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INNOVATION AND LEARNING DYNAMICS IN THE CHILEAN AND ARGENTINE WINE INDUSTRIES

Fulvia Farinelli

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Innovation and Learning Dynamics in the Chilean and Argentine Wine Industries

Fulvia Farinelli [*], UNCTAD

1. Introduction

This paper focuses on the magnitude, variety, and sources of innovation introduced by the Chilean and Argentine wine industries during the past two decades. It analyzes whether the prolonged export growth of Chilean and Argentine wines has been achieved by building the innovation capacity of local actors and creating domestic linkages with local grape producers, winemakers and input providers, or by relying exclusively upon FDI and knowledge flows generated abroad. In line with the evolutionary tradition, this study explores the hypothesis that, much as in the case of high-tech sectors, the ability of developing countries to enter knowledge-intensive natural resource-based sectors, such as wine, depends on their ability to access capital, technology and knowledge from abroad, that is, on what can be defined as "external" sources of innovation. It also depends, however, on the ability to absorb and adapt imported technology and know-how to the local environment, that is, on the creation of local tacit knowledge and endogenous R&D capabilities.

This paper measures, first of all, the innovativeness of the leading 25 Chilean and of the leading 25 Argentine exporters of bottled wines, and looks at the variety of innovations introduced, focusing not only on new methods of production, but also on the development of new products and new ways of organizing business. Subsequently, it identifies the role played by external sources of innovation □ such as FDI, as well as capital-embodied and codified knowledge flows □ in triggering the phenomenal technological upgrading process of the Chilean and Argentine wine industries. Finally, it looks at the role played by internal sources of innovation, namely at the creation of local tacit knowledge and incremental innovation, at the emergence of a wide pool of highly qualified human resources, and at the role of sectoral R&D programmes, local universities and research centres in the creation of endogenous technological capabilities.

This paper is structured as follows: Section 2 measures the innovativeness of the leading 25 Chilean and of the leading 25 Argentine exporters of bottled wines. Section 3 looks at the variety of innovations introduced, focusing – in line with the Schumpeterian tradition – not only on new methods of production, but also on the development of new products and new ways of organizing business. Section 4 looks at the triggering role of FDI in stimulating the phenomenal technological upgrading process of the Chilean and Argentine wine industries over the past two decades. Section 5 focuses on the importance of external sources of innovation in sustaining such a process, namely, on the importance of capital-embodied and codified knowledge flows channelled through imports of foreign machinery and quality certification mechanisms. Section 6 looks at the creation of local tacit knowledge and incremental innovation in the Chilean and Argentine wine industries, and at the emergence of a wide pool of highly qualified local oenologists, agronomists and viticulturalists. Section 7 analyses the role of sectoral R&D programmes and of local universities and research centers in the creation of endogenous technological

[*] UNCTAD. Email: Fulvia.Farinelli@unctad.org

capabilities. Section 8 concludes with some considerations on the longer-term sustainability of the export boom of Chilean and Argentine wines.

2. Innovativeness of the leading Chilean and Argentine wineries

In the modern wine industry, a remarkable number of scientific and technological changes have made possible a shift from the production of ordinary table wines to the production of fine, premium wines ☐ that is, from a basic, undifferentiated commodity to an increasingly sophisticated and differentiated luxury good ☐ induced by the changing demands of international consumers. This has become known in the specialized literature as the "wine revolution" (Adams, 1973; Unwin, 1991; Crowley, 2001). The term refers to a combination of technological advances and new equipment in the winery, establishing the predominance of the production of quality over quantity in wines. In the winery, these include temperature-controlled stainless steel tanks, bladder presses, the use of and frequent turnover of oak barrels for aging, and sophisticated bottling lines. Analogously, in the vineyards, these include new trellising methods, drip irrigation, clone selection, mechanical harvesting and frost protection.

In these circumstances, both the Chilean and the Argentine wine industries had to learn to compete based on far more than their natural comparative advantages and their competitive cost structure, gradually meeting new international standards and new consumer preferences in the time span of a few decades. Evidence from the field work undertaken to carry out this study, focusing on the top 25 Chilean and the top 25 Argentine exporters of bottled wines, shows that they did learn to compete by gaining greater technological complexity and a better control of wine-making habits and practices, as well as by gradually incorporating modern vine growing and marketing techniques.

The choice of the unit of analysis is justified by the high level of consolidation of both the Chilean and the Argentine wine industries, which makes 25 a quite representative number of the most (presumably) innovative exporting wineries. Despite its wide production base (in 2010, there were 934 registered wineries by the National Institute of Vitiviniculture), in **Argentina** only five companies account for 80 percent of the basic segment in the domestic market. In terms of export concentration, the leading 25 exporters account for 75 percent of total exports, while the top 5 companies account for 55 percent of all wine exports. In **Chile**, in 2010 there were 360 wineries registered by SAG, and the level of export consolidation was comparable to that of Argentina. However, the leading exporting companies are larger (albeit relatively small compared to the US and Australian giants) and remain family controlled or are owned by national industry groups. In terms of export concentration, 4 companies account for 42 percent of the total export market.

In the case of **Chile**, the list of the top 25 exporters of bottled wines (see Table 1) comprises the group of the 10 most famous old Chilean wineries established after Chilean independence in 1850: Carmen (1850), Cousiño Macul (1856), San Pedro (1865), Errazuriz (1870), Tarapacà (1874), Santa Carolina (1877), Valdivieso – earlier named Santa Elena – (1879), Santa Rita (1880), Concha y Toro (1883) and Undurraga (1885). There is also a group of new companies, founded after the official liberalization of the Chilean wine market in 1974, with the arrival of foreign investors. These are Bisquertt (1975), Felipe Edwards (1976), Casa Silva (1977), Miguel Torres (1979), Canepa (1980) and Santa Emiliana (1986). Moreover, there are a group of new wineries established after the return to democracy in 1988, when the Chilean wine industry started to resurge after a period of dramatic stagnation and decline. These are Los Vascos (1988), Montes (1988), Cono Sur (1993), Ventisquero (1998),

Casa Lapostolle (1994) and Almaviva (1997). This is not surprising, considering that more than 50 percent of the 360 officially registered Chilean wineries are less than 15 years old, and that in Chile the decades after liberalization and after the end of dictatorship were characterized by high rates of new entrants, with wealthy local entrepreneurs and foreign firms suddenly showing interest in the wine industry.

Table 1. List of the top 25 Chilean exporters of bottled wines, 2010

	Winery	Type of investment	Year	Top brand	Max rating by *Wine Spectator*
1	Concha y Toro	National investment (Guilisasti-Larrain group since 1960)	1883	Don Melchor (Cabernet Sauvignon)	96 points (2007)
2	San Pedro	National investment (CCU since 1991)	1865	1865 Limited Edition (Syrah)	90 points (2007)
3	Santa Rita	National investment (Ricardo Claro Group since 1980)	1880	Triple C (blend)	92 points (2002)
4	Cono Sur	National investment (Concha y Toro)	1993	Ocio (Pinot Noir)	90 points (2006)
5	Errazuriz	Old family business	1870	Don Maximiano (blend)	91 points (2005)
6	Undurraga	Old family business	1885	Altazor (blend)	92 points (2006)
7	Montes	National investment (A. Montes, A. Vidadurre, D. Murray, P. Grand)	1988	Montes Alpha M (blend)	95 points (2005)
8	Santa Carolina	National investment (Larrain family since 1974)	1877	VSC Maipo Valley (Cabernet Sauvignon)	89 points (2005)
9	Santa Helena	National investment (Junta de Exportación Agricola and CCU since 1994)	1942	Aureus (Cabernet Sauvignon Gran Reserva)	88 points (2007)
10	Tarapacà	National investment (Carlos Cardoen from Compania Chilena de Fosforos since 1992)	1874	Tarapacà Gran Reserva (Cabernet Sauvignon)	88 points (2008)
11	Carmen	National investment (Ricardo Claro Group since 1985)	1850	Carmen Gold Reserve (Cabernet Sauvignon)	92 points (2002)
12	Santa Emiliana	National investment (Concha y Toro)	1986	Ge Colchagua Valley (Syrah blend)	93 points (2005)
13	La Rosa	Old family business	1824	Don Reca Cuvée (blend)	87 points (2009)
14	Ventisquero	National investment (G.Vial Group, poultry, salmon and fruit)	1998	Grey Cabernet Sauvignon Maipo Valley	88 points (2005)
15	Los Vascos	Joint-venture Baron de Rothschild- (France) with Santa Rita	1988	Le Dix, Colchagua (blend)	89 points (2003)
16	Valdivieso	Old family business	1879	Caballo Loco (blend)	91 points (2008)
17	Casa Lapostolle	Joint-venture Marnier-Lapostolle (France) and Chilean Rabat family	1994	Clos Apalta (blend)	96 points (2005)
18	Miguel Torres	Foreign investment (Spanish)	1979	Conde de Superunda (blend)	92 points (2002)
19	Canepa	Family business	1980	Magnificum (Cabernet Sauvignon)	92 points (2005)
20	Felipe Edwards	Family business	1976	Doña Bernarda (Cabernet Sauvignon)	89 points (2004)

	Winery	Type of investment	Year	Top brand	Max rating by *Wine Spectator*
21	Bisquertt	Family business	1975	La Joya (Reserve Syrah)	90 points (2008)
22	Cousiño Macul	Old family business	1856	Lota (blend)	92 points (2006)
23	Santa Ema	Old family business	1931	Rivalta (blend)	91 points (2003)
24	Casa Silva	Family business	1977	Altura (blend)	89 points (2001)
25	Almaviva	Joint-venture between Baron Phillippe de Rothschild (France) and Concha y Toro	1997	Almaviva (blend)	95 points (2005)

Source: Author's survey

In the case of **Argentina**, the list of the top 25 exporters of bottled wines (see Table 2) includes 8 traditional wineries, founded at the end of the nineteenth to beginning of the twentieth century, 6 of which are still family owned companies.[1] Five of these are of Italian origin and were created after Alberto Zuccardi, Valentin Bianchi, Angelo Pulenta, Pasquale Toso and Nicola Catena emigrated to Argentina in 1946, 1928, 1923, 1890 and 1902, respectively. Another 3 are of Spanish origin (mostly Catalan), and were created after Don Juan de Dios Correas, Don Leoncio Arizu and Don Miguel Escorihuela Gascon emigrated to Argentina in 1824, 1901 and 1884, respectively. Unlike in Chile, where only 4 of the top wineries are foreign invested (out of which 3 are joint-ventures), in Argentina the large majority of the 25 leading wineries (17) are owned by foreign investors (mainly of French, Chilean and Spanish origin) and only 1 is an Italo-Argentine joint-venture. All of these were created – or bought and then completely renovated and equipped with state-of-the-art technology – after 1991, with the exception of the Terrazas winery, founded by Chandon in 1950. As it will be explained more in detail in the following section, the scarce presence of joint-ventures in the Argentine wine industry, compared to that of Chile, is a phenomenon that deserves some attention, and is presumably due to a strong sense of uncertainty associated with the Argentine political, economic and regulatory framework.

[1] Immediately after 1991, a wide group of local winery owners sold their wineries to foreigners, fearing to be put completely out of the game as a consequence of the liberalization process. The phenomenon was so profound that in the 1990s only six of Argentina's traditional family wineries had remained in the hands of the founding families.

Table 2. List of the top 25 Argentine exporters of bottled wines, 2010

	Winery	Type of investment	Year	Top brand	Max rating by *Wine Spectator*
1	Zuccardi	Old family business	1946	Q Malbec	92 points (2007)
2	Tivento	Foreign investment (Chilean Concha y Toro)	1996	Malbec Eolo Golden Reserve	93 points (2005)
3	Catena Zapata	Old family business	1902	Catena Zapata Malbec	95 points (2006)
4	Trapiche	Foreign investment (US investment d since 1998)	1920	Trapiche Malbec Single Vineyard	92 points (2006)
5	Norton	Foreign investment (Austrian Swarowsky Group since 1989)	1895	Norton Privada (blend))	92 points (2006)
6	Finca Flinchman	Foreign investment (Portuguese SOGRAPE group since 1998)	1883	Cabernet Sauvignon	94 points (2009)
7	Navarro Correas	Foreign investment (DIAGEO since 1996)	1824	Alegoria Malbec	90 points (2005)
8	Pascual Toso	Old family business	1890	Toso Magdalena (blend)	92 points (2005)
9	Terrrazas	Foreign investment (French, Moët et Chandon) since 1950	1999	Terrazas Malbec Mendoza	91 points (2003)
10	Luigi Bosca	Old family business	1901	Malbec Reserva	91 points (2005)
11	Escorihuela Gascon	Foreign investment (US investment fund since 1992)	1884	Malbec Don Miguel Gascon	89 points (2003)
12	La Celia	Foreign investment (Chilean San Pedro since 2000)	1890	La Celia Malbec Reserve	90 points (2005)
13	Dominio del Plata	National investment (Susana Balbo)	1999	Nosotros Malbec	94 points (2008)
14	Séptima	Foreign investment (Spanish-Catalonian Codorniu since 1999)	1999	Séptima Malbec	87 points (2007)
15	O.Fournier	Foreign investment (Spanish family Ortega Gil-Fournier)	1999	Alfa Crux (blend)	92 points (2002)
16	Lurton	Foreign investment (French Lurton family)	1996	Belondrade y Lurton Rueda	90 points (2001)
17	Salentein	Foreign investment (Dutch)	1998	Uco Valley Malbec	89 points (2004)
18	Dona Paula	Foreign investment (Chilean Claro group)	1997	Estate Malbec	92 points (2006)
19	Nieto Senetiner	Foreign investment (Brazil) since 1998	1888	Cadus Malbec	90 points (2002)
20	Chandon	Foreign investment (French, Moët & Chandon, and LVMH group since 1998)	1959	Alta Vista Alto (Malbec)	94 points (2005)
21	Alta Vista	Foreign investment (French, D'Aulan family)	1997	Atemporal Blend	90 points (2007)
22	Alto Las Hormigas	Foreign investment (Italian)	1996	Malbec reserva	92 points (2005)
23	Valentin Bianchi	Old family business	1928	Elsa Malbec	88 points (2004)
24	Augusto Pulenta	Old family business	1923	Malbec Calchaqui Valley	92 points (2007)
25	Achaval Ferrer	Joint-venture (Italy-Argentina)	1998	Malbec Finca Altamira	96 points (2006)

Source: Author's survey

The present study reveals that, during the last two decades, a large amount of effort was put into place by both the Chilean and Argentine leading exporting wineries in order not only to integrate the most advanced winemaking knowledge and technologies in their current practices, but also to continuously innovate their products and improve their positioning in the international market (see Table 3). This finding is of utmost importance, as, according to the literature (Pavitt, 1984; Malerba, 2004), in natural resource-based sectors, innovation would mainly consist in process innovation, as very few innovative efforts would be required by the product

characteristics *per se,* due to the specific sectoral patterns of acquisition of innovative knowledge. This study shows that this is not always the case. Even if to a different extent, in both the Chilean and Argentine wine industries an incredible amount of product, process and organizational innovations have been introduced during the last two decades. This confirms the widespread view in the literature that Pavitt's (1984) original taxonomy of the sectoral patterns for the acquisition of innovative knowledge should be revisited, in order to reflect the rising knowledge intensity of natural resource-based industries and the importance of product differentiation and marketing strategies in sustaining their export growth.

Table 3. Degree of innovativeness of the top 25 Chilean and Argentine exporters of bottled wines, 2010

Type	Main innovations	Top 25 Chilean wineries	Top 25 Argentine wineries
Product / Viticulture	Identification of best *terroirs* and of best clones for each variety	23/25	14/25
	Introduction of new varieties (in addition to top four most widely diffused)	16/25	24/25
	Introduction of drip or furrow irrigation systems (*vs.* flooding irrigation)	24/25	14/25
	Limitation of the yields for top quality brands	22/25	14/25
	Introduction of organic and/or biodynamic farming cultivation techniques	19/25	8/25
Process / Viniculture	Replacement of old big casks for aging with smaller oak *barriques* imported from USA and/or France	25/25	25/25
	Use of stainless steel tanks for vinification	25/25	25/25
	Installation of refrigeration devices for both fermentation and maturation	25/25	25/25
	Replacement of old vertical presses with pneumatic presses	25/25	24/25
	Use of gravity flow mechanisms	5/25	3/25
Organization & marketing	Creation of new "terroir" brands	20/25	12/25
	Participation at international wine competitions	25/25	25/25
	Use of social networks (Facebook, Youtube and/or Twitter) for marketing purposes	9/25	4/25
	Organization of winery tours, food and wine tastings, cultural events	24/25	24/25
	Adoption of a sophisticated architectural design of the winery as a marketing tool	7/25	8/25

Source: Author's survey

The table above shows that the leading Chilean and Argentine exporting wineries managed to integrate an equally pervasive series of **process innovations**, mainly belonging to the vinification process. In particular, 25 out of 25 firms in both countries have adopted all the most modern winemaking technologies, except for gravity flows, which remain everywhere in the world a quite sophisticated, expensive technique adopted by a minority of winemakers. By contrast, in the area of **product innovation**, mainly belonging to the viticulture practice, there is a relatively larger discrepancy, in that the Chilean wineries seem to have been inclined much more than the Argentine ones to introduce modern viticulture techniques related to irrigation, yield management and clone selection – except for the search for new varieties, where Argentine firms clearly appear more advanced. This difference is not matched by much of a difference in the area of **organizational innovation**, where the

situation appears relatively balanced. The reasons for such discrepancies are explained in the following section.

3. Types and varieties of innovation

The findings of the field survey show that, in the case of **Chile**, a huge technological restructuring process at the cellar level has been matched by the introduction of a massive amount of new viticulture habits and marketing practices. In particular, on the *viticulture* side, the survey shows that in the top 25 Chilean exporters of bottled wines, the old technique of irrigation by simply flooding and letting the water drain down, thanks to purposely dug channels, has been fully replaced by the use of drip irrigation systems, which allow better control of the amount of water that each vine receives. Key techniques in maximizing quality and producing grapes for top brands, such as the reduction of excessive yields and the introduction of trellising systems, have been introduced in 22 out of 25 wineries. New *terroirs* are also being sought, in contrast to the traditional areas in the hot Central Valley. In such new areas, the climatic conditions are often more difficult, especially when located in the extreme North or extreme South of Chile, but all companies interviewed are convinced that this goes along with a strong potential for quality.

On average, Chilean exporting wineries are used to handling three main grape varieties, namely, Cabernet Sauvignon, Merlot and Chardonnay. Most of them, however, are paying growing attention towards diversification in order to reach new, demanding consumers of developed countries. To this purpose, vine varieties are also matched more carefully to the sites on which they are grown. Just to cite a few examples, Santa Rita has pioneered Viognier and Riesling in Chile, and owns the oldest Pinot Noir vines in the country, for which it has recently built a new "premium" winery. Santa Helena has focused its search for non-traditional varieties on Mourvedre, Viognier and Malbec, while Casa Lapostolle has focused on Tempranillo, Monastrell and Gewürztraminer. Cono Sur pioneered plantations in Aconcagua Costa, a new viticultural area where grapes had never been grown before, to start new plantations of Sauvignon Blanc and Pinot Noir.

In Chile, the top exporting wineries are also paying particular attention to the production of organic wines. Chile benefits in fact from unique phyto-sanitary barriers, since the Andes, the Pacific Ocean, the Northern Desert and Antarctica are natural obstacles, matched by the rigorous preventive efforts of Chile's Agricultural and Ranching service (SAG) in the border areas. Therefore, there are very few diseases and pests that seriously affect Chilean vines, making it possible and relatively frequent to manage vineyards free of agrochemical products and pesticides. These conditions have made Chilean wineries increasingly appropriate for integrated, organic or biodynamic vineyard management. According to SAG, currently 4.2 million litres of organic wine are produced in Chile, from approximately 2,000 hectares of planted vineyards. Three wineries, namely Santa Emiliana, Lapostolle and Matetic, also produce biodynamic wines. In early 2010, they invited French consultant Nicolas Joly, who is considered the world leading expert on biodynamic wines, to hold seminars and teach them about the most recent biodynamic techniques. Overall, 19 out of the 25 leading wineries are adopting organic or biodynamic farming techniques, as well as other types of eco-friendly practices.

On the *viniculture* side, among the most important technological changes introduced into the Chilean industry are the use of stainless steel vats in place of large wooden casks, the installation of refrigeration devices both for fermentation and maturation, the use of pneumatic presses rather than old vertical ones, and the use of small oak barrels in place of the old large vats made of native beech, called "raulí", where previously all Chilean red wines were kept. These innovations are common to the

totality of the top 25 exporting wineries, which possess, on average, 4,000-5,000 American and French (225 litre) oak barrels each, with the exception of San Pedro and Concha y Toro that possess more than 7,000 each. In five cases, namely Montes, Carmen, Ventisquero and Almaviva, modern facilities were also designed to incorporate gravity flow mechanisms, which are key to avoiding the traumatic effects of hydraulic pumps on must and fermented wines.[2] More generally, the US Foreign Agricultural Service has estimated that in the Chilean wine industry, over 46 percent of wine storage containers at wineries are stainless steel tanks, while 39 percent of the wineries use oak barrels made from French or American wood, for an average of 3-5 years, which shows a high technological development standard for the whole industry (USDA, GAIN Report, 2010).

On the *marketing* side, the leading Chilean wineries seem to possess the capacities for developing their market knowledge, brand names and economies of scale. Practically all of them have opened doors to visitors, added tasting rooms and gift shops, and transformed wine into a social and cultural occasion. Only 7 of them, though, rely on sophisticated modern stylistic and architectural aspects to encourage wine tourism. Montes, for example, owns a feng-shui inspired facility; Casa Lapostolle, a luxury 6-floor winery buried into the granite of the Apalta hillside, with gravity flows applied throughout the natural slope of the hill; Almaviva owns a native wooden facility designed by the famous Chilean architect Martin Hurtado-Covarrubias, which also includes a Mapuche crafts and silver museum. Several other wineries, however, such as Concha y Toro, Cousiño Macul, Santa Rita and Undurraga, have preserved and beautifully restored century old buildings, dating back to the 1870s, which are also historical monuments and effective tourist attractions. The most striking finding is that all 25 wineries possess a website, but only 9 of them sell on-line or use social networks, such as Facebook and Twitter, for marketing purposes.[3]

In the case of **Argentina**, the "wine revolution" is clearly reflected in the number of producers working mainly in their own estates using grapes from their own vineyards. This enables total control and monitoring of the grapes, and is at the origin of the rise in the number of good quality Argentine wines. According to Robinson (2005), in Argentina the strongest brake on progress in the past has been the gap and the diverging interests between grape-growers and wine producers. The practice of yield reduction and irrigation control for improving quality has been largely unknown in Argentina until very recently, and wines were rather made with extraordinary high yields and with grapes that were pumped of melted Andean snow by irrigation channels constructed in the nineteenth century.

The present survey reveals that, on the *viticulture* side, by the mid-1990s, the majority (14) of the 25 leading Argentine exporters of bottled wines had planted heavily in order to be more self-sufficient in terms of fruit supply, and could finally give more emphasis to lower yields, better irrigation, more attention to the vines, and careful assessment of vineyard sites. Vines have also begun to be planted in cooler areas than the hot Mendoza area (Lujan de Cuyo at 1100 m, or Tupungato at 1200 m)

[2] Following the gravitational concept, the grape reception area is located on higher levels, and de-stemmers are placed over maceration and fermentation tanks. The difference in levels is also used to transport wine from fermentation tanks to aging barrels.

[3] This is corroborated by the research findings of Kunc (2007), who carried out a survey on the managerial practices of Chilean wineries. The respondents perceived a strong need to develop their innovative capabilities in the area of market development, brand management and consumer behavior, especially with respect to the use of the Internet, on-line sales and social network-related tools.

to prolong the ripening process, and to be trained carefully on wires to obtain the maximum quality of the resulting fruit. Trivento, for example, established in 2005 a "Terroir Wines" project for high-end wines, whereby vineyards have been divided into three micro-regions and vinified separately. Catena Zapata produces Malbec blends with specially selected lots from different high altitude vineyards. Terrazas has undertaken a special experimental programme to identify the ideal altitude for each variety. Altos las Hormigas has launched a "Terroir Project" to study geomorphology and soil profile, with the support of the consultant Pedro Parra, the only specialist of South American *terroirs*.

Almost all the 25 Argentine wineries surveyed have been busy with the search and introduction of new varieties, in addition to the top four most widely diffused, namely Malbec, Cabernet Sauvignon, Syrah, and Torrontés. Alto las Hormigas is the only exception, as it is a Malbec-only winery. The other 24 have been testing an amazing series of unusual and less known varieties, symbolizing the curiosity, openness and fantasy of Argentine winemaking culture. Just to cite a few examples, Zuccardi has created a micro-vinification room with small stainless tanks, in order to regularly test new varieties and new wines. It has trial plantings of 35 varieties, among which Grenache, Mourvèdre, Tannat, Aglianico and Zinfandel. Norton owns 90-year-old Malbec vines that are meticulously cared for. In addition, Zuccardi is experimenting with such new varieties as Barbera, Sangiovese, Aspiran Bouchet, Tannat, Raboso, Semillion and Grunner. Finca Flichman planted the first Viognier in Argentina, and is now experimenting with new varieties, such as Aspiran Bouchet, Raboso and Barbera. Escorihuela Gascon is starting to vinify (but not yet to commercialize) Verdicchio and Barbera grapes, while Dominio del Plata has been experimenting with grafted Syrah vines, Tannat, Petit Verdot, Chenin Blanc and Angelotta. Doña Paula is experimenting on plots with Pinot Noir, Tannat, Angelotta, Marsanne, Aglianico, Touliba, Casavecchia, Riesling, Petit Verdot and Grenache.

In Argentina, organic grape production seems to be far less advanced than in Chile. Zuccardi is a leading exponent of organic viticulture in Argentina, with 35 percent of its vineyards grown organically and certified under European, Canadian and Japanese standards. The remaining 65 percent are grown through sustainable production systems. Overall, between 2005 and 2008 its exports of organic wines increased by 203 percent, and were directed mainly to European Union countries. Two other wineries, Trivento and Catena Zapata, are experimenting with biodynamic vine cultivation. Overall, sustainable cultivation techniques and other eco-friendly practices have been adopted by 8 of the 25 leading Argentine exporters of bottled wines. Given the rising demand for organic wines, especially in countries with higher standards of living, and the increasing interest of Argentine wineries in adopting eco-friendly practices, the National Institute for Vitiviniculture has recently decided to regulate organic wine production and create a national register of authorized certifying companies. This is the first step towards what, based on the Chilean experience, seems poised to be a sustained process of expansion.

On the *viniculture* side, as in Chile, all the Argentine leading wine exporters own state-of-the-art wineries, equipped with the most advanced machineries and technologies, the closest possible to international standards. Until the 1980s, for example, Argentine wineries used to ferment wines in old "fudres", which were difficult to keep clean and sometimes released undesirable flavours and unpleasant smells onto wines. Today, stainless steel tanks are widely diffused, as well as refrigeration devices, to control fermentation and pneumatic presses. Some wineries continue to use cement vats, but these are all covered with an epoxy layer that makes them easy to clean, completely safe and good keepers of temperature. While innovative winemaking techniques from California and Australia were put in place at the cellar level, isolated ageing rooms were also built, equipped with French and

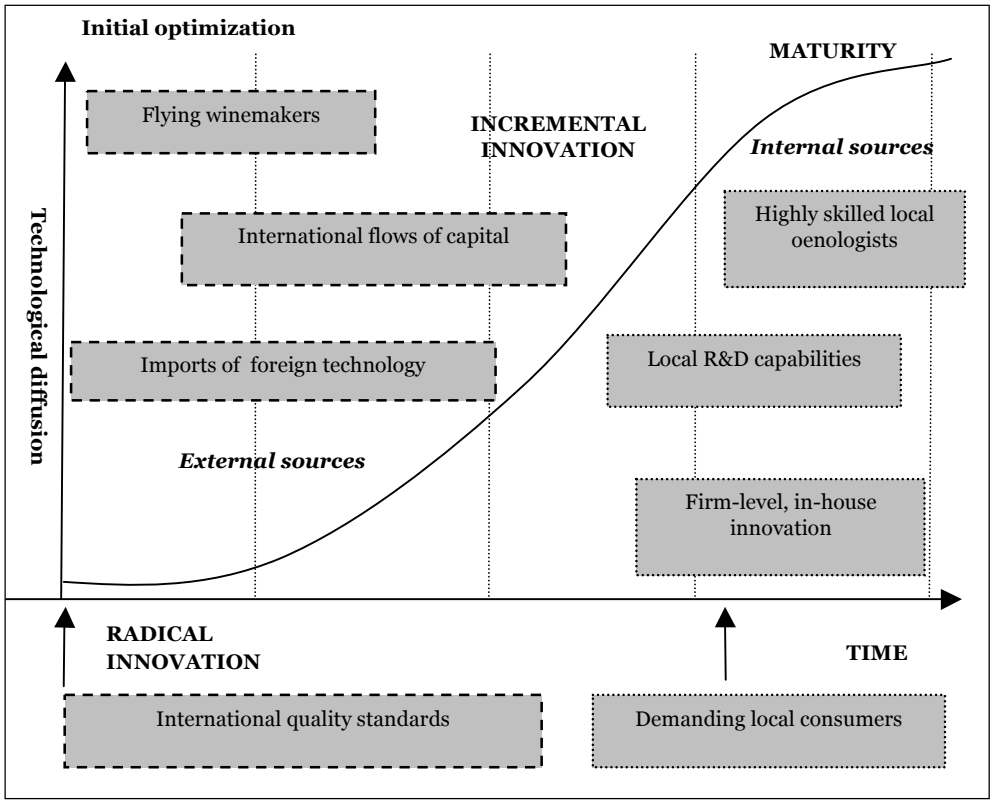
American oak barrels to let top quality wines mature, which is essential to producing good quality wines. As in Chile, gravitational flows, which are effective for avoiding brusque wine movements, are being used only by a limited minority of wineries, namely 3 out of the 25 leading exporters.

On the *marketing* side, new management and marketing styles have also been widely adopted, based on state-of-the-art product development and quality control, on some emphasis on regional identity and branding, and on the launching of communications campaigns. Practically all 25 leading Argentine wineries participate in international wine competitions, and organize wine tastings or cultural events to promote oeno-tourism. Most have their own websites (in English and Spanish), but few (9) use on-line selling techniques or social networks for marketing purposes. An exception is Luigi Bosca, which offers the possibility of "virtual tasting" and of chatting on line with the chief oenologist. A few avant-garde wineries (7) are also relying on sophisticated architectural design in their quest for distinctiveness. Five of them – namely Navarro Correas, Norton, Fournier, Salentein and Séptima – are designed by renowned Argentine architects Bormida and Yanzón. In particular, Séptima, with its construction inspired by an ancestral dry-stone wall system used by the native population, and Salentein, with its cross-shaped building inspired by ancient classical temples, have become points of reference among the most recent generation of Argentine wineries.

Overall, therefore, this survey reveals that the technological upgrading process of the Chilean and Argentine wine industries over the past two decades has been deep and impressive, if not surprising, considering that it took place in two developing countries. This confirms the hypothesis that the export growth of Chilean and Argentine wines was made possible by the increased capability of local wineries to innovate, both radically and incrementally, as will be illustrated in more detail in the following section.[4] In order to understand to what extent this process was embedded in the local environment and was conducive to development, it will be necessary first to analyze what sources of innovation drove it and how sustainable they are (see Figure 1).

[4] The basic principles of modern winemaking are centuries old. However, since the 1970s both viticulture and viniculture have been characterized by continuous incremental improvements and a set of important radical innovations. In viticulture, the latter are mainly related to vine clone selection, thanks to genetic engineering techniques, which have gradually replaced the old cross-breeding techniques. In viniculture, the introduction of revolutionary automated equipment for controlling temperature has allowed not only the processing of wines in hot areas where it was unthinkable before, but also the determination of precise temperature variations in terms of time and degree, thereby raising the quality of the wines produced to levels that were impossible to attain before.

Internal and external sources of innovation and technological change in the Argentine and Chilean wine industries



Source: Author's elaboration based on Dosi, 1982

4. The triggering role of FDI

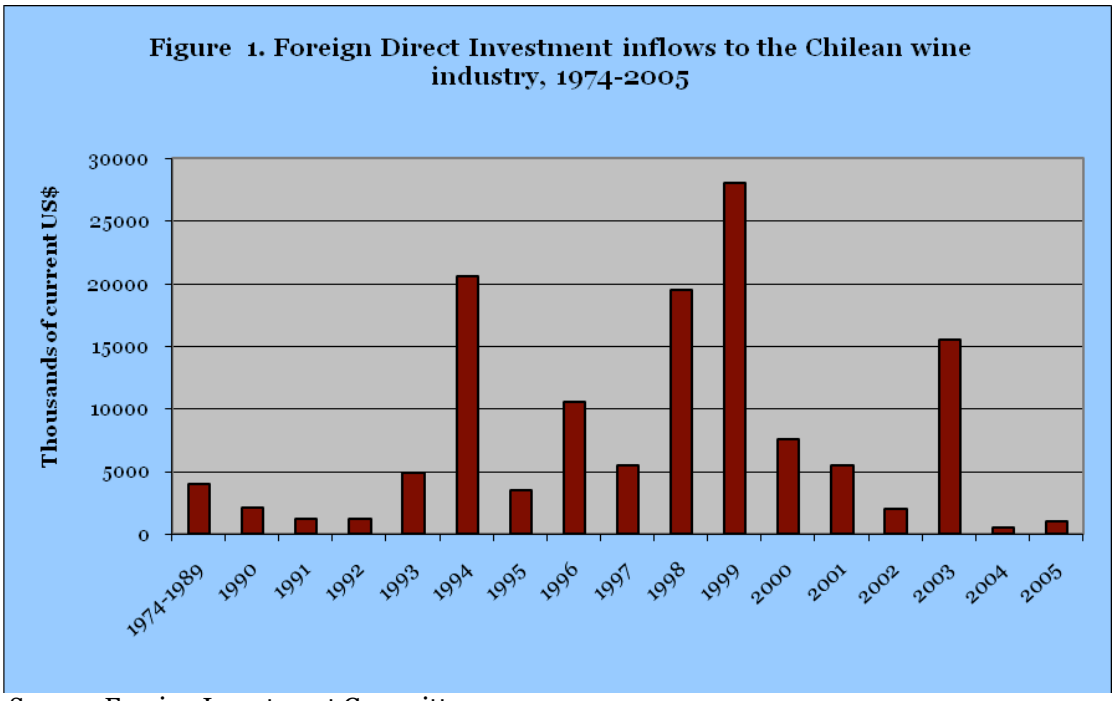
The technological modernization process of the Chilean and Argentine wine industries was triggered by the protracted access of both countries to **external sources of innovation**, namely to massive international flows of knowledge, capital and technology, which took place in the late 1980s in Chile and in the mid-1990s in Argentina. This allowed the Chilean and Argentine wine industries to undertake a deep transformation process – from isolated and protected industries, which had gradually *"run out of ideas and sunk into mediocrity"* (Veseth, 2010), into newly successful wine producers and exporters, that is, into major players in the current era of global wine. In 1988, Chile returned to democracy and started to take advantage of the neoliberal market reforms introduced by Pinochet, which had opened up its protected and isolated market. Argentina had returned to democracy earlier on, in 1983, but political and economic instability persisted until 1991, when a drastic trade liberalization and privatization process was introduced by the newly elected president Carlos Menem. Thereafter, a massive acquisition of foreign knowledge and technology took place, thanks to various transmission mechanisms of which FDI and the transfer of foreign technology embedded in imported machinery and equipment were amongst the most important.

In the case of the Chilean and Argentine wine industries, it is undeniable that the massive flows of FDI initially brought along financial resources, the knowledge of international good practices, human resources and the technological inputs needed to drag both countries closer to international quality standards and to international consumers' tastes in a surprisingly condensed time. In the **Chilean wine industry,**

it is unanimously acknowledged that the triggering element of the technological revolution was a foreign investor, Miguel Torres, a Spanish winemaker from a traditional wine family in the Catalonia region. He moved to Chile in 1979, when the Chilean wine industry was undergoing a deep crisis and was actually very close to disappearing. A Chilean university fellow from Talca who had studied oenology with Torres in Dijon, Alejandro Parot, had convinced him that Chile was the ideal place for modern winemaking.

Notwithstanding the military dictatorship of General Augusto Pinochet and the consequent political isolation of Chile, Torres bought his 100-hectare vineyard in the Curicó Valley and brought with him the revolutionary production tools and techniques (i.e., stainless steel tanks instead of the traditional concrete vats, strict temperature control fermentation, small oak barrels instead of the big wooden casks), which were commonly used in Europe in those years but practically unknown in Chile. At first, his wines met stark resistance. His fresh and fruity wines were denigrated as "wine for girls", since they had lost the traditional taste of prematurely old tannins linked to uncontrolled oxidation characterizing most Chilean wines. Despite the initial scepticism, however, Torres did produce a powerful demonstration effect, based on the success he visibly achieved in the export markets. In recognition of the innovation and technological revolution introduced into Chile, and of the pioneering role he played in attracting a large number of foreign investors, Miguel Torres was awarded the "Bernardo O'Higgins" Grand Official distinction by the Chilean Government in 1997.

A few years after the return to democracy and the election of Patricio Alwyn in 1990, Torres's example was followed by several other foreign investors (see Figure 1), who intensified and sped up the learning-by-imitating process he had originated, drastically upgrading the quality of Chilean wine exports (Benavente, 2006). Encouraged by the high rates of export growth, but especially by the enactment of favourable investment promotion policies (the liberalization Decree on Foreign Investment), a notable number of foreign investors, such as Rothschild-Mouton Lafite, Grand Marnier and Robert Mondavi, made a massive amount of capital flows converge into the Chilean wine industry starting in the early 1990s. As shown above, out of the top 25 Chilean exporting wineries, 11 are owned by national investment groups, such as Claro, Larrain or CCU; 10 by national investors represented by traditional wine families – out of which 6 date back to the late nineteenth century, such as Errazuriz, Undurraga or Cousiño Macul; 4 are national financial investors; 3 are joint-ventures; and only 1 is fully owned by a foreign investor, the Spaniard Miguel Torres.



Source: Foreign Investment Committee, 2009

It can be argued, therefore, that both national and international investors have played a key role in leading the growth of Chilean wine exports. However, the latter also brought with them, in addition to the capital needed for massive improvement in technology, the knowledge of international markets and the most updated technical advice on international consumer tastes, mostly through foreign chief oenologists and "flying winemakers", as will be illustrated in more detail in the following sections. In fifteen years (1990-2005), Chile received 118.1 million US$ foreign investment, including both green-field investment and joint-ventures (Foreign Investment Committee, 2009). These were mainly American, but also French and Canadian, and more recently also Spanish and Italian. From a development perspective, it is interesting to highlight that between 1990 and 2005 more than 52 million US$ were invested in joint-ventures between Chilean and foreign wineries (see Table 4), with a peak between 1990 and 1998, when investment in joint ventures, especially French, reached 38 million US$ (Visser and de Langen, 2006). During 1974-1989, investment through joint-ventures had amounted to 4 million US$ only, representing just the beginning of a trend showing an increasing interest of foreign investors in Chile as a wine export platform but also in Chilean domestic wine companies as partners for strategic cooperation.

Just to cite a few emblematic examples, Chateau Rothschild-Lafite created the Los Vascos winery in 1988, together with the Chilean family Eyzaguirre-Echenique from Vina Santa Rita; the French Marnier Lapostolle group arrived in Chile in 1988, and in 1994 created the joint-venture with the Chilean Rabat family called Casa Lapostolle, which now produces the icon wine Clos Apalta; Mondavi set up the Caliterra winery in 1996, together with the Chilean Vina Errazuriz; in 1997, the French Domain Barons Philippe de Rothschild created a joint-venture with the Chilean Guilisasti family, owner of Concha y Toro, which led to the production of Almaviva, one of the few Chilean icon wines and the only one to be sold *en primeur*;[5] the joint-venture

[5] Like in the futures market, wines sold *en primeur* are paid a certain year and delivered on release one or more years later. The *en primeur* market is especially and almost exclusively developed for Bordeaux wines, as it represents a profitable form of investment for those wines that are expected to have a higher price when they are released, compared to their *en primeur*

between Chateau Dassault and the Chilean winery San Pedro led to the creation of Altair in 2005.

Table 4. Joint-ventures between foreign and Chilean wineries, 1988-2005

Name	National company	Foreign company	Country of origin	Year
Veramonte	Augustin Huneeus	Franciscan State Vineyards	USA	1991
Caliterra	Vina Errazuriz	Mondavi Corporation	USA	1996
Los Vascos	Vina Santa Rita	Château Rotschild-Lafite	France	1988
Chateau los Boldos	Vina Amalia	G.E. Massenez	France	1990
Casa Lapostolle	Familia Rabat	Marnier Lapostolle	France	1994
De Larose	Granella Family	Chateau Larose Trintaudon	France	1994
Selentia	Mayol Buchon	Bodegas y Bebidas	Spain	1999
Almaviva	Concha y Toro	Baron Philippe de Rotschild	France	1997
William Fevre	Victor Pino	Soc. Vignoble William Fevre	France	1991
Aquitania	Felipe de Solminhac	Bruno Prats, Paul Pontallier	France	1990
Dallas Conté	Santa Carolina	Mildara Blass	Australia	2000
Villard Estate	Santa Emiliana	Thierry Villard	France	1989
Corpora-Boisset	Gracia y Porta	Boisset	France	2002
William Cole	Gomez Soffia Family	William S.Cole	USA	2001
Guelbenzu Jardin	Viñas Peralillo	Guelbenzu	Spain	2002
Terravid	Viña Portal del Alto	Mata Romera	Spain	2002
Santa Eliana	Jaime Izquierdo	Viñedos de Jalon	Spain	2002
Conde de Aconcagua	Viñas Mercedes-Estampa	Gonzales Byass-Engel	Spain	2002
Pirque/ Antinori	Haras de Pirque	Marchese Antinori	Italy	2003
Altair	San Pedro	Château Dasseau	France	2004
Erasmo	Caliboro	Marone-Cinzano family	Italy	2005
Mapocho	Vina Canepa	BRL Hardy	USA	2005

Source: Author's elaboration from different sources (CEPAL, 2011; SAG, 2002; Chilevid, 2006; Central Bank Foreign Investments Committee: 2001)

The high value of the Chilean wines produced by joint-ventures and the analysis of the price trends over time have led some authors to argue that in the Chilean wine industry, the partnership between foreign and local companies is definitely a driver of high quality, value added and commercial value (Vergara, 2001; Mac Cawley and Contreras, 2006; Bustos, Torres and Willington, 2007). In particular, according to Bustos, Torres and Willington (2007), during the period 1998-2004 the average price per unit of exported wines was remarkably higher for Chilean joint-ventures than for foreign affiliates without a domestic partner, namely 4.9 US$ per bottle versus 2.1 US$ per bottle, against an overall average of 1.6 US$ per bottle. Additionally, joint-ventures controlled between 23 and 30 percent of the market of super premium wines, against 9-17 percent of foreign affiliates.

From interviews, it emerged that in the Chilean wine industry joint-ventures were often considered a unique combination of local and international knowledge, and a precious learning opportunity for both local and international partners. In particular, most local partners saw in the joint-venture a vehicle for accelerating technological change and accessing international markets, while international partners chose the joint-venture form of investment to reduce the time and efforts needed to acquire the necessary knowledge of local soils, climates and vine-growing patterns. From a development perspective, such reciprocity points to the existence of a win-win situation, whereby the positive impact of FDI is maximized thanks to the creation of linkages and strategic partnerships with domestic producers and suppliers, originating technological spillover effects and learning opportunities.

prices. From the producers' perspective, this is also a very attractive sales strategy, as they don't have to wait until the wine is released to sell their production.

The choice of joint-ventures as the predominant mode of foreign investment, however, is very specific to the wine industry in Chile and cannot be considered the rule in the global wine industry, as the case of Argentina demonstrates**.** In Chile, during 1988-2004 more than 50 percent of the investments in the wine industry were done through joint-ventures. From interviews, it emerged that the reasons foreign investors clearly privileged joint-ventures above all other possible forms of investment in Chile are related to a mix of both industry-related factors and institutional advantages. These are the capability of Chilean firms to make a significant commitment; the perception of mutual benefit derived from continued cooperation; the generation of tangible synergies obtained by combining human and intangible resources, which would be undermined or diminished by more centralized control; and the political and economic stability, together with a solid regulatory framework and low corruption levels, characterizing the new image of Chile after the dark decades of the military dictatorship.

None of these positive factors were recurrently mentioned during field interviews with foreign investors in Argentina. Here, the presence of joint-ventures is quite exceptional, presumably due to the strong sense of uncertainty associated with the Argentine political, economic and regulatory framework. It is estimated that, during 1992-2004, only 14 percent of the investments in the wine industry were joint-ventures. The first ones actually started to operate quite recently, in 1998-2000. The best known example is that of Bodega Caro, a joint venture between Domaines Baron de Rotschild (Lafite) and the Catena family, established in 1998. In 2000, Italian winemakers Roberto Cipresso and Tiziano Sivieiro became associated to create the Achaval-Ferrer winery, producer of one of the most upscale Argentine Malbecs, which is sold on the market at more than 100 US$. The limited number of joint-ventures represents a key element differentiating the Argentine from the Chilean wine industry, which otherwise show strong similarities in several other aspects. Together with the initial delay in the starting-up of the "wine revolution", this fact also contributes to explaining the lower speed of the planting conversion and the slower penetration of international markets which characterize the Argentine wine industry compared to the Chilean.

In the **Argentine wine industry**, a deep restructuring and technology modernization process started only in 1992, well after the end of the military dictatorship of Alfonso Videla (1976-1981), as a consequence of the market liberalization process initiated in 1991, which reduced fears of hyperinflation, thanks to monetary reforms pegging the peso to the dollar. As in the case of Chile, a pioneering role in the "wine revolution" was played by a foreign investor, Chandon, who had moved to Argentina already in 1959, attracted by the good natural conditions and the size of the internal market. Since the early 1950s, the President of Moët & Chandon, Count Robert Jean de Vogue, was convinced that in Latin America he would find the ideal conditions to produce sparkling wines in line with the Moët & Chandon style. In 1957 he entrusted his technical advisor and chief oenologist, Renaud Poirier, to explore different countries and different areas in the continent, and to rent small plots of vineyards in the areas with the highest potential.

In Argentina, Poirier considered several provinces, including Rio Negro, Salta and Mendoza, until, after the first pilot harvest, he decided that the first foreign affiliate of Moët & Chandon outside France would be set up in Agrelo, in the South of Mendoza. Since then, Chandon has constantly expanded its production and consolidated its position as a leading producer and exporter of sparkling wines, including a visitor centre, certified under the ISO 9001 norm, receiving more than 20,000 tourists per year. More than three decades later, following the pioneering example of Chandon

but only after the country had partially regained political and economic stability and defeated hyper-inflation, foreign investors discovered Argentina as a potential destination for foreign investment in the wine industry (Chudnovky et al., 1994).

From 1992 to 2008, an estimated 550 million US$ was invested in the Argentine wine industry. Most FDI originated from the US, but also from France, Spain, the UK and, later on, Chile (see Table 5). Foreign investors introduced modern management techniques, planted new varieties and developed new production areas, bringing Argentine wines closer to international taste than they had ever been (Onofri, 2000). Interestingly, during those years a wide group of local winery owners sold their wineries to foreigners, fearing to be excluded as a consequence of the liberalization process. The phenomenon was so profound that in the 1990s only six of Argentina's large family wineries remained in the hands of the founding families. As observed earlier, of the top 25 Argentine exporting wineries, 17 are owned by foreign investors; one is an Italo-Argentine joint-venture; six are old family businesses, established at the beginning of the twentieth century; one is a more recent national investment (Susana Balbo). It should be noted, though, that the availability of fresh capital offered a second chance to several local winemakers and their descendants, who, after having sold their company to foreign investors, went back to winemaking with renewed culture and habits, setting up small but fully export-oriented "boutique" wineries.

Table 5. Main foreign investment in the Argentine wine industry, 1992-2008

Winery	Foreign Investor	Origin	Total amount (million US$)	Year
Santiago Graffigna	Allied Domecq	UK	43	2004
Santa Ana	Donaldson, Luftkin y Jenrette	USA	40	1999
Penaflor	Donaldson, Luftkin y Jenrette	USA	40	1999
Trapiche	DLJ Merchant Banking	USA	40	1998
Kendall Jackson	Kendall Jackson	USA	30	1996
Finca La Celia	San Pedro	Chile	30	1997
Covisan	SCH	Spain	25	1995
Santa Ana	Santa Carolina	Chile	25	1996
Maison Calve	Allied Domecq	UK	22	1992
Bodegas Norte	Marqués Grignon	Spain	22	1995
Trivento	Concha y Toro	Chile	17.5	1996/2008
Bodegas Norton	Gernot Swarovsky	Austria	16	1992
Resero	Marubeni	Japan	16	2000
Terrazas	Moët Chandon	France	16	1999
Navarro Correas	CINBA	UK	15	1996
Santa Maria	Bernard Taillan	France	15	1998
Lopez	Exxel Group	USA	15	2003
Viñas Argentinas	Marubeni Corp.	Japan	14	2000
Salentein	Salentein	Holland	14	1999
Bodegas Flichman	Sogrape Vinhos	Portugal	15	1997
Doña Paula	Santa Rita	Chile	10	1998
Bodegas Premier	Concha y Toro	Chile	8	1996
O.Fournier	Fournier Family	Spain	8	1999
Bodegas Balbi	The Hiram Walker	US	7	1992
Bodegas Etchart	Pernod Ricard	France	7	1992
Navarro Correas	Diageo	UK	6	1997
Montalembert	Montalembert	France	6	1995
Domain Vistalba	Domain Vistalba	France	5	1992
Finca El Origen	Santa Carolina	Chile	5	1998/2001
Henri Piper	Extreme	France	5	1998
Chateau Los Boldos	Sogrape	Portugal	5	2008
Séptima	Codorniu	Spain	2.5	1999
Martins Domingo	ARCO Bodegas Unidas	Spain	2	1997
Universo Austral	Viñedos Corpora	Chile	2	2008
Kaiken	Viña Montes	Chile	0.4	2003
Tarapacà	Tamari	Chile	0.25	2003
Total			551.65	

Source: Author's elaboration from different sources (CEPAL, 2001; SAG, 2002; Chilevid, 2003; Central Bank Foreign Investments Committee, 2009; SAGPyA, 2009; FLACSO, 2008)

It may be surprising to realize that Chilean foreign investments in the Argentine wine industry are second only to US investments. Chilean producers started to invest in Argentina in the mid-1990s, especially in Mendoza, just across the Andes, taking advantage of the geographical and cultural proximity with Santiago de Chile (van Tienhoven, 2008).[6] The presence of Chilean investors is certainly a good sign for the Argentine wine industry, since Chilean wineries have invested there in order to diversify their wine export basket and to exploit the Argentine quality factors (see Table 6). The wider range of varieties available in Argentina, especially Malbec, and the relatively easier access of Argentine wines to the higher priced wine segment were the key pull factors. Contrary to what is often claimed, Chilean investors give priority to Argentine wine characteristics, and have helped to position Argentine wines in international markets through their own established distribution and commercialization networks, especially in Asia and the United States. In this respect, it emerged from interviews that Chilean capital and know-how were key to teaching their Argentine neighbours how to penetrate international markets. Emblematically, Trivento has become the second largest Argentine wine exporter, while Finca la Celia was the first in Argentina to introduce quality management and certification. During an interview held in Buenos Aires, the director of the wine consulting firm Caucasia estimated that in 2010 more than 12 percent of Argentine exported bottled wine originated from Chilean investment, and that this figure could more than double to at least 25 percent during the next five years.

Table 6. Chilean FDI in the Argentine wine industry, 1992-2008

National company	City	Name of the company	Amount of investment (million US$)	Extension	Year
Concha y Toro	Mendoza	Trivento	17.5	300 ha	1996/2008
Santa Rita	Mendoza	Doña Paula	10	730 ha	1998
San Pedro	Mendoza	Finca La Celia	30	600 ha	1997
Santa Carolina	Mendoza	Santa Ana	25	1,800 ha	1996
Tarapacà	Mendoza	Tamari	0,25	120 ha	2003
Viña Montes	Mendoza	Kaiken	0.40	80 ha	2003
Santa Carolina	Mendoza	El Origen	5	300 ha	1998/2001
Concha y Toro	Mendoza	Bodegas Premier	1	250 ha	1996
Viñedos Corpora	Mendoza	Universo Austral	2	150 ha	2008

Source: Author's elaboration from different sources (CEPAL, 2001; SAG, 2002; Chilevid, 2006; Central Bank Foreign Investments Committee: 2001)

5. The role of capital-embodied and codified knowledge flows

With the arrival of a large amount of foreign investment and fresh capital flows, the removal of the trade barriers that had sheltered the Chilean and Argentine wine industries from global influences, and the rising international demand for New World wines, the right incentives and conditions were present for domestic wineries to drastically improve the quality of their product, in order to meet the increasingly sophisticated demand of international consumers. In both countries, radical structural changes occurred in all aspects of wine-making, from production technologies to product development, bottling, distribution and commercialization techniques. As shown above, all 25 leading Chilean and Argentine exporting wineries adopted most modern winemaking technologies, including the use of stainless steel vats in place of large wood casks; the installation of refrigeration devices, both for fermentation and maturation; the use of pneumatic presses rather than old vertical

[6] For more than two centuries (1561-1776), both Santiago and Mendoza belonged to the Kingdom of Chile (Provincia de Cuyo de Reino de Chile). During that period, winemakers from both cities and surrounding areas formed the most important viticultural pole of Latin America, characterized by a regular transport system across the Andes, continuous exchanges of information, and simultaneous incorporation of new ideas and technological innovations into their wine production. This was sold jointly and often exported to other Latin American countries – mostly to Peru (Lacoste, 2008).

ones; and the use of small oak barrels in place of the old large vats made of native beech. It, therefore, comes as no surprise that, according to Comtrade data, in the last three decades Chile and Argentina have been gigantic importers of machinery and equipment for winemaking from European leading producers (see Table 7).

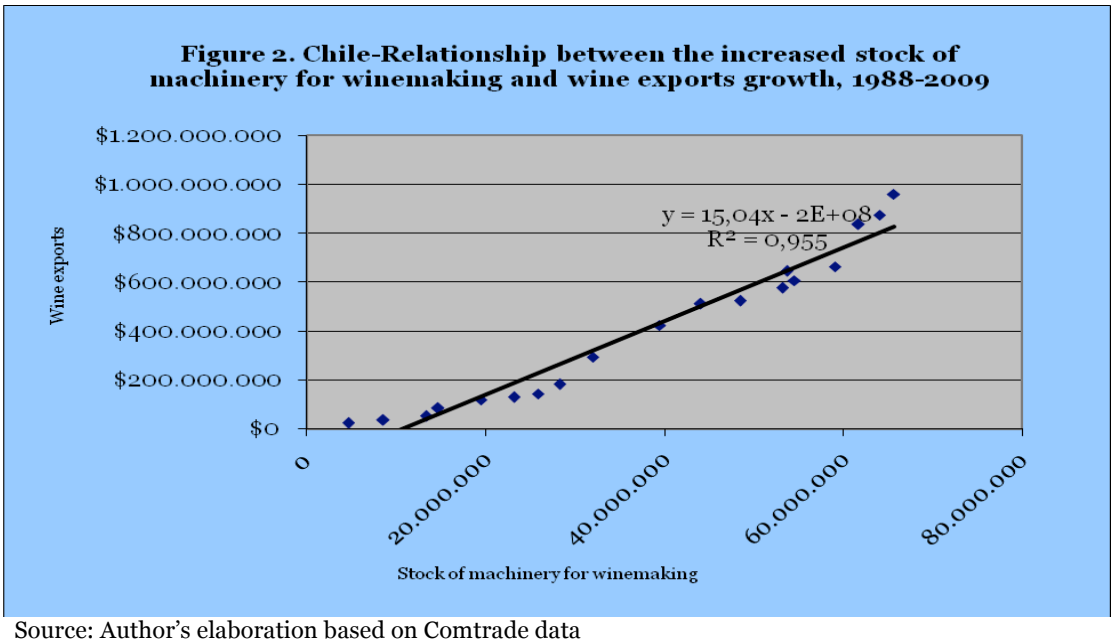
Table 7. Imports of presses, crushers, and other machinery for winemaking in Chile and Argentina, 1988-2008

	Chile	Argentina
1986	$287,908	n.a
1987	$546,938	n.a
1988	**$3,408,123**	n.a
1989	$4,022,475	$248,565
1990	$5,080,370	$784,822
1991	$1,736,348	$496,302
1992	$5,230,740	**$2,090,380**
1993	$4,250,406	$3,512,829
1994	$3,408,294	$4,376,705
1995	$3,182,857	$1,956,683
1996	$4,559,024	$2,660,663
1997	$8,438,233	$4,428,383
1998	$5,767,716	$5,634,570
1999	$5,722,333	$6,743,544
2000	$6,164,867	$3,106,598
2001	$2,166,226	$2,953,625
2002	$2,406,589	$1,036,517
2003	$6,163,404	$3,481,963
2004	$4,383,744	$3,092,773
2005	$4,232,099	$5,485,351
2006	$3,540,261	$4,084,391
2007	$3,704,517	$5,035,765
2008	$5,723,738	$5,089,815
Total	$93,292,364	$66,300,244

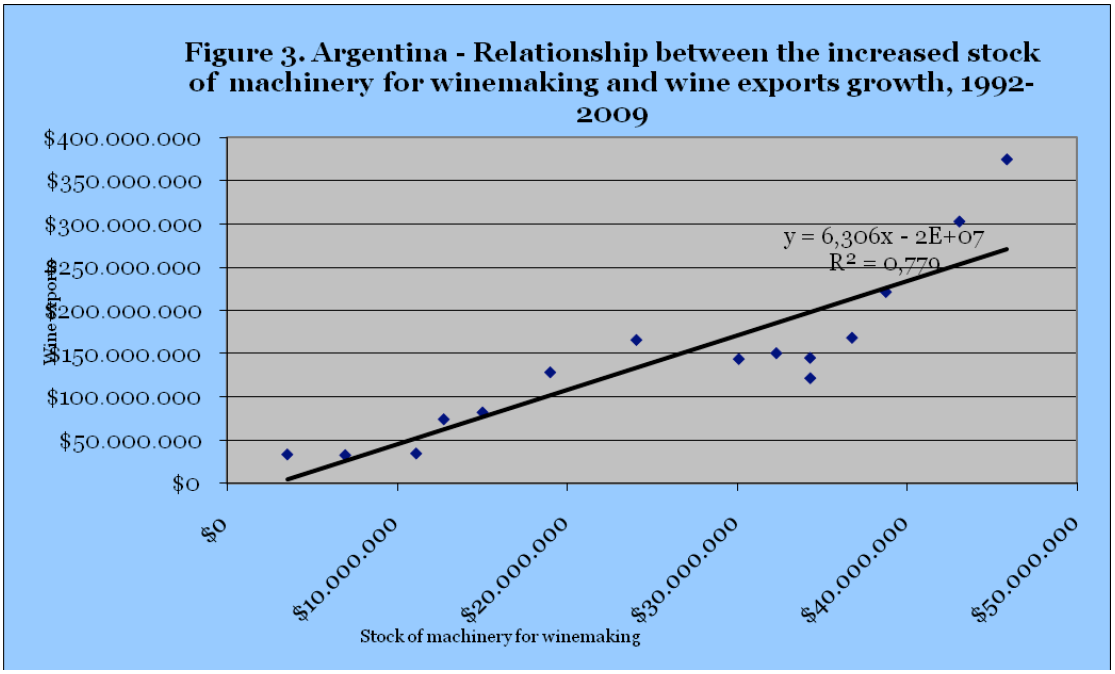
Source: Comtrade, SITC Rev.2, 72191

In the case of **Chile**, a huge investment in machinery and modern cellar equipment (including presses, crushers and other machinery) at the enterprise level started to take place in 1988, the very same year dictatorship ended, and market reforms started to unleash their positive effects. This led to a deep technological conversion process and the overall upgrading of the local wine industry, with several wineries being transformed into state-of-the-art wineries, equipped with the most advanced machineries and technologies. From 1988 to 2008, Chile undertook an investment in foreign winemaking machinery of more than 93 million US$, and for five consecutive years the country represented the largest importer of European winemaking equipment, to the point that it can be said without exaggeration that today the Chilean wine industry is one of the best equipped in the word. In the case of **Argentina**, the acquisition of foreign machinery for winemaking (as in Chile, imported from Europe, mainly France, Italy, Germany and Switzerland) took off a few years later, in 1992, after the liberalization decree entered in vigour. From 1992 to 2008, the total imports of Argentina in foreign machinery reached almost 67 million US$ – a figure that, despite being remarkable in itself, ranks well below that of its Chilean neighbours in absolute terms, and even more so if one relates it to the higher amount of vine cultivated land over the same years.

The regressions below, based on Comtrade data, show that there could be a direct correlation between the increase in the stock of capital equipment for winemaking, imported from abroad, and the growth of Chilean and Argentine wine exports (see Figures 2 and 3). However, they also point to the presence of a very different pace at which technological change spread out among domestic wineries and increased their export capacity.



Source: Author's elaboration based on Comtrade data



Source: Author's elaboration, based on Comtrade data

Data on elasticity variations show that in **Chile**, from 1988-2009, a 1 percent increase in the amount of imported technology increased wine exports by 15 percent. In **Argentina**, from 1992-2009, a 1 percent increase in the amount of imported technology increased wine exports by 6.3 percent only. This can be explained by the fact that, beyond the most advanced segment of the leading exporting firms – which, as illustrated above, performed quite similarly in terms of innovative behaviours – the Argentine "sleeping giant" is awakening but at relatively slow pace compared to the more agile and fully export-oriented Chilean competitor. In other words, as *The Economist* put it a few years ago, *"Argentina is catching up with Chile, but not as fast as it might"* (*The Economist*, 2007).

The slower speed of technological diffusion and export growth can be ascribed to both the stark economic fluctuations that have characterized the Argentine economy

until quite recently (versus the Chilean economic and political stability), and to the mere fact that the industry structure and the size of the Chilean and Argentine wine industries are very different. Argentina presents not only double the area cultivated with wine grapes than Chile (217,000 hectares versus 114,000), but also almost half of the hectares per grower (8.3 versus 14), almost three times the total number of officially registered wineries (934 versus 360), and more than double the number of exporting wineries (257 versus 120). Only the degree of export concentration is very similar, with respectively 65 and 75 percent of exports originated by the group of the leading 25 exporting wineries. In both countries these wineries have been able to reach high international standards and a better consistency of the quality levels of their wines, thereby meeting international consumers' preferences and gaining increasing export shares in the international market.

Thanks to the incorporation of imported machinery and equipment, as well as sustained flows of knowledge and techniques brought by foreign investors, the majority of the leading Chilean and Argentine exporting wineries (14 out of 25 in both cases) have been certified not only under ISO and HACCP norms, but also under social and environmental standards. The most widespread quality certifications are ISO 9001 (quality management systems), ISO 14001 (environmental management systems), HACCP (Hazard Analysis Critical Control Points) and the British Retail Consortium, which is regarded as a global benchmark for best practices in the food industry. In addition, Argentine wineries are paying increasing attention to ISO 22000 (food safety management system), the most recent ISO standard aimed at ensuring that there are no weak links in the food supply chain.

In both Chile and Argentina quality certification is playing an increasingly important role in improving the winemaking processes, and especially in stratifying different production segments (e.g., premium brands from lower quality brands) and setting up corresponding prices. This confirms the increasing importance of quality and safety standards, namely of non-price competition factors, in the consolidation of the entry strategy of "latecomers" in the global wine industry (Humphrey, 2003). Therefore, it can be argued that, in some cases, global quality standards may represent a useful external factor in triggering innovation, pushing local suppliers to ensure increased quality, integrity and reliability of their production, without necessarily undermining the capacity of developing countries to compete in the international market.

6. The importance of tacit knowledge flows

This section examines the role of tacit knowledge flows as a way of learning and de-codifying imported knowledge, and looks at the emergence of domestic abilities of learning, innovating and adapting foreign technologies and know-how to local conditions. In this respect, Giuliani (2007) argues that in the wine industry the capacity to absorb codified knowledge through a process of decoding and the capacity to absorb tacit knowledge are equally important. Tacit knowledge is the result of a process of accumulating experience over time and is complementary to codified knowledge. Oenologists and agronomists, who both embody tacit skills, are decoders of codified knowledge and apply it to a complex, ever-changing environment.

The evolutionary literature suggests that, as technology becomes more sophisticated and science advances, the ratio of codified to tacit knowledge also increases. It also suggests that, as codification is never complete, some forms of tacit knowledge always play an important role (Cowan and Foray, 1997). In the wine industry, although procedures used for winemaking have been, to a large extent, codified, the adaptation

of both vinicultural and viticultural techniques to local geographical and climatic conditions, and to the type of wine being made (whether it is for immediate or deferred consumption) cannot be codified, and relies rather on the application of tacit knowledge. Therefore, it is important to assess the extent to which in the Chilean and Argentine wine industries technology and knowledge have been absorbed in a way that is conducive to development, namely the extent to which a solid **local absorptive capacity** was created.

The findings of the present filed survey show that, in Chile and Argentina, the "embeddedness" of the production of high-quality wines for exports and the creation of endogenous tacit knowledge and wine-related R&D were key to sustaining export growth for more than two decades and to obtaining deeper benefits from it. At the very initial stages, in order to "decode" the knowledge embodied in capital and intermediate goods, both Chilean and Argentine wineries relied on international oenologists, who were regularly consulting for foreign-owned wineries on a semi-permanent basis. Given the complex knowledge base of the wine industry, and the increasing codification of knowledge in scientific publications, manuals, software and digital equipment, a "knowledge conversion process" was needed in order to make it accessible to local actors and to bring the Chilean and Argentine wine industries closer to international quality standards.

Still today, international oenologists are key in transferring frontier techniques on grape growing and winemaking, and in bringing to Chile and Argentina a dynamic, periodical flow of new information. However, these are mostly "flying winemakers", namely consultants who regularly go to Chile and Argentina only for the harvest, on a counter-seasonal basis. Local oenologists, in fact, are now producing a considerable amount local tacit knowledge as a basis for the diffusion of innovation and for the use of foreign knowledge in the local context. The present survey of the leading Chilean and Argentine wine exporters reveal that in both countries, wineries have started to look for national rather than international short-term consultants in order to secure the quality of the harvest and source specific technical knowledge. It also reveals that in order to recruit permanent staff, they are increasingly looking to highly qualified national rather than international chief oenologists, and to a large pool of highly skilled agronomists with advanced university degrees.

In particular, in the case of **Chile** the transmission belt of intangible knowledge flows were initially a group of foreign consultants who established themselves in Chile for long periods to work as chief oenologists (see Table 8). Some of them, such as the Spanish chief oenologist of Torres, have played a key role in showing how Chilean wine could meet the requirements of international demand and are still in place today. Others were hired by supermarkets and distribution chains (especially from the UK) to help adapt Chilean wines to international characteristics. The development of internationally recognized icon wines is still triggered by international oenologists, but of a different kind. Rather than permanent oenologists or consultants hired by buyers to tailor wines to their home market, these are rather flying winemakers – many French, as the famous Michel Rolland, but also Australians, Germans and Americans – who are hired by Chilean wineries and travel to Chile only once a year, during the harvesting season.

Table 8. Flying winemakers hired by the top 25 Chilean exporters of bottled wines

	Winery	Type of investment	International consultants ("Flying winemakers")
1	Concha y Toro	National investment	Jacques Boissenot (FR) and Goetz von Gersdorff (DE)
2	San Pedro	National investment	Paul Hobbes (US) for reserve line
3	Santa Rita	National investment	Christian Le Sommer (FR)
4	Cono Sur	National investment	Martin Prieur (FR)
5	Errazuriz	Old family business	Edward Flaherty, US
6	Undurraga	Old family business	-
7	Montes	National investment	-
8	Santa Carolina	National investment	Christian Wylie and Sven Bruchfeld (AUS)
9	Santa Helena	National investment	Pascal Chatonnet (FR)
10	Tarapacà	National investment	-
11	Carmen	National investment	Christian Le Sommer (FR)
12	Santa Emiliana	National investment	-
13	La Rosa	Old family business	-
14	Ventisquero	National investment	John Duvall (AUS) for Syrah
15	Los Vascos	Joint-venture	Christian Le Sommer (FR)
16	Valdivieso	Old family business	-
17	Casa Lapostolle	Joint-venture	Michel Rolland (FR)
18	Miguel Torres	Foreign investment (SP)	-
19	Canepa	Family business	Ian Mackenzie and David Morrison (AUS)
20	Felipe Edwards	Family business	Mike Farmilo and Brian Light (AUS)
21	Bisquertt	Family business	-
22	Cousiño Macul	Old family business	Matias Rivera (US)
23	Santa Ema	Old family business	Goetz Von Gersdorff (DE)
24	Casa Silva	Family business	-
25	Almaviva	Joint-venture	-

Source: Author's survey

From the point of view of human resources, therefore, both Chilean and international oenologists and agronomists have actively contributed to the technological revolutions that have shaped the wine industry in Chile more quickly and more extensively than in any other developing country, New World producer. The first technological revolution, strictly related to winemaking processes and the import of foreign machinery, took place in the 1980s and early 1990s and was triggered by foreign investors, such as Miguel Torres, foreign oenologists (mainly French) and a small group of "old" Chilean oenologists, such as Prof. Alejandro Hernandez,[7] who then became renowned university professors in Chilean universities. The second technological revolution started in the mid-1990s, and was driven by seasonal foreign consultants (from both the Northern and the Southern hemisphere), as well as by a

[7] The Chilean winemaker and oenologist Prof. Alejandro Hernàndez was the first non-European to hold the position of Director General of the International Organization of Vine and Wine (OIV), a Paris-based organization created in 1924 for the purpose of connecting all actors who were active in the international winemaking scenario and of sharing scientific best practices and technical learning. Since 2001, both Chile and Argentina have become respected members of OIV, and are particularly active in organizing regional activities in Latin America. Twelve annual congresses on Viticulture and Oenology have been organized in Latin America, under the auspices of OIV. At the conferences, OIV provides participants (mostly scientists, oenologists and professionals) with information on the scientific work carried out by OIV experts during the annual meetings, as well as with documentation related to the most relevant discoveries and innovations worldwide in the areas of viticulture and viniculture.

much broader group of young Chilean oenologists and agronomists. It mainly consisted in the diffusion of tacit knowledge in viticulture, made necessary by modern cultivation techniques, such as limiting yields and excessive irrigation, and in the identification of the distinctive character of Chilean wines, including that of its typical variety, Carmenère. This new generation of young, highly qualified oenologists, including several women with extensive experience abroad and well reputed university degrees (in Chile they have to graduate first as agricultural engineers, so they are usually doubly qualified), has rapidly taken over technical and commercial tasks, as well as full decision-making responsibilities in both foreign and nationally owned wineries.

Currently, 18 out of the 25 top Chilean exporting wineries employ Chilean rather than foreign oenologists as chief winemakers, with top academic credentials and a broad working experience abroad, and at least one, but usually more, highly skilled agronomists with a university degree. For example, in the case of Concha y Toro, the Chilean oenologist Marcelo Papa joined the company in 1998 and was very quickly promoted to Chief Winemaker of the Puente Alto cellar. In 2002, he became Chief Winemaker of the Maycas del Limarí winery, in line with a sustained tradition of mobility and rotation of oenologists among top Chilean wineries. Max Weinlaub – who holds an oenology degree from the Universidad Mayor in Chile and has working experience in Oregon and California (Crema Winery in Santa Rosa and Franciscan Estates in Oakville) – joined Concha y Toro in 2000, where he worked for seven years as Marcelo Papa's right hand, making the highly successful global brand Casillero del Diablo. He is now chief winemaker of Viña Maipo and Viña Canepa. Ignacio Recabarren, a pioneer of the Chilean wine industry, has worked in California (Tyland Vineyard, Mendocino County), France (Chateau Mocallaux, Chateau Margaux, Chateau Lafite) and New Zealand (Morton Estate, Matua and Cloudy Bay). He is currently responsible for three of Concha y Toro's top wines, namely Carmin de Peumo, Amelia and Terrunyo. Amelia was the first Casablanca Chardonnay to receive a *Wine Spectator* 90-point rating, while the Carmin de Peumo Carmenère is the highest rated Carmenère in the country .

The present survey also reveals the emergence of a local group of well recognized national consultants, that travels abroad regularly to provide specialized expertise or to participate in harvests on a counter-seasonal basis – mainly in France, Australia and the United States. For example, Adolfo Hurtado, the Chilean chief winemaker of Cono Sur since 1997, is the most passionate proponent of organic viticulture in Chile, and has been a long-time leading consultant in Chile and abroad on environmentally friendly production techniques. Another Chilean oenologist, Alvaro Espinoza, chief winemaker of Emiliana, is unanimously considered the father and one of the most competent national and international specialists of biodynamic wines. Felipe de Solminihac holds a degree in Oenology from the Catholic University of Chile and a specialization degree from the University of Bordeaux. He is the founder of the Aquitania winery and has working experience in France, Spain, New Zealand, Australia, China and South Africa. Furthermore, he is the President of the Chilean Association of Oeno-agronomists, the Director of the Chilean Wine Corporation, and one of the most respected national consultants and academics in the field of vine sciences.

In Chile, three universities offer a specialization in Oenology: the Catholic University of Chile, the University of Chile, both located in Santiago, and the University of Talca. All Chilean oenologists are also agronomists, a peculiarity of the Chilean education system which guarantees a particularly solid preparation of local oenologists. The profession of agricultural engineer has incorporated the specialization in Oenology since 1950. The National Association of Engineers-Oenologists was created in 1953.

In the 1990s, 321 oenologists graduated in Chile, compared to 177 in the 1970s, and 50 in the 1980s. Therefore, it can be estimated that more than 600 highly qualified professionals are currently operating in Chile. All Chilean Faculties of Oenology are part of international networks and alliances that allow recently graduated agricultural engineers to undertake post-graduate studies abroad, particularly in France (Montpellier and Bordeaux).

Based on the above, it may be less surprising to realize that at the origin of super-premium Chilean brands (>95 points *Wine Spectator*) there are joint-ventures or national investment, rather than foreign investment alone, which are very often led by Chilean oenologists. It is also easier to understand why, based on the presence and availability of such highly skilled professionals, all 25 Chilean wineries interviewed commented that they regularly introduce incremental innovations based on in-house R&D efforts, aimed at continuously improving and adapting current habits and practices. Many also added that it would not have been possible to introduce such large amounts of foreign technologies as they did in the last twenty years without the presence of highly qualified local professionals who were aware of the existence of frontier technologies and could quickly learn their functioning modalities when these were finally imported. In this sense, the "technology capture" tours organized and financed by the Chilean government to stimulate "learning by looking" and "learning by interacting" processes have been key to empowering Chilean oenologists, and to stimulating their own innovation capabilities in the area – not only of winemaking, but also of marketing and vine growing.

As in the case of Chile, **Argentina** foreign winemakers have played a very important role in the systematic "decodification" of the knowledge transferred from abroad through the massive imports of capital and intermediate goods. They have also shown that high-quality wines could be produced in the country and be recognized by international consumers as such. In the past, only Chandon, the foreign investor who played a pioneering role, brought to Chile its own French oenologists and kept them in place for several decades. In most other cases, foreign consultants were called upon only at the beginning of the technological conversion process in order to assess the technological level of the winery equipment and related procedures, and to obtain advice on the changes to be introduced. Afterwards, they maintained an on-going relationship with the wineries but only on an counter-seasonal or occasional, problem-solving basis. Presently, as in the Chilean case, the majority of the leading Argentine exporters of bottled wines (16 out of 25) rely on "flying winemakers" (see Table 9).

Nowadays flying winemakers are mostly called upon to broaden the knowledge of international consumption styles, fashions and trends, and to meet the requirements of new markets. It is striking to note that three of the most renowned foreign consultants, namely the French winemaker Michel Rolland, the Italian winemaker Alberto Antonini and the US winemaker Paul Hobbes, have been advising several Argentine wineries at the time, thereby laying the ground for a certain "repetitiveness" of styles that has often been criticized by the specialized literature (Nossiter, 2009), and which is not so pronounced in Chile, where the choice of foreign consultants is more diversified.

Table 9. Flying winemakers hired by the top 25 Argentine exporters of bottled wines

	Winery	Type of investment	International consultants ("Flying winemakers")
1	Zuccardi	Old family business	Enrique Tirado (CL)
2	Tivento	Foreign investment	Alberto Antonini (IT)
3	Catena Zapata	Old family business	Paul Hobbes (US)
4	Trapiche	Foreign investment	Michel Rolland (FR)
5	Norton	Foreign investment	–
6	Finca Flichman	Foreign investment	Michel Rolland (FR)
7	Navarro Correas	Foreign investment	Jeffrey Strambot (US)
8	Pascual Toso	Old family business	Paul Hobbes (US)
9	Terrrazas	Foreign investment	Nicolas Aubert (FR)
10	Luigi Bosca	Old family business	–
11	Escorihuela Gascon	Foreign investment	–
12	La Celia	Foreign investment	Paul Hobbes (US)
13	Dominio del Plata	National investment	–
14	Septima	Foreign investment	–
15	Fournier	Foreign investment	–
16	Lurton	Foreign investment	Olivier Ruhard (FR)
17	Salentein	Foreign investment	Michel Rolland (FR)
18	Doña Paula	Foreign investment	Andrés Ilabaca (CL)
19	Nieto Senetiner	Foreign investment	Alberto Antonini (IT)
20	Chandon	Foreign investment	–
21	Alta Vista	Foreign investment	–
22	Alto Las Hormigas	Foreign investment	Alberto Antonini (IT)
23	Valentin Bianchi	Old family business	Robert Pepi (US)
24	Augusto Pulenta	Old family business	–
25	Achaval Ferrer	Joint-venture	Roberto Cipresso (IT)

Source: Author's survey

Another major factor differentiating Argentina and Chile is the presence in Argentina of a large number of "old family businesses", namely of traditional wineries founded at end of the nineteenth century by Italian and Spanish immigrants, who were passionate winemakers and who transmitted their passion for winemaking to their direct descendants. In several cases, despite the decision to sell part of the company to foreign shareholders, the family remained in charge of the winery and personally brought to completion its renovation and modernization process. Nicolas Catena, Alberto Zuccardi, Leoncio Arizu and Valentin Bianchi are all winemakers of the same generation, who led the diffusion and adaptation of radical innovations in Argentine wine production routines. Despite the large presence of flying winemakers, equivalent to that of Chile, this may explain the more pronounced character and "distinctive" personality of Argentine compared to Chilean wines, and the fact that they have been much less accused than their neighbours across the Andes of having adopted a uniform, homogenized international style, without paying enough attention to local uniqueness factors.

It is important to note that, in contrast to Chile, the real driver of the wine revolution in Argentina was a national winemaker – Nicolas Catena, owner of the Catena Zapata winery. When Catena took over the family winery from his father in 1982, he

immediately sold the table wine part of the business and kept only the higher quality, bottled wine part, meeting with the scepticism of all his peers. Catena was the first to believe in the potential of Mendoza's poorest soils near the Andes, which immigrants had initially discarded due to their scarce fertility. As he suspected, those soils were actually ideal for high-quality viniculture, and also ideal for the cultivation of Malbec, which was thought would never ripen at high altitudes. Catena was also the first to believe in the potential of Malbec. As there was no tradition of clonal selection in Argentina, in order to improve local plants, he imported new clones from Cahors in France, with disappointing results. So, he decided to develop his own clonal selection of Argentine Malbecs. He planted 145 clones and selected the best 5, then planted those 5 at different altitudes and in different *terroirs*. In 2003, he identified the best *terroir* for Argentine Malbecs. Recently, with his daughter Laura, he invented the revolutionary concept of "single varietal, microclimate blending", which seeks to combine the different advantages of various microclimates in Mendoza, by vinifying plots of the same grape variety, situated at different altitudes separately and blending them just prior to bottling based on their specific characteristics.

The case of Catena is not unique. For example, José Alberto Zuccardi, son of an Italian engineer from Avellino, took over the largest family-owned winery in Argentina from his father in 1976. Always at the forefront of winemaking innovations, he was the first to bring back to Argentina the rights for the most modern forms of irrigation introduced in California. Zuccardi always believed that good wine was made in the vineyard, even when this thinking was still very new to Argentina. Since he had always considered irrigation strategic for the quality management of the vineyards, he invested heavily to equip his vineyards with the most updated irrigation technologies, and his irrigation system was a fundamental contribution to agricultural modernization of viticulture in Mendoza. Zuccardi, though, continued to produce only for the domestic market until 1991, namely until having built an ultra-modern winery in 1998, which allowed him to reach the quality standards of export markets. In 1999, he produced the first ultra-premium wine in Argentina (Zuccardi Q Malbec), as well as the first premium wine made of a non-traditional grape variety (Zuccardi Q Tempranillo). The "old" generation of winemakers belonging to the best known family, however, is not the only important local actor generating endogenous innovation in the Argentine wine industry. As it happened in Chile, a younger generation of national oenologists and consultants, with solid academic backgrounds and extensive working experience abroad, seems to have taken over, or at least to play an increasingly important role.

As in the Chilean case, only a small minority (3 out of 25) of the leading 25 Argentine exporters of bottled wines have opted for a foreign oenologist as their chief winemaker – two of them are Italian and one French. From interviews, it emerged that this is specifically due to the passion and personal involvement of Italian winemaking investors in Argentina, on the one hand, and to the still close relationship of foreign affiliates with their headquarters in France on the other. To the contrary, the vast majority (22 out of 25) of wineries currently relies on Argentine rather than foreign chief winemakers, as well as on a substantial pool of local agronomists, viticulturalists and consultants in their thirties.[8]

[8] In 2012 Claudia Inès Quini, the President of the Argentine National Institute of Vitiviniculture, based in Mendoza (INV), was appointed President of the International Organization of Vine and Wine (OIV). Ms. Quini is a chemical engineer and is the first woman to be appointed as head of the prestigious intergovernmental organization based in Paris. At the 25th OIV World Congress, held in Smirne, Turkey, on 18-22 June 2012, it was announced that Argentina will be the host of the OIV Congress in 2014.

For example, Paula Borgo, the chief oenologist of Séptima, graduated from the Cuyo National University in Mendoza, holds a master's degree in Viticulture and has worked in the US (Kendall Jackson) and Spain (Solis). Gustavo Marin is the chief winemaker of Escorihuela Gascon; after his degree in Oenology at Don Bosco University in Mendoza, he took a master's degree in quality control in Portugal and a postgraduate degree in Winemaking Planning and Quality Management in France. Alejandro Vigil, the chief winemaker of Catena Zapata, graduated from the Agricultural Engineering Faculty of Cuyo National University in Mendoza. He holds a master's degree in Irrigation Management and Microclimate Definition, and headed the Soil Analysis Department of the National Institute of Technology (INTA) for several years. In 1995, Raul de la Mota, graduated from the Oenology school of the National University of Cuyo, was awarded the distinction "Best Oenologist in Argentina in the Twentieth Century" by the World Wine Press Association in Bordeaux, subsequently becoming one of the most renowned national consultants, together with Angel Mendoza, current director of the postgraduate courses at Maza University in Mendoza.

In Argentina, becoming a licensed oenologist now requires five-years of tertiary specialized education, in addition to a high school degree. However, it was not like this in the past. Until 1999, when the Federal Law on Education was reformed, accredited oenologists were not only those graduated from the Mendoza-based University Juan Agustín Maza, which represented the only university-level training institution in oenology of the country, but also those who had a secondary education degree from the technical school Don Bosco, situated in the province of San Juan. In 2000, the Don Bosco School merged with the Catholic University of Cuyo, which consequently inaugurated a new Faculty of Oenology and Fruit-culture, and is now only awarding a tertiary degree. According to the data collected by Walters (1997), until 1979 in Argentina there were only 81 oenologists (both with a secondary and a tertiary education degree). From 1980 to 1989, the number increased to 159, but fell again to 34 from 1990 to 1997, due to the heavy crisis of the sector. According to more recent data, collected during field interviews, in 2009 there were 65 oenologists in Argentina with a university degree from a Faculty of Oenology, out of which 41 from the Faculty Agustín Maza. There were also 427 technical specialists with a secondary education degree in oenology from the Don Bosco School. Additionally, however, there were around 600 Agronomists graduated at the University of Cuyo, who had chosen to specialize in oenology.

An interest in the discipline of oenology and an increasing demand for oenologists with tertiary education and higher is proven by the number of universities now offering courses and post-graduate degrees in the subject. In 2004, the National University of Technology, based in Mendoza, inaugurated a master's degree in wine technologies; in 2007, the University Agustín Maza inaugurated a master's degree in Management and Strategic Planning in Wine Business; in 2010, both the Universities of Catamarca and Salta created a new Faculty of Oenology, bringing to four the number of universities now providing the opportunity to undertake oenology studies in Argentina. Contrary to Chile, a degree in Agronomy is not a prerequisite, even though the increasing demand for agronomic competencies has led the National University of Cuyo to inaugurate in 2009 a master's degree in Agronomic Sciences and Vitiviniculture, and to launch a new research programme on applied agronomic research, with the direct involvement of firms.

It is not very surprising, therefore, as neither it was in the Chilean case, that all 25 leading Argentine exporters of bottled wines argued that a large amount of innovation of all types (product, process and organizational) was introduced during the last five years, thanks to local tacit knowledge and internal human resources,

based on continuous trial-and-errors, observation and adaptation of imported technologies and know-how. The findings of the survey, therefore, are in line with the hypothesis that the ability of developing countries to enter knowledge-intensive natural resource-based sectors, such as wine, depends not only on their ability to access capital, technology and knowledge from abroad, but also on their ability to absorb and adapt them to the local environment, thanks to the creation of local tacit knowledge by highly skilled human resources of national origin.

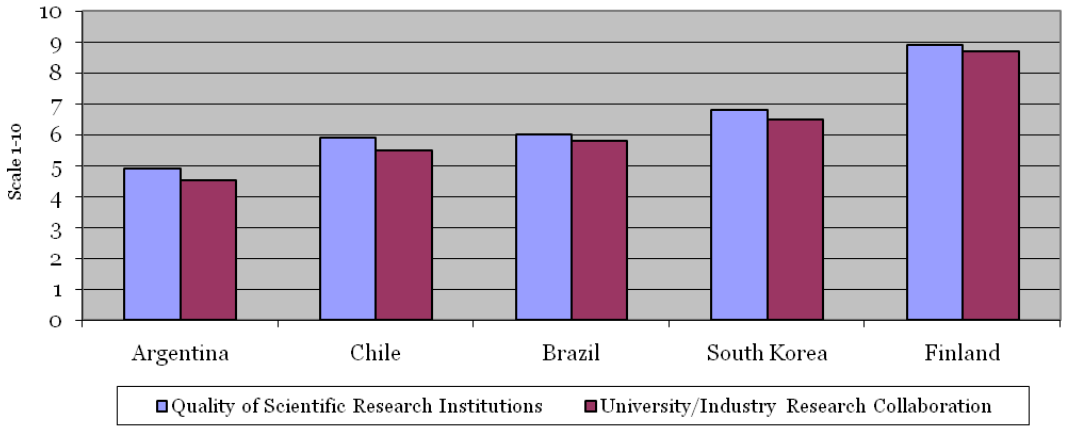
The following section will verify whether the creation of local tacit knowledge by highly qualified local oenologists, agronomists and viticulturalists was also paralleled by the creation of endogenous R&D capabilities of local universities and research centres. According to Giuliani (2005), strengthening domestic capabilities through advanced education and R&D activities in the wine industry remains key to planting the seeds of continuous innovation, knowledge diffusion and technology upgrading. From an evolutionary perspective, it is widely acknowledged that firms cannot be only passive recipients of new knowledge, and the acquisition of skills and resources from outside has to be matched by the generation of expertise internally (Powell, 1995). Also, the ability to exploit external knowledge is a function of the level of prior related knowledge, conferring the ability to recognize the value of new information, assimilate it, and apply it to commercial ends (Cohen and Levinthal, 1989).

7. The performance of domestic R&D programmes and institutions

In Chile and Argentina, the overall amount of resources allocated to R&D is rather negligible, compared to other developing countries.[9] Additionally, both countries seem to suffer from weak university/industry linkages and a lack of responsiveness of research institutions and universities to industry needs (see Figure 4). If one looks specifically at R&D expenditures in the wine sector, Chile and Argentina appear to lag behind other wine producing countries with respect to the level of public and private spending allocated to research institutions for wine-related R&D (Kunc and Tiffin, 2008). For example, in 2000 the US spent 6 million US$ in R&D in wine, and Australia spent 9 million US$, half of which was co-funded by the public sector. It has been estimated that in the same year Chile spent a total of 400,000 US$, while Argentina spent 270,000 US$ (Mouguillanksy, Salas and Cares, 2006; Thorn, 2005).

[9] In Chile, total R&D expenditures went from 0.3 percent of GDP in 1965 to 0.7 percent in 2007, while in Argentina they went from 0.2 percent in 1965 to 0.4 percent in 2007. This is a modest achievement if one considers that in 2007 Brazil spent 0.9 percent of its GDP on R&D, not to consider countries like South Korea, which exceeded 3 percent (Source: OECD at www.oecd.org/sti/rds).

Figure 4. Perceived university/industry research collaboration and quality of public research



Source: World Economic Forum, 2002

Paradoxically, however, the research infrastructure devoted to R&D in the Chilean and Argentine wine industries appears to be quite comprehensive and articulated, and the types of projects undertaken significant. Despite the limited amount of resources destined to R&D expenditures, the clear gaps in terms of university and industry collaboration, and research outputs that are sometimes below expectations given their ranking as global exporters, Chile and Argentina are intensifying their scientific efforts on wine in order to face the increasing competition of other wine producers from both the Old and New Worlds.

In their bibliometric analysis of wine publications and citations over a time span of one decade (1991-2001), for example, Glanzel and Veuglers (2006) show that among New World producers, Argentina and Chile rank quite low (respectively 22nd and 26th out of 28) in the list of countries that have undertaken sustained scientific activity on wine-related issues, as measured by the number of publications on the subject, as well as by the number of citations to these publications (see Table 10).

Table 10. Wine publication (P) output and citation (C) rates of the 28 most active countries, as well as specialization in wine research with their mean observed citation rate (MOCR) and relative citation rate (RCR), 1991 -2001

Rank	Country	Papers	P-share (%)	Citations	C-share (%)	Specialization in wine research (%)*
1	United States	1174	20.50	131796	27.20	0.04
2	France	978	17.07	35044	17.63	0.20
3	Spain	834	14.56	34259	12.45	0.42
4	Italy	600	10.47	27706	9.84	0.20
5	Australia	439	7.66	24538	7.16	0.22
6	Germany	341	5.95	18498	5.74	0.05
7	Japan	238	4.16	12833	3.89	0.03
8	United Kingdom	200	3.49	9599	6.41	0.03
9	Canada	187	3.26	10547	3.95	0.05
10	Portugal	168	2.93	8992	2.30	0.74
11	Switzerland	130	2.27	8049	1.54	0.10
12	Greece	118	2.06	9020	1.87	0.28
13	Israel	96	1.68	6987	2.83	0.10
14	Hungary	88	1.54	6197	0.72	0.28
15	South Africa	73	1.27	4958	1.42	0.10
16	Brazil	71	1.24	2173	0.94	0.23
17	New Zealand	68	1.19	4303	1.24	0.18
18	Netherlands	56	0.98	4456	2.43	0.03
19	Austria	55	0.96	1542	1.14	0.08
20	Denmark	44	0.77	2852	2.23	0.06
21	India	41	0.72	*3162*	0.23	0.02
22	**Argentina**	**35**	**0.61**	**2937**	**0.46**	**0.10**
23	China PR	35	0.61	3018	0.53	0.02
24	Russia	34	0.59	2419	0.14	0.01
25	Slovakia	33	0.58	2014	0.34	0.21
26	**Chile**	**31**	**0.54**	**1675**	**0.43**	**0.18**
27	Finland	31	0.54	2106	0.65	0.05
28	Slovenia	30	0.52	1912	0.23	0.18
	World total	**5728**	**100.0**	**19546**	**100.0**	**0.07** (average)

Source: Glanzel and Veugelers, 2006

* The revealed specialization in wine research is calculated by relating the share of the given country in the publications on wine to the overall world share of the given country in world total publications.

According to the authors, this finding would not support the hypothesis that the shift in the globalization patterns of the wine industry is correlated to the geographical trends in the scientific wine community.[10] However, the interpretation of such important research findings should be more nuanced. The data collected by Glanzel and Veugelers show in fact that Chile and Argentina belong to a small group of countries (together with, for example, Portugal, Switzerland, Greece, Israel, Hungary and South Africa) where the absolute number of wine publications is relatively small, but the specialization in wine research is higher than the average (and >1), if related to the national publication output. Additionally, looking at the trends more dynamically, by examining the number of publications within two sub-periods,

[10] This view is corroborated by *The Economist* (1999), which observed that Australia may well have only a tiny share of the world's wine input, but produces 20 percent of the world's scientific papers in viticulture and oenology. Anderson (2011) also highlights how investments in wine R&D have represented the most significant feature of the Australian wine industry since the 1970s, and have grown in importance following the creation of the Australian Wine Export Council and the Wine R&D Corporation in the early 1990s. Nevertheless, Australia has recently experienced a drastic slowdown of its wine exports. This can be attributed to an insufficient diversification of the supply, as well as to the lack of attention to regional diversities (Veseth, 2011).

namely 1991-1995 and 1997-2001, it emerges that Chile belongs to the group of countries where the number of wine publications has increased most significantly, together with Italy, Spain and Portugal – a group of Old World producers that seem to have perceived the need to intensify their scientific efforts in order to face the increased competition of New World producers in their traditional export markets.

During field interviews, it became clear how advanced the research laboratories are in both countries working on key wine issues, such as the relationship between wine and health, the improvement of genetic characteristics of new grape varieties, the identification of chemical and sensorial characteristics of red and white wines, or the improvement of integrated production viticultural techniques, and also how impressive the premises, human resources, and research outputs of newly created university centres look that have the potential to become centres of excellence in the academic wine world.

In the case of **Chile**, several institutions related to technological development in the wine industry can be mapped. Among the main public ones are CONICYT (the National Commission for Research on Science and Technology); INIA (the National Institute for Agronomic Research); INDAP (National Institute for the Agriculture and Livestock Development); CNI (the National Commission for Irrigation). Among the main private or public/private ones are Fundaciòn Chile (the National Agency for Technology Transfer) and CCV (the Chilean Wine Corporation), mainly created to manage publicly funded technology development projects. The academic sphere includes the CTVV (the Centre for Vine and Wine of the University of Talca) and CEVIUC (the Centre for Viticulture of the Catholic University of Chile). In the past decades, many of these institutions have been actively involved in vine and wine research-related activities, financed mainly by two national science and technology development funds managed by CONICYT, namely FONDECYT and FONDEF.[11]

From interviews, it emerged that all the 25 leading Chilean exporting wineries were generally well aware of the activities carried out by both CTVV and CEVIUC, the wine research centres created, respectively, under the University of Talca and the Catholic University of Chile. The majority (17 out of 25) revealed that they had received some form of assistance from such centres or had participated in events, such as technical workshops or conferences, which were frequently organized and widely advertised. Fewer (11 out of 25), however, confirmed that they were actively participating in a research project, or had done so in the past. Moreover, none were actively involved in, or even aware of, any concrete activities carried out by other research organizations, such as INIA, INDAP or CNI.

In addition to the research institutions and universities mentioned above, the most proactive government agency in the development and funding of technology and innovation in the wine industry is the Chilean Economic Development Agency (CORFO). CORFO has played a key role in the re-birth of the Chilean wine industry, a role which is widely acknowledged by the vast majority (23 out of 25) of the leading exporting wineries interviewed. Among others, CORFO has promoted the study of the

[11] CONICYT, the National Commission for Scientific and Technological Research, was created in 1971 to stimulate science and technology in Chile and orient it towards the economic and social development of the country. Its two main funds, FONDECYT and FONDEF, were created in 1982 to finance scientific and technological research projects at a high level of excellence. In the wine industry, several research projects have been financed since the 1990s, when emerging Chilean universities and research institutions started succeeding in preparing the complex applications required to run in the annual competition for research projects, normally of 1-3 years of duration.

Chilean vitivinicultural potential, the modernization of the existing small winemaking cooperatives, the creation of sectoral wine associations, as well as financial and technical assistance to wineries needing technological upgrading.[12] Among CORFO's policy instruments deserving special attention in terms of impact on the wine industry, there are: PROFO (Proyectos de Fomento); FAT (Fondo de Asistencia Técnica); FONTEC (Fondo Nacional de Desarrollo Tecnológico y Productivo); FDI (Fondo de Desarrollo e Innovación); PDP (Programa de Desarrollo de Proveedores); PAG (Programas de Gestión). These have been applied in the wine sector in a very selective, punctuated way, always jointly funded by public-private actors, and whenever there was a need for strategic and demonstrative interventions with a public good component and a "free rider" type of constraint. By implementing such a variety of instruments since the early 1990s, CORFO has demonstrated long-term vision and valuable strategic capabilities.

Despite the notable engagement of local universities and research institutions described above, the relatively substantial amount of research funds allocated by CONICYT through both FONDECYT and FONDEF and the proactive role of CORFO, in the past several years criticisms have been levelled concerning the fact that until now Chilean institutions have devoted insufficient priority to research in the wine industry (Mouguillansky, Salas and Cares, 2006), or that research carried out in universities has often been far too basic, of an academic rather than a commercial nature (Hernandez, Bodeau and Vallejos, 2005). Additionally, CORFO's main instruments aimed at technological innovation in the wine industry, namely FONTEC and the Development and Innovation Fund (FDI), have been sometimes criticized for having benefitted the larger exporting wineries – such as Concha y Toro, Santa Rita, Carmen, Santa Emiliana and Cousiño Macul – at the expense of smaller wineries (CEPAL, 2006).

Lately, however, this situation has been changing drastically, with more coordination and more funds devoted to wine research, and more efforts devoted to the objective of promoting commercial innovation in the wine industry. For example, during the last decade two new technological and R&D consortia have been created, both with government support: Vinnova in 2004 and CCDV (Centro Cooperativo para el Desarrollo Vitivinicola) in 2006. Both consortia represent a very important step towards institutional renewal, and respond to the urgent need for increased collaboration between the industry associations, the main research institutions and the universities (Cusmano, Morrison and Rabellotti, 2009). Their aim is to promote investment in innovation and research in order to enhance the quality and competitiveness of Chilean wines (see Table 11).

[12] CORFO, the Chilean Economic Development Agency, was created in 1939 to help rebuild the country after the terrible earthquake of Chillan. In the 1990s, CORFO radically changed its approach and operational tools to foster development. It stopped functioning mainly as a provider of loan extensions and started integrating its portfolio with a series of instruments and non-financial services, focusing on productive and territorial development, innovation and technology, regional and national competitiveness. CORFO supported the export and innovation capacity of the Chilean wine industry earlier and more intensively than other public institutions, such as ProChile (the Chilean Export Promotion Agency). For example, CORFO was key in the creation of the first association of wine exporters that started to make Chilean wine known to the world in the mid-1990s, as well as in the diffusion of a wide set of tools aimed at increasing quality and environmental sustainability among wine exporters, thereby increasing their access to global markets.

Table 11. Wine-related research projects implemented by the Vinnova Consortium, 2010-2015

Project	Objective	Timeframe
1. Sustainability programme	Establish a National Sustainability Code to guide Chilean wineries towards increasingly sustainable practices	2010-2011
2. Social responsibility	Develop a guide to SR using the Global Reporting Initiative methodology and provide training to the wineries	2010-2011
3. Meteorological stations	Create the first network of meteorological stations in all Chile's winegrowing valleys and produce on-line information	2010-2011
4. Energy efficiency	Develop a guide for wineries to use as an energy efficiency roadmap and an indicator to measure Carbon Footprint	2010-2013
5. Consumer preference	Develop a scientific methodology to match the chemical and sensorial characteristics of wine with consumer preferences	2010-2013
6. Germ plasma	Make up the foundation block for the development of certified and disease-free of Chilean vine clones	2010-2015
7. Virus and phytoplasma	Evaluate the incidence of viral pathogens and phytoplasma in grapevines, associated to a decrease in productivity	2010-2013
8. Sauvignon Blanc aroma	Determine the impact of variables such as irrigation, light and climate on the aromatic quality of white wine grapes	2010-2013
9. Quality of red wines	Seek economically reasonable solutions to the problem of cold stability in red wines	2010-2014
10. Commercial yeasts	Study the characteristics and requirements of commercial yeasts and their impact on the sensorial attributes of wines	2010-2013
11. Flavonoles	Provide information to stimulate the production of wines with higher levels of antioxidant flavonoles	2010-2013
12. Dynamics of plaguicides	Compile and produce scientific data for the zonification of plaguicide use in the different wine producing valleys	2010-2012
13. Fungi and micotoxines	Identify the presence of fungi and toxins species in vineyards that have a negative effect on wine and/or on human health	2010-2013
14. Liquid Industrial Residues	Generate knowledge and technology allowing cost-effective solutions for the management of Liquid Industrial Residues	2010-2012
15. Technology transfer	Build an efficient link between wineries and universities, along with a permanent communication channel	2010-2015

Source: Author's survey

Vinnova is co-owned by the association Viñas de Chile (55 percent), the Catholic University of Chile (39 percent) and the University of Concepción (6 percent). It is a pioneer R&D programme, matching public and private funds, and is supported by CORFO for 60 percent of its total budget (about 5 million US$). It is currently working on 15 research projects, focused mainly on wine quality, productivity and environmental sustainability issues. Before the creation of Vinnova, Viñas de Chile (representing 45 wineries and 90 percent of exports) had cooperated with the Catholic University of Chile on a three-year project (2003-2006), for 1.5 million US$, aimed at solving technical problems in vine cultivation, based on the engineering, agronomic and agro-biological competencies available at the university (Benavente, 2004). CCDV is a large consortium formed by ChileVid, the University of Talca, the University of Chile, the Technical University Santa Maria, CCV (Corporación Chilena del Vino) and the firm Toneleria Nacional. For its operations, CCDV receives financial

support from the Chilean government to the tune of about 3 million US$. Since 2010, it has been carrying out eleven different innovation projects, focusing on key strategic areas for the consolidation and further upgrading of the quality of Chilean wines, and in particular of the Carmenère variety (see Table 12). CCDV is undertaking special efforts to involve dynamic wineries of smaller size. It is expected that the results will generate enough resources to sustain the activities of the consortium in the long term.

Table 12. Wine-related research projects coordinated by the CCDV Consortium, 2006-2011

Project	Objective	Research centre
1. Market analysis and benchmarking	Develop a tool for each winery to make a comparative analysis of its consumption of inputs and its costs	University of Talca
2. Development of biosensors	Improve productivity and precision in the vinification of quality wines through the use of biosensors	Technical University Santa Maria
3. Varietal composition and origin	Detect origin and control quality and composition of wines through intelligent instrumentation	University of Chile
4. Characterization of Carmenère	Improve organoleptic characteristics of Chilean Carmenère from the Maipo Valley	University of Chile
5. Quality assessment of new clones	Broaden the genetic basis of varietals and vine clones cultivated in Chile through the diffusion of new clones developed at the University of Talca	University of Talca
6. Characterization of terroirs	Identify the best *terroirs* for each of the most common international varieties grown in the Colchagua Valley	University of Talca
7. Study of Carmenère physiology	Understand the impact of light, water and climate on the ripening of Carmenère grapes	University of Chile
8. Resistance to stress of Carmenère	Understand why stressful climatic conditions affect the Carmenère variety more than, e.g., the Cabernet Sauvignon variety and increase its tolerance	University of Talca
9.Detection of unwanted flavours	Detect the presence of unwanted bacteria in premium wines and study their evolution in bottles or *barriques*	University of Chile
10. Detection of pesticides residuals	Certify the safety standards of Chilean export wines and the absence of dangerous chemical residuals	University of Talca
11. Detection of spontaneous yeasts	Understand the development pattern and reduce the presence of Brettanomyces in Chilean wines	University of Chile

Source: Author's survey

Like Chile, **Argentina** can traditionally count on a relatively low level of resources allocated to R&D, but on a solid institutional framework and highly qualified human resources devoted to science and technology in wine. FONTAR (Fondo Tecnológico Argentino) is the public fund that finances innovation projects through different instruments, such as subsidies, loans or direct fiscal credits. The projects are approved upon participation to public calls and periodic tenders, and have to be matched by private sector funds. FONTAR is administered by the National Agency for the Promotion of Science and Technology (ANPCyT), set up in 1996 within the Ministry of Education, with the exclusive role of financing research. In particular, it operates a line of non-repayable contributions designed to help firms upgrade their innovative capacity, including resources for developing business plans, building in-house R&D capacity, preparing technology blueprints and modernizing products and processes (Dahlman et al., 2003). Additionally, since 1997 the Argentine government has operated a program of tax credits for R&D activities that allows Argentine firms to deduct a maximum of 50 percent of their R&D expenditure. In the wine industry, through FONTAR, between 1998 and 2008 about 17 projects were approved under the tax credit line, 24 under subsidies and less than 15 projects under the credit line, for a total contribution of FONTAR of approximately 2 million US$.

During the interviews, it emerged that all 25 leading Argentine exporting wineries were aware of the role of FONTAR as a potential source of funding to carry out technological upgrading activities, to introduce new equipment and/or modern winemaking techniques and to carry out applied research in the field of viticulture. Most of them (15 out of 25) had applied in the past in one form or another to one of FONTAR's project lines, and felt that the loan or fiscal credit lines were the most appropriate lines for their needs, while the subsidy line allowed access to more limited amounts of funds, which were more appropriate for smaller wineries. They also unanimously (25 out of 25) agreed that the reference for anything related to innovation in the wine industry was INTA, the National Institute for Agricultural Technology, whose technicians had carried out and were still carrying out work on oenology and viticulture that was known and directly relevant to all of them.

Research in Argentina is currently conducted in thirty-seven public universities and research centres, three of whom are active in wine-related research. For the wine industry, the most relevant is INTA, founded in late 1956 with the aim of improving productivity in the Argentine agro-food industry. INTA has been leading Argentina's agricultural research efforts since its founding and has been responsible for many of the successes that transformed the "pampas" into the nation's agricultural economic powerhouse (Walters, 1997). INTA's regional experimental station located in Lujan de Cuyo (Mendoza) has played a crucial role in fighting the backwardness of the wine industry in the late 1980s and greatly contributed to the diffusion of the radical innovations needed to start producing fine varietal wines for the export market. During the 1980s, the agency's technicians were involved in two main projects aimed at the quality upgrading of the primary production and the technological conversion of the existing vineyards (see Table 13).

Table 13. INTA projects for the technological upgrading of the wine industry in Argentina, Multi-year plan, 2009-2013

Objective	Amount (US$)
Study and control of vine diseases	70,000
Clonal selection for the improvement of Malbec varieties through new imported clones	66,500
Technological upgrading and mechanization of irrigation techniques in Mendoza	100,000
Study of the viticulture and viniculture value chains in Argentina	15,000
Improvement of research laboratory equipment for chemical and macro-biological analysis	160,000
Technology transfer to grape producers in Mendoza for quality upgrading	55,000
Equipment for the Centre of Oenological studies in Mendoza	75,000

Source: INTA, 2009

The first project was aimed at mapping the region's 120 varietals and at shedding light on the characteristics of the planted vines, in order to clarify widespread confusions and mistakes in the use of grape names (for example, the fine Italian grape Barbera d'Asti was confused routinely with Bonarda, of intermediate oenological quality, while Chardonnay and Chenin were both called Pinot Blanc, which never existed in Mendoza). The second project was aimed at mapping which kind of grape variety was better adapted to which microclimate. INTA's oenologists also began a systemic comparison across the country, sometimes confirming what people knew but also announcing veritable surprises, published in a well known report in 1987 (e.g., Chenin and Tocai Friulano, which usually prefer cool temperatures, did quite well in Eastern Mendoza, while red grapes which prefer hot climates did quite well in Mendoza's highest altitudes).

In order to achieve a higher impact on the technological transformation of smaller and poorer producers, in the early 1990s INTA was involved in projects aimed at transferring technologies to small farmers, through an extension programme called Rural Change (Cambio Rural). The program was specifically designed to help groups of small farmers to improve their production technology by exchanging their experiences in technological upgrading and occasionally sharing the costs of a consultant (Walters, 1997). In the late 1990s, INTA's research efforts in Cuyo focused on issues related to the study and control of vine diseases, to clonal selection and irrigation techniques, and to the study of vineyard handling systems aimed at optimizing the quality produced by independent vine growers. Over the years, INTA has played a crucial role in advancing the knowledge and categorization of Argentine wines, including, more recently, the identification of new export varieties and new wine regions, thereby allowing Argentine winemakers to keep diversifying their offer and meeting the demand of international consumers for increasingly high-quality wines.

From the data presented in this study, therefore, it emerges that the spectacular rise of the Chilean and Argentine wine industries can be ascribed to a deep technological modernization process stimulated by external sources of innovation, such as foreign knowledge and machinery, but sustained over time by the emergence of a national pool of highly skilled professionals, as well as of a local research community capable of adapting foreign technologies to local needs and to introduce "local" incremental innovation.

8. Conclusions

The high quality of contemporary wine is the long term result of modern oenology, originating from Pasteur's and Riberau-Gayon's discoveries less than one century ago, as well as from the technological revolution led by California and Australia in the 1970s (Paul, 1996). Most industry innovations introduced in Argentina and Chile in the 1980s and 1990s were, therefore, transferred from abroad, through imported, off-the-shelf technologies and the continuous flow of foreign winemakers. This study has demonstrated, however, that the substantial adaptation of new technologies to local conditions, factors and needs was also crucial. Such adaptation was increasingly carried out with the sporadic assistance of foreign consultants and flying winemakers, and by highly skilled local oenologists, agronomists and viticulturalists.

These were also key to the creation of local tacit knowledge and to the actualization of incremental changes based on learning-by-doing and internal trial-and-error efforts. Therefore, it has been demonstrated that Chile and Argentina are gradually becoming producers of wine-related knowledge in their own right, and that they are increasingly recognized as authoritative and well-respected members of the international wine community, thanks to their active participation in international wine fairs and competitions, to the solid reputation of some of their most knowledgeable winemakers, and to the active role they play in such organizations as the OIV.

Quite importantly, it has also been highlighted that not all the innovations introduced by Chilean and Argentine wineries have implied a reliance on suppliers of machinery for production, as many of the innovations were product or organizational innovations that were not necessarily linked to the machinery and equipment used in the winemaking process. This confirms the hypothesis that the development of technological capabilities involves more than the straightforward acquisition of machinery and product designs, or the simple access to foreign knowledge, which is increasingly facilitated by liberalization policies and by the presence of foreign direct

investment. The development of technological capabilities also (and mostly) depends on domestic technological efforts, namely on incremental innovations, and on the improvement and adaptation of imported technologies by local actors. In the case of the Chilean and Argentine wine industries, external sources of innovation, such as imported machinery, international movements of capital and international knowledge flows, initially helped trigger the entire process of technological change. However, continued growth would not have occurred without the subsequent development of domestic abilities to exploit such external knowledge and technology flows through the creation of a pool of highly skilled human resources, and of universities and research centres with the potential to become centres of excellence in the future.

Neither the Chilean nor the Argentine wine industries, though, should sleep on their laurels. The fact that both seem to have completed the earlier phase of the wine technological revolution does not mean that they are well prepared to meet future challenges and to sustain their export growth in the long term. In the second phase, every single step towards the technological frontier is much more complex and difficult, and is characterized by a higher level of knowledge intensity from a systemic perspective. For example, it would seem that, on the demand side, the future behaviour of international consumers is going to be increasingly influenced by two factors – the potential health benefits of wine and its environmental sustainability (Anderson, 2004; Bisson et al., 2002). These can be strategically exploited only if the technical and scientific understanding of the latest developments in a wide-ranging spectrum of science and technology disciplines is present and well diffused among all main industry stakeholders. Reflecting on the future of the wine industry, Bisson et al. (2002) argue:

> *As we gain knowledge of the basic biology of human perception and flavour preferences, wine will become even more targeted to the genetic differences of the consumers. Consumer olfactory profiling will be common and used to guide production decisions as well as marketing of wines. Studies currently in progress will continue to document the healthful properties of wine. In addition, the industry will need to play a highly visible role in the promotion of sound and sustainable environmental stewardship, as this will be a strong motivating factor in the purchase of wines. The stakes of success in meeting consumer expectations are high, as the value-added aspects of enhanced tourism are undeniable and economically beneficial for entire regions (Bisson et al., p.21).*

Additionally, and most importantly, consumers from all over the world are becoming increasingly knowledgeable about and attentive to varieties and *terroirs*, and expect varietals from a specific region to taste very differently from the same varietals grown in other regions. This is radically changing the production and marketing strategies of winemakers worldwide, to the point that even the owners of the French Domaine de la Romanée Conti – the most renowned producer of Burgundy wines in the world – are now looking for appropriate *terroirs* in California to plant some hectares of Pinot Noir, which represents the base of Burgundy wines (*Wine Spectator*, July 2011). For a long time these winemakers have refrained from producing Pinot Noir abroad not to compete with their own Burgundy wines. However, as their foreign investment behaviour indicates, they decided to start do it to appeal to consumers who are looking for wine varieties with unique qualities which can be ascribed to specific sites, cultures and regions.

Therefore, it would seem that on the supply side, the key driver of competitiveness and profitability in the wine market will be largely determined by the diversification of choices, in terms of regions of origin, grape varieties, altitudes and microclimates

(Veseth, 2011). Even countries like Australia, which built its success on the strength of its one-dimensional varietals (mostly Shiraz or Chardonnay) and on a national brand providing little information on regions, and never about *terroirs*, has now launched a marketing plan called "Landmark Australia", meant to shed light on the diversity of its *terroirs* and on the rediscovery of the importance of smaller wineries.

In the future, the capability of local actors to extract a unique, original taste from different grape varieties and to reflect faithfully the characteristics of the local *terroir* is going to be crucial. In order to meet these expectations, wine producers need to recognize the technical characteristics and the composition specificities of the different soils up to the slightest detail. They also need to master the vinification process in all its phases and learn to minimize as much as possible any manipulation or any modification of the growing environment, so that the taste of the *terroir* may prevail without much interference of technology (Bisson et al., 2002).

The Chilean and Argentine wine industries are clear examples of how international routines, standardized technology and foreign winemakers are generally weak in extracting regional character and uniqueness factors from their wines (Robinson, 2001). In order to discover the "uniqueness character" of their varieties, local oenologists are increasingly trying to abandon their "scholastic" approach and become more self-confident and original. In this sense, it is emblematic that the discovery of Torrontés as a typical Argentine export variety of high-quality white wine can be ascribed to Susana Balbo, an Argentine winemaker graduated "cum laude" in Mendoza in 1981, and that the discovery of the Casablanca Valley, where nobody had ever thought vines could grow before, as the new wine area for top quality Chilean white wines, can be ascribed to Aurelio Montes, a Chilean winemaker graduated "cum laude" in Santiago in 1975.

At a more systemic level, however, this can hardly be achieved by individual producers, talented winemakers and fragmented efforts. Rather, it requires the development of systematic relations among the public and private sectors, dynamic inter-firm and inter-institutional linkages, and a strong interaction among the production system and the knowledge system at the local and regional level. In particular, it requires the creation of networking dynamics that are rooted in a specific territory and nurtured by proximity effects, which are indispensable for strengthening competitive advantages at the local level.

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