the in-degree centrality (C_IND) and the in-eigenvector centrality (In_Eigen) are considered. These indexes measure the extent to which each node is recipient of technical knowledge.

Table 2  Ranking of firms according to the two different definitions of centrality

<table>
<thead>
<tr>
<th></th>
<th>Most central</th>
<th>Least central</th>
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<tbody>
<tr>
<td>Degree centrality</td>
<td>F5  F1  F9  F8  F7  F13  F22  F3  F14  F17</td>
<td></td>
</tr>
<tr>
<td>Eigenvector centrality</td>
<td>F9  F13  F14  F6  F1  F7  F5  F8  F22  F23</td>
<td></td>
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</tbody>
</table>

Nodes which are central according to Freeman’s definition may be not so according to Bonacich’s definition. In this case, the same eight firms score among the first ten in both these measures, although occupying different positions in the ranking. Nevertheless, the eigenvector measure has the potential to highlight those firms that had a low degree but which were, nevertheless, connected to highly central actors (Table 2, third row, in italics), or actors with many linkages but to not very central nodes (Table 2, second row, in italics).
4.2.3 The control variables

The control variables included in the model are those that the literature indicates as main determinants of innovation. Among these, we include the variable SKILLS as a proxy for firm’s internal TC. This variable is the percentage of skilled labour in the firm (workers with technical or university degree). In sectors where R&D plays a role, R&D expenditures or people working on R&D could also be used as proxies for TC, but in the meat sector most firms do not even have employees exclusively dedicated to R&D activities.

Firm age is another control variables often included in similar studies. This reflects the idea that knowledge is cumulative and therefore firms that have been active in the sector for a longer time have an advantage in terms of innovation performance. Here, we adopt the operational definition most widely used in the literature and we include in the model the variable AGE which is the number of years the firm has been operating.

Firm size also often notably affects innovation, although the direction of the relationship is still controversial. We measure firm size with the number of employees (SIZE).

Empirical evidence also suggests that export oriented firms are also more productive than non-exporters. Although in this case, the direction of causality is still controversial, many studies argue that firms learn by exporting, as they interact with foreign customers and learn from the pressure of international competition (Wagner, 2006). This seems to be especially the case for less developed and relatively small economies, where the greater difference in technology levels between domestic and foreign firms increases the possible learning gains of exporting firms through contacts with more developed foreign partners (Pietrobelli and Saliola, 2008). In this paper, the variable that measures export orientation, EXPORT, is dichotomous. Table 3 provides some descriptive statistics.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Number of firms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Above the average</td>
</tr>
<tr>
<td>INNOV</td>
<td>-</td>
<td>18\textsuperscript{a}</td>
</tr>
<tr>
<td>C_IND</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>In_Eigen</td>
<td>3.76</td>
<td>15</td>
</tr>
<tr>
<td>SKILLS</td>
<td>13%</td>
<td>13</td>
</tr>
<tr>
<td>AGE</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>SIZE</td>
<td>175</td>
<td>10</td>
</tr>
<tr>
<td>EXPORT</td>
<td>-</td>
<td>17\textsuperscript{c}</td>
</tr>
</tbody>
</table>

Notes: a – number of firms that innovate
b – number of firms that do not innovate
c – number of firms that export
d – number of firms that do not export

In conclusion, the equation we want to test is the following:

$$\text{INNOV} = f (\text{C_IND, In_Eigen, SKILLS, AGE, SIZE, EXPORT})$$
4.3 The relationship between knowledge flows and innovation: findings

Figures 3a and 3b show the relationship between innovation and two different measures of centrality, degree centrality and eigenvector centrality. The network in the figure has been obtained by sizing the nodes according to their centrality. The size of the nodes represents the (direct or indirect) knowledge inflows: it is small when the inflows are below the average and it is big when they are above. Innovative firms are represented with squares and non-innovative firms with circles. The triangles indicate organisations other than firms. The figures clearly show that most of the innovative firms also have knowledge inflows above the average. However, the relationship between centrality and innovation seems stronger when measured with the degree rather than with the eigenvector. Indeed, in the former case, of the 18 firms that innovate, 16 have in-degree centrality above the average (89%), while only 11 have eigenvector above the average (61%). Since one way to interpret degree centrality would be in terms of an implicit communication process that involves no indirect links and, likewise, the measure is to be considered as a measure of immediate effects only (i.e., of what happens at time $t + 1$), our results suggest that in the specific case, direct knowledge transfers seem more important than the indirect. Indeed, while degree centrality can be considered a direct and immediate flow measure, eigenvector centrality is a long-term, indirect flow measure (Borgatti, 2005).

Figure 3 (a) Innovation and knowledge inflows measured with degree centrality (b) innovation and knowledge inflows measured with eigenvector centrality
Overall, the graphical analysis suggested the existence of a positive relationship between knowledge inflows (however measured) and innovation performance. In this section, we test such positive relationship through the logistic regression model presented previously, the results of which are shown in Table 4. The table provides the odds and the p-value for the regression coefficients.

**Table 4**  
Model estimation

<table>
<thead>
<tr>
<th>Model</th>
<th>$C_{IND}$</th>
<th>$In_{Eigen}$</th>
<th>SKILLS</th>
<th>SIZE</th>
<th>AGE</th>
<th>EXPORT</th>
<th>Nagelkerke R-square</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.091</td>
<td>1.140</td>
<td>1.762</td>
<td>1.258</td>
<td></td>
<td></td>
<td>0.680</td>
</tr>
<tr>
<td></td>
<td>(0.015)*</td>
<td>(0.031)*</td>
<td>(0.057)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>4.081</td>
<td>2.503</td>
<td>1.734</td>
<td>1.021</td>
<td>1.014</td>
<td>1.379</td>
<td>0.791</td>
</tr>
<tr>
<td></td>
<td>(0.037)*</td>
<td>(0.050)*</td>
<td>(0.018)*</td>
<td>(0.045)*</td>
<td>(0.065)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: cases included in the analysis = 36, cases missing = 0; *regression coefficients with a p-value $<0.05$ (i.e., statistically significant); Nagelkerke R square: estimation terminated at iteration number ten because parameter estimates changed by less than 0.001

Model 1 in Table 4 only includes the control variables, showing that the firms’ knowledge base, their size and international exposure are positively related with the dependent. Quite in line with the existing literature, the results of the regressions show
that especially firms with stronger internal capabilities (i.e., knowledge bases) are likely to achieve higher innovating performance.

Model 2 tests our hypothesis of a relationship between the centrality in the knowledge network and the probability to innovate. The results of the logistic regression suggest that knowledge inflows contribute significantly in explaining firms’ innovation performance. The odd (innovate/not innovate) > 1 indicates a strong positive relationship between knowledge inflows (measured by C_IND) and the probability to innovate (INNOV). That is, having many ties in the network and receiving external knowledge is likely to increase a firm’s probability to innovate by four times, while being connected to the nodes that are more connected, more than doubles the probability to innovate.

SKILLS also appears to be positively correlated with the probability to innovate. This confirms the idea that TC and external sources of knowledge are complements (Lall, 1992). For firms to acquire exogenously the knowledge available and convert it into innovation, they must recognise, capture and assimilate this knowledge (Cohen and Levinthal, 1990). These activities require a minimum threshold of pre-existing TC within the firm.

5 Conclusions

This paper has investigated the relationship between knowledge inflows and the probability to innovate. This is done by looking at the relationships firms establish with competing firms and other organisations including universities and government agencies. The results suggest that knowledge inflows, which are the results of firms’ interaction with other players, increase by four times firms’ probability to innovate in the sector.

This can be explained by the fact that in today’s rapidly changing world, competitiveness depends heavily on knowledge and firms rarely possess within their borders all the knowledge they need in order to innovate.

These results are consistent with most of the organisational sociology’s literature, which supports the view that the structural position of a firm in the knowledge network is positively related to the firm’s innovative performance. Moreover, they help explain Chilean meat sector’s heterogeneity in innovation performance.

They also carry important implications for the development of industrial policy as well as for firms’ future knowledge management and networking activities, suggesting the need to stimulate knowledge exchanges by creating opportunities for formal and informal collaborations among firms.

Future research could extend the analysis either cross-country or cross-sector and distinguish different forms of innovation (e.g., product and process). This would also allow for a higher generalisation of results.

Acknowledgements

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References


Notes
1 Disclaimer: The views and interpretations in this document are those of the authors and should not be attributed to the Inter-American Development Bank, or to any individual acting on its behalf.
2 For a detailed description of the sector please see Maino et al. (2007) and Agosin and Bravo-Ortega (2009).
3 Both incoming and outgoing linkages are considered, and therefore centrality in this case could also be due to prestige, i.e. being regarded as a reference point for the other firms.
4 Fundacion Chile was behind the development of the country’s salmon industry (Maggi, 2007; Pietrobelli, 1998).