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The Role of Technological Gatekeepers in the Growth of Industrial Clusters: Evidence from Chile

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THE ROLE OF TECHNOLOGICAL GATEKEEPERS IN THE GROWTH OF INDUSTRIAL CLUSTERS: EVIDENCE FROM CHILE

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Abstract

Industrial clusters are often associated with innovative success. However, there is very little research on what types of organizational models apply to clusters as they grow, to facilitate upgrading and innovation – and especially in emerging/developing countries. This paper uses longitudinal micro-level data for a wine cluster in Chile. They show that the most advanced firms in the cluster behave as Technological Gatekeepers – i.e. they acquire knowledge outside cluster boundaries and contribute to diffusing knowledge to other, potentially rival, local firms – and do so persistently over time. The results are explained by combining three theoretical perspectives: evolutionary economics theory; business studies on communities of practice and knowledge workers' know-how trade; and embeddedness theory.

Key words: Industrial clusters, technological gatekeepers, knowledge networks, wine industry, Chile.

SECTION 1 INTRODUCTION

There is widespread consensus that industrial clusters can promote economic development. This optimism about the effect of clusters is fed by well known successful cases such as Silicon Valley, Baden-Württemberg, and the Third Italy (BAGNASCO, 1977; COOKE AND MORGAN, 1994; SAXENIAN, 1994). Based on these and similar accounts, especially since the 1990s, cluster policies are being promoted by national governments and international organizations (e.g. ANDERSSON ET AL., 2004; UNIDO, 2004; RODRIGUEZ-CLARE, 2007). However, there is also a growing literature showing that industrial clusters are not always successful and may not result in participation in global markets (e.g. MCCORMICK, 1997; VISSER, 1999), or may result in decline following decades or centuries of sustained growth and prosperity (see e.g. the case of the Prato textile cluster in Italy, or the recent crisis in the Michigan automotive industrial complex in the US). This has led scholars to elaborate theories of cluster life cycles, peculiar to the cluster phenomenon and independent of the life cycles of their respective industries (MENZEL AND FORNAHL, 2010; BERGMAN, 2008). These theories try to explain why clusters emerge, grow and decline – although not all clusters follow the same trajectory. One way to explain how clusters move from an emerging to a sustained growth phase is to look at how cluster firms learn and innovate. Innovation is widely considered to be key to promoting economic development and growth (FAGERBERG ET AL., 1994; DOSI AND NELSON, 2010) and clusters that manage to obtain and maintain global (or national) leadership in their markets do so thanks to their firms' investment in the creation of innovative ideas, and the generation of technological, organizational and marketing innovations.

In the attempt to explore and understand how clusters innovate, scholars have produced a large and fairly consolidated body of knowledge, which shows the importance of connecting local learning processes in clusters, with extra-cluster sources of technologies and knowledge (i.e. from suppliers or clients, universities and other organizations) (among many others, see: BELL AND ALBU, 1999; HUMPHREY AND SCHMITZ, 2002; BATHELT ET AL., 2004; WHITTINGTON ET AL., 2009). Studies have pointed to the different nature of local vs extra-cluster knowledge, showing that the former is more fine-grained and tacit and is diffused through local social networks, while the latter is typically more codified and conveys a larger

variety of knowledge types and sources. These complementary sources of learning are considered to be vital for innovation. However, not all clusters are equally capable of connecting local to extra-cluster sources of knowledge and certainly not all organizations within clusters are equally exposed to external knowledge. In order to understand how local actors tap into extra-cluster knowledge, some scholars have explored the role of *gatekeepers,* that is, firms with strong connections outside the cluster which contribute also to the diffusion and recombination of external knowledge within the local context (among others see: GAMBARDELLA, 1993; BELL AND ALBU, 1999; GIULIANI, 2003; GIULIANI AND BELL, 2005; MALIPIERO ET AL., 2005; HAUGE, 2006; BOSCHMA AND TER WAL, 2007; BELUSSI ET AL., 2008; MORRISON, 2008; RYCHEN AND ZIMMERMANN, 2008; SCHIFFAUEROVA AND BEAUDRY, 2008; AAGE, 2010; GRAF, 2010). Technological gatekeepers (hereafter TG), named after Allen's (1977) seminal work,[1] are very important firms in clusters since, first, they are capable of searching and selecting extra-cluster knowledge and, hence, are able to identify new techniques, products or ideas that could be introduced into their own firms or others in the territory. Second, in addition to being open to external (and often distant) knowledge sources, TG contribute also to the diffusion of acquired knowledge at the local level, hence they potentially help firms with poor connections outside the cluster to access new knowledge.

Gatekeeping behaviours have been often associated with leading cluster firms (ALBINO ET AL. 1998; LAZERSON AND LORENZONI, 1999; MALIPIERO ET AL., 2005; MORRISON, 2008 – for a different view see BOSCHMA AND TER WAL, 2007), that is, with firms that orchestrate the local value chain, establishing relationships with a large body of local suppliers. Through their vertical networks, leading firms are seen as promoting "an intense knowledge exchange with … supplier firms to achieve higher performance in terms of innovation, efficiency, quality, time, and therefore competitiveness" (ALBINO ET AL., 1998: 58). MALIPIERO ET AL. (2005: 2) add that "leading firms within the cluster assume the role of "gatekeepers" in driving the processes of new knowledge creation and diffusion. They introduce external technological novelties in the cluster and enact new useful knowledge production locally, thus enhancing international competitive capabilities of all firms in the cluster". According to these studies, the incentive of leading firms to behave as technological gatekeepers in local vertical networks is explained by the fact that their own performance depends on the performance of downstream stages (e.g. quality of production of

components or raw materials), hence they have an interest in transferring knowledge and capabilities to their suppliers to improve the quality of their own operations (MESQUITA AND LAZZARINI, 2008). More interestingly, studies show that leading firms may be concerned about maintaining their gatekeeping role over time, since stable and trustful local linkages with their suppliers reduce transaction costs and improve bi-directional learning opportunities (LORENZONI AND LIPPARINI, 1999).

While there is little controversy about the motivations for firms to behave as gatekeepers in local vertical networks, the motivations for TG to transfer knowledge horizontally, that is, to other – potentially rival - firms operating at the same stage in the value chain, are somewhat less understood. Shedding light on this aspect is important because production is increasingly organized along global value chains (GEREFFI AND KORZENIEWICZ, 1994) and over time clusters are progressively less Marshallian and less likely to maintain entire value chains within their geographical boundaries. As BATHELT ET AL. (2004: 37) note, "it has been well known for a long time that clusters and agglomerations are seldom characterized by strong internal input-output linkages". This tendency is becoming more prominent over time, as low-skilled production and knowledge-intensive activities are increasingly off-shored to other countries (UNCTAD, 2004). This displacement of production and innovation activities across the globe is consistent with *local* value chains becoming shorter over time, and specialized in only one (or a few) phases of the whole global production chain. This applies particularly to developing and emerging countries, where clusters have managed to enter global value chains by performing narrowly-defined activities for global buyers (HUMPHREY AND SCHMITZ, 2002).

This paper explores what leads certain firms in industrial clusters to behave spontaneously as TG in horizontal knowledge networks and explores the persistence of this cognitive role[2] in order to throw light on the possible growth trajectories of clusters. More precisely, we investigate the characteristics and persistence of TG compared to two other cognitive roles, namely: External Stars (hereafter ES),[3] that is, firms with high external openness but whose local knowledge linkages are either weak or primarily absorption-centred; and Isolated Firms (hereafter IF), which are firms with very few connections outside or inside the cluster. We take these two roles as a benchmark because both are relevant phenomena in clusters and, in contrast to TG,

neither is likely to contribute to cluster learning, innovation or growth, although for different reasons. ES like TG are open to extra-cluster sources of knowledge and, hence, are potentially valuable channels of knowledge for other cluster firms, but their local knowledge linkages are weak or absent – a characteristic consistent with many cluster narratives, e.g. the behaviour of multinational corporations operating within satellite platform districts (MARKUSEN, 1996) such as Export Processing Zones or similar productive enclaves, where linkages with local firms are rare, especially in developing countries (KOKKO, 1994; ALTENBURG AND MEYER-STAMER, 1999). Recent studies show that IF are a significant phenomenon in clusters (e.g. BOSCHMA AND TER WAL, 2007), and especially in developing countries, where their lack of linkages is often a sign of poor internal skills and capabilities (GIULIANI AND BELL, 2005).

Understanding the behaviour of TG compared to ES and IF, not just to all other firms in a cluster, is important because it can provide useful insights into the evolution of the cluster over time. In clusters where the dominant trend is disappearance of the TG and increased significant of ES and IF the cluster learning system will likely be turned 'inside out' (GIULIANI AND BELL, 2005), with the knowledge linkages in the cluster being almost exclusively external. Without vibrant exchange of knowledge within the local environment (i.e. the local 'buzz') such clusters can lose the opportunity to diversify with respect to other clusters, through the exploitation of local idiosyncrasies. In this case, geographic proximity would be a contingency with no real impact on the success of the cluster firms (as in the case of Export Processing Zones). In contrast, a cluster where the dominant trend is the persistence of TG and where most firms behave as TG is likely to have both local linkages and external connections which can be exploited creating the right conditions for the cluster to grow. Thus, understanding the motivations underpinning TG behaviour over time, compared to other behaviours can provide useful insights for cluster life cycle theory and for the development of clusters more generally.

This paper explores the TG's motivations and behaviour over time by looking at the case of a successful and growing wine cluster in Chile. Based on identical surveys in 2002 and 2006, we show that TG are relatively more persistent over time than ES, while IF tend to persist or to exit the cluster. The paper explains the behavior of TG by combining three theoretical perspectives: evolutionary economics theory on innovation;

business studies on communities of practice and knowledge workers' know-how trade; and embeddedness theory. The remainder of the paper is organized as follows: Section 2 develops the conceptual framework and shows how the theories mentioned above help our investigation. Section 3 discusses why the study of a wine cluster in Chile provides a good research context for our investigation, and Section 4 summarizes the methodology. Section 5 presents the empirical results and discusses them in light of the conceptual framework. Section 6 concludes.

SECTION 2 CONCEPTUAL FRAMEWORK

Why do certain firms in clusters behave as TG and is such behaviour persistent over time? To investigate this question we draw on three theoretical perspectives: evolutionary economics theory on firm innovation and learning (NELSON AND WINTER, 1982; DOSI, 1988; BELL AND PAVITT, 1993; DOSI AND NELSON, 2010); business studies on communities of practice (Brown and Duguid, 1991) and on knowledge workers' know-how trade (VON HIPPEL, 1988); and embeddedness theory (GRANOVETTER, 1985; UZZI, 1997).

Evolutionary economics theory is an essential building block for understanding why TG exist in the first place because it suggests that firms' internal capabilities are the result of a process of cumulative learning, which is inherently imperfect, complex and path-dependent (ARTHUR, 1988; DOSI, 1997).Evolutionary economics theory also suggests that firms are bounded-rational actors, with very incomplete understanding about the 'optimal' choice to improve innovative performance; hence, they try to reduce this uncertainty connected through heuristics and trial and error (DOSI AND NELSON, 2010). These features of the processes of learning and technical change deliver persistent heterogeneity among firms, which means in turn that at any given point in time some cluster firms will have stronger capabilities[4] than others (GIULIANI, 2007a). These differences are likely to influence the nature of their knowledge networks (DANTAS AND BELL, 2009) and the degree to which the firms are capable of forming linkages with extra-cluster sources of knowledge and with other local firms – and thus to behave as TG.

The core of our argument is that firms with stronger internal capabilities are more likely to be more open to extra-cluster knowledge sources than firms with weaker capabilities, since they are better equipped to scan and absorb external knowledge, due to their reduced technological distance from external (frontier) knowledge compared to other firms in the cluster (COHEN AND LEVINTHAL, 1990, among others). Heterogeneity in firm capabilities also influences the pattern of knowledge exchange within the cluster, as firms with stronger capabilities are more likely than firms with weaker capabilities to establish local linkages for two main reasons. First, the former know more and therefore have more knowledge to transfer to other firms. Second, firms with particularly strong capabilities are likely to be perceived by other cluster firms as 'technological leaders' or 'early adopters' of technologies in the local area, leading to their being sought out as sources of advice and knowledge more often than firms with weaker capabilities. By the same token, firms with very limited or weak capabilities are less exposed to being used as sources of technical knowledge by other cluster firms. This theory is supported by recent empirical evidence, based on study contexts as widely different as the Chilean wine industry (GIULIANI AND BELL, 2005), the Italian packaging industry (MALIPIERO ET AL., 2005) and the German regional innovation networks (GRAF, 2010), which show that TG have consistently higher capabilities and absorptive capacity compared to the other firms in their clusters or regions.

While evolutionary theory is important to predict how firms behave on the basis of their different internal characteristics, it does not provide a complete explanation of why firms exchange knowledge locally at the horizontal level. While a *prima facie* consideration might be that rival firms aim at protecting their proprietary knowledge and at minimizing inter-firm leakages of knowledge, the extant literature on communities of practice and on knowledge workers and know-how trade show the opposite is true, i.e. that rival firms exchange significant knowledge via their knowledge workers or other professionals,[5] who seek advice on technical or professional problems outside the firm. Business scholars explain inter-organizational transfer of knowledge via the formation of communities of practice (CoP) (BROWN AND DUGUID, 1991; LAVE AND WENGER, 1991), that is a "group of people informally bound together by shared expertise and passion for a joint enterprise" (WENGER AND SNYDER, 2000: 139). CoPs are informal and spontaneous networks of professionals working in different

organizations whose knowledge transfer is motivated by moral obligation and community interest and not necessarily by narrow self-interest (ARDICVILI ET AL., 2003). Economists' studies on know-how trade also focus on the transfer of technical know-how among different and often rival firms, although they maintain that professionals transfer knowledge to peers on the expectation of receiving useful knowledge back in due course (i.e. reciprocity is the expected pay-off) (VON HIPPEL, 1987; SCHRADER, 1991). To reconcile these views (i.e. community interest vs self-interest), Bouty (2000) suggests that the transfer of knowledge based on community interest occurs when professionals are tied by a strong and long standing acquaintance, and trust each other. In the absence of a personal relationship they "act like pure investors, and their decisions are induced by expectations of short-term return. Reciprocity and immediacy are central to these situations" (BOUTY, 2000: 57)

In a nutshell, studies on CoPs and know-how trade show first, that professionals are a powerful channel of knowledge transfer across competing organizations. Their relationships break away from the logic of competition, are informal and to a certain extent invisible, but their role in promoting incremental innovation is crucial (VON HIPPEL, 1988; SAXENIAN, 1994). Second, the need to find a solution to a technical problem that cannot be solved in house leads professionals to consult peers in competing organizations. Third, acceding to these requests for help and advice from people in competing companies, may depend purely on community membership or on the self-interested expectations of the help being reciprocated. Within the context of industrial districts, LISSONI (2001) provides an excellent case-study on the functioning of these communities. The present paper draws on these studies and argues that, as TG are likely to be firms with strong internal capabilities (in line with evolutionary theory discussed above), they are also likely to employ bright and capable professionals. These will be critical for embedding TG in local knowledge networks, facilitating the transfer of knowledge at the horizontal level.

Finally, embeddedness theory is an important complement to the abovementioned theories because it contributes to explaining why TG are persistent over time. At the core of embeddedness theory is the idea that markets are embedded in systems of social relations, which reduce transaction costs and sanction opportunistic behaviours and malfeasance (GRANOVETTER, 1985; UZZI, 1997; for an economic

geographer's perspective on this subject see, among many others, KEEBLE ET AL., 1999; GORDON AND MCCANN, 2000). Powell (1990: 303) considers networks to be a distinguished form of governance in which "transactions occur through networks of individuals engaged in reciprocal, preferential, mutually supportive actions". The key issue is that firms use networks because they deliver certain advantages vis-à-vis other governance structures such as pure markets or pure hierarchies (POWELL, 1990). First, they permit the informal exchange of unique and idiosyncratic assets such as knowledge or know-how, which market mechanisms are unlikely to transact. Second, they are a relatively loose and rapid way to put individuals or organizations in contact, even if there is no formal connection between them. Third, they have the power to maintain stable and high quality relationships over time, fostering trust and reciprocity. In their study of automatic packaging machinery manufacturers in Italy, LORENZONI AND LIPPARINI (1999: 332) show that leading firms aim at establishing trustful linkages with suppliers and clients and make serious efforts to deliberately create stable networks of selected partners in which knowledge and information are generated and transferred, arguing that "this may foster the learning process in the network". Hence, embeddedness theory provides additional insight into the behaviour of TG. The conjecture is that TG have an interest in cultivating local knowledge networks with trustful partners which may represent valuable sources of learning and are worth maintaining over time.

SECTION 3 THE CONTEXT: WHY A WINE CLUSTER IN CHILE?

This empirical study is contextualized in the wine industry. Known for being a traditional industry, wine production has recently emerged as a dynamic and fairly knowledge-intensive activity (LOUBERE, 1990; PAUL, 1996; GIULIANI ET AL., 2010). Since 1990, wine consumption has changed radically, with market preferences shifting from quantity to quality. The huge increase in wine quality and value on the market is due, to a large extent, to the efforts expended by various industry actors, primarily the wine producers, but also universities and firms in related industries, to introduce changes to the production process and to develop new wine blends (CUSMANO ET AL., 2010). For instance, higher quality has been achieved by modifying planting densities in vineyard and by more refined pruning to achieve higher concentrations of tannins and antocyans in the harvested grapes. Advancements in fermentation and ageing processes have

been remarkable and include the introduction of ad hoc enzymes for different types of vines (for an overview of the process and product innovations in this industry since 1990, SEE GIULIANI, 2007B). In addition to product and process innovations, marketing has been very important to the success of this industry, in terms of branding, supply-chain management, and appropriate market positioning. However, as most industry experts would agree good value wine comes from good grapes, and good grapes are the result of the right innovative choice and much experimentation.[6]

These changes have been accompanied also by a significant revolution in the geography of wine production. During the past two decades, and particularly in the 1990s, New World (NW) countries, such as Australia, New Zealand, South Africa, Chile and Argentina, have become competitive in the international market for premium wines, challenging Old World (OW) producers such as France, Italy, Spain and Portugal (MCDERMOTT ET AL., 2009; CUSMANO ET Al., 2010). The OW countries' shares of world wine total exports have been eroded over time in favour of NW exporters (ANDERSON AND NORMAN, 2001). Chile is an important NW exporter which has caught up to the global frontier of wine production despite being an emerging economy and suffering from infrastructural backwardness compared to the advanced countries (GIULIANI AND RABELLOTTI, 2010).

Chile has a long-standing tradition in wine production going back to cultivation by the Spanish-Mexican Jesuits in Latin America in the 19th century (Del Pozo, 1998). Throughout the 19th and into the mid 20th century, Chilean wine production has low quality and directed at the undemanding domestic market. In the 1960s, Chile was producing large volumes of wine, but exporting a very small proportion compared to other NW producers (about 1% of production compared to 5% in the case of Australia), and commanded a very small share of world exports (about 0.2%). Over the next 30 years, Chilean wine production growth followed a similar path to that in Australia and the NW group as a whole, but its exports as a proportion of total production rose much more rapidly than in the other NW countries to overtake Australia in the early 1990s. By the late-1990s nearly half of total production was being exported – an extraordinary transformation in the structure of production and trade. In terms of quality, the value of its exports increased slowly during the 1970s and 1980s, with its share of world exports remaining constant at around 0.3% throughout most of that

period. Chile's qualitative transformation began in the mid 1990s. Between 1995 and 1999 the value of exports nearly trebled from US$182 m. to US$526 m., accounting for a rising share of rapidly growing NW exports, and reaching a share of world exports (3.6%) by 1998, roughly the same as Australia's share in 1996. This growing trend in exporting accelerated after 2000, and in 2006 Chilean wine exports overtook the USA and caught up with the NW leader, Australia (CUSMANO ET AL., 2010).

The above shows that Chile is an example of an emerging economy that managed to pool its resources to achieve success in this industry.[7] Chile has several production areas;[8] this study focuses on Valle de Colchagua, knownfor being one of the currently most thriving and successful areas in the country (SCHACHNER, 2002, 2005). The Valle de Colchagua cluster is located about 180 km south-west of Santiago. It is a rural area, densely populated by wine producers and grape growers; the other firms in the wine production value chain – either upstream or downstream – are located outside the cluster territory – close to Santiago or other major urban areas, or abroad. As a result, the vertical division of labour within the cluster is rather shallow. In addition to the wineries, the cluster traditionally has hosted a business association, aimed primarily at the promotion of wines and the marketing of the local wine route, but with no specific mandate to foster innovation or the dissemination of technical knowledge. Other organizations are being incorporated into the cluster (see later in this section).

Wineries in the cluster focus on the production of high quality wines and target similar domestic and international markets – although not all firms are equally successful. Much of the evidence from interviews and secondary data in the form of specialized journals and videos[9] about Colchagua wineries, suggest that they aim at producing high quality and competitive, world quality wines based on innovative wine making processes and the unique characteristics of the climate and *terroir*. The key challenge for the leading firms in the cluster is to produce in Chile a wine that can compete with the best wines in the world - an objective met in 2008, as one of the cluster wines was awarded the "Wine of the Year" Prize by *Wine Spectator.* Most industry accounts clearly suggest that each firm in the cluster aims at achieving individual success through a constant search for product differentiation. Hence, although firms in the cluster may feel that the overall improvement in Chilean or Colchaguan wine positioning in the international market may have positive

indirect repercussions for their own competitiveness,[10] each winery is keen to improve the quality of its own wines. Because all the firms trade in the international market, their wines are inevitably in competition on the shelves of international retailers. Thus, even within the same cluster, firms try to out-compete one another. This is in line with WHITTINGTON ET AL. (2009: 91), who suggest that "competition within regions is often much more intense than outside them".

At the time of the first survey (in 2002), the wine industry in the Valle de Colchagua was beginning to taste success following ten years steadily increasing investment in the area.[11] New modern wineries had set up operations in the cluster and there was a general feeling that Valle de Colchagua would become one of the leading wine areas in Chile. Despite the problems connected to in rural Chile (inadequate infrastructure being the most important), private investors, mostly powerful Chilean families, were making considerable efforts, in some cases jointly with public institutions (e.g. CORFO)[12] to renovate and modernize the industry and catch up to the technological frontier. Already in 2002, some Colchagua wineries were as modern as wineries in the advanced countries, and a substantial proportion of firms was using advanced technologies, employing skilled knowledge workers (enologists and agronomists) and undertaking substantial experimentation in their vineyards and cellars. This was reflected in the quality of wines that became increasingly cited and rated in international specialized wine journals, such as *Wine Spectator, Decanter, Wine Enthusiast*, etc.[13] Nevertheless, in 2002, a considerable number of the firms in the cluster were technological laggards.

By 2006 the cluster had changed quite strikingly. The most visible change was the improvement in the local infrastructure: there were new paved roads, a training institute specialized in wine production had been set up for local students, and arrangements were in progress to establish a research laboratory and a technology transfer office connected to the University of Talca. A set of marketing initiatives was being promoted ranging from strengthening of the wine route to the set up of new ventures connected to the flourishing local economy (promotion of local artisans, fairs, new restaurants, etc.) A number of new wine producers had established themselves in the area and, from 2005, local enologists held formal monthly meetings (*Reuniones de Enologos*) to exchange views about the local wines and to compare production methods. These changes

were paralleled by continuous commitment of the wineries to match international standards in wine quality. In 2005 Colchagua has been awarded the title "Wine Region of the Year" by *Wine Enthusiast*, and in 2007, *Wine Spectator* listed two wines from Colchagua among its Top 100 wines.

This context is particularly suited to the present research because, as a result of this recent wave of changes in the wine industry, cluster connections with external (both foreign and national) knowledge and technologies have been vital. For example, TG may be able to identify new techniques related to pruning or irrigation of the vines. The adoption of Israeli-produced equipment for drip irrigation is an example here. At the same time, the wine industry is one where adaptation to the local *terroir* (i.e. climate and soil conditions) is critical to achieve high quality standards. For instance, understanding what type of vine clones are appropriate for the local *terroir* requires significant local experimentation by cluster firms. Hence, interaction within the cluster is important to compare experiences and learn from one another about. the introduction of new techniques or machine-embodied technologies, for example. In this context, TG are critical for fostering external connections and boosting the local diffusion of knowledge.

SECTION 4 METHODOLOGY

4.1 The data

This study is based on micro-level data, collected at firm level in the Valle de Colchagua cluster at two points in time: 2002 and 2006. Prior to the main fieldwork, we conducted exploratory interviews with industry experts to obtain in depth knowledge on the wine industry and the contextual and historical background to the wine industry in Chile. This involved interviews with agronomists and enologists employed in several Chilean firms (other than those in Valle de Colchagua); with industry representatives in the main country business associations and consortia (Vinas de Chile, Chilevid, Corporacion Chilena de Vinos, Vinnova), with researchers at university research laboratories specialized in wine-related fields and in other public research organizations (University of Chile, Catholic University, University of Talca, Instituto Nacional de Investigacion Agropecuaria- INIA). A pilot study was conducted to test the questionnaire used in the main fieldworks, which involved interviews with agronomists and enologists working in firms outside the Valle de Colchagua cluster. For the main fieldwork, interviews followed the same procedure. All

interviews in both periods were face-to-face, and were conducted at the same time of the year (August-September), based on an almost identical structured questionnaire.[14] The survey was directed to wineries and did not include suppliers or clients – mainly because with the exception of the grape growers these actors are located outside the cluster boundaries. In both years, interviews were carried out with the firms' skilled workers (i.e. enologists or agronomists) in charge of the production process at firm level and lasted an average of 90 minutes. The surveys in both years covered the whole *population* of fine wine producers in the cluster – 32 firms in both cases.

Table 1 indicates that there have been considerable changes in several characteristics of the firms over the four years – reflecting the cluster's development over these years. Their increased size is particularly striking: nearly half (48%) employed more than 100 people in 2006, compared with only 6 per cent in 2002. The proportion of firms with fewer than 20 employees had fallen to less than 10%, and the average size of the firms had doubled from 55 to 110. The number of firms established since 2000 increased from the original 6 to 10 (2 established in the 2000s exited the cluster before 2006, and 6 new entrants joined the cluster). This reflects part of a broader pattern of entry and exit in the cluster, with six firms exiting and six entering.[15] There was considerable increase in the proportion of foreign owned firms – rising to about one-third by 2006. This increase is not a direct result of entry and exit: all entrants were domestic firms that established new businesses, and one of the six exiting firms was foreign owned. The increased foreign ownership arose as a result of the acquisition of incumbent businesses by foreign owned firms, and by the involvement of one domestic incumbent in a joint venture partnership with a foreign owned firm.

[Table 1 about here]

In addition to the general background variables presented at Table 1, the questionnaire was structured to collect information about: (i) firms' innovative behaviour and internal capabilities (e.g. skills, training and experience of technical workers; introduction of innovations; intensity and types of experimentations carried out internally and/or in connection with other actors); (ii) different types of inter-firm linkages within the cluster (e.g. knowledge linkages, business linkages); (iii) extra-cluster linkages formed with different sources

of knowledge at the national or international level (supplier, clients, universities, business associations, consultants, others); (iv) firms' market and performance indicators (e.g. percentage of exports; main exporting markets; profitability trends).

The remainder of this section discusses the types of questions asked in the survey to identify TG, ES and IF. These questions were designed to capture: (a) the external openness of firms, measured on the basis of the linkages established with extra-cluster sources of knowledge; and (b) the connections of firms within the intra-cluster knowledge network. The information was collected as described below.

(a) External openness: acquisition of knowledge from extra-cluster sources

We asked about the acquisition of knowledge from sources outside the cluster, both national and international. Specifically, respondents were asked to indicate from a list of possible extra-cluster sources of knowledge (universities, suppliers, consultants, business associations, etc.), those that had contributed to the technical enhancement of their firms. They were also asked about cooperation with any of those sources for joint research and experimentation. The questions formulated are reported below:

> ***Q1**: **Technical support received***
>
> Could you mark, among the actors included in the roster, those that have transferred relevant technical knowledge to this firm?
>
> ***Q2: Joint experimentation***
>
> Could you mark, among the actors included in the roster, those with whom this firm has collaborated in research projects in the last two years?

The list included all national research organizations, business associations, consortia and other institutional bodies potentially relevant to the industry. It included a relevant private actors (e.g. test laboratories) and a generic category of consultants and suppliers. Respondents were asked to indicate any other national or international sources of relevant knowledge.

(b) The local knowledge network

In the interviews, these relational data were collected using a roster recall method (WASSERMAN AND FAUST, 1994), meaning firms were given a list (roster) of the other wine producing firms in the cluster and asked questions related to the transfer of innovation-related knowledge. *Q3* and *Q4* (reported below) specifically address problem solving and technical assistance and involve some effort related to improvements and change the wine firm's economic activity. For example, knowledge is transferred through a suggestion about how to treat for a pest or how to deal with high acidity levels during wine fermentation. The knowledge is transferred usually in the form of a reply to a query on a problem that has emerged,[16] as indicated below:

> ***Q3: Technical support received [inbound]***
>
> If you are in a critical situation and need technical advice, to which of the local firms mentioned in the roster do you turn? [Please indicate the importance you attach to the information obtained in each case by marking the identified firms on the following scale: 0= none; 1= low; 2= medium; 3= high].

> ***Q4: Transfer of technical knowledge [outbound]***
>
> Which of the following firms do you think have benefited from technical support provided from this firm? [Please indicate the importance you attach to the information provided to each of the firms according to the following scale: 0= none; 1= low; 2= medium; 3= high].

These relational data are expressed in a matrix composed of *n* rows and *n* columns, corresponding to the number *n* of firms in each cluster. Each cell in the matrix reports the occurrence of knowledge transfer from firm *i* in the row to firm *j* in the column.[17] The matrices resulting from these data specifically capture important characteristics of inter-firm horizontal knowledge transfer, in line with the objectives of this paper.

4.2 Operationalization of key concepts

The analysis requires the definition of the different cognitive roles, as described below.

(i) TG

Conceptually, TG are firms with high external openness, which represent significant sources of knowledge for other firms in the cluster. To capture both these dimensions, we consider TG as firms with *both* of the following characteristics: (a) higher than average external openness; (b) active engagement in purposive transfer of knowledge to other cluster firms.

External openness (a) is measured by considering the knowledge linkages of firms with extra-cluster sources of knowledge (*Q1* and *Q2*). In the analysis, we grouped linkages into ten sources and channels of extra-cluster knowledge ((i) universities and public research laboratories; (ii) other public institutions; (iii) suppliers; (iv) clients; (v) other firms outside the cluster – including the headquarters when the firm is foreign; (vi) business associations and consortia; (vii) domestic consultant; (viii) foreign consultant; (ix) private laboratories; and (x) other sources). The importance of each source for the transfer of technical knowledge into the firm was measured on a 0-3 scale, where 0 is 'no importance' and 3 'maximum importance'. For example, if three different universities were listed as sources of extra-cluster knowledge and all were ticked, the value for 'universities and public research labs' for this respondent would be 3. If none was ticked, the value would be 0. According to these criteria, the value of a firm's external openness could range from 0, in the case of no linkages with extra-cluster sources of knowledge being established, to 30 when maximum extra-cluster interconnection was achieved by a firm for all categories.

For (b), we refer to GIULIANI AND BELL's (2005) distinctions between different intra-cluster 'cognitive positions' in the knowledge network: mutual exchangers, sources, absorbers and local isolates.[18] We consider TG to be firms which, at local level, behave as *mutual exchangers* or as *sources* of knowledge, as these two positions reflect active engagement in the transfer of knowledge to other cluster firms. The propensity of a firm to be a local *source* of knowledge is measured as the ratio between two sociometric measures, calculated on the basis of the knowledge network described earlier (Section 4.1 (b)): *in-degree centrality*, which measures the number of knowledge linkages of a firm (a measure of the extent to which technical knowledge is *acquired by* a firm from other local firms), and *out-degree centrality*, which measures the number of knowledge linkages originating in a firm (a measure of the extent to which technical knowledge *is transferred by* that firm to other local firms). Hence, a local *source* of knowledge is defined as a firm whose

in- and *out-degree centrality* ratio is lower than 1. Similarly, *mutual exchangers* are defined as firms whose *in-* and *out-degree centrality* ratio is equal or proximate to 1 (see Appendix A-1 for more detail on these measures).

(ii) ES

ES are firms with high external openness, but with limited knowledge links with other cluster firms. Where they exist, these intra-cluster links are primarily inward and absorption-centred, in line with GIULIANI AND BELL (2005). Hence, ES are identified considering the characteristics of: (a) having higher than average external openness similar to TG; (b) behaving as net *absorbers* of local knowledge or as local *isolates*. Absorbers are measured as firms whose *in-* and *out-degree centrality* ratio is higher than 1; while local *isolates* are firms whose *in-* and *out-degree centralities* are approximately 0 (see Appendix A-1 for more detail on these measures).

(iii) IF

IF are firms that are poorly linked at both local and extra-cluster levels. Hence they have lower than average external openness and behave as local *isolates* at local level.

It is important to remember that this is a case-study, hence the method used to measure the presence of TG, ES, or IF is validated by the qualitative evidence collected through the interviews with firms on learning behaviour.[19] For instance, a wine producer from a foreign country very well connected with several foreign sources of knowledge (e.g. headquarters, consultants, etc.), in the 2002 survey explicitly stated unwillingness to interact with other firms in the local area mainly for fear of revealing proprietary knowledge. Data collected on this firm's extra- and intra-cluster linkages show that it falls into the group of ES, confirming the interview data. Similar cross-validations were carried out for all firms in the gatekeeper and isolated groups, as these roles emerged prominently during interviews.

Table 2 reports descriptive statistics for the three cognitive roles. It shows the distribution of firms in 2002 and 2006 according to these roles. The number of TG has barely changed – accounting for 37% of firms in

2006 and 35% in 2002. In contrast, the number of IFs decreased by about 30%- accounting for 22% of firms in 2006 and 31%in 2002. The number of ES has fallen even more sharply, accounting for 16% of cluster firms in 2002 and only 6% in 2006.[20]

[Table 2 about here]

SECTION 5 EMPIRICAL RESULTS

5.1 TG: key characteristics and motivations

TG are fairly pivotal actors in the wine cluster investigated here. Figures 1 and 2 show that they are responsible for much of the local connectivity as well as the cluster's openness to external sources of knowledge. Figures 1(a) and (b) show the whole local knowledge network with black squared nodes highlighting the positions of TG in 2002 and 2006 respectively. Figures 2(a) and (b) show that if TG are removed the knowledge networks are totally disrupted. Given their critical role, it is important to investigate the characteristics and motivations of TG firms.

[Figures 1(a-b) and Figures 2(a-b)]

A starting point is to look at selected features of TG compared to ES and IF. In descriptive terms, firms with higher than average external openness, such as TG and ES, display strong connections with domestic universities and foreign suppliers and consultants (and in some cases even with foreign universities). Their outward orientation in 2006 is quite striking. Almost all have connections with the four leading research institutions in the country, the Catholic University, the Universities of Talca and of Chile and the INIA. In addition, most of these firms have established knowledge linkages with international sources of knowledge (suppliers and consultants). They have significant linkages to national business associations (esp. Chilevid and Vinas de Chile). In contrast, IF extra-cluster linkages are less frequent and where present, they involve mainly suppliers, domestic and foreign, and domestic consultants. Some also have linkages to national

universities (Catholic University and the University of Talca); while connections with business associations are negligible.

Focusing more specifically on their characteristics, Table 3 reports descriptive statistics for TG, ES and IF. Table 3-i reports general characteristics (size, origin of capital, years of cluster membership), showing that none of them differs significantly across the three cognitive roles. What is striking is that the share of foreign firms in total firms in the group of TG is not very high (27% in 2002; 42% in 2006) and that some wineries with foreign capital fall into the IF group.[21] Also, ES are younger firms in the cluster, although the differences with other groups are not statistically significant, at least in 2002.[22] Moving from general to innovation-related characteristics, statistical differences start to emerge (Table 3-ii). First, TG and ES employ more employees with undergraduate or post-graduate technical profiles (i.e. knowledge workers, in this context agronomists and enologists) than IF (Table 3-ii-a). Second, TG and ES are more involved in experimentation than IF (Table 3-ii-b) and the composite indicator of their knowledge base, reflecting both internal skills and experimentation intensity, is significantly higher in TG and ES than in IF (Table 3-ii-c). Differences between TG and ES and the remaining firms in the clusters are not reported here, but indicate that TG and ES have stronger internal capabilities (as reflected by their higher internal skills and experimentation activities).

[Table 3 about here]

The results are consistent with other empirical studies (e.g. MALIPIERO ET AL., 2005; GIULIANI AND BELL, 2005: GRAF, 2010) and can be explained by evolutionary theories and the role played by the persistent heterogeneity of firms in shaping networks. This paper argues that, due to their advanced capabilities, TG are more open externally and also are more capable of transferring knowledge to the local context, both because they have more to transfer and because their more advanced knowledge acts as a signal to other firms about which firms to consult for advice: other firms are attracted to TG like bees to honey.

The qualitative evidence collected during the fieldwork helps to identify the motivations of TG firms. It shows that firms with advanced capabilities, such as TG, transfer or exchange technical knowledge through the social connections built by their knowledge workers – i.e. the enologists and agronomists – who are members of the local CoP. The behaviour of these workers is noticeably similar to that of the steel engineers described by von Hippel (1987: 76), who "when required know-how is not available in-house, engineers …learn what they need to know by talking to other specialists. Since in-house development can be time consuming and expensive, there can be a high incentive to seek the needed information from professional colleagues". As the following interview extract show, technical advice from other knowledge workers in the cluster provides significant input into the production and innovative process:

> "Other's advice is necessary for reasoning on your problems. It is not that you apply what the others tell you but you use those bits of knowledge adapting them to your context and trying to improve upon them. It is always interesting to see how others solve the problems or the methodologies they use for that purpose."[Interview with an enologist, 2002]

Sharing knowledge seems to be part of agronomists and enologists' day-to-day practice and they seem to be unphazed by the possibility of proprietary knowledge being revealed among the CoP. Qualitative insights collected during the interviews reveal that most respondents agree that releasing technical knowledge does not easily result in lost profits or loss of market position for the releasing firm, because "the peculiarity of firms reside in the *terroir*, [and] the same 'piece' of technical knowledge produces different results when applied to practice" [Interview with an agronomist, 2002], This should be understood with the caveat that not *all* the proprietary knowledge is disclosed to peers. Instead, knowledge workers select the knowledge that they transfer and some 'secrets' are not fully disclosed. Quite consistent with von Hippel (1987), the undisclosed knowledge is likely to represent considerable competitive advantage for the firm as illustrated by the following extract:

> "One thing I am keeping secret concerns our experimental clones, which are 'hidden' in the vineyard and not easy to find. This is because otherwise anyone could go in the vineyard cut

some part of the plant shoots and propagate our material somewhere else." [Interview with an agronomist, 2002]

These insights are additional evidence about the importance of knowledge workers' social connections to transfer technical knowledge across organizations and, more importantly, points to the fact that this mode of knowledge transfer is not a characteristics just of high tech cluster or "hot spot" locations (WHITTINGTON ET AL., 2009), and can be important in more "traditional" clusters in developing world sectors. This result is consistent with prior studies on CoPs and know-how trade (e.g. BROWN AND DUGUID, 1991; LAVE AND WENGER, 1991; LISSONI, 2001), showing that knowledge workers' interactions are not inhibited by the fear of dissipating proprietary knowledge and instead are motivated by the need to learn about how their peers solve problems for which inhouse investigations would be too costly or too lengthy.

5.2 TG over time

A second objective of this paper was to explore the extent to which TG in industrial clusters maintain this position over time compared to the roles of ES and IF. To explore this question, Table 4 reports the changes in firms' cognitive roles between 2002 and 2006. It shows that TG is the most persistent cognitive role: 64% of TG firms in 2002 were still TG in 2006 – i.e. seven firms are persistent TG (see also Table 5-i). Only two firms' roles changed and they became IF. In contrast, none of the ES firms persisted in that cognitive role – they moved in different directions with one becoming more embedded at the local level and becoming a TG and the other three taking on poorly connected roles or exiting. Finally, 50% of IF remained completely isolated and 30% exited the cluster (and the industry). Only one IF became slightly more connected at the intra-cluster level.

[Table 4 about here]

Having established that TG are stable actors, it is interesting to investigate what underlies this stability. We do this by looking at the characteristics of the relationships and the firms to which these

persistent TG have direct connections, that is, we investigate the properties of persistent TG 'social neighbourhoods'.

Table 5-i shows that, on average, a persistent TG social neighbourhood more than doubled in size – shifting from an average of 5.73 firms in 2002 to an average of 12.5 in 2006. This indicates that these firms over time increased the number of firms to which they transfer (or exchange) technical knowledge. In terms of the nature of the relationships (Table 5-ii), we see that some 70% of persistent TG maintained at least 50% of their social neighbours over time, indicating significant stability of their social relations, while two persistent TG (30%) maintained their social neighbourhood almost unaltered. Relatedly, it is interesting that the percentage of mutual exchangers within the social neighbourhood progressively increased over time, shifting from 43% in 2002 to 65% in 2006 and that almost all (89%) of the mutual exchangers in the TG's neighbourhood in 2002 persisted in that position in 2006 (Table 5-ii).

The stability of social ties and the growing presence and persistence of mutual exchangers seems consistent with reciprocal ties becoming progressively more important over time. This result is coherent with embeddedness theory and shows the importance of stable and reciprocal relationships for fostering trust and increasing the quality and value of the knowledge flowing within a TG social neighbourhood (UZZI, 1997). The fieldwork interviews reflect this and suggest that trust influences the quality of the knowledge that is transferred to other firms in the cluster:

> "It is the quality of the technical advice that changes when you trust a person. For example, if a professional asks me: "have you started treating the vineyard?", if I trust him I'll answer: 'no, I'll start next week!'; if I don't trust him I just say 'no!'….and by 'trustful' I mean a reliable and correct person." [Interview to an agronomist, 2002]

> "We are all "on the same boat" …that's why I tend to release information. Sometimes people that do not fully trust the other professionals, tend to disclose only half truths, but when they trust you they disclose much more fine-grained knowledge. They tell you everything!" [Interview with an agronomist, 2002]

However, trustful and stable ties are not established with just *any* firm in the cluster. Table 5-iii reveals that TG social neighbours have some special characteristics. In both 2002 and 2006, more than half of their social neighbours were other TG (66% in 2002; 52% in 2006). Accordingly, TG's social neighbours have higher external openness, conduct more experiments and have stronger knowledge bases than the other firms in the cluster (i.e. an ANOVA test give significant results for all three indicators). [23]

[Table 5 about here]

These results point to the fact that TG have an interest in maintaining linkages with firms from which they can learn since the firms they establish persistent linkages with are capable of transferring high quality knowledge – based on their external openness and internal advanced capabilities – and hence offer significant learning opportunities to the focal TG. Being connected to a wide variety of extra-cluster actors, may render the TG a constant source of fresh ideas and learning opportunities for the other firms in the social neighbourhood. Hence, the search for trustful and reciprocal ties with these firms is a way of guaranteeing that the knowledge circulated through these linkages is valuable.

5.3 ES and IF

While the focus of this paper was on TG, with ES and IF as benchmarks, it is important and interesting to comment on their behaviour. In the case of ES, an obvious explanation for their role is that knowledge workers employed by these firms are not allowed to disclose or exchange knowledge with other nearby firms, based on the presumption that extra-cluster knowledge will be more than enough to feed the internal learning and innovation process. This view is in line with several cluster accounts, including Morrison (2008: 828), who cites the case of Natuzzi in his study on the Murge Sofa district in Italy, suggesting that:

> "the top management of Natuzzi has been described by respondents as particularly concerned about the risks of leakages of the firm-specific knowledge held by some employees (e.g. designers), which are now subject to explicit non-disclosure agreements, as well as exclusivity rules that have been implemented also with providers of critical inputs".

Another interpretation refers to ES more recent establishment within the cluster compared to other firms, a condition that may justify the presence of a certain degree of social distance from other firms – an interpretation that is consistent Boschma and Ter Wal's (2007) explanation about leading firms not behaving as gatekeepers in the Barletta footwear district in Italy. Other interpretations are related to the quality of the other local firms since some firms may be unwilling to establish linkages with others if they perceive that the technological distance is too great, in terms either of quality (e.g. application of different techniques and production of different types of wines) or of quantity (e.g. ES are far advanced technologically compared to the other firms in the cluster). These interpretations are plausible and consistent with much of the existing literature on technological distance and knowledge flows (see e.g. ARORA AND GAMBARDELLA 1990; MOWERY ET AL., 1996; MOWERY ET AL. 1998; LANE AND LUBATKIN, 1998). However, given the highly unstable role of ES in the cluster studied here, none of these interpretations appears sufficiently robust to predict their behaviour over time.

In the case of IF, two interpretations hold. On the one hand, exit of IF is largely the result of market selection: these firms exit the industry because their weaknesses severely hamper their competitive position in the market. On the other hand, the persistence of some IF in spite of their lack of improvement, is due to weak selection in the market and is in line with recent work in evolutionary economics that shows that different types of market imperfections "allow firms characterized by diverse degrees of efficiency and product qualities to coexist without too much selective pressure" (DOSI AND NELSON, 2010: 111; see also BOTTAZZI ET AL., 2009). This explains why some IF exit the industry, while others survive.

SECTION 6 CONCLUSION

Globalization makes industrial clusters both more vulnerable, due to increased competition and to growing international division of labour, and more important as they promote innovation. To explore how clusters manage to grow in this context, this paper takes the case of a wine cluster in Chile. It tells the story of a successful and growing cluster where a spontaneous dominant organizational model emerges and becomes consolidated. This model is characterized by the presence and persistence of TG, which are among the most

externally-oriented and technologically advanced firms in the cluster and are also significant contributors to the local knowledge network. TG play a critical role in both reducing cluster technological uncertainty and avoiding negative technological lock-in. While the reasons for their existence can be found in their advanced capabilities and the formation of local knowledge communities by their professional workers (agronomists and enologists), their persistence is due to the fact that TG firms have an interest in tapping into local knowledge and in maintaining stable and high quality linkages with other firms – especially those that are similarly advanced and are also TG. Thus, *TG feed other TG*, whereas connections with weaker firms such as IF rarely occur.

The emergence and consolidation of this organizational model appears to be due to the spontaneous need of firms' knowledge workers to find valuable partners with whom to exchange critical knowledge and advice on day-to-day working practice. However, this result is not obtained in an institutional vacuum. As already pointed out, since the 1990s, Chile has made significant progress in the wine industry through investment in university research and the training and education of a whole new generation of experts, specialized in different fields spanning agronomics, enology, chemistry, engineering and biotechnology, whose skills have been critical to promote technical change in the industry. In most cases, wine entrepreneurs have been successful in valorizing these talents, by allowing and boosting their connections both within and beyond the local context. In this sense, Chilean wine-makers appear not to be narrow-minded and obsessed with protecting their proprietary knowledge assets. This was the situation in the phase of market expansion. Following the financial crisis , it remains to be seen whether the socialization of knowledge by TG will continue.

This research has implications for the industrial cluster literature. First, it provides insights relevant to building a cluster life cycle theory. It shows that during the early growth phase of a successful cluster, leading firms working as TG become progressively more popular sources of local learning (as reflected by their bigger social neighbourhood) – a condition that may breed success in the cluster (cf. GRAF AND KRÜGER, 2010). Hence, this evidence seems to support the view that, as clusters evolve, firms tend to move towards more successful companies (see MENZEL AND FORNAHL, 2010), for technical advice or

imitation. However, this study does not provide full support for the idea that, as clusters grow, heterogeneity is reduced by way of this imitation and adjustment process. This paper shows that the weakest firms (IF) do not benefit from the presence of nearby TG. Other works in the wine context suggest that weak and disconnected actors typically escape complete marginalization through connection with local bridging public or private-public institutions (e.g. LORENTZEN, 2010; MCDERMOTT ET AL., 2009). Without doubt, the participation of weak firms in local knowledge networks, including TG social neighbourhoods, is an area requiring more research.

Second, this paper contributes to research on industrial cluster learning and innovation. Research in this area has flourished since 1990, and the emphasis recently has been on understanding how local learning processes can be fed by (and can feed) global knowledge pipelines (BATHELT ET AL., 2004, among many others). Recent publications on gatekeepers reflect this growing interest (GIULIANI AND BELL, 2005; MALIPIERO ET AL., 2005; HAUGE, 2006; BOSCHMA AND TER WAL, 2007; BELUSSI ET AL., 2008; MORRISON, 2008; RYCHEN AND ZIMMERMANN, 2008; SCHIFFAUEROVA AND BEAUDRY, 2008; AAGE, 2010; GRAF, 2010). This paper progresses the research by looking at the behaviour of gatekeepers over time. Very little research has been undertaken on the dynamics of gatekeepers (for an exception see: GRAF AND KRÜGER, 2010). Also, while most research focuses on TG's vertical networks, this work is original in exploring how TG contribute to spark and sustain local horizontal networks.

Third, this paper contributes to the study of industrial district innovation and upgrading in developing/emerging countries (e.g. HUMPHREY AND SCHMITZ, 2002; SCHMITZ, 2004; MCDERMOTT ET AL., 2009). At the end of the 1990s, scholars called for a new research agenda in the study of developing country industrial clusters. One of the key directions called for was investigation of the ways in which cluster firms enter into global competition and upgrade their capabilities by establishing connections outside the cluster (BELL AND ALBU, 1999; SCHMITZ AND NADVI, 1999). Since 2000, scholars have shown that cluster firms in developing countries can access global knowledge and upgrade their products and processes by entering global value chains (SCHMITZ, 2004; CAMMET, 2006) or global production networks (ERNST, 2002), or by connecting to subsidiaries of multinational corporations located

nearby (ALTENBURG AND MEYER-STAMER, 1999; YEUNG ET AL., 2006). While most of these studies focus on foreign actors, comparatively less research has been undertaken on how clusters manage to enter global knowledge pipelines without going through foreign buyers or multinational firms. This paper shows the emergence of an organizational model where extra-cluster knowledge is bridged into the cluster through foreign *as well as* domestic firms. It is possible that the latter have learnt from the former how to access extra-cluster knowledge and, therefore, that foreign firms have played a historic role in sparking the openness of the cluster. Anecdotal evidence about the history of the cluster shows that some foreign firms such as Casa Lapostolle (a joint venture between a Chilean family and the French family Marnier) or Los Vascos (a Château Lafite Rothschild property) have sparked innovation in the cluster introducing significant novelties in wine making, especially the French wine-making approach. However, there is also evidence of local champions, such as Aurelio Montes or the Luis Felipe Edwards wineries, to mention the most prominent cases. More research on how local champions emerge and become gatekeepers is important since, in developing countries, domestic capabilities should be strengthened from the inside, not just through foreign actors.[24]

This analysis is set within specific empirical and methodological limits. The first is that this is a single industry study. The generalization of its results is therefore bounded by the specificities of the wine industry. In particular, this industry is characterized by rather incremental innovation by cluster firms, which allows proprietary knowledge to be diffused without problematic competitive backlash effects. It is conceivable that in industries where the pace of innovation is higher and the relevant knowledge is protected by patents, the local horizontal transfer of knowledge will be more limited, and different will also be the characteristics of TG social neighbourhoods.

The second limitation concerns the conceptual framework. Alternative explanations about TG behaviour might exist. For instance, TG may have an interest in promoting local knowledge exchange as they seek to increase the overall quality of the wine in the cluster– thus improving the quality of the 'cluster brand' and generating a collective good.[25] Over a hundred interviews carried out with agronomists and enologists prior and during fieldwork suggest that this is not a good interpretation in this case, but further research could

explore the validity of this motivation further. Also, while this study is in line with Boschma (2005), who suggests that geographical proximity is not sufficient to promote learning and innovation, it does not explore whether other types of inter-firm proximities (cultural, social, organizational, etc.) favour knowledge linkages and promote the inclusiveness of cluster firms within TG social neighbourhoods. Other studies might want to probe these motivations. Furthermore, while focusing on private TG, this study does not analyse the gatekeeping role of public institutions (relay centres, regional development agencies, public research organizations, etc.). Other studies on wine clusters focus on these actors (see GIULIANI AND RABELLOTTI, 2010; LORENTZEN, 2010; MCDERMOTT ET AL., 2009).

The third limitation refers to the operationalization of the gatekeeper concept. This paper considers only one type of gatekeeper (the TG), which channels *technical* knowledge only. However, other types of knowledge gatekeepers (acting as channels of marketing, strategic, or other types of knowledge) can be equally relevant to feed cluster firms' competitiveness. Also, this paper uses a single measure of TG – in line with previous works by the author. Other works might wish to develop alternative measures. The fourth and final limitation is related to the time frame considered, which is able to capture changes only at four years' distance. Results should therefore be interpreted bearing in mind this caveat. However, recall that the years considered are rather critical years in the history of this cluster, as they capture exactly the period from emergence to international success and recognition.

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Figures

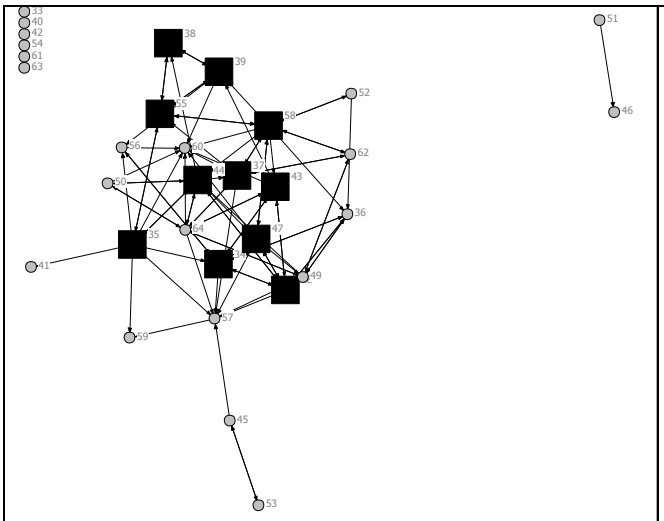


Figure 1(a) TG in the intra-cluster knowledge network in 2002

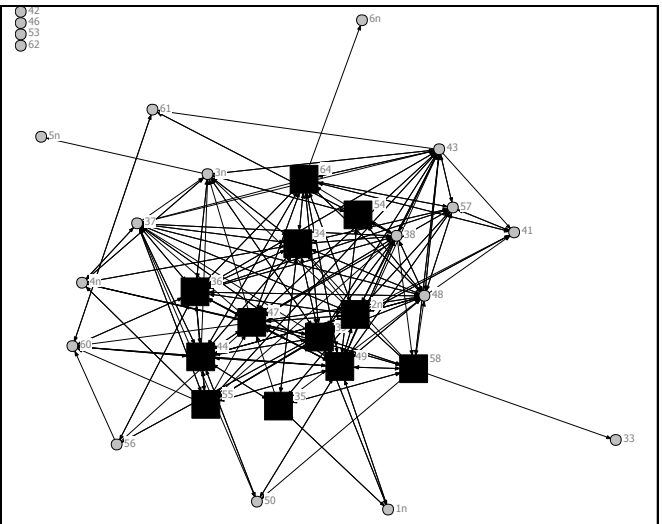


Figure 1(b) TG in the intra-cluster knowledge network in 2006

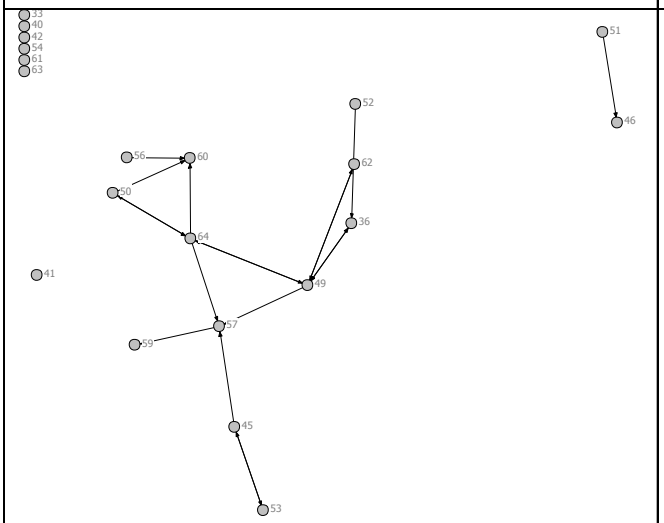


Figure 2(a) The intra-cluster knowledge network in 2002 without TG

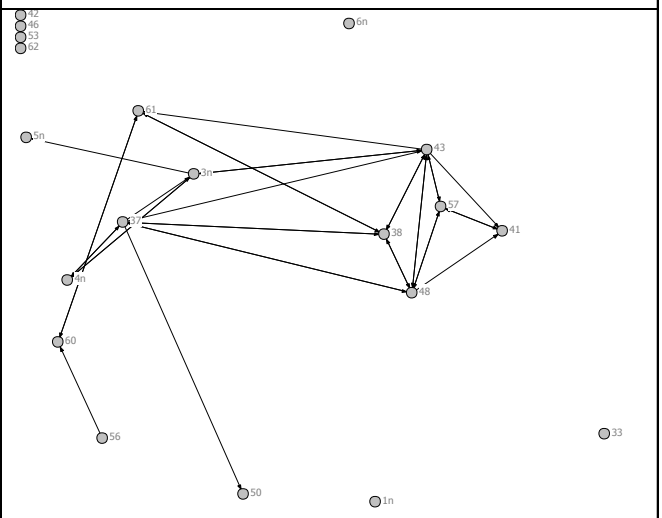


Figure 2(b) The intra-cluster knowledge network in 2006 without TG

Tables

Table 1 Firm characteristics in the two survey years

			2002	Entry/Exit	2006
Characteristics of firms			(N= 32)	2002 – 2006	(N= 32)
(a)	**Size (number of employees)**				
	Small (1-19)	(%)	28		9
	Medium (20-99)	(%)	66		43
	Large (≥100)	(%)	6		48
	Average Number of Employees per firm	(number)	55.5		110.5
(b)	**Year of establishment in the cluster**				
	Up to 1970s	(number)	6	-1	5
	During the 1980s	(number)	8	-1	7
	During the 1990s	(number)	12	-2	10
	During the 2000s	(number)	6	-2 + 6	10
(c)	**Firm entry and exit: 2002 – 2006**				
	Exit – Number of firms	(number)		6 (5 domestic)	
	Entry - Number of firms	(number)		6 (All domestic)	
(c)	**Ownership**				
	Domestic	(%)	81		66
	Foreign	(%)	19		34

Table 2 Key features of Technological Gatekeepers, External Stars and Isolated Firms

	TG		ES		IF	
	2002	**2006**	**2002**	**2006**	**2002**	**2006**
Number	11	12	4	2	10	7
Percentage (on total firms per year)	35%	37%	12%	6%	31%	22%
External openness (avg.)	10.27	24.12	11	25.5	2.8	4.43
In-degree (avg.)	4.27	11.66	2.75	8.5	0.4	0.85
Out-degree (avg.)	5.73	12.5	2.5	5.5	0.4	0.28
Differences across roles are statistically significant (ANOVA and Bonferroni tests: p*<0.000)						

Table 3 Characteristics of Technological Gatekeepers, External Stars and Isolated Firms

	TG		*ES*		*IF*		*ANOVA/phi test*	
	2002	***2006***	***2002***	***2006***	***2002***	***2006***	***2002*** ***(p-value)***	***2006*** ***(p-value)***
Number	11	12	4	2	10	7		
Percentage	35%	37%	12%	6%	31%	22%		
(i) General characteristics:								
a) Size (n. employees) (avg.)	96.36	141.83	36.25	45.00	37.90	43.28	n.s.	n.s.
b) Origin of capital:								
• % foreign on total foreign	50%	50%	33%	0%	17%	20%	n.s.	n.s.
• % foreign on total cognitive role	27%	42%	50%	0%	10%	43%		
c) Number of years since establishment in the cluster (avg.)	16.09	36.0	5.25	8.0	41.4	25.6	n.s.	n.s.
(ii) Innovation-related characteristics:								
a) Number of employees with graduation or MSc (avg.)	4.00	6.41	3.24	5	0.90	1.66	(0.000)	(0.010)
b) Experimentation intensity(avg.)*	2.55	2.79	1.75	2.25	0.70	0.66	(0.019)	(0.001)
c) Knowledge base (avg.)**	0.86	0.73	0.61	0.20	-0.70	-0.20	(0.000)	(0.000)

Note (*): **Experimentation intensity** is a count variable that ranges from 0 to a maximum of 4.
Note (**):**Knowledge base** is a composite indicator (mean =0 and st.dev.=1): it is based on Principal Component Analysis of three indicators: the skills and experience of technical professionals employed by the firm, and firm's experimentation intensity.
Details about these measures are reported in Appendix A-3.

Table 4 The change of cognitive roles from 2002 to 2006

	PERSISTENCE*	**CHANGES TOWARDS*:**				
		TG	**ES**	**IF**	**Other roles**	**Exit**
TG	**64%**	**-**	0%	0%	**36%**	0%
ES	0%	25%	-	0%	50%	**25%**
IF	**50%**	10%	0%	-	10%	**30%**

Note (*): The percentages are calculated on the population of firms present in 2002 (32). It thus includes incumbents of 2006 but not new entrants.

Table 5 The TG's social neighbourhood: characteristics and changes over time

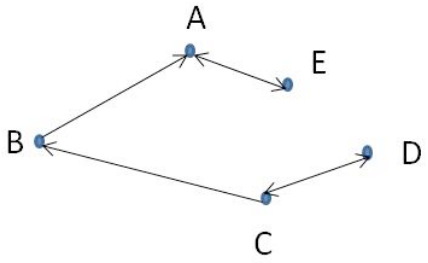
	2002	2006
(i) Statistics		
N° TG in each year	11	12
N° persistent TG	7	
Average N° of firms in the TG's social neighbourhood	5.73	12.5
(ii) Indicators of stability in the relationships		
% persistent TG with at least 50% of same firms in social neighbourhood	71%	
% persistent TG with at least 80% of same firms in social neighbourhood	30%	
% of mutual exchangers in the social neighbourhood of persistent TG	43%	65%
% of mutual exchangers in *both* 2002 and 2006	89%	
(iii) Indicators on the characteristics of persistent TG's social neighbours		
% of TG	66%	52%
Average external openness	8.85***	19***
Average experimentation intensity	2.35***	2.34**
Average knowledge base	0.71***	0.26**

Note: The statistical differences are based on a *t*-test, calculated against the firms that do not belong to the TG's social neighbourhood. Significance: ** (5%), *** (1%).

Appendix

A-1 Sociometric measures:

Degree centrality depends on the links between one node and the other nodes in the network. It is a simple measure that counts the direct ties with other nodes. It can be calculated for both undirected and directed graphs. In this study, the knowledge network is a directed graph, meaning we can calculate both in-degree and out-degree centrality. In-degree of a node *(i)* counts the number of ties received by *(i)*; while out-degree counts the number of ties initiated by *(i)*. Since the study is based on a single network, we do not normalize centrality values. See examples below.

Network	**Examples**
	In-degree centrality of A is =2 Out-degree centrality of A is = 1 In-degree centrality of B is =1 Out-degree centrality of B is = 1

Centrality measures are used to identify **cognitive positions**. Cognitive position identifies the extent to which a firm receives knowledge, relative to how much it transfers it to other cluster firms, distinguishing between:

- Source (S): ratio between a firm's in-/out-degree centrality is < 1
- Absorber (A): ratio between a firm's in-/out-degree centrality is > 1
- Mutual exchanger (ME): ratio between a firm's in-/out-degree centrality is $= 1$
- Local isolate (I): in- *and* out-degree centralities approximate 0.

A-2 Cognitive roles in the cluster

Table A identifies all possible cognitive roles in the cluster and each cell reports statistics on numbers in 2002 and 2006. The group of "other cognitive roles" cited in the text includes roles other than TG, ES and

IF. Note that TG includes TG-S and TG-ME, i.e. firms whose local cognitive position is source (S) or mutual exchanger (ME). Similarly, ES includes ES-A (absorber) and ES-I (local isolate).

Table A: Cognitive Roles

Intra-Cluster Cognitive Position	**External Openness**		
	Low *(below average)*	**Medium** *(average)*	**High** *(above average)*
Source *In/Out Degree centrality <1*	Externally-isolated Sources (EI-S) N° (2002=0; 2006=1)	Externally-connected Sources (EC-S) N° (2002=0; 2006=0)	**Technological Gatekeepers (TG-S)** N° (2002=5; 2006=3)
Mutual exchanger *In/Out Degree centrality → 1*	Externally-isolated Mutual Exchangers (EI-ME) N° (2002=1; 2006=5)	Externally-connected Mutual Exchangers (EC-ME) N° (2002=2; 2006=2)	**Technological Gatekeepers (TG-ME)** N° (2002=6; 2006=9)
Absorber *In/Out-Degree centrality > 1*	Externally-isolated Absorbers (EI-A) N° (2002=1; 2006=1)	Externally-connected Absorbers (EC-A) N° (2002=1; 2006=1)	**External Stars (ES-A)** N° (2002=2; 2006=2)
Local isolate (or poorly interconnected) *In = Out and →0*	**Isolated Firms (IF) N° (2002=10; 2006=7)**	Externally-connected Isolates (EC-I) N° (2002=2; 2006=1)	**External Stars (ES-I)** N° (2002=2; 2006=0)

A-3 Measures of Knowledge Base and Experimentation Intensity

Consistent with previous studies (e.g. GIULIANI 2007A; GIULIANI AND BELL 2005), the measure Knowledge Base is a composite indicator with three dimensions: (i) human resources' formal training; (ii)

human resources' experience in the field; and (iii) firm experimentation intensity (see below). While (i) and (ii) refer to human resources at the time the interviews took place (2002 and 2006), (iii) takes account of experimentation activity up to two years prior to the interviews because the pilot fieldwork showed that two years was a reasonable time span to get an idea of intensity of experimentation by a wine producer. The variables were defined as follows:

(i) Human resources' formal training: represents the cognitive background of each firm's knowledge skilled workers in terms of their level of education. In line with previous work on the returns to education, we assume that the higher the education degree received, the higher will be their contribution to the firm's economic returns. On this assumption we weight each knowledge skilled worker according to the education degree attained:

Human Resource = 0.8 Degree + 0, 05* Master + 0,15* Doctorate*

A weight of 0.8 is applied for number of graduate employees in the firm which includes workers with higher levels of specialisation. Thus we add 0.05 times for number of employees with masters degrees and 0.15 for number with a PhD degree. Note that only degrees and higher levels of specialization in technical and scientific fields related to the activity of wine production (i.e agronomics, chemistry, etc.) are taken into account.

(ii) Human resources' experience: represents the working experience of the abovementioned resources in temporal terms. Time is indicative of accumulation of knowledge via 'learning by doing'. The variable is the result of a weighted mean of months of work for each knowledge skilled worker in the country and abroad:

Months of Experience in the Sector= 0,4 n° months (national)+ 0,6* n° months (international)*

To time spent professionally abroad we attribute a higher weight because diversity of the professional environment might stimulate active learning behaviour and a steeper learning curve. Only learning experiences related to the wine industry are considered.

(iii) Experimentation intensity

Experimentation intensity is a proxy for knowledge creation efforts. This is measured on a 0 to 4 scale, according to the number of areas in which the firm experiments: e.g., if the firm experiments in all the production phases, from the introduction of different clones or varieties to the vineyard *terroir*, the management of the irrigation and vine training systems, and fermentation techniques and enzyme and yeast analysis, to analysis of the ageing period, it will score 4 for experimentation intensity. Firms conducting no in-house experimentation will score 0.

Although these variables measure different aspects of firms' knowledge bases, they are highly correlated - especially *Human Resource* and *Months of Experience in the Sector* (> 0.7). This high correlation means construction of a composite indicator for firm's knowledge base is appropriate. The composite indicator is extracted by Principal Component Analysis (PCA). We extracted a single factor that represented 73% of data variation, referred to as firm knowledge bases. Factor loadings and uniqueness are available upon request.

Endnotes

[1] Please note that in Allen's work the focus of analysis is *professionals* within organizations; this paper uses *firms* as the unit of analysis.

[2] By 'cognitive role', I mean the position of firms in interfacing extra-cluster and local knowledge.

[3] This term is from Allen (1977) and describes individuals within organizations with strong links to external sources of knowledge and weak links to the internal knowledge system.

[4] The term 'capabilities' is used somewhat loosely here to indicate the technological capabilities of firms, which depend on their internal skills and knowledge-generating activities.

[5] The term knowledge workers is from Drucker (1977, 1993); Richard Florida defines them as the creative class, i.e. "professionals whose primary responsibilities include innovating, designing and problem solving" (Florida and Goodnight, 2005: 125).

[6] Most industry accounts suggest that moving up the quality ladder through product and process innovation is critical for success in this industry. However, opposite views exist, which suggest that successful strategies can also be pursued through the production and export of large quantities of cheap and low quality wine, which require more supply-chain management skills than product and process innovations (e.g. Ponte and Ewert, 2009).

[7] The evolution and success of the wine industry in Chile has been underpinned by several policy initiatives aimed at funding research and innovation at firm and university levels. For instance, a new generation of agronomists and enologists has been nurtured and trained in local public (and private) universities.

[8] In Chile there are currently 14 different wine areas, see http://www.survino.com/wp-content/uploads/2007/12/mapa_zonas_vitivinicolas_chile_2008.jpg.

[9] References to videos are not included in this paper. Details available from the author.

[10] I want to thank an anonymous referee for pointing this out.

[11] The available data indicate that, within the cluster, the number of hectares of vines planted for wine production has almost tripled from 1997 to 2002 (www.sag.gob.cl).

[12] CORFO is Corporacion de Fomento, a Chilean government institution that promotes industrial development.

[13] E.g., the number of times Colchagua's wines have been cited annually by *Wine Spectator* increased tenfold in the period 1994-2002.

[14] The 2006 questionnaire included some slight modifications which did not affect the key variables used in this paper.

[15] Note that entry and exit of 6 firms does not mean that the exiting firms were taken over by the new entrants. It is coincidental that over the period studied there was perfect turnover, which did not change the overall population of the firms in the cluster, resulting in 32 firms in operation in both periods observed.

[16] The focus on technological knowledge is due to its importance for producing high quality wines, a key requirement for competition in high-end international markets (see Section 3).

[17] In a very few cases, responses did not match (e.g. if firm *i* did not indicate firm *j* as a source of knowledge, when *j* claimed it transferred knowledge to firm *i*). In this paper, we consider the flow of knowledge to take place if either *i* or *j* claims a knowledge link, which minimizes the risk of missing data due to poor recall. In previous research we analysed data coding non-matching responses as non-existent ties: this affected neither the structure of the knowledge network, nor the positions of the actors in the network in any significant or visible ways.

[18] The classification of firms according to cognitive position is based on the acknowledgement that firms play different, sometimes asymmetric roles within the cluster knowledge network: while some firms exchange knowledge on a mutual basis (i.e. *mutual exchangers*), there are other cases where knowledge linkages are not reciprocal, so that some firms

behave as net *sources* of knowledge and therefore may *transfer* more knowledge than they receive from other local firms; other firms may display an absorption-centred learning pattern within the cluster, i.e. they absorb more knowledge than they release, acting as net *absorbers* of knowledge. In yet other cases, firms are *isolated* within the cluster knowledge network, i.e. they neither receive nor transfer knowledge to other cluster firms.

[19] Although data were collected through a structured questionnaire, face-to-face interviews in all cases offer significant opportunities for discussion about the nature and history of the firm and its learning behaviours.

[20] The remaining firms in the cluster play other cognitive roles, depending on their external openness and positions in the local knowledge networks. These roles are marginal in terms both of number of firms involved and the contributions they make to cluster learning and innovation processes; for these reasons they were not the focus in this paper. More information is contained in Appendix A-2.

[21] Note that foreign firms are not necessarily subsidiaries of multinational corporations; they may be the result of a private foreign investor with no other investments in the wine industry elsewhere.

[22] In 2006 the differences could not be tested due to the limited number of observations in the ES group.

[23] Data on geographical distance between firms in the cluster are available upon request from the author. They are not shown here but firms in TG social neighbourhoods are not necessarily more geographically proximate within the cluster.

[24] The reader should note that the innovative push of this cluster is driven not by the presence of global buyers, which instead are considered to be a key extra-cluster source of learning in many clusters in developing countries (Schmitz, 2004). In general, the wine industry is not a context where global buyers play a dominant role in firms' upgrading processes, at least in the period in which this and earlier studies by the author took place, as reflected also in Giuliani et al. (2010).

[25] I want to thank an anonymous referee for raising this issue.