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The Emergence of Successful Export Activities in Uruguay: Four Case Studies

by

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Acronyms and abbreviations

ALADI	Asociación Latinoamericana de Integración
ANP	Administración Nacional de Puertos
ANTEL	Administración Nacional de Telecomunicaciones
BCU	Banco Central del Uruguay
BROU	Banco de la República Oriental del Uruguay
BRS	Black River Sturgeon
BSE	Banco de Seguros del Estado
CAN	Comunidad Andina
CCC	Centro de Construcción de Cardioestimuladores
CEPAL	Comisión Económica para América Latina
CES	Centro de Ensayos de Software
CET	Common External Tariff
CITES	Convention on International Trade in Endangered Species
CIU	Cámara de Industrias de Uruguay
COFIS	Impuesto de Contribución al Financiamiento de la Seguridad Social
COFOSA	Compañía Forestal Oriental S.A.
COFUSA	Compañía Forestal Uruguaya S.A.
CUTI	Cámara Uruguay de Tecnologías de la Comunicación
DILAVE	División Laboratorios Veterinarios
DILFA	Dirección de Lucha contra la Fiebre Aftosa
DINAMA	Dirección Nacional de Medio Ambiente
DINARA	Dirección Nacional de Recursos Acuáticos
DNPI	Dirección Nacional de la Propiedad Intelectual
EU	European Union
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
FMD	Foot-and-Mouth Disease
FTZ	Free Trade Zones
GDP	Gross Domestic Product
GDP	Gross domestic product
IDB	Inter-American Development Bank
ICT	Information and Communication Technologies
IIBCE	Instituto de Investigación Biológica Clemente Estable
IIE	Instituto de Ingeniería Eléctrica
IIP	Instituto de Investigaciones Pesqueras
IMESI	Impuesto Específico Interno
INAPE	Instituto Nacional de Pesca
INAVI	Instituto Nacional de Vitivinicultura
InCo	Instituto de Computación
INIA	Instituto Nacional de Investigación Agrícola
IRIC	Impuesto a las Rentas de la Industria y Comercio
JICA	Japan International Cooperation Agency
LATU	Laboratorio Tecnológico del Uruguay
LKS	Local Knowledge Spillovers

MERCOSUR	Mercado Común del Sur
MGAP	Ministerio de Agricultura, Ganadería y Pesca
NADE	Nomenclatura Arancelaria de Exportación
NAFTA	North American Free Trade Agreement
PACC	Programa de Apoyo a la Competitividad de Conglomerados y Cadenas Productivas
PACPYMES	Programa de Apoyo a la Competitividad y Promoción de Exportaciones de la Pequeña y Mediana Empresa
PDT	Programa de Desarrollo Tecnológico
PEDECIBA	Programa para el Desarrollo de las Ciencias Básicas
PRENADER	Programa Recursos Naturales y Desarrollo del Riego
R&D	Research and development
R&D	Research and Development
R-H model	Rodrik and Hausmann model
SME	Small and Medium Size Enterprises
SME	Small and medium size enterprises
TAR	Admission Regime
UDELAR	Universidad de la República
USA	United States of America
UTE	Administración Nacional de Usinas y Trasmisiones Eléctricas
VAT	Value Added Tax
VCP	Vino de Calidad Preferente
Zonamerica	Free trade park Zonamerica

Abstract[*]

This paper consists of four case studies of the emergence of four successful export activities in Uruguay: computer software, forest products, caviar and sturgeon meat, and animal vaccines. Each case study discusses how companies, associations, and governments at various levels have addressed market failures and facilitated the provision of public goods necessary for each activity. The case studies additionally profile first movers in each activity and describe the positive externalities they provide to imitators, particularly diffusion of export knowledge. Also included in each case study is a counterfactual case of a less successful activity (electronics, wine, frog meat, and biotechnology, respectively) and a section on policy implications.

JEL Classifications: H41, L26, L65, L84, Q13
Keywords: Agriculture, Exports, Manufacturing, Services, Uruguay

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"Social benefits from self-discovery are huge: for a small economy such as Uruguay, detecting a few products that can be profitably produced for world markets can make the difference between prosperity and stagnation. Generating incentives for self- discovery should therefore be a key objective of economic policy."

Hausmann, Rodríguez-Clare, and Rodrik (2005)

1. Introduction

This study was conceived to contribute to the Inter-American Development Bank's project on "The Emergence of New Successful Export Activities in Latin America," which seeks to:

- Identify the key elements in successful export cases to inform an outward-oriented development strategy in each country.
- Promote and facilitate policy reforms that are more likely to achieve the desired development objectives, based on a more thorough understanding of the relative importance of various market failures.

Accordingly, the specific objectives of the Uruguayan study included:

- Carrying out in-depth case studies of four export activities that are new for the country, within the theoretical framework proposed by the Inter-American Development Bank (IDB) and according to the common methodology defined for all participating countries, and drawing conclusions in terms of policy lessons.
- Constructing a harmonized database of Uruguayan exports at the product and firm levels, because changes introduced on four occasions in the product market (1985, 1990, 1997, and 2002) impeded work with consistent, long time-series; and using the new database to analyze export activity at the firm and product levels in the past two decades.

The starting point and underlying approach of the study can be conveniently summarized in the following statements by Hausmann, Rodriguez-Clare, and Rodrik (2005):

> "Markets are pretty good at signaling the profitability of activities that already exist, but poor at uncovering the profitability of activities that might exist but do not. Even if these activities are not new in the sense that they are present in other, richer economies, they confront potential producers with considerable uncertainty as regards costs and productivity under local conditions. Breaking into these new sectors typically requires a pioneer investor, who signals to other investors the profitability of these new activities. We call this process of discovery of the underlying cost structure of the economy 'self discovery.'" (Hausmann and Rodrik, 2003)

> "The self discovery process is rife with information externalities because the cost information discovered by an entrepreneur cannot be kept private. If the pioneer is profitable, this can be readily observable by others. Imitative entry then follows, the incumbent's rents are dissipated, and a new sector takes off. If, on the other hand, the pioneer firm goes bankrupt, the losses are borne in full by the entrepreneur. Hence entrepreneurship of this kind is not a very rewarding economic activity: the losses are private while the gains are socialized. Consequently markets *underprovide* entrepreneurship in new activities." (Hausmann, Rodriguez-Clare, and Rodrik, 2005).

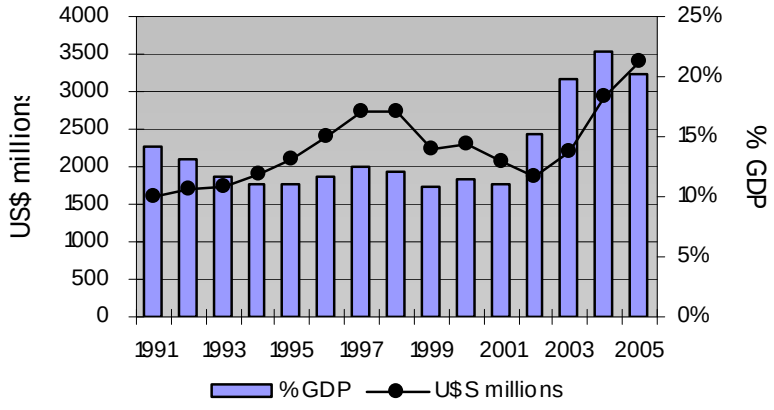
This study aims to reach a better understanding of these issues in the case of Uruguay. It is structured in five chapters. Chapter 2 provides a brief overview of Uruguayan export performance and the main features of its trade policy, as a framework for the core of the study. Chapter 3 presents the preliminary results obtained from the newly constructed database at the firm and product levels. In Chapter 4, we present the case studies for the four selected export discoveries in Uruguay—namely, software, forestry, caviar and sturgeon, and animal vaccines—with their corresponding conclusions. Finally, we conclude the study in Chapter 5 with some policy lessons that can be drawn from the research.

2. Background on Export Performance and Policies

2.1 General Export Trends

Despite exchange rate-based stabilization polices that led to considerable exchange rate depreciation, Uruguayan exports presented an increasing path in the 1990s. Exports reached their maximum level of that decade in 1997-1998 (Graph 2.1). Exports then decreased until 2001, along with Uruguay's gross domestic product (GDP). The mid-2002 devaluation that accompanied the 2001-2002 crisis was followed by large increases in exports in 2003-2005.

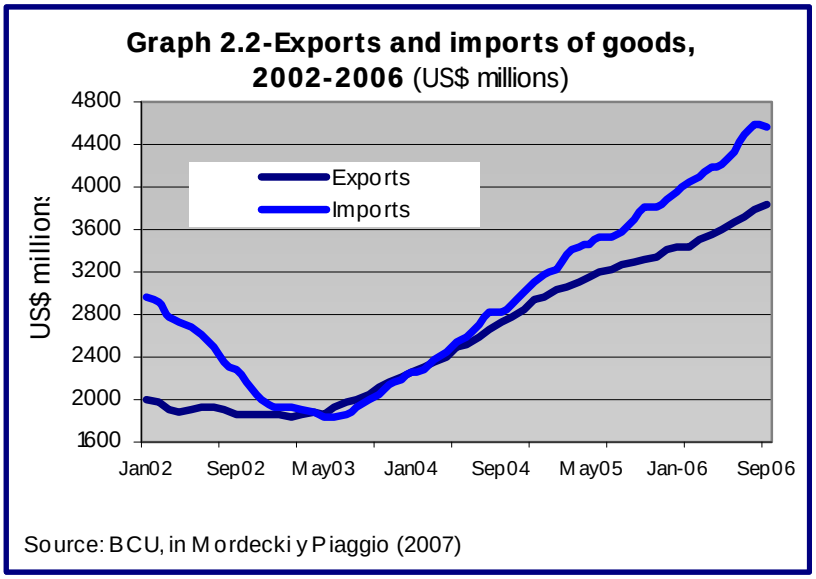
Graph 2.1 - Exports of goods and share in GDP, 1988-2005 (US$ millions and %)



Source: BCU, in Mordecki & Piaggio (2007)

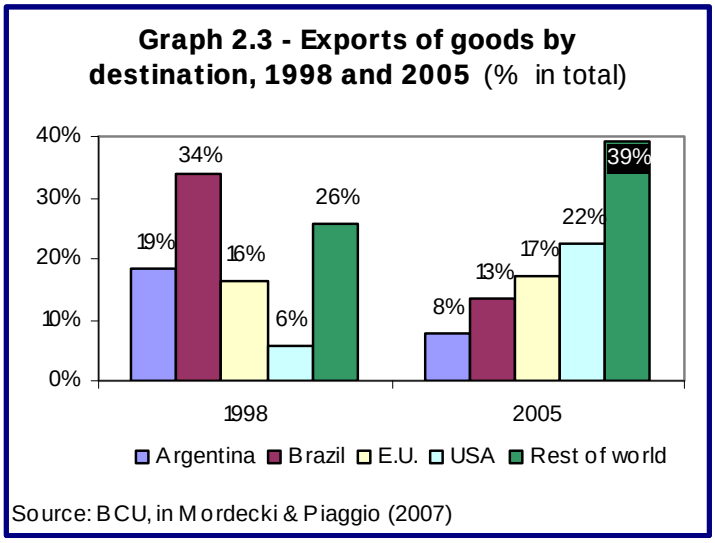
The economic recovery that took place starting in 2003 was closely related to export growth, which was spurred by the fall in dollar terms of national production and a very favorable international context for commodities. From 2002 to 2005, exports grew at an average annual rate of 22.4 percent and reached US$3,400 million (close to US$4,000 million in 2006), a significantly higher level than the maximum value attained in the 1990s (US$2,700 million in 1997). The share of exports in GDP reached 22 percent in 2005, about twice the ratio of the mid-1990s.

The contraction in imports and exports during the crisis resulted in equilibrium in the external trade balance in 2003, after 12 years of increasing trade deficits. However, the recovered dynamism of the economy in the following years was accompanied by even greater growth in imports than exports, and consequently a trade deficit (Graph 2.2).



The destination of exports has changed considerably in recent years. The 1990s were characterized by the signing of the MERCOSUR Treaty between Argentina, Brazil, Paraguay, and Uruguay, which established a schedule of tariff reductions and convergence to a common external tariff. Uruguay's large neighbors also pursued macro policies that led to depreciation. However, when this was done at a faster rate than in Uruguay, it increased the competitiveness of Uruguayan exports with respect to Argentina and Brazil, which represented an important share of Uruguayan exports.

After the Brazilian devaluation of 1999 and the deep Argentinean crisis of 1999-2002, the effects of currency devaluation in Uruguay implied that extra-regional exports became increasingly important (Graph 2.3). The European Union (EU) and, mostly, the United States increased significantly their share. In the latter case, the share grew from 6 percent in 1998 to 22 percent in 2005. In the early 1990s, meat represented 1 percent of exports to the United States; it now represents 60 percent.

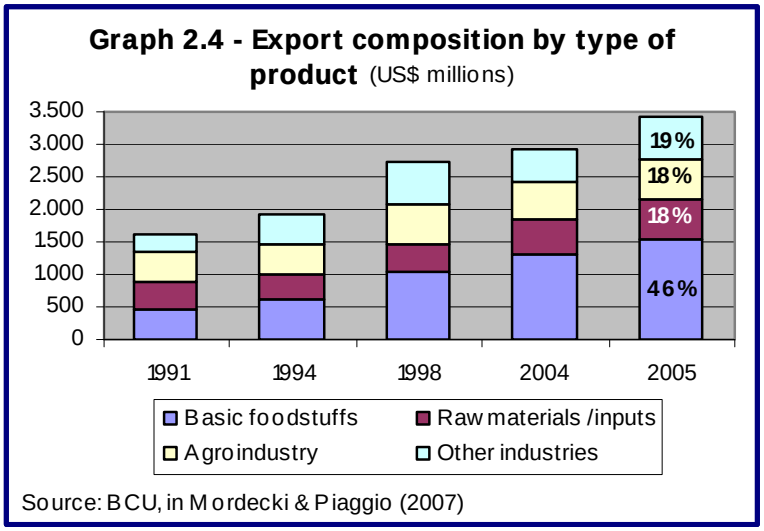


Along with the increase in export volumes, prices evolved favorably in 2003-04 after several years of falling export prices in the 1990s. Once Uruguay abandoned a fixed exchange rate and started a floating regime in 2002, the currency depreciated significantly and hence the competitiveness of Uruguayan exports increased sharply. This process came to a halt in 2004, when real exchange rate devaluation was observed to some extent. The fall in competitiveness has been larger with respect to the EU and North American Free Trade Agreement (NAFTA) trade partners than with the region.

2.2 Composition of Exports

Most Uruguayan exports can be classified as basic foodstuffs highly associated with agriculture and livestock (meat, dairy products, citrus fruit, rice, barley, oils, etc.), raw inputs (wool, leather, wood, fish, etc.), natural resource based manufacturing products (processed food, beverages, textiles, leather, and paper goods), or other manufacturing goods (glass, ceramics, chemicals, plastics, and metallurgical products). Graph 2.4 shows the overwhelming share of agro-industry related products in exports, notably basic foodstuffs.[1] Exports are also very concentrated in a limited number of products: bovine meat, leather and dairy products, rice, and plastics accounted for close to half of total exports in 2005.

[1] The increased share of basic foodstuffs in total exports was mainly the consequence of meat sales, which represented 22 percent of total exports in 2005 as compared with only 10 percent in the early 1990s.



Sales to the region are of a larger manufacturing content than extra-regional exports. Basically, exports to the region are intensive in industrial products; Uruguay's exports to the rest of the world are basically commodities.

When looking at the long-term trend in the composition of exports and imports in Uruguay (Table 2.1), a significant increase in manufactured goods and technology-based products can be observed throughout the second half of the last century. However, the limits of this process of export transformation are evident in the import structure, which is highly intensive in manufactured and technology-based products (Bértola et al., 2004).

Table 2.1 – Export and Import Structure by Type of Product
(in percentages)

	Primary products		**Manufactured products**		**More technology-intensive products**		**Fuel**		**Total**	
	Imp.	*Exp.*	*Imp.*	*Exp.*	*Imp.*	*Exp.*	*Imp.*	*Exp.*	*Imp.*	*Exp.*
1950-69	43.16	88.63	12.64	10.55	28.10	0.31	16.09	0.51	100.0	100.0
1970-89	14.91	66.62	14.79	27.53	42.88	5.51	27.42	0.33	100.0	100.0
1990-00	13.43	52.65	24.56	34.49	50.69	12.20	11.32	0.57	100.0	100.0

Source: Duque and Roman (2003).

2.3 Trade Policy

Uruguay's trade policy is mainly determined by its membership in MERCOSUR. In spite of the existence of special regimes and exceptions to the Common External Tariff (CET), the country has little flexibility in using trade policy with a view toward attaining industrial policy objectives. The sector structure of CET was the result of negotiations in which the interests of the major nations prevailed and these only partially corresponded to Uruguay's needs. This section presents the main features of the export-promotion regime, the general MERCOSUR regime and its exceptions, and the role of the real exchange rate.

2.3.1 Export Promotion[2]

Refund of Export Taxes (Law 17.555) and VAT

The objective of these measures is to refund all indirect taxes levied during the production process in order not to restrict export competitiveness through the domestic fiscal system. Exports of goods and services are thus exempted from the value-added tax (VAT) (Texto Ordenado, 1996, tit. 10, art. 5) and some other taxes. Decree 220/998 establishes that exporters can deduct from their general VAT liabilities the VAT paid on acquisitions integrating the exported goods. Beneficiaries include both producing firms and trading companies that export their products (Decree 54/003, 2003). This regime is relevant for some economic activities in which exports depend on this refund to be profitable, although the refund level is rather limited (6 percent).

Decree 393/991 (1991) establishes that the indirect tax policy should be sufficiently explicit to create a stable and foreseeable framework for investment decisions, notably allowing the anticipation of possible changes in the refund level and items included. In fact, although the tax refund regime has been applied without interruption since its (re)introduction in 1991, this mechanism has often been subordinated to the public accounts situation, which implied delays in the promulgation of extensions and refund level decrees, thereby creating uncertainties concerning its prolongation and structure.

[2] This section is mainly based on Terra et al. (2004, Chapter V). See also Giordano and Quevedo (2006).

Export Financing

This regime allows exporters to access credit at a preferential interest rate for an amount equivalent to a certain proportion of the committed exports. The proportion (10 or 30 percent of the committed exports) depends on the guarantee level chosen by the beneficiary. This mechanism is applicable to the acquisition or production of goods destined for export (pre-financing) and to the exporting process itself until final payment.

Temporary Admission Regime and Drawback

These regimes date from the early twentieth century and entitle the executive in power to grant incentives to national firms that process and export products with foreign raw inputs (Law 3.816 of 1911 and Law 4.268 of 1912). The Temporary Admission Regime (TAR, regulated by Decree 420/990, 1990) allows duty-free imports of inputs that are further substantially transformed or embodied in the production of goods for export. The exports must be completed within 18 months. The Drawback mechanism establishes the refund of various import duties; but it is virtually not used, probably due to the flexibility of the TAR, which allows the eventual re-export of—or payment of import duties payment for—the corresponding input.

It has been estimated that about 20 percent of total imports were channeled through the TAR in 2003-04, and that it represents an average savings of more than 13 percent of the total amount of goods imported through it. The TAR has been an essential factor for the initiation of exports in several import-substituting industries and for enhancing competitiveness in the main export sectors.

Maintaining the regime in the region is one of the main claims of the Uruguayan industrial sector in the MERCOSUR negotiations, together with the special regime for capital and intermediate goods, and the special regime for imports of agricultural inputs. The negotiations led to the extension of the TAR until the end of 2010 (Decision 32/03, 2003). Although special import regimes in the region are in principle inconsistent with a customs union, the argument for maintaining the regime is based on the existence of important asymmetries in the region.

Export Insurance

The Banco de Seguros del Estado (BSE) is the only institution providing insurance for export credit. The insurance covers breach of payment of foreign clients but, in contrast to countries such as Argentina, Brazil, and Chile, it does not cover political, foreign exchange, or extraordinary risks. The cost of insurance includes premiums of between 0.7 and 4 percent of total exports (according to destination market and importer qualification) and the cost of investigation of the importer's reliability. Uruguayan exporters consider that the insurance has several shortcomings.

2.3.2 MERCOSUR General Regime

Imports from a MERCOSUR country member are not subject to tariffs but require a Certificate of Origin establishing that the good complies with the origin conditions (at least 60 percent of the value must be of regional origin). When the good has a lower percentage of regional integration, it is treated as an extra-regional product and the CET is applied.

Imports coming from extra-regional countries with no special agreements are subject to the CET, with a number of exceptions. The CET has 11 levels, going from 0 to 20 percent.[3] In general terms, the CET level increases with the level of value added of the imported good. However some inputs produced in the region are protected by relatively high tariffs, which can lead to negative effective protection in activities that use them in their production process. Indeed, this has been a complaint of the Uruguayan electronics sector.

Import tariffs in the framework of preferential agreements depend on the particular conditions that were agreed upon. Such agreements exist between MERCOSUR and Chile and Bolivia (complete trade liberalization in 2014 and 2015), the Comunidad Andia (CAN) countries, and Venezuela. Uruguay has a special agreement with Mexico that foresees tariff relief for all items. Also in force are the partial agreements signed with ALADI member countries before the setting up of MERCOSUR.

[3] Agricultural products in their original state or with minimal processing: 10 percent; agro-foodstuffs: 14 to 16 percent; agricultural inputs: 0 to 6 percent, except <?> for agrochemicals (12 or 14 percent; in the case of Uruguay: 0 percent); petroleum and derivates: 0 percent; chemicals and petrochemicals: 2 percent if no national production, 10-14 percent otherwise; other minerals: 2 to 6 percent; textile products: depends on added value (maximum 20 percent for garment industry). Manufactured products for final consumption: 18 to 20 percent (Lorenzo 2004, in Giordano and Quevedo, 2006).

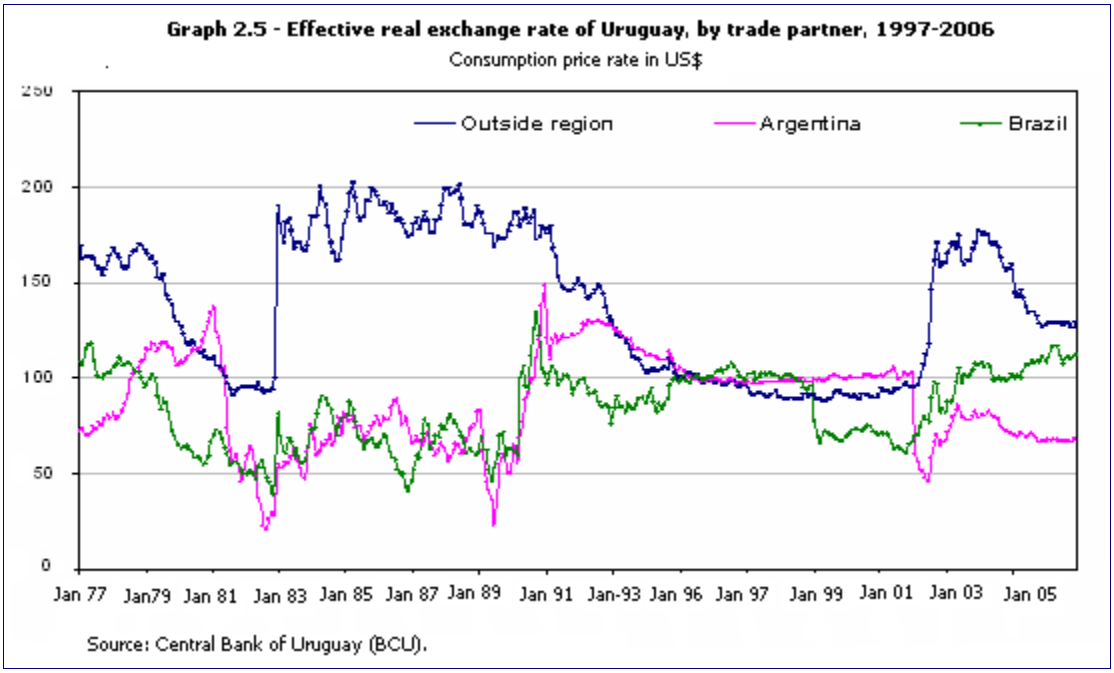
The Uruguayan fiscal system also includes other taxes, the effects of which are equivalent to tariff protection, mainly: a 3 percent tax to finance the social security system (COFIS) is levied on imports (except for TAR products) as on national products; the BROU commission (3 percent of imports, except for TA and capital goods); the consular tax (2 percent, same exceptions as previous); and VAT and IMESI advance deposits (3 to 10 percent of VAT).

2.3.3 Exceptions to the CET

A special regime was established for capital goods and informatics and telecommunication goods, as well as a schedule aiming at progressively converging toward the CET. However, the convergence process came to a halt and presently each member country applies its own criteria. In Uruguay, a 2 percent tariff is applied to capital goods when there is no local production. When domestic production exists, the CET is applied and can reach 14 percent for capital goods and 16 percent for information technology (IT) goods. A high CET for these good would imply a substantial surchange on investment in to be confirmed for these goods, the surcharge it would mean on investment in machinery and technological equipment, which are not extensively produced in Uruguay. Special regimes also exist for the sugar and automotive industries. On the whole, each MERCOSUR member country has the possibility of selecting 125 items for CET exemption.

2.3.4 Real Exchange Rate

Undoubtedly, exchange rate and monetary policy has affected the export sector. Graph 2.5 reveals the high volatility of the real exchange rate. This factor determined important difficulties for enterprises located in Uruguay in their planning and external insertion strategies as well as for newcomers with export strategies.



Since 1990, inflation control policies operated by a pre-announced devaluation schedule. Inflation inertia in turn led to an appreciation of the effective real exchange rate vis-à-vis the extra-regional trade partners until 1995; it remained stable throughout the rest of the decade. An important outcome of the 2002 crisis management has been the reestablishment of macro balance in the context of a more competitive exchange rate. A significant degree of continuity can be found between the government administrations before and after 2004.

The real intra-regional exchange rate was influenced by exchange rate policies in Argentina and Brazil, with both pursuing similar currency board arrangements. Appreciation also occurred vis-à-vis the neighboring economies, but it was to a lesser extent than with respect to the rest of the world. The gap between the two real effective exchange rates led to greater concentration of Uruguay's exports with its MERCOSUR partners, at least until 1998. Since 2001 the opposite effect has taken place, and incentives were set for a larger share of extra-regional trade and diversification of export destinations. Only with Argentina are relative prices for Uruguay now in a situation that is less advantageous than before the 2002 crisis.

Exchange rate volatility has thus led to changes in commercial destinations, which entails serious problems in terms of firms' specialization. This in turn affects optimum resource allocation and the product policy of the firm.

2.4 Investment Promotion

The 1998 *Law for the Protection and Promotion of National and Foreign Investments* (No. 16.906) promotes and protects investments carried out by national and foreign investors in the national territory, without discriminating according to the origin of capital.[4] The main benefits of the law include:

- Exemption from capital tax for fixed assets directly linked to the production process and for data processing equipment.
- Exemption from VAT (23 percent) and excise tax (IMESI) for the import of these goods and refund of VAT when they are acquired in the domestic market.
- Exemption from capital tax for fixed asset improvements that enhance manufacturing, agricultural and livestock activities, and certain intangible goods (patents, etc.) and other assets that incorporate technological innovation and involve technology transfer.
- Exemption from income tax (IRIC, 30 percent) on 40 percent of net profits if the exempted profits are reinvested.
- Training expenses of personnel in priority areas and expenses in research and development (R&D) and technological development may be deducted for income tax purpose at between 1.5 and 2 times the amount spent.

In addition, the law includes a series of specific benefits for projects declared of "national interest,"[5] mainly:

- Exemption from import duties, VAT, COFIS, and IMESI for imported fixed assets that do not compete with locally produced goods.
- Exemption from capital tax for three years in Montevideo and five years in the rest of the territory, for fixed assets incorporated into the project.
- Exemption from income tax on 50 percent of the investment financed by the company's own capital.

[4] Foreign direct investment does not need approval or previous registration and it has the guarantee of free transfers of profits and capital.
[5] Fiscal benefits for projects declared of national interest have existed since 1974 and were regulated by a previous law until 1998.

In principle, to be declared of national interest, investments must: incorporate technical progress, increase and diversify exports, generate productive employment, promote activities of small and medium-size enterprises (SMEs), and contribute to decentralization. In fact, this instrument has been applied loosely, without much discrimination according to projects' objectives and multiplier effects on the economy. Between 1992 and 1998, industrial projects were approved under this regime for a total of US$817 million, 45.6 percent of which corresponded to foreign companies. Tourism-related projects totaled US$1,184 million between 1993 and 1998 (70 percent of foreign investment). Although investors now resort more than before to this mechanism, a serious shortfall derives from not using it pro-actively. The recently created Office for Investor Assistance—a single office coordinating all investment-related procedures—tends to improve the system's efficiency, but no systematic actions are undertaken to seek or call potential investors on the basis of the incentives offered. Moreover, there is no evaluation of its work.

The creation of a *Free Trade Zones Regime* has also promoted investment. Free trade zones have been established in seven cities in Uruguay. The most relevant in terms of international business and technology is Zonamerica, located 20 km from Montevideo.[6] It offers high quality installations, infrastructure (including telecommunications), and services to international and national companies involved in logistics, financial services, biotechnology, informatics, call centers, consultancies, and trade in general. Companies operating in Zonamerica or other Free Trade Zones (FTZs) enjoy a very favorable fiscal regime that exempts them from all national and import taxes. Additional non-tax benefits include the following:

- There are simplified procedures for setting up the relevant legal entities.
- State utility monopolies (telecommunications, fuel, and energy) are not in force in the FTZ.
- There is unrestricted freedom to transfer securities and local and foreign currency into or out of the FTZ. Although this may seem redundant because the same right applies in the Uruguayan customs territory, the relevant point is

[6] In 1987, Law No. 15.921 declared the development of free trade zones to be of "national interest" with the purpose of promoting investment, expanding exports, increasing the use of the Uruguayan labor force, and promoting the international integration of the economy.

that the state guarantees this benefit (and all other benefits) for FTZ users during the whole period of the respective contract.

By law, at least 75 percent of the personnel hired by FTZ companies must be Uruguayans.

Decision No. 8 of the MERCOSUR Council establishes that goods physically imported into the MERCOSUR territory from a Uruguayan FTZ are subject to the CET (in contrast with the FTZ regime prevailing in Tierra de Fuego, Argentina, and Manaus, Brazil). In the same way, goods introduced into an FTZ from Uruguayan territory are considered exports.

Exports of goods from Zonamerica to the rest of the world amounted to about US$277 million in 2006 (CIU, 2006), which represents less than 7 percent of Uruguay exports (although FTZ exports are not considered in the official export records). Services are probably much more important than goods in Zonamerica, but no figures are available. There are 150 firms located in Zonamerica (including several Uruguayan software firms and Tata Consulting Services, the Indian informatics giant), employing around 2,000 people. Zonamerica thus still has a limited impact on the local labor market. A relevant spillover is its contribution to creating an image of the country abroad, especially as a "high-tech" producer.

This brief review of export and investment policies in Uruguay shows a diversity of measures and instruments providing, on the whole, substantial pecuniary incentives. Many if not most of them are inheritances of bygone days that, to some extent, have been mended or adjusted to present times without an overall perspective. A tax reform proposed by the administration of the present government, approved by the legislature, was scheduled for implementation in 2007.

3. Export Activity at the Firm Level[7]

This chapter presents an exploratory statistical analysis of export activity at the firm level, as a contribution to our general framework. It is based on official Uruguayan export databases, which first had to be harmonized to obtain homogeneous, long time-series because four different classification criteria have been applied during the past decades.

After briefly reviewing older research studies on Uruguayan exporting firms (Section 3.1), we explain how export data were treated in the present study (Section 3.2) and analyze the export growth process from the firm's viewpoint (Section 3.3). We then track the discovery process using statistical methods (Section 3.4) and establish a link between exporting and productivity (Section 3.5). Finally, we summarize our main findings and highlight the shortcomings of using statistical data to detect export discoveries (Section 3.6).

3.1 Prior Research Results

Uruguayan exporting firms have been analyzed in a series of research papers, mainly using evidence from the 1980s. The first references are CEPAL (1989, 1990), which find a very concentrated structure of exports across firms, and a fluctuating mean value of exports by firm between 1981 and 1988. Roche and Vaillant (1990) analyze two main dimensions along which they evaluate the performance of exporting firms: survival in export markets and export growth. Firms present in all sample years (1981-1988)—generally larger firms—account for 80 percent of total export value. Roche and Vaillant estimate qualitative response models for several types of survival and growth performance (i.e., permanent exporters, dynamic exporters, etc.) conditional on size, measured by export value, and type of product. They find a relation between size and export performance that is interpreted as a life-cycle phenomenon, by which entering firms are smaller in size but dynamic, and tend to stabilize later, exporting larger values.

Cassoni and Vaillant (1993) also analyze data from the 1980s. They define export performance using survival and growth of export value, based on data for survivors until 1990. They study the association of those indicators with size, sector, and product and market specialization/diversification, using contingency tables and log linear models. Their findings are interpreted in terms of the life-cycle of firms in the export market, characterizing the sequence of

[7] Gastón Carracelas provided excellent research assistance in the preparation of this chapter.

stages of the firms. These include the first stage for *new firms*, basically exporting to neighboring countries, concentrating their exports in a single product and a single destination market. In the second stage, firms seek to expand their export sales and diversify their destination markets and products. The third stage is characterized by stability and larger size.

Vaillant and Bittencourt (2001) use data for a longer period, adding some years in the 1990s. They find that although the number of Uruguayan exporting firms increased in the 1980s, entry began to decrease in the second half of the 1990s. They also find an increase in the mean export value by firm in the second half of the 1990s. Fewer than 100 firms accounted for more than 75 percent of total export value in both decades. Permanent exporters (i.e., firms present in all years of the sample since they first appeared) accounted for 90 percent of total exports in 1998.

Vaillant and Bittencourt find that a large part of firms entering in a given year exit in that year or the next. The authors also detect an increase in the number of foreign owned firms among Uruguayan exporters in the 1990s. Exports are concentrated among firms with only one destination market, and market diversification increases as firms stay longer in the export markets. In the 1990s, there is a clear increase in the number of firms with a regional orientation in their export sales. The authors find a pattern of association between destination orientation and product specialization, by which raw inputs are directed outside the region, while manufacturing goods are sold to neighboring countries. Exports of basic foodstuffs are more uniformly distributed between market destinations.

3.2 Data

We rely on Banco de la República (BROU) and Customs Office export records. The coverage includes export transactions on goods for all products during 1981-2005. The variables included are exporter ID, value, quantity, product, and destination market. Export values are recorded in current U.S. dollars.

Firm Identification

BROU data cover 1981-99, and firms are identified by their *exporter number*. The BROU administered differential exchange rate policies when those were in place decades ago and managed some of the export tax incentive policies until the mid-1990s. Historically, every

transaction was recorded as exporters used to present their dollars for exchange to BROU. Hence, BROU registered firms with a banking criterion, and the *exporter number* is a current account number set for transactions related to exports. The exporter number does not always uniquely identify a firm, however, because companies subcontracting production from others may register many shipments under the same number. In addition, export transactions were recorded for firms that did not have continuing export activity or did not open a current account but did export. These firms were labeled with the code "999997"—the same for all—and termed "sporadic." Thus, for a fraction of the transactions (about 1 percent of all sales), firms are not identified before 2000. The Foreign Trade Department of BROU was dismantled in the 1990s. Since 1999, registration of exports has been undertaken only by the National Customs Office, which also became the relevant source for national accounts compiled by the Central Bank of Uruguay.

The Customs Office records transactions by the firm's Tax Register Number (RUC). Hence, the number of total exporting firms recorded is larger than the number that had an exporter number in BROU. Correspondence between BROU export numbers and RUC numbers was obtained for a significant portion of the exporting firms. As the shipping of commercial samples is also included, to avoid distortions we exclude in a given year those firms that exported less than US$10,000. This leads to a negligible reduction in the export value included in our analysis.

Product Classification

Product classification criteria are not uniform throughout the period under study. Prior to 1993, the system was based on Brussels Tariff Nomenclature, which was the source for the Tariff Export Classification (*Nomenclatura Arancelaria de Exportación, NADE*). The first version present in our data is the NADE 1978, which was revised in 1985 (NADE 1985). Since the signature of MERCOSUR in 1990, the system has evolved toward adopting the Harmonized System (HS) and this led to a new NADE in 1993. The NADE 1993 had the first eight digits in common with the Latin American Integration Association (ALADI) classification, based on the HS. In turn, it was replaced in 1997 by the Common MERCOSUR Classification (*Nomenclatura Común del Mercosur, NCM*), also based on the HS. The NCM finally went through a revision in 2002, so along our period of analysis five different classifications were used.

An effort was made to construct conversion tables. The criterion was to adapt all data to the last classification used, i.e., NCM 2002. In practice, this implied recoding the observations starting with the first classification used, i.e., the NADE 1978 in 1981. The main problem here is that the classification changes, so that current items are disaggregated in many new, more detailed varieties; conversely, others are condensed in aggregates where individual categories cease to be identified.

Categories that the new classifications aggregated in new, broader categories were also condensed in the older datasets to reflect the aggregation level of the last classification. Conversely, old categories that the new classification split in a larger number of new cells were aggregated in the newer datasets. Hence, the aggregation level is given by the minimum number of categories consistent with common classification criteria from 1981 to 2005. Conversion tables were constructed for those products that translated on a one-to-one basis onto the next classification. This included NADE 1978, NADE 1985, NADE 1993, NCM 1996, and NCM 2002. As a result, we obtained a consistent database at the product, firm, and destination levels of Uruguayan exports, which is itself a product of this project and a contribution to future studies. The database is based on an 8-digit aggregation level, except for those categories that were collapsed into more-aggregated items for the sake of compatibility.

Destination Codes and Prices

Destination codes were not constant through time. We constructed a one-to-one conversion table whenever it was possible. In cases where countries have split up or combined in larger units, we maintained them as different countries. As price indexes at the product level are unavailable, we work with current dollar values across the entire sample period.

3.3 The Export Growth Process from the Firm's Viewpoint

The purpose of this section is to provide a picture of the export growth of Uruguayan firms. Using our export database, we undertake a description of the activity of exporting firms during the past two and a half decades, in terms of the value of exports, number of products, number and type of destination markets, concentration, diversification, cohort of entry into export markets, and survival of exporters. Statistical analysis describes the evolution of the number of firms, the contributions of entries into and exits from the export markets, and decompositions of export growth in terms of continuers, entry, and exit.

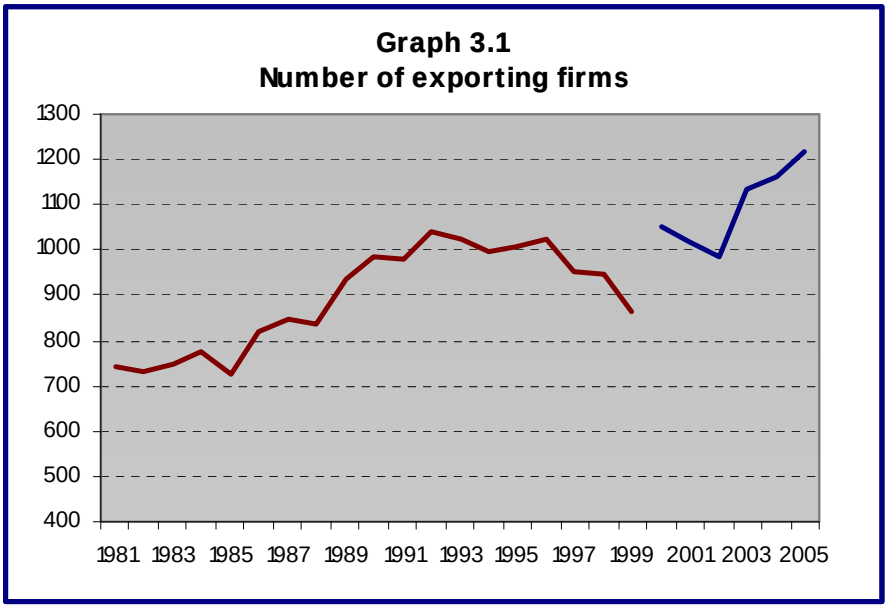
We analyze the value of exports in terms of the number of products and mean export sales by firm and product. The analysis provides simple decompositions of the change in export value between the contribution of increases in the value of products that were already being exported and those that were not previously traded.

We analyze concentration in terms of products, firms, and markets, and provide measures of diversification in terms of destination market, by product and firm. Although we do not have data on the starting dates of firm activity, we can construct measures for cohorts of entrants. We do so to construct classes of exporting firms according to their degree of permanence in export markets.

3.3.1 Number of Firms

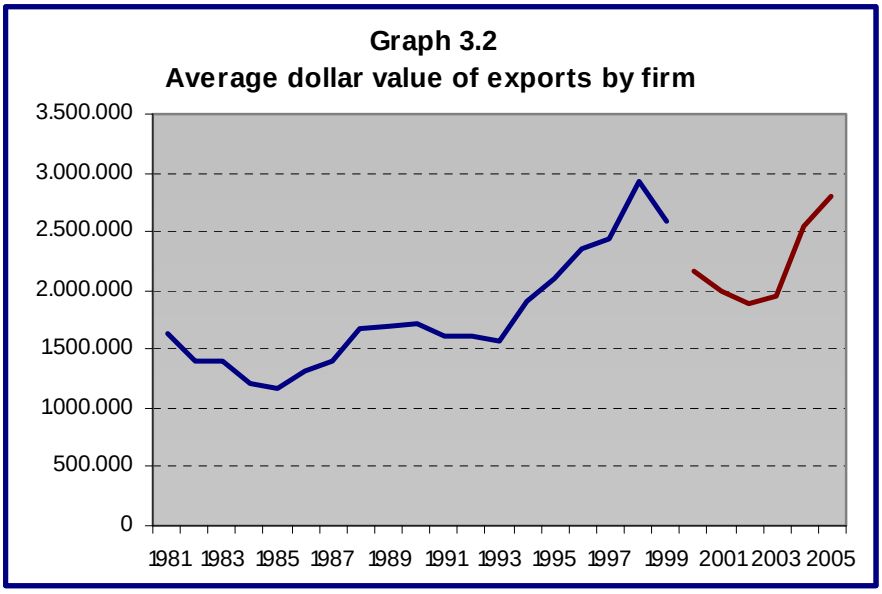
We provide two separate measures of the number of firms, due to different registration criteria before and after 1999. For 1981 to 1999, we use the number of exporter codes registered as exporting in BROU's databases. This does not include all exporting firms for two reasons. First, more than one firm could export under the same exporter code. Second, firms that did not open a current account in BROU were assigned the same "sporadic" code. Therefore, the figure until 1999 can be interpreted as an indicator of the number of more formal, established exporting firms in Uruguay. From 2000 to 2005, all RUC numbers are registered by the Customs Office, so every exporter is included.

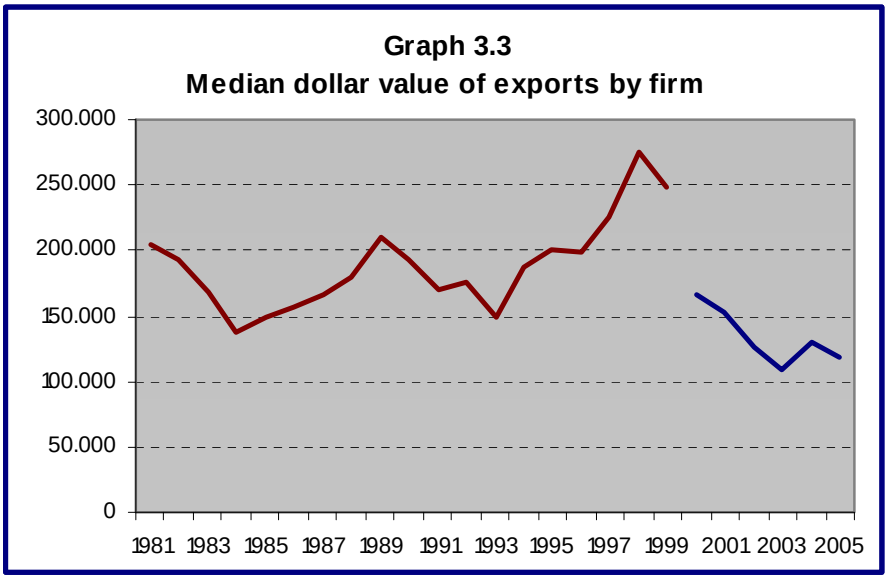
Measuring the number of exporter firms by those with recorded exports, there was a steady increase through the 1980s, reaching a peak in 1992 (Graph 3.1). At that point, macro policy had reverted to an exchange rate-based stabilization plan that led to considerable appreciation of the domestic currency. At the same time, the signature of the MERCOSUR treaty and advantageous relative exchange rates with its neighbors led to a redirection of Uruguay's exports toward the region. The number of exporting firms declined until 1999. For 2000 on, we use the series of the total RUC numbers obtained from the Customs Office. There was a discrete upward jump due to the change of registration criteria, but also a steady increase in the number of exporting firms, particularly since 2002, corresponding to the sharp change in relative prices that followed devaluation in the 2002 crisis. By 2005, the number of exporting firms was 16 percent higher than in 2000.



3.3.2 Value of Exports by Firm

To provide a picture of the type and size of firms involved in export activities, we show their median and average export values during the period under study (Graphs 3.2 and 3.3). Again, we have to consider separately the 1981-99 and the 2000-05 series. The former tracks the behavior of export value for the set of more established and stable exporters. Both median and average values put the increase in value exported by firms between 1993 and 1998. The data after 2000 (Customs Office) reflect the weight of smaller exporters that the BROU dataset does not identify separately. Although the averages increase after 2002, median values still show a decreasing path.

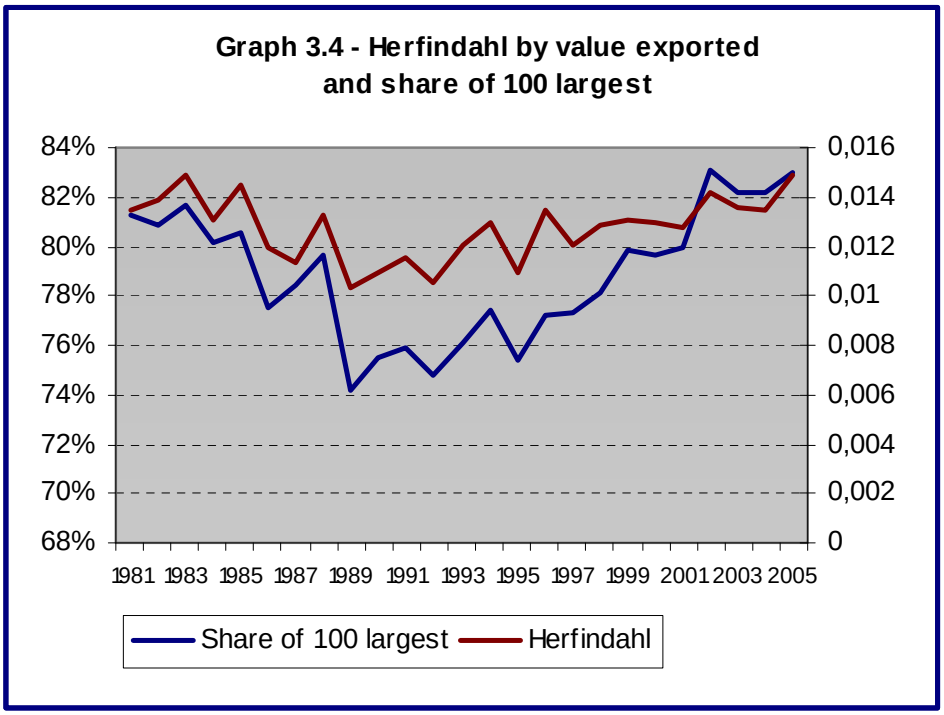




As in the 1990s, the number of firms was decreasing, and those surviving or entering tended to be larger. After 2002, entry may be including a larger number of smaller-size firms.

3.3.3 Firm Export Concentration

A complementary view of the development of export activity at the firm level is given by the evolution of concentration. This is measured by the traditional Herfindahl index[8] as well as by the share of export sales of the 100 largest firms in total sales. The story in both cases is the same.



The data show the relative decline in concentration of exports among the largest exporters in the 1980s (Graph 3.4). The 1990s, by contrast, show a pattern of increasing concentration. The data for 2000-05, which include the whole set of firms, were expected to present a larger share of smaller firms and hence less concentration. This is not the case; the values of both indexes for 2000 are not significantly different from those for 1999. From 2000 to 2005, in turn, the pattern seems to be of increased concentration.

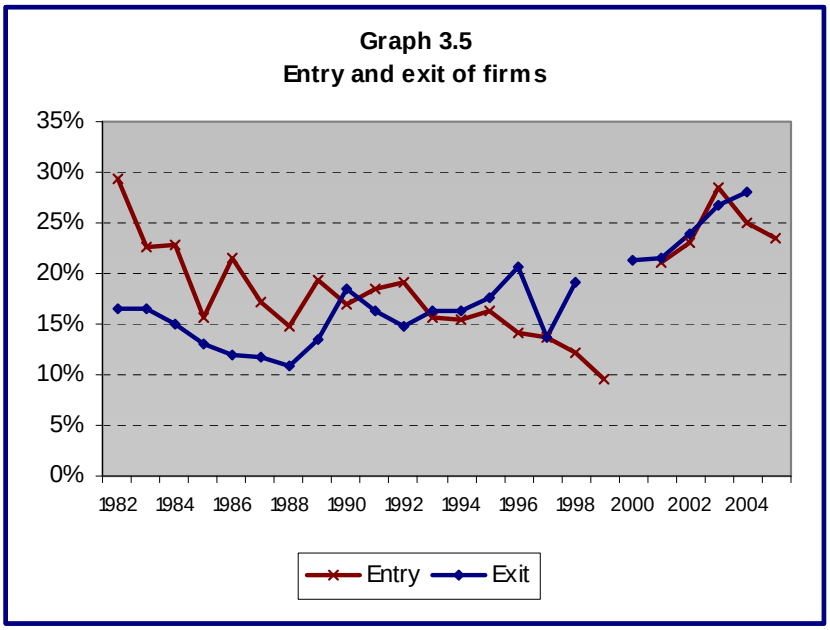
[8] The Herfindahl index is defined as $H = \sum_{j=1}^{n} \left(x_j \Big/ \sum_{j=1}^{n} x_j \right)^2$, where x_j are exports of good j.

3.3.4 Entry and Exit of Firms

To provide an overview of entry and exit in Uruguay's export markets, we linked the two databases, finding correspondences between the export numbers in the BROU database and the RUC numbers in the Customs Office data. This was not feasible in a number of cases. However, using each of the databases, we can provide consistent statistics on entering, exiting, and continuing firms; the only year for which data are not available is 2000.

We do not have data on the activity starting dates of firms, and we can only identify cohorts of entrants in the database using the first appearance of a firm in the data. Once entering, firms may not be present for a number of years and then re-enter, or exit the exporting activity not to reappear again. We define the entry and cohort of each firm by the year it first appears in the data. Continuers are those that were present in periods *t* and *t-1*, while we distinguish temporary exit (the firm will reappear at some future period) and re-entry (the firm was not present one period before but this is not its first time of appearance). Exit is defined when the firm does not reappear in the data.

Graph 3.5 shows the flows of entry and exit, net of re-entries or temporary exits. Exits are calculated as the fraction of firms observed each year that are not be present in the data again. Entry is calculated as the fraction of the number of firms observed each year that are present in the data for the first time. Exit is not reported in 2005, and entry is not reported in 1981. The gaps in the series correspond to changes in data sources: exit is not calculated in 1999, and entry is not calculated in 2000.



The main message of the figure is that the dynamic of entry and exit is substantial in Uruguay's export markets. Even in the years when we record firm activity by the BROU exporter number (and hence we expect more stability in attachment to export activity), we find that between 15 and 20 percent of the firms present in the data are newcomers or will not be present again. It should be kept in mind that firms with an exporter number (i.e., a bank account in BROU) are those with more established export activity. This figure increases sharply when we take into account the full registration of exporting activity by the Customs Office RUC records.

With respect to entry, three clearly differentiated periods appear. Entry was important in the years following the 1982 crisis, with a sharp devaluation that increased incentives to export. The path was irregular until 1990, when a second decreasing period is observed until 1999. Changes in registration criteria imply a discrete jump but beyond that, during 2000-05, entry flows (relative to the incumbent stock) become more important.

The contributions of entering and exiting firms represent a substantial portion of year-to-year change in the number of firms. In spite of considerable churning in export markets, Uruguayan exports also display considerable stability in terms of the export value contribution of larger exporters. In a given year, those firms with relatively longer years of presence in the export market provide the bulk of the export value. We take as an example the year 1999, in which we recover the last observation from the BROU database. The caveat is that firm identification by the BROU exporter number biases the data toward the more established exporters.

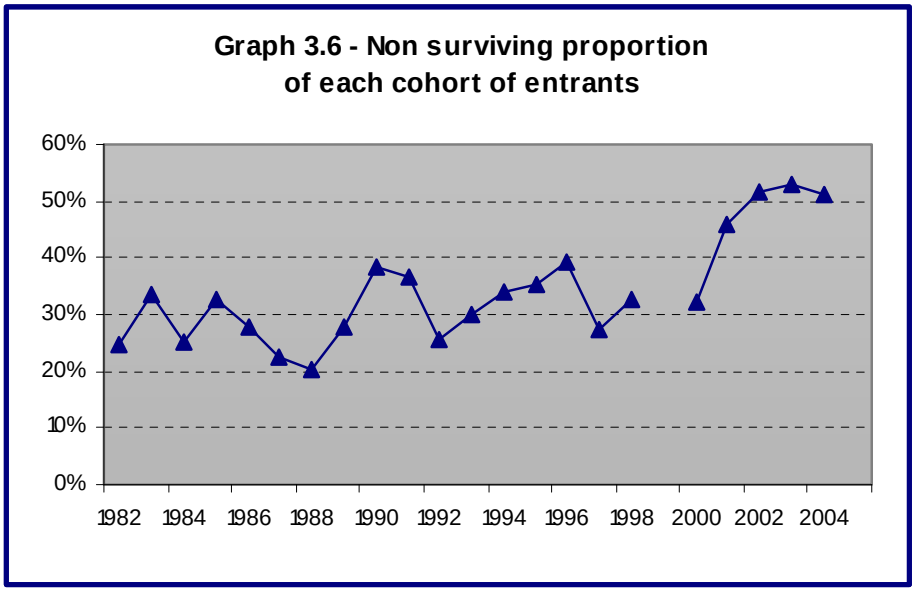
Table 3.1
Firms Exporting in 1999 by Entry Cohort

Cohort	Mean value (US$)	n	Value (US$)	Share (percent)	Accumulated share (percent)
1981	5,561,995	202	1,123,523,081	51.1	51.1
1982	4,040,391	51	206,059,917	9.4	60.5
1983	2,147,969	29	62,291,088	2.8	63.3
1984	766,501	35	26,827,517	1.2	64.5
1985	2,793,988	20	55,879,750	2.5	67.0
1986	2,042,496	26	53,104,887	2.4	69.5
1987	1,057,012	30	31,710,360	1.4	70.9
1988	2,082,485	30	62,474,558	2.8	73.7
1989	3,536,762	38	134,396,964	6.1	79.9
1990	642,615	39	25,061,979	1.1	81.0
1991	647,381	44	28,484,752	1.3	82.3
1992	1,092,700	75	81,952,510	3.7	86.0
1993	335,651	44	14,768,620	0.7	86.7
1994	912,597	45	41,066,844	1.9	88.6
1995	830,951	46	38,223,751	1.7	90.3
1996	1,205,634	53	63,898,600	2.9	93.2
1997	1,247,170	57	71,088,666	3.2	96.4
1998	490,724	80	39,257,891	1.8	98.2
1999	385,350	102	39,305,651	1.8	100.0

Source: Customs records database.

Table 3.1 presents the distribution of firms by year of first appearance in the records and decomposes 1999 exports by cohort. The data show that a large part of exports is explained by the largest, established firms. Roughly half of the export value in 1999 is supplied by firms that were in the export markets 20 years before.

An interesting question is: What is the probability that a firm entering in a given cohort will survive in the exporting activity? To approximate this, we calculated for each cohort the ratio of firms that do not appear again in the data (i.e., the entry and exit date from the database coincide). The ratio is shown in Graph 3.6.



Because firms that exited in more recent years might reenter in the future, hazard rates are more likely to be overstated for years after 2000. At the same time, in 1982-99 we did not adequately register smaller and more sporadic firms because we used their BROU export numbers; hence, entry and exit may be underestimated. The figure shows high hazard rates even for the sample period in which we have underestimated such flows. The years 2000-04 provide a picture in which hazards are even higher.

We also estimated the contributions to overall export growth of entries and exits from the export market.[9] Table 3.2 presents (for all years except 2000) a decomposition of export growth in terms of continuers, entry, and exit (irrespective of re-entries and temporary exits). The data show that the bulk of the change in export value is provided by the contribution of continuing firms. This seems to carry on after 2000, when we use a more encompassing registration of firms.

[9] We write $\sum_i X_t - \sum_i X_{t-1} = \sum_{i \in C}(X_t - X_{t-1}) + \sum_{i \in E} X_t - \sum_{i \in X} X_{t-1}$, where the sets C, E, and X denote continuers, entrants, and exiting firms, respectively.

Table 3.2
Contributions to Export Growth by Continuing, Entry, and Exit Firms
(Percent)

Year	Growth rate	Continuers	Entry	Exit
1982	-15.9	-17.5	4.5	-2.9
1983	1.6	4.0	3.6	-6.1
1984	-10.7	-8.0	2.1	-4.8
1985	-8.4	-8.4	2.5	-2.4
1986	27.5	25.3	4.1	-1.9
1987	9.5	7.6	3.8	-1.9
1988	17.3	17.5	2.3	-2.5
1989	14.2	11.5	4.4	-1.8
1990	7.0	5.3	3.2	-1.5
1991	-7.5	-7.3	2.0	-2.3
1992	6.8	5.2	3.8	-2.2
1993	-4.4	-5.4	4.2	-3.2
1994	18.0	16.3	3.2	-1.4
1995	10.3	9.7	2.6	-2.0
1996	13.7	14.1	2.7	-3.1
1997	-4.6	-6.6	3.9	-1.9
1998	18.3	16.7	2.5	-0.9
1999	-18.0	-17.9	1.7	-1.8
2000				
2001	-10.6	-10.4	1.3	-1.6
2002	-9.1	-9.1	2.2	-2.2
2003	19.5	17.7	3.9	-2.2
2004	33.5	28.6	6.7	-1.8

Source: Customs records database.

3.3.5 Number of Products

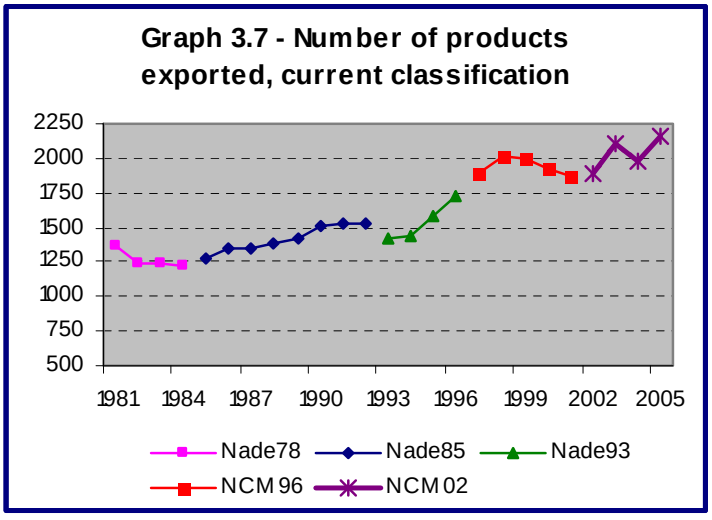
We also analyze the evolution of the number of products in Uruguayan exports. Classification changes many times along the sample period, in part reflecting the inclusion of products new in every respect, i.e., not known or produced before, as is the case of many information technology related products. In other cases, such products were already known but are new to Uruguayan

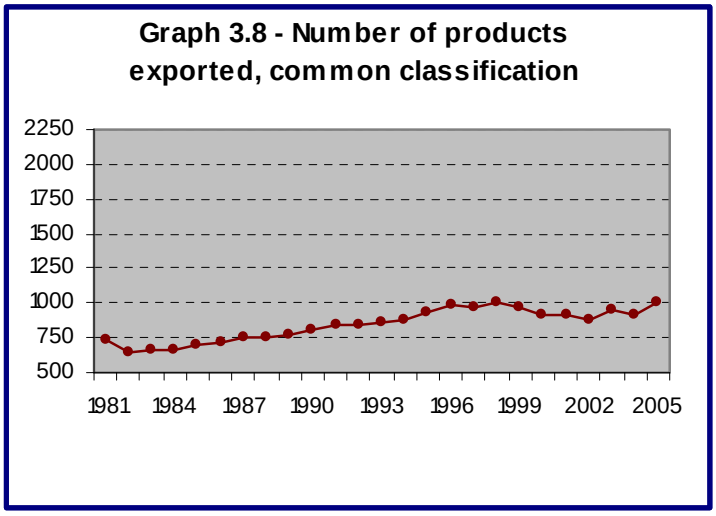
trade. The number of products may increase or decrease due to changes in classification criteria, which may condense in a single category products that were described by a larger number of more disaggregated items (as is the case with some Uruguayan meat products before 1993), or may allow for more detailed description of a number of categories described before by a single group. Reclassification may produce the statistical illusion of an increase or decrease in the number of products traded.

Our approach is to analyze the changes in the number of products, keeping that caveat in mind, and comparing data from two classification exercises. One of them consists of considering the number of products traded in each of the sub-samples in which the same classification is used. Classification changes tend to open a significant number of new categories every time, affecting a large proportion of both goods and value traded. For instance, the 1996 NCM opens up in more detailed categories goods that account for more than 30 percent of the 1995 exports.

The second approach is to produce a common classification that uses each year the minimum set of compatible categories for the whole sample period (1981-2005). The level of aggregation used is 8 digits. The common classification requires grouping some items at the 6-digit level or sometimes lower levels; hence, this classification greatly reduces the number of products (between 43 and 61 percent of the number of products under the current classification in any given year).

Graphs 3.7 and 3.8 depict the evolution of the number of products under both the current and the common classification.

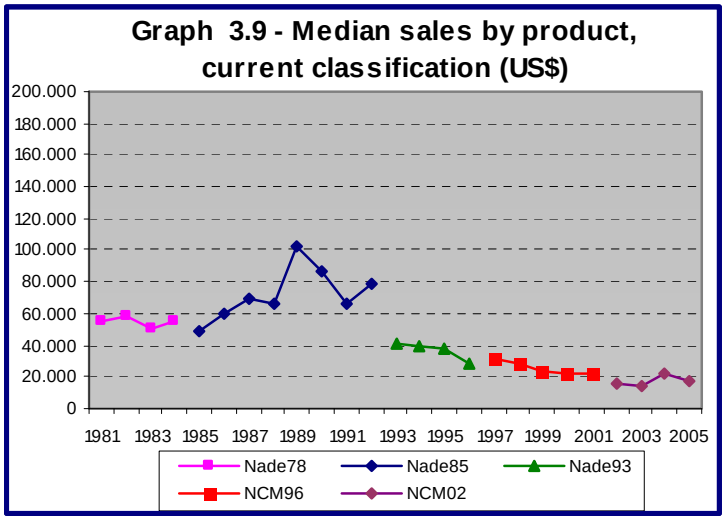


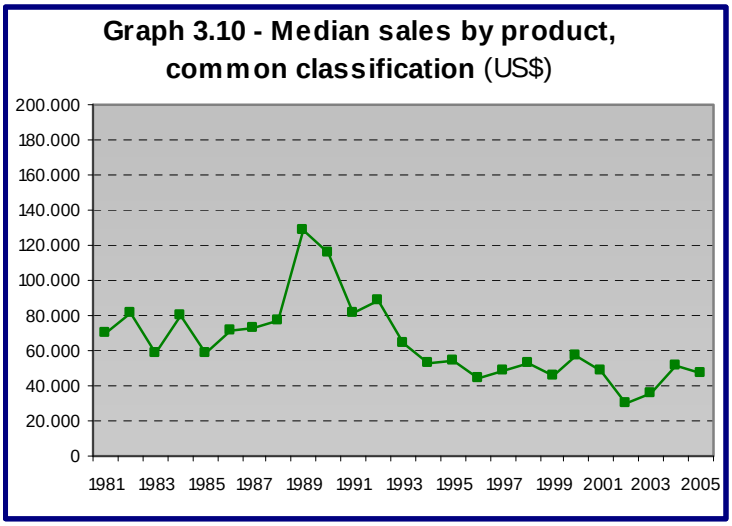


The changes coincide in each period, using each of the classifications, and for the whole sample, using the common classification. However, in 1993, when the Brussels Trade Classification was abandoned to adopt versions of the Harmonized System (HS) in the context of MERCOSUR, the reduction of the number of categories can be attributed to the change of system. Both classifications indicate a reduction in the variety of products in the last half of the 1990s. In the last years in our sample, the number of products exported increased.

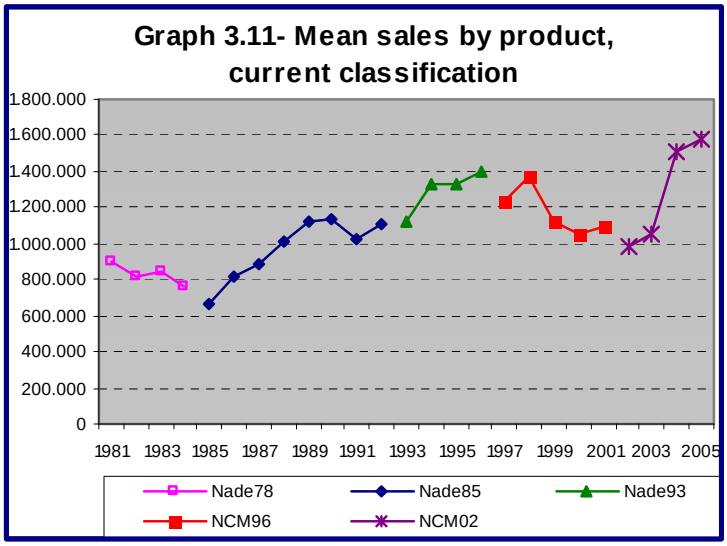
3.3.6 Sales by Product

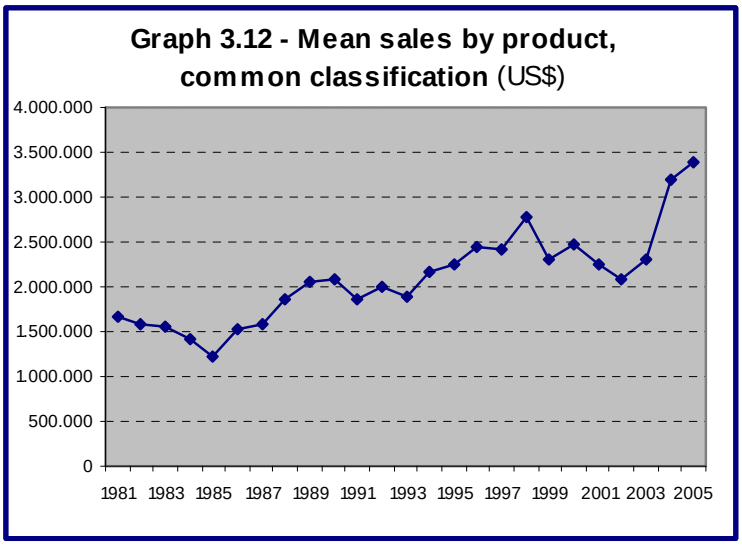
Graphs 3.9 to 3.12 provide information on mean and median sales by product. Both the original classification and the common classification tell the same story. Using both the current and common classifications, median sales by product increase until 1989 (the year before the change in exchange rate policy) and then follow a smoothly descending path (Graphs 3.9 and 3.10).





Mean sales by product follows an increasing path since 1985, so that in spite of the distribution of sales by product having shifted slightly to the left, the weight of the largest-selling products seems to have increased so as to pull the average value upward (Graphs 3.11 and 3.12).





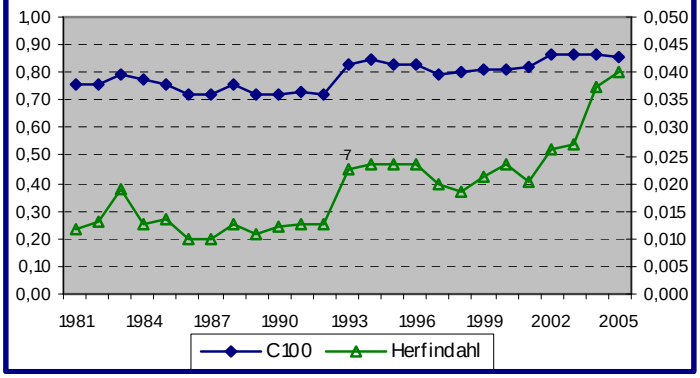
3.3.7 Product Concentration

Changes in the relative weights of sales by product reflect the concentration of sales by product. In all of our 8-digit classifications, the largest-selling 100 products account for more than 70 percent of Uruguayan exports. Changes in concentration are shown both by the evolution of the Herfindahl index by product and by the share of the largest-selling products. The calculations were carried over for the original and common classifications (Graphs 3.13 and 3.14). In what follows, the indexes calculated over current classifications are displayed in a single continuous series.

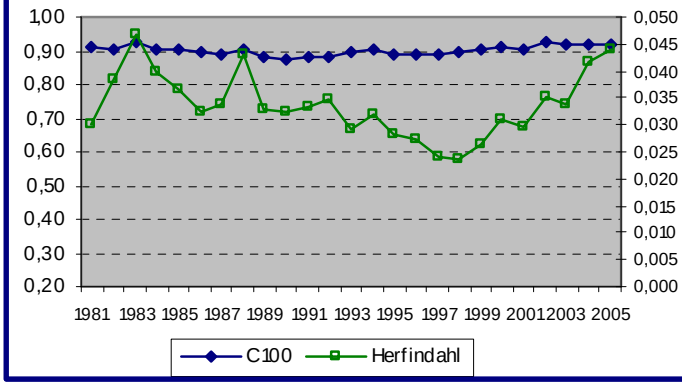
Calculations based on the current classification may be misguiding due to the change of classification in 1993, when the harmonized system was adopted. The data display an increase in

concentration at this point, which may arise artificially from changes in statistical classification criteria. When the common classification is used, a trend is shown of product concentration decreasing during the 1980s and 1990s, and increasing in the 2000s, particularly in the last years. In fact, the dramatic rise in the last years is due to the weight of a single 8-digit product (frozen boneless bovine meat) that alone accounts for more than 15 percent of total exports. The path of concentration by product bears close resemblance to changes in concentration by firm.

Graph 3.13 - Herfindahl by product and share of 100 largest, current classification



Graph 3.14 - Herfindahl by product and share of 100 largest, common classification



3.3.8 Entry and Exit of Products

To analyze the persistence of export products, we proceed in a similar fashion as with firms. Entry is the presence of a product in the present year but not in the year before; exit is presence in the actual year but not in the next. Substantial flows are observed both in the entry and exit. Due

to the continuous changes of classification criteria in our data, we work only with our common classification for the entire period.

The data are characterized by the fact that a large proportion of the year-to-year variation in the number of exported products is explained by products not present one period before or that will not be present in the next period. Graph 3.15 illustrates an insurmountable problem in the attempt to make different classifications compatible. Despite the common classification, there are spikes in the exit of products in the years prior to, and spikes in entry in the years coincident with, the changes in classification.

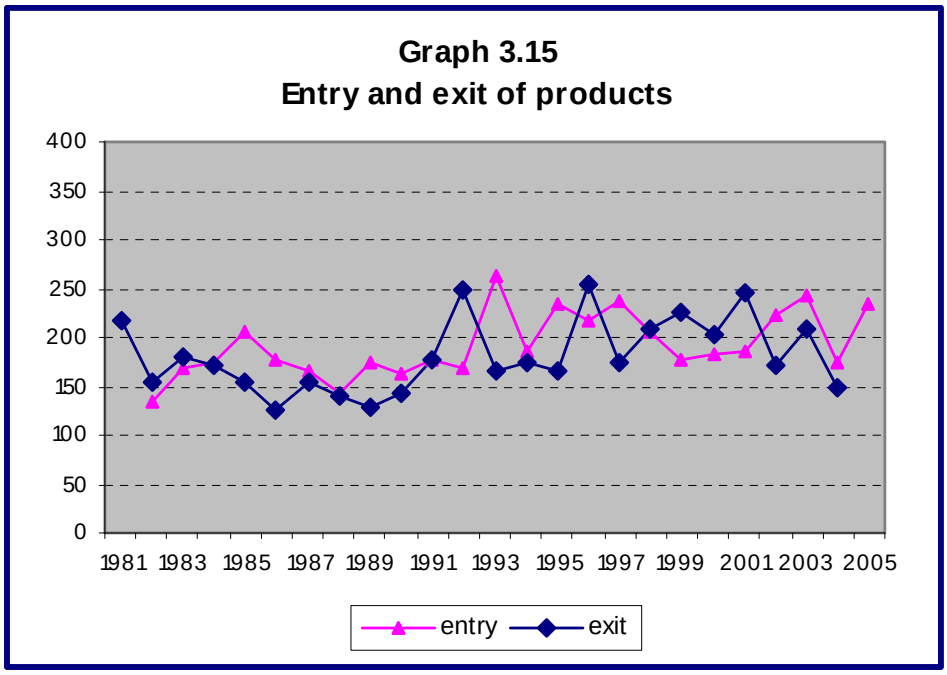


Table 3.3
Products Sold in 2005 by Cohort of Entry

Year	N	Percentage of products	Percentage of sales
1981	415	41.2	74.9
1982	70	7.0	1.9
1983	61	6.1	2.6
1984	49	4.9	0.6
1985	51	5.1	5.3
1986	33	3.3	2.4
1987	32	3.2	2.9
1988	24	2.4	0.8
1989	22	2.2	0.2
1990	16	1.6	2.0
1991	19	1.9	0.8
1992	14	1.4	0.0
1993-2005	201	20.0	5.6

Source: Customs records database.

At the classification level we used, a relatively stable structure is observed, in which some products explain the bulk of Uruguayan exports. The structure coexists of more volatile appearance of a large number of products that have shorter lives in the set of exports. For 2005, we present the distribution of exported products by cohort of appearance (Table 3.3). The share of more-established or "traditional" products (those appearing in the database since the starting period) in sales is larger than their share in the number of products.

Table 3.4 presents a simple decomposition of the change in export growth between the contribution of entering, continuing, and exiting products. Again, the contribution of continuing products tracks closely the rate of growth of exports (Table 3.4).

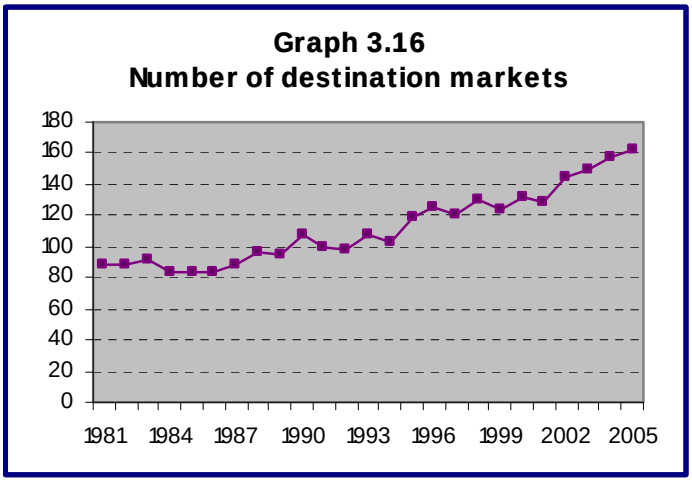
Table 3.4
Contributions to Export Growth by Continuing, Entering, and Exiting Products (Percent)

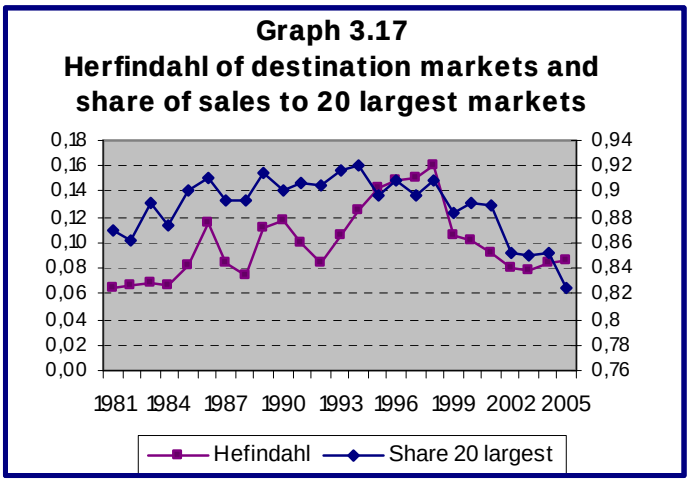
Year	Change	Continuing	Entry	Exit
1982	-15.8	-14.1	0.9	-2.6
1983	2.0	1.2	1.4	-0.6
1984	-11.1	-11.2	1.3	-1.1
1985	-8.3	-7.1	2.3	-3.4
1986	27.6	26.4	2.4	-1.2
1987	9.6	9.5	0.9	-0.9
1988	17.1	16.9	1.2	-1.0
1989	14.2	12.1	2.9	-0.8
1990	6.9	5.7	1.6	-0.4
1991	-7.6	-6.8	1.1	-1.8
1992	6.8	7.3	0.6	-1.0
1993	-4.5	-1.4	5.6	-8.7
1994	18.4	18.4	0.3	-0.4
1995	10.7	9.4	1.7	-0.4
1996	13.9	14.0	0.2	-0.4
1997	-3.1	-4.4	4.4	-3.0
1998	18.7	18.5	0.4	-0.2
1999	-18.8	-18.7	0.3	-0.4
2000	1.7	1.6	0.6	-0.5
2001	-10.6	-10.5	0.5	-0.5
2002	-9.1	-8.0	0.4	-1.5
2003	19.5	17.5	2.3	-0.3
2004	33.5	33.5	0.5	-0.5
2005	15.3	14.9	0.6	-0.3

Source: BROU and Custom records database.

3.3.9 Destination Markets

Our data also show an increasing trend toward diversification of export markets. The total number of export destinations shows a steady increase, particularly since the 1990s (Graph 3.16). The Herfindahl index and the share of sales to the 20 largest export markets measure concentration. The trend has been toward greater concentration in the second half of the 1980s and the 1990s, and less after 1999 (Graph 3.17).





The concentration indexes track closely the weight of the largest trade partners, particularly Argentina and Brazil. Changes in bilateral exchange rates after 2002 led to a reduced share of the neighboring economies; hence, the destination structure becomes more diversified.

3.3.10 Firm-level Product and Destination Market Diversification

There is also diversification at the firm level when new products and new markets are incorporated. We present simple data on the evolution of the number of products and markets by firm (Tables 3.5 and 3.6). Despite considerable entry of firms, the figures on the number of products by firm remain fairly constant. As far as the number of destination markets, after 2000, the trend shows a larger share of firms that export only to one market.

Table 3.5
Number of Products Exported by Firm

Year	Mean	Median	Min	Max
1981	3.2	2	1	32
1982	3	2	1	20
1983	3	2	1	18
1984	3	2	1	18
1985	3.1	2	1	19
1986	3.1	2	1	24
1987	3	2	1	28
1988	3.1	2	1	21
1989	3.1	2	1	23
1990	3.1	2	1	23
1991	3.1	2	1	23
1992	3	2	1	22
1993	2.9	2	1	30
1994	2.9	2	1	36
1995	3	2	1	24
1996	3.2	2	1	31
1997	3.2	2	1	38
1998	3.4	2	1	41
1999	3.5	2	1	35
2000	3.4	2	1	54
2001	3.4	2	1	36
2002	3.5	2	1	39
2003	3.6	2	1	44
2004	3.4	2	1	62
2005	3.8	1	1	62

Source: BROU and Customs records databases

Table 3.6
Number of export destinations by firm

Year	Mean	Median	Min	Max
1981	3.9	2	1	39
1982	3.7	2	1	35
1983	3.5	2	1	31
1984	3.4	2	1	31
1985	3.5	2	1	29
1986	3.5	2	1	31
1987	3.6	2	1	33
1988	3.8	2	1	34
1989	3.6	2	1	36
1990	3.7	2	1	35
1991	3.7	2	1	32
1992	3.6	2	1	30
1993	3.4	2	1	35
1994	3.5	2	1	37
1995	3.5	2	1	40
1996	3.5	2	1	39
1997	3.6	2	1	39
1998	3.8	2	1	37
1999	4	2	1	39
2000	3.6	2	1	39
2001	3.6	2	1	39
2002	3.8	2	1	41
2003	3.7	2	1	40
2004	4	2	1	50
2005	4	2	1	49

Source: BROU and Customs records databases.

3.3.11 Main Destination and Product Dynamics

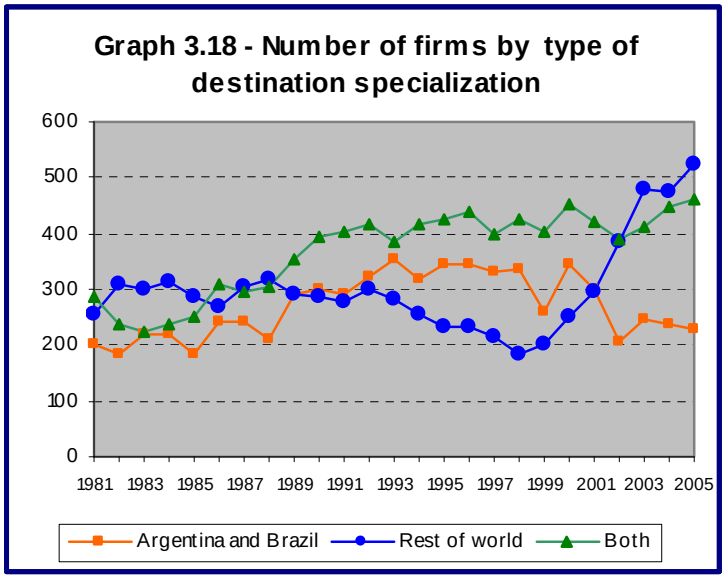
Simple groupings of destinations and product categories can explain part of the firm-level export dynamics in Uruguay. We will consider the dichotomy between the region and the rest of the world, considering separately Brazil and Argentina as regional partners. The analysis uses broad groups of 4-digit product categories to reinterpret the concentration, size, entry, and exit results.

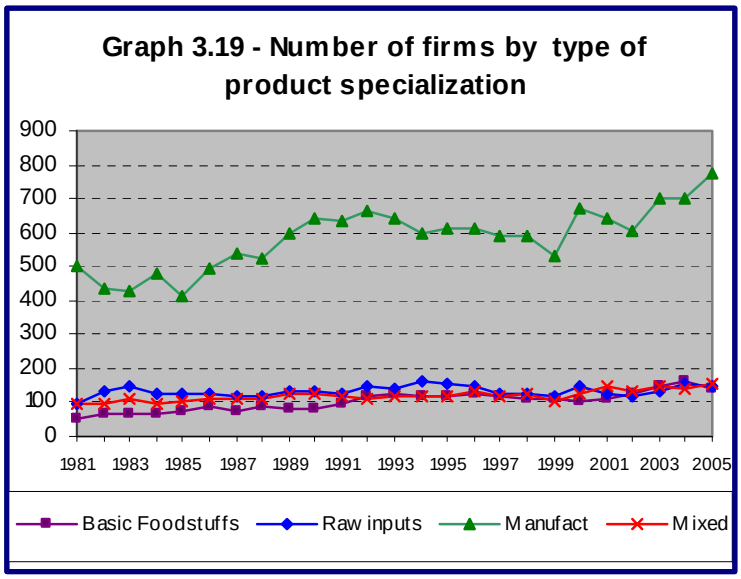
One of the main basic facts observed in the aggregate is that the share of exports to Argentina and Brazil surged after 1992, reaching nearly half of all Uruguayan exports in 1998. This share fell after the Brazilian and Argentine devaluations (in 1999 and 2002, respectively) to a low of 20 percent, comparable only to the share observed in the aftermath of the 1983 crisis.

At the same time, the composition of Uruguayan exports shifted. We look at the composition considering a simple classification of three large groups of products: basic foodstuffs including meat, dairy, citrus, fish, rice, malt, and oleaginous products; raw inputs including raw wool, wool tops, leather, wood, live animals, and electricity; and other manufactures including processed food, beverages, tobacco, and other manufactured goods.[10] The share of raw inputs shows, if anything, a very slight upward trend since 1999. The share of manufacturing goods tends to decrease after 2000. The evolution of their share is closely mirrored by the increase in the export share of basic foodstuffs. This trend speeds up after 2002. Exports to the region and the rest of the world differ in the types of products sold. Exports to the region are characterized by a larger weight of manufactured goods, and a more volatile pattern linked to the particular conditions of each of the neighboring partners.

We can identify three types of firms according to their specialization in a given year, i.e., selling only to the region, only to destinations outside the region, and to both types of markets. We also define four types of firms by their product specialization in a given year: only basic foods, only raw inputs, only manufactures, and a mix of two or more of these product categories. The results in terms of the number of firms are described in Graphs 3.18 and 3.19.

[10] This classification follows closely—but not exactly—Instituto de Economía (2005).



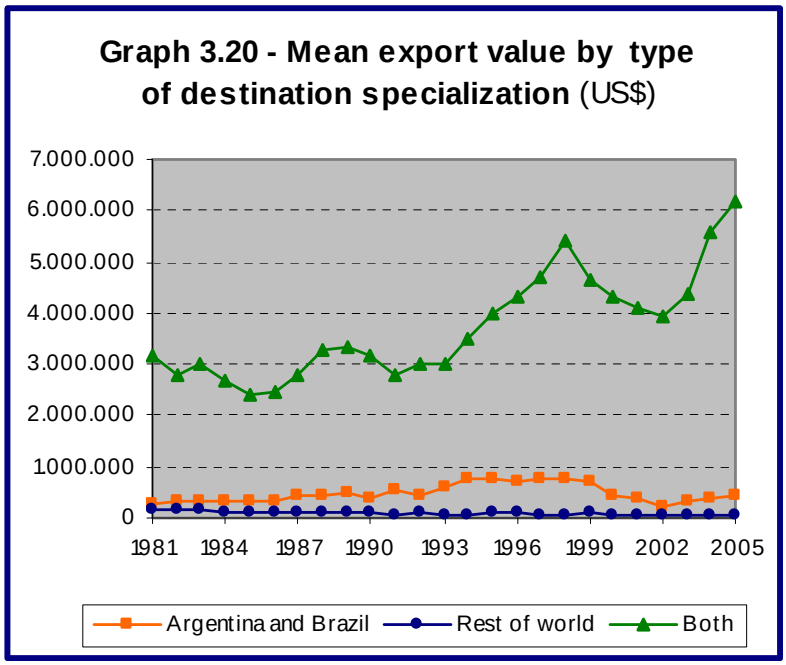


There is a noticeable change in the composition of the universe of Uruguayan exporting firms, particularly after 1999, toward manufacturing firms and firms oriented outside the region. Graphs 3.18 and 3.19 are also affected by the changes in statistical registration criteria, because it is possible that BROU's databases were missing part of the exporting firm universe.

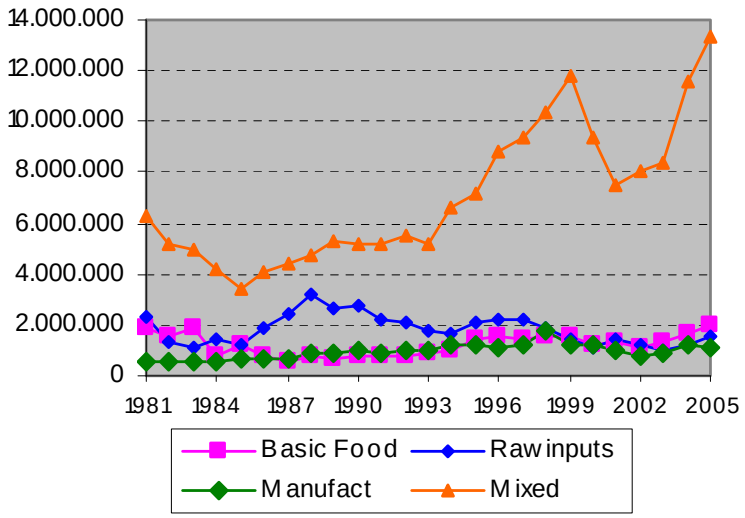
Graphs 3.20 to 3.23 describe some of the results on size, concentration, entry, and exit in terms of product and destination specialization. With respect to size, we observe that firms that sell both in the region and in the rest of the world have much larger average sales compared with

firms that specialize in selling to Uruguay's neighboring countries (Graph 3.20). At the same time, firms that do not specialize in one type of broad product category have on average much larger sales than those that do specialize (Graph 3.21). In terms of Cassoni and Vaillant (1993), firms that survive in export markets become large exporters and diversify their products and destination markets. In general, complete product and destination specialization has a role in defining large groups of firms, but does not discriminate clearly among large portions of the total value of exports.

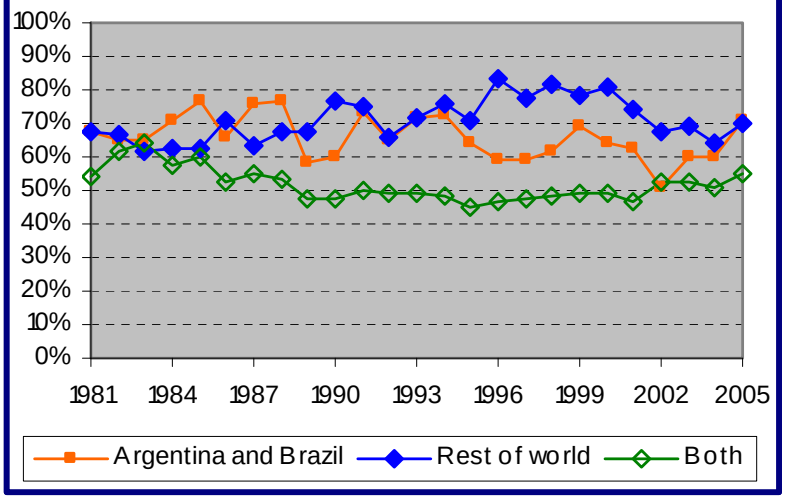
With respect to concentration, the data show a concentrated pattern within groups of firms by type of product and destination specialization (Graphs 3.22 and 3.23). Of the categories considered, there seems to be less concentration among firms exporting other manufactured goods and among those selling both to the region and to the rest of the world.

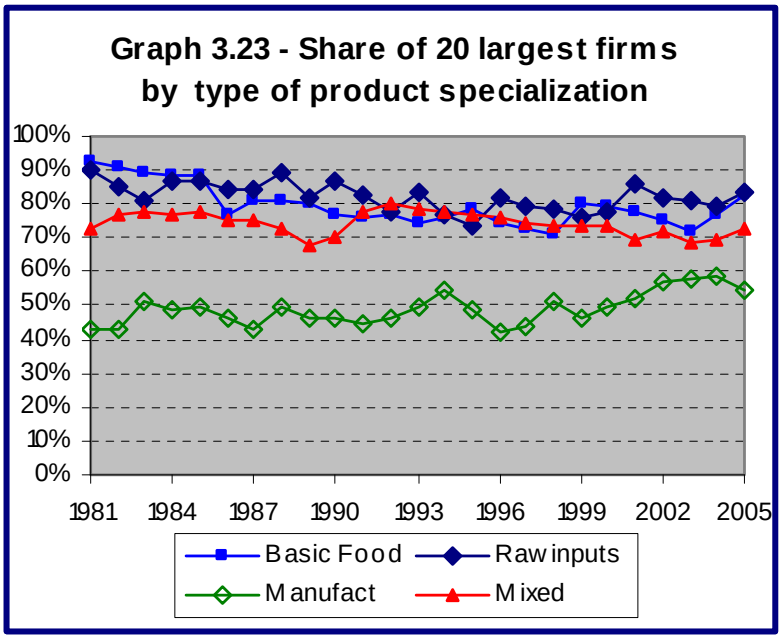


Graph 3.21 - Mean export value by type of product specialization (US$)

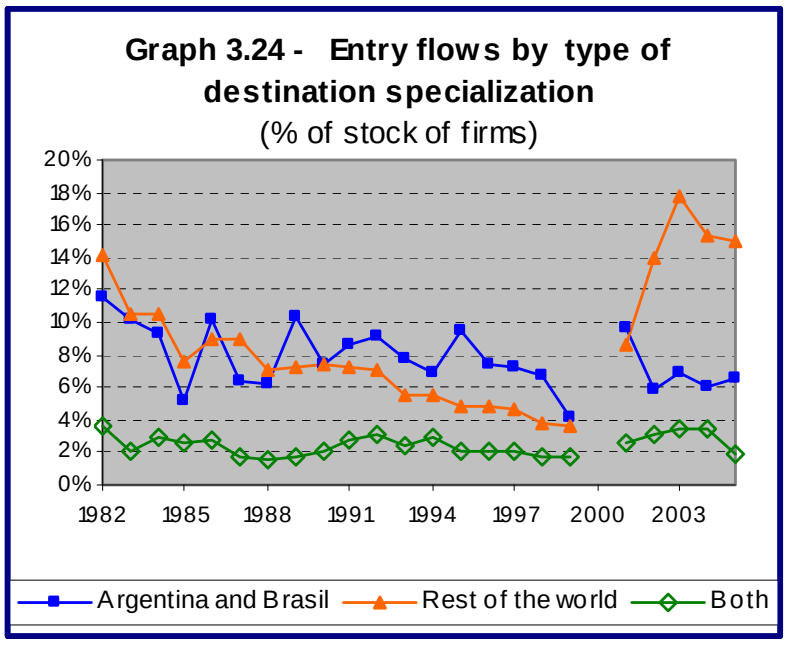


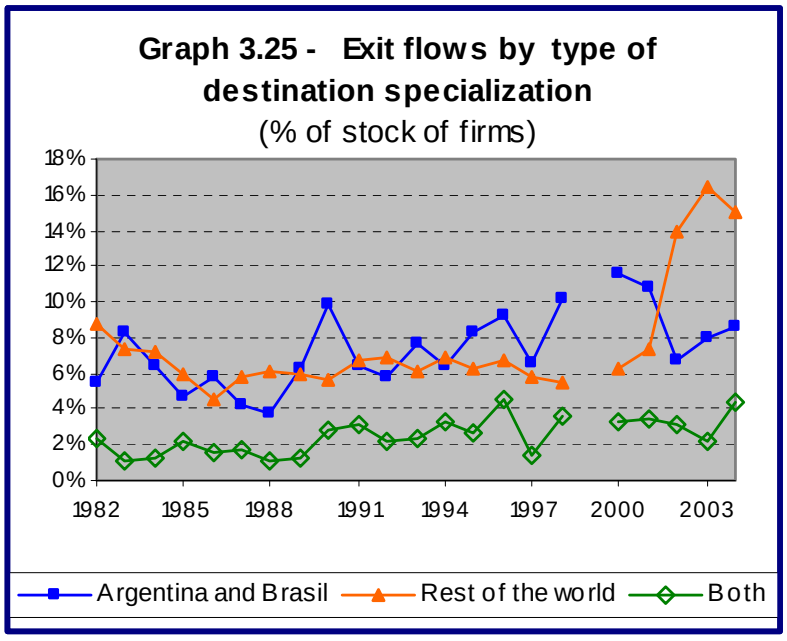
Graph 3.22 - Share of 20 largest firms by type of destination specialization



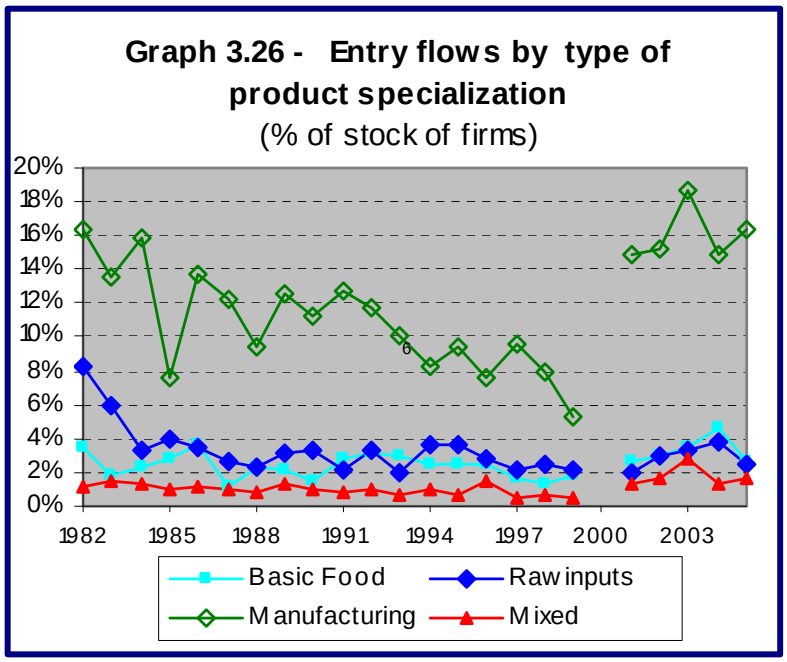


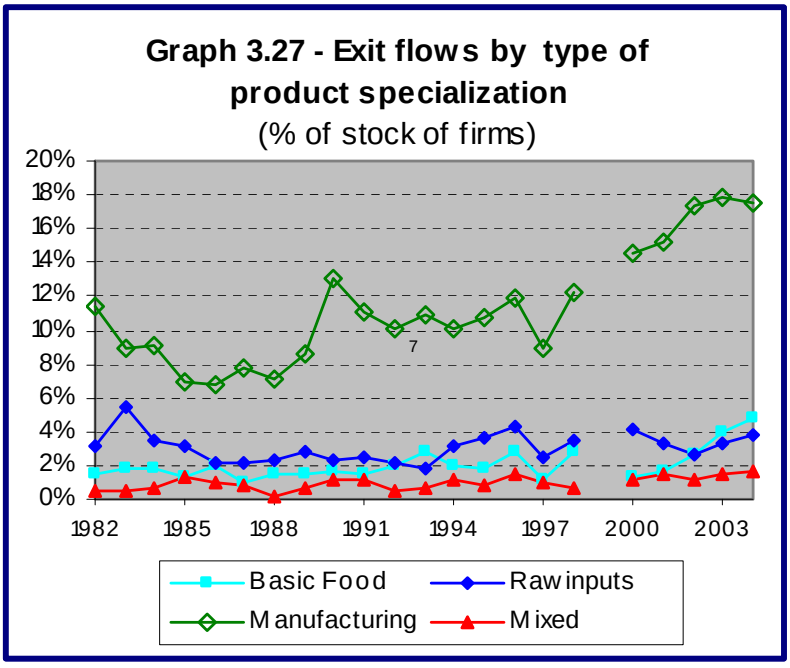
Firms with different types of specialization are very disparately represented in the basic entry and exit flows from the export markets. It is natural to observe that firms entering the export market do not have a tendency to export both to the region and to the rest of the world; hence, the entry flows are explained by firms specialized only in one of these destinations. However, there does not seem to be evidence of a sequential process, i.e., first approaching the regional markets and then jumping to the rest of the world, since entering firms appear to roughly specialize in both types of market. The same occurs with those firms exiting the export markets. There is a noticeable change in the share of firms exporting to the rest of the world in entry and exit recorded after 2000 (Graphs 3.24 and 3.25).





Both entry and exit flows are mostly explained (in terms of firms) by units specialized in other manufactured goods. This is particularly true after 2000, with the usual warning about changes in the registration of firms (Graphs 3.26 and 3.27).





3.4 Tracking the Discovery Process

We tentatively explored the potential of our export databases (containing product, exporter, and destination market data) for describing the features of the discovery process. A candidate criterion is to establish lower and upper thresholds on export values and a time interval such that

export values that pass from below the lower to above the upper threshold indicate the presence of a discovery process.

The investigation uses the common 8-digit classification, based on the Common MERCOSUR Classification.[11] Classification changes occurred constantly after short periods of time. Categories that in most cases opened up in many new codes in the next classification update were all too common and grouping was necessary to keep statistics consistent. This led to a very significant loss of product diversity. This is a relevant limitation because Uruguay is a relatively small economy, and its export universe is not extremely diversified even at the 8-digit level. As Table 3.7 shows, the highest ranked 8-digit exports tend to repeat in Uruguay's top 20 after 25 years.

There is an additional problem, even assuming that the classification is uniform. Excessively disaggregated data would show discoveries from an accounting point of view but not from an economic point of view. Therefore, Klinger and Lederman (2004) recommend considering results at different aggregation levels. Levels of aggregation affect products differently, and for some—for instance, agricultural products, where diversification has limits—the results do not differ sharply at different aggregation levels, although disaggregating leads to a larger number of products in manufacturing.

We must determine an adequate threshold for the increases in export value that characterize a discovery. In 2005, Uruguay exported 2,340 different 8-digit NCM products, with total exports valued at more than US$3,000 million. The structure is concentrated, and the first 100 8-digit NCM products explain 86 percent of total exports. The 100th 8-digit product's export value is just above $US4.5 million and the smallest 8-digit product with export value above US$1 million is ranked 243. That is, the 90th percentile of the distribution is just above US$1 million, while the median is below US$12,500.

[11] The 8-digit data allow tracking homogeneously defined product classes. The last two digits of the 10-digit level classification are left for each country to determine and are subject to discretion.

Table 3.7
20 largest exports of Uruguay in 1981 and 2005; 1981: NADE 8 digit products; 2005: NCM 2002 8 digit products

Rank	1981 highest selling exports	US$ millions	Share (percent)	2005 highest selling exports	US$ millions	Share (percent)
1	Frozen bovine meat, with bones	49.1	4.0	Frozen bovine meat, boneless	563.8	16.5
2	Chilled bovine meat, with bones	47.5	3.9	Chilled or fresh bovine meat, boneless	174.1	5.1
3	Polished white rice	41.4	3.4	Light petrol oil and preparations	144.1	4.2
4	Wool tops	33.9	2.8	Polished white rice	130.0	3.8
5	Whitened rice	31.2	2.6	Wool tops	105.4	3.1
6	Tanned bovine leather, undivided	30.5	2.5	Soy beans	96.8	2.8
7	Peeled rice without further preparation	28.0	2.3	Tanned bovine leather, undivided	81.9	2.4
8	Wool tops, breed II	24.1	2.0	Concentrated milk with no sugar addition	80.0	2.3
9	Wool garment form women, children	23.3	1.9	Other bovine leather after tanning	78.1	2.3
10	Bovine leather garment	20.6	1.7	Unroasted malt	74.7	2.2
11	Ovine leather garment	19.8	1.6	Plastic bottles, jars	66.7	1.9
12	Malted barley grain	17.8	1.5	Firewood, wood waste	60.2	1.8
13	Wool tops, breed B	17.5	1.4	Rough wood	57.3	1.7
14	Knitted wool	16.8	1.4	Other cheese	54.7	1.6
15	Rough wool	16.2	1.3	Other canned bovine meat	43.8	1.3
16	Wheat	16.1	1.3	Gold	42.8	1.3
17	Other frozen bovine meat	15.4	1.3	Tanned bovine leather, divided	42.2	1.2
18	Car tires	14.4	1.2	Fish fillets, (Merluccius spp.)	42.2	1.2
19	Rough wool breed I Superior or Supra	13.6	1.1	Seats	40.1	1.2
20	Other frozen, chilled or fresh fish	12.7	1.0	Sunflower seeds	34.0	1.0
	T O T A L	**489.9**	**40.3**		**2013.1**	**58.8**

Source: BROU and Customs Office records.

In 1981, Uruguay exported only 1,413 different 8-digit NADE products, with total exports valued at more than US$1,200 million. The structure was less concentrated, and the first 100 products accounted for just 75 percent of total exports. The 100th 8-digit product export value was just above US$2.5 million, while the smallest 8-digit product selling above US$1 million ranked 188. That year, the 90th percentile of the distribution was close to US$1.5 million, while the median was just below US$50,000. Therefore, 8-digit thresholds of US$50,000 as a lower bound and US$5 million as an upper bound were our starting point. We will not consider exactly 8-digit products, since our common classification groups some 8-digit products in broader classes, but the bounds will be reasonable approximations.

Finally, a criterion must be supplied as to what time span to consider for describing discoveries. We partitioned our panel in a continuous sequence of sub-panels of fixed time length with a starting date and an ending date. Each sub-panel can be thought of as a "sliding time window" indexed by its starting date. We consider sub-periods of ten years and compare for each product the average sales in the first three years and in the last three years to classify the product as a discovery case. Klinger and Lederman (2004) also track changes with respect to periods of three consecutive years at the start and end of the period under analysis.

We also needed a criterion to attach the discovery to a particular date. Because the change in sales volume might have been sharp, the same product might appear as a discovery in subsequent time windows. In such case, we registered the last time window in which the product still registered as a discovery. The database yields 10 discovery cases obtained when only products that were not exported at all were considered (see the Annex to this chapter).

It may also be the case that the product was being exported before starting a growth process. Then a second criterion was used, by which the discovery process starts when the product satisfied both conditions: passing from below the lower bound to above the upper bound between the time window endpoints. We obtained 29 cases under this criterion. Of these, only five correspond to products for which a one-to-one classification correspondence could be obtained between the different classification systems. The rest were product categories that required forward or backward aggregation to construct compatible categories within the common classification.

Summing up, the many changes of classification in short periods of time do not leave a significant margin for detecting export discoveries through statistical methods. Some of the cases

that will be part of our study are picked up in the data, such as the case of wine and wood products, while others, such as vaccines, are missed due to high aggregation.

3.5 Firm Characteristics and Export Performance

Some recent literature has stressed the link between exporting and productivity. Theoretical models, such as Melitz (2003) and Bernard et al. (2003), establish relationships between export performance and plant productivity, finding that exposure to international trade will affect differently firms of different productivity levels, hence conditioning entry to the export market and in some cases causing the least productive firms to exit the domestic market.

There is also an empirical literature on exports and productivity. Girma et al. (2004) analyze a panel of firms in the United Kingdom in search of links between productivity and the export market. Using propensity score matching and difference-in-differences techniques, they find evidence of self-selection, in the sense that entering firms are more productive before they enter the export market, but also that exporting further enhances their productivity. Aw, Chen, and Roberts (1997) focus on turnover (entry, exit, and survival of firms). They analyze domestic and export markets separately, estimating total factor productivity and the contribution of exiting, entering, and continuing firms. They find that differences in productivity have an effect in turnover patterns, and that exporters are more productive than non-exporters: domestic and export markets sort out less and more-productive firms.

An interesting question is which firms become exporters. The probability of being an exporter can be calculated conditional on firm and industry characteristics. Bernard and Wagner (1998) study entry and exit by German firms, testing the role of firm characteristics and sunk costs. They find evidence of the importance of sunk costs, and that plant success as measured by size and productivity increases the likelihood of exporting. Finally, Bernard and Jensen (2001) analyze a model of the export decision and find, using U.S. data, evidence on the importance of entry costs, while spillovers are small. Export promotion policies have little effect on the decision to export, and plant characteristics substantially influence entry decision, as do favorable exchange rate shocks.

Interesting evidence can be obtained by using a panel of Uruguayan firms from the Manufacturing Survey from the Instituto Nacional de Estadística for 1988-95. The Manufacturing Survey provides detailed data on input use, factor intensity, production, employment, etc. Capital

stock values are constructed for the survey years and total factor productivity measures can be estimated. Using this database, a wide number of firm variables can be directly correlated with measures of the exporting activity. Our primary objective is to investigate whether there is an export productivity premium for Uruguayan firms and to estimate its magnitude.

We estimate the following regression equation:

$$TFP_{ijt} = \alpha + \beta X_{ijt} + \gamma\, Age_{ijt} + \delta\, Size_{ijt} + \sum \phi_j s_j + \sum \eta_t d_t + \varepsilon_{ijt}$$

where TFP_{ijt} is total factor productivity of firm *i* in sector *j* at time *t*, X_{ijt} is a dummy variable equal to one if the firm exports in year *t*, Age_{ijt} is the number of years since the firm started operations, $Size_{ijt}$ is a dummy variable if the firm employs more than 100 workers, s_j and d_t are sector and time dummies, and ε_{ijt} is white noise. We are interested in parameter β, measuring the productivity differential between exporters and non-exporters (defined also as the "export premium").

Table 3.8
Export productivity premium estimates, Fixed-effects (within) regression
Dependent variable is ln of total factor productivity (Levinsohn-Petrin estimates)

Number of groups	655		Number of obs.	4,132		
R-sq: within =	0.004		Obs. per group: min	1		
between =	0.0011		avg	6.3		
overall =	0.0005		max	8		
			F(3.3474)	4.63		
Corr (u_i, Xb) =	-0.1488		Prob > F	0.0031		
	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
exp	0.13	0.04	3.34	0.00	0.05	0,20
size	0.08	0.05	1.60	0.11	-0.02	0,17
EDAD	0.00	0.00	-0.22	0.82	-0.01	0,01
_cons	6.81	0.15	44.19	0.00	6.51	7,12
sigma_u	0.81					
sigma_e	0.56					
rho	0.68	(fraction of variance due to u_i)				
F test that all u_i=0:	F(654, 3474) =10.7			Prob > F =0		

The data show a primary estimate of a 13 percent productivity premium, and there is a significant productivity differential between exporting and non-exporting firms. This is not far from the results reported for Chile by Alvarez and López (2004), after controlling for size and foreign or domestic ownership. In our case, the size variable is significant only at the 11 percent level.

3.6 Summary of Findings

To briefly summarize our results so far, we start by pointing out that there were three clearly defined periods regarding the number of exporting firms in Uruguay. Although the number of exporters grew steadily in the 1980s, reaching a maximum in 1992, it decreased through the 1990s. After 2000, a clear growth trend is observed. Toward the end of the 1990s, fewer firms made larger sales. After 2000, the number of firms increased but the sales of the largest increased more than those of the smaller ones; hence, the median sales by firm fell as the average increased. Coincidently, the concentration of firm sales decreased until 1989, and has increased until the present.

Flows of entry into and exit from the Uruguayan export markets are substantial. Entry flows show a decreasing trend between 1991 and 1999. Conversely, entry of firms into export activity gained new momentum after 2001. Exit flows in the 1990s were high, in the presence of low entry. Exit after 2001 was even higher, but the difference is that in the last five years entry flows were also very large. Hazard rates for entrants are generally above 30 percent.

In spite of a significant contribution of entry and exit to the stock of exporting firms, a stable structure in terms of export values is observed. The contribution of older and larger firms is substantial. Contributions of continuing firms tend to explain the bulk of export growth.

The number of products shows an increasing trend. Mean sales by product increased over time—particularly in the last five years—while median sales fell, which is reflected in larger concentration of sales by product. Entry and exit of products were also very large, but there was also a stable structure in which very traditional products explained a large proportion of export sales.

The number of destination markets increased, and aggregate concentration indexes by destination market show a fall in concentration, tracking the reduction of the share of Argentina and Brazil as large trade partners.

The shifts in destinations and products observed in the aggregate for Uruguayan exports translate into changes at the firm level. According to their destination and product specialization, recent changes include an increase in the number of firms selling other manufactured goods (not including basic foodstuffs or raw inputs) and oriented to sell outside the region. Large firms do export both to the region and the rest of the world, and also do not tend to specialize in one of the broad groups of products.

Firms entering the market tend to be specialized in selling to the rest of the world or to the region. Specialization in selling to the rest of the world is largely represented in entry and exit flows after 2000. Both entry and exit flows are mostly explained (firm-wise) by producers of other manufactured goods.

After the construction of a homogeneous classification to link four different classifications of Uruguayan exports, we are skeptical about the usefulness of statistical databases for tracking discoveries because the data are too sensitive to classification changes.

An exploratory scan of the manufacturing data shows that in the Uruguayan case, there is an association between exports and productivity. The explanation for this productivity differential remains an interesting topic for future research.

Annex: Export Discoveries in Uruguay According to Statistics

Table A.3.1
Number of discoveries in Uruguayan exports
Products previously not exported, ten years sliding time window
Compares averages of three starting and ending years

Cod_prod	Name	Starting period		Ending Period	
4018383	Fluid milk	1988	1990	1995	1997
4069083	Cheese, other	1984	1986	1991	1993
10019083	Wheat, other	1992	1994	1999	2001
15179083	Mixes of vegetable oil	1991	1993	1998	2000
29041083	Benzenosulphonic acids	1994	1996	2001	2003
39041010	Vinyl chloride polymers	1982	1984	1989	1991
44012200	Lumber, wood in pellets	1983	1985	1990	1992
51018383	Wool, other	1987	1989	1994	1996
73064000	Other tubes and hollow pieces	1990	1992	1997	1999
87120083	Bicycles	1991	1993	1998	2000

Source: BROU and Customs records

Table A.3.2
Nr. of discoveries in Uruguayan Exports: All products
Ten year sliding time window
Compares averages of three starting and ending years

cod_prod	Name	Starting period		Ending Period	
2068383	Bovine meat, other	1994	1996	2001	2003
3838383	Other fish, crustacean and mollusks	1991	1993	1998	2000
4018383	Fluid Milk	1988	1990	1995	1997
4069083	Cheese, other	1984	1986	1991	1993
10019083	Wheat, other	1992	1994	1999	2001
12060010	sunflower seeds	1994	1996	2001	2003
15179083	Mixes of vegetable or animal oil	1991	1993	1998	2000
21069083	Other food	1983	1985	1990	1992
22048383	Other wine	1993	1995	2000	2002
24028383	Other cigarettes	1988	1990	1995	1997
29041083	Benzenosulphonic acids	1994	1996	2001	2003
39041010	Vinyl chloride polymers	1982	1984	1989	1991
40058383	Synthetic rubber	1988	1990	1995	1997
44012200	Lumber, wood in pellets	1985	1987	1992	1994
44039983	Raw wood, other	1990	1992	1997	1999
44071083	Sawn pine wood	1992	1994	1999	2001
44838383	Wood, carbon and wood manufactures	1989	1991	1996	1998
48108383	Other coated paper and cardboard	1991	1993	1998	2000
49111083	Commercial catalogs	1990	1992	1997	1999
51018383	Other raw wool	1990	1992	1997	1999
61142000	Other knitted garment	1982	1984	1989	1991
71081283	Raw gold, non monetary use	1981	1983	1988	1990
73064000	Iron tubes and parts	1990	1992	1997	1999
84798383	Mechanical machinery	1989	1991	1996	1998
85118383	Motors or electrical devices	1990	1992	1997	1999
87038383	Automobiles	1983	1985	1990	1992
87048383	Other automobiles for transport of goods	1990	1992	1997	1999
87120083	Bicycles	1992	1994	1999	2001
94019083	vehicle seats and parts	1995	1997	2002	2004

Source: BROU and Customs records.

4. Case Studies of New Export Activities

4.1 Selection Criteria for Discoveries and Comparators

Several cases of successful export discoveries were identified from varying sources (export data, sector and innovation related studies, success stories, interviews, consultancies, national and international seminars, etc.). Two very different sectors called for consideration as export-driven development. One is the forestry chain, which is now showing increasing exports as a result of long-term investment in forestation. It has a potential structural impact on exports. The second sector is the software industry, which developed during the 1990s and experienced booming exports earlier than in other software producing nations in Latin America. It is a contrasting case with the forestry chain—and Uruguay's export tendency in general—because the discovery is not related to natural resources. Another important difference concerns the public response: a forestation process has been highly stimulated by government incentives, while the software sector has emerged without specific promotional measures and government support was slow to develop. Finally, foreign direct investment (FDI) was very important in the development of the forestry chain and mainly irrelevant in the building up of the software industry. In both sectors, a pioneer investor could be traced, who also played the first mover role in penetrating foreign markets.

To check the consistency of our forestry analysis with a comparator case, we chose to explore another natural resource based sector with less promising export growth: the wine sector. Traditionally oriented toward the domestic market, the wine sector experienced a sharp export increase during the second half of the 1990s but this trend could not been sustained in the present decade. Similarities between the forestry and wine cases include, among others, the following: both are traditional activities that used to be tariff protected and experienced drastic restructuring in the past decades; the transformation process was based on the assumption of comparative advantage deriving from natural resource endowment; their development is highly dependent on relatively long biological cycles, especially when high quality raw material is targeted; firms tend to be vertically integrated in both sectors (producers frequently own plantations); a pioneer firm could be traced in vine growing as in forestry; and both sectors benefited from government support in their restructuring process, as well as for foreign market penetration. Is the difficulty of sustaining the growth of wine exports due to a failure in evaluating the conditions required to take advantage of the commercial opportunity that appeared in the global market in the 1990s? Was

the sector unable to overcome local coordination failures? Since FDI was relatively low in the wine sector, could this be a confirmation of the importance of FDI as a factor in the forestry discovery? The analysis of these issues should contribute to a better understanding of the forestry discovery and of the policy lessons to be drawn.

For the software discovery, we chose as a comparator another high-tech sector: the electronics industry. In addition to their similar technological intensity, they both emerged as new "sectors" at the end of the 1980s and were driven to exporting due to the limitations of the domestic market. The spectacular growth of information and communication technology (ICT) opened a window of opportunity for these sectors in countries well below the technology frontier but rich in qualified human capital and capable of developing niche strategies. However, electronics exports did not develop significantly.

In order to diversify the dimensions covered by the research and broaden the evidence for the lessons to be drawn, we selected two additional discoveries of a different kind. In Uruguay, there are a number of cases of first movers exporting successfully a differentiated product but with apparently no diffusion process taking place. It is often not clear whether the discovery failed to generate imitators or if diffusion is a question of time when uncertainties are complex and slow to be solved by the first mover. We chose the case of sturgeon and caviar exports as a discovery with no diffusion process yet—but bright prospects for diffusion—and concentrate on the analysis of the types of uncertainties to be solved by the first mover. To some extent, this case is similar to Chile's salmon discovery in terms of global commercial opportunities and different types of difficulties to be solved before diffusion could begin.

A comparator, i.e. a case of failed exports, was sought in the aquaculture sector. It appeared that frogs started to be exported by Uruguay in 1997 and raised enthusiasm among imitators; however, various factors led to the failure of export growth. Similarities between the caviar and frog cases include: a global commercial opportunity for a gourmet product from the aquaculture sector; technological research to adapt production to local conditions; and no specific government support.

Finally, the fourth discovery was detected through statistical evidence. Animal vaccine exports, especially bacterial vaccines, emerged in the mid-1990s and increased significantly in the following years. Three producing firms were detected, which all started exporting at the same time. Previously, in the 1970s and 1980s, large-scale animal vaccine production in Uruguay had

developed mainly to eradicate viral foot-and-mouth disease. And, for once, the domestic market could absorb massive production due to the size of the livestock industry (three times the human population) and because sanitary conditions were vital for meat exports, an essential sector of the Uruguayan economy. An interesting question is thus whether there is any relation between the recent emergence of (bacterial) vaccine exports and the skills and knowledge previously developed in (viral) vaccine production. Is there a comparative advantage in animal vaccine production derived from qualified human resources in the field of biology? In this case, we chose as a comparator for the vaccine discovery the new Uruguayan biotechnology-based firms because they have not been able to export, or only marginally, in spite of enjoying the same critical public goods as vaccine pioneers.

A synopsis of the distinctive features of the selected discoveries is presented in Table 4.1.1.

Table 4.1.1 - Distinctive features of the selected export discoveries

	Software	**Forestry chain**	**Caviar**	**Animal vaccines**
Economic sector	High tech manufacturing and services	Natural resource based manufacturing (traditional)	Natural resource based manufacturing (non-traditional)	Manufacturing based on traditional biotechnology
Export growth (US millions)	4.5 (1993) to 104 (2005)	4.7 (1990) to 141 (2005)	0.003 (2000) to 1 (2005)	1 (1995) to 4.5 (2005)
Main comparative advantage	Skilled human resources	Country natural conditions	Country natural conditions	Skilled human resources
Type of products or services	Niche related	Mainly commodities	Brand related	Commodities
Specific public support	Not initially but in diffusion process	Yes	No	No
Foreign direct investment	Limited	Very strong	Some interest expressed	Strong
Potential structural impact in exports	Moderate	High	Uncertain	Low

4.2 Software Discovery

4.2.1 Introduction

Software exports are a novel diversification of Uruguayan exports that took place in the 1990s. Although some software firms appeared during the 1970s, the sector really emerged in the second half of the 1980s when personal computers (PCs) were introduced in the country and spurred the demand for programs and IT-related services. A new generation of entrepreneurs appeared, several of whom still head some of the most successful software firms. One of these is ARTech, the first firm to export a product on a sustained basis. Undoubtedly there are other local pioneers, because this discovery involves an activity that includes several types of products and services. But ARTech and its flagship product, GeneXus, are an excellent illustration of a first-mover strategy that included the promotion of a product diffusion process through setting up what might be called a community of practice.

This chapter focuses on the key elements of this discovery and checks the consistency of the analysis through a review of the conditions that prevented a positive outcome in the case of the electronics sector. Research carried out in the early 1990s (Snoeck, Sutz, and Vigorito, 1992) showed that both the software and electronics industries were developing in Uruguay and were contributing to the build-up of a knowledge-intensive sector in the country. Commercial opportunities deriving from the fast expansion of IT could be matched thanks to qualified human resources and some research tradition in these fields at the public university. Both sectors had star products that were finding their way into foreign markets. However, difficulties of several types hindered further growth in electronics and the diffusion process was truncated.

With respect to the software industry, Snoeck, Sutz, and Vigorito concluded: “If demand for specific or tailor made software increases, existing firms will probably grow and will be joined by new firms. However, were this to happen, it is not obvious that this increase will be accompanied with the reversal of the aspects that most clearly characterize the present weakness of the sector, namely: very low individual turnover in general; limited export capacity; poor management of commercial issues, especially marketing; limited sales volume per unit of production; etc.” (Snoeck, Sutz, and Vigorito, 1991, p. 273). Although most of these difficulties

still hold true for a great number of the 300 firms that make up the sector,[12] nowadays Uruguay sells software products and services to 50 markets. It even became the largest software exporting country of Latin America at the turn of the century, a condition that would later vanish. Exports grew from practically nothing in 1989 to close to $US80 million in 2001, and reached US$104 million in 2005 (Graph 4.2.1).[13] In spite of some decrease in 2002 and 2003 due to the regional economic and financial crisis, as well as to the drop in the global IT business, the software sector performed much better than the total country's exports in the same years (Graph 4.2.2).

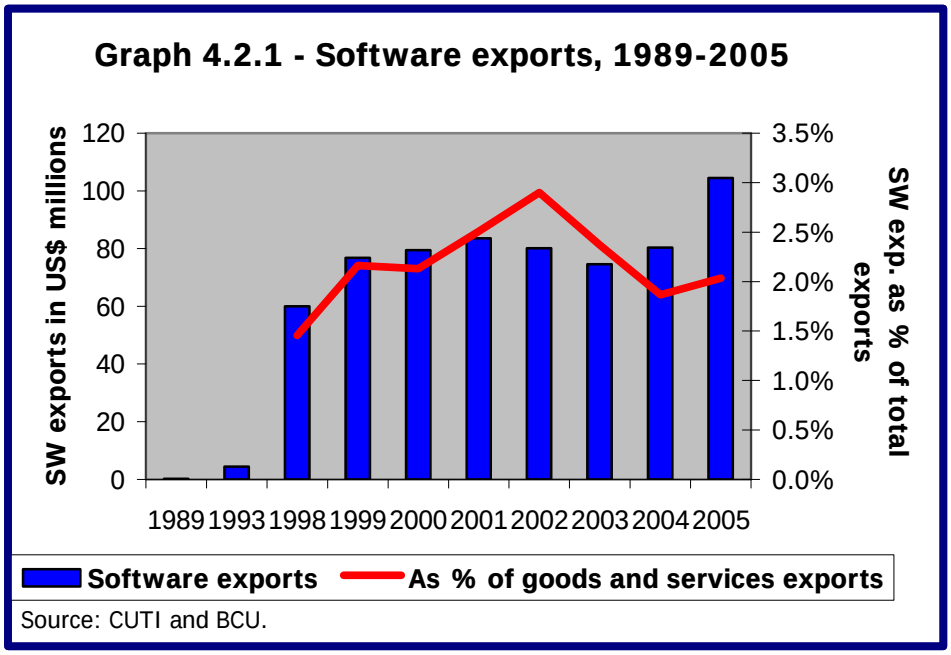
In the present decade, software exports represent an average of 2.3 percent of the country's total goods and services exports,[14] most of which originate from natural resource commodities and tourism. Despite this modest share, the software sector contributes to export diversification and, more significantly, it is the first time in Uruguay's history that knowledge accumulation at the national level has generated exports that (i) are not based in natural resources; (ii) are not anecdotal because they stood firm in a medium-term period; and (iii) are not so marginal in the economy compared with some of the most successful software exporting countries.[15]

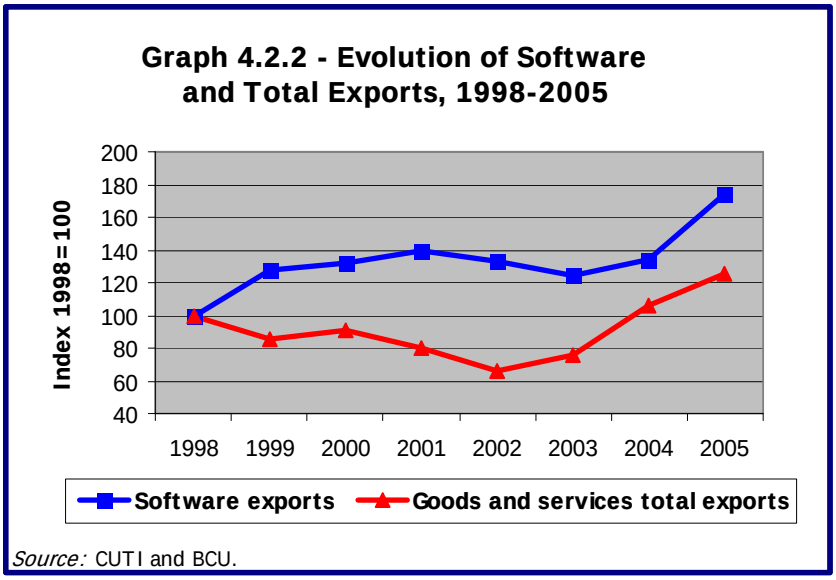
[12] Roughly half of them are software developers (also providing services related to the applications they develop); the rest perform different types of services and consultancies. The sector's total turnover (excluding single-person firms) amounted to US$200 million in 2004.

[13] This is based on annual surveys undertaken since 1998 by the Uruguayan Chamber of Information Technologies (CUTI). Since 2004, CUTI has been the official software export data provider of the Central Bank of Uruguay, in charge of export statistics.

[14] Software exports registered by CUTI are not exactly comparable with exports of goods and services registered by the Central Bank, since the latter, according to national accounting criteria, considered as exports only sales coming from the national territory. Instead, CUTI figures also include resident factor incomes coming from abroad.

[15] In Ireland, software exports represented 10 percent of total exports in 2000 and in India, 8 percent in 1999-2000 (Arora, 2003, and Kumar, 2001). In Ireland, Israel, India, Brazil, and China, the software industry accounts for at best 2-3 percent of GDP (Arora, 2004). In Argentina, it represents about 1 percent of GDP. In Uruguay, the figure is about 1.2 percent (excluding sales of hardware products).





Nevertheless, the average annual growth rate of software exports (6 percent in 1998-2005) lags behind the two-digit rate of the international software trade. Software exports and imports of the OECD region, for instance, increased at an average annual rate of 17-18 percent in 1999-2002 (Eurostat data). Software spending at the world level grew 11.4 percent per year between 2001

and 2005, on average (WITSA, 2006).[16] It is precisely the dynamism of the demand for software, together with the globalization of the IT business, that offers opportunities for Uruguay to find market niches and establish agreements with transnational companies, latching onto global value chains. As regarding Latin America, some forecasts indicate that it will become the second-highest increasing region for IT business in the world, behind Eastern Europe (Business News America, 2005).

4.2.2 First Mover ARTech

ARTech Consultores S.R.L. was co-founded in 1988 by two Uruguayan computer engineers. One of them previously headed the computer center of the Uruguayan social security institution and both had carried out consultancies abroad (in Brazil and the United States) in the field of the relatively recent technology of relational data bases. Having found out that it was feasible to automate part of the database programming process, they decided to create a software tool that would enable consultants to develop their own applications more efficiently. After an unsuccessful intent to sell the project to get funds to develop it, they faced the following options:

> "Either we abandoned the project and continued with normal consultancy tasks or we continued fighting for it. Since we thought our development was useful, we decided to create an enterprise to host our GeneXus project. Initially it had quite minor objectives, consisting mainly in assisting in the design of a database but then, as time passed, we ended up using it to generate applications." (Valverde et al., 2006)

The first version of GeneXus was released at the end of 1989. The first client was a firm from the North of the country; a few more clients followed, including the Ministry of Defense and De Larroble y Asociados (DL&A), a firm that would become a strategic partner of ARTech and a leader in banking software in Uruguay. Abroad, Chile was the first destination of GeneXus, followed by Brazil, the "natural" market for ARTech's partners since they had been working extensively there. By 1991, ARTech had sold 350 copies of GeneXus, mostly in the Latin

[16] The World Information Technology and Services Alliances (WITSA) tracks ICT national spending in 75 countries according to four categories: software, computer hardware, services, and telecommunications. Average growth of spending in the whole ICT sector was 8.9 percent from 2001 to 2005.

American market and by way of direct sales abroad. Foreign revenue represented roughly US$250,000 (Snoeck, Sutz, and Vigorito, 1991), while other exporters were mainly exporting on an experimental basis.[17]

In the past 15 years, ARTech evolved from a small company founded by two inquisitive, creative computer engineers to a large-scale, prosperous business with worldwide trading of its product, which is used by more than 4,500 firms. ARTech does not reveal data on its turnover or its exports, but in 1997 it disclosed that GeneXus license sales amounted to US$10 million (with 2,200 clients) and generated another US$50 million by way of related services: consultancies, development of turn-key systems, etc. Exports grew dramatically and now represent 85 percent of total sales.

ARTech's capital is still entirely national and the founders maintain their position as President and Vice President of the company as well as of GeneXus Consulting, a sister firm created to provide consultancy services.

Main Uncertainties Faced and Solved by ARTech

The greatest uncertainties at the planning stage concerned the technological challenge and demand, which was potential but not explicit. Development costs were unknown and assumed as sunken costs. It turned out that the development of the first version of GeneXus required about 20 person-years and cost about US$500,000 (Snoeck, Sutz, and Vigorito, 1991). Because of the lack of initial capital, this investment was indirectly financed by consultancies carried out by ARTech's people.

Once the product was developed and launched in the local market with a reasonable degree of success, uncertainty concerned, in the first place, foreign market penetration. The lack of specialized management and marketing skills in the early phase of ARTech made it difficult to discover the right export strategy. Furthermore, there was no experience in the country in terms of exporting software, a highly intangible good. Although such goods are similar to services, exports of services were not much developed at that time in Uruguay (late 1980s).

[17] There are no official records of software exports in these years. Even today, software exports by firm are not available because the Customs Office does not register exports of services.

When ARTech aimed to properly export GeneXus instead of selling it directly in foreign markets, it clashed with the inadequacy of official procedures for the specificities of software products. The following comment illustrates the situation:

> "So far we have exported only one package for US$15,000. We had to pack the program and fill in a form specifying how much it weighed, what color it was, etc., just as if it were about shoes. There is absolutely nothing specific for software. And there are no custom duties on it, fortunately… In addition, as a professional company, we could not export. It had to be done through a business firm because, according to the Banco de la Republica [the state bank in charge of foreign trade], a professional company cannot be an exporter. (Snoeck, Sutz, and Vigorito, 1991, p. 260)

This problem vanished as the development and spread of the Internet enabled online downloading. However, more generally, some of the obstacles faced by ARTech—and the software sector in general—can be ascribed to differences between traditional industry and the software business. Laws and regulations in the country tend to be based on the former model, which can result in awkward situations in the case of software. For instance, the software industry typically works on a project basis and would therefore require flexible employment mechanisms. This difficulty at the policy level was only recently tackled by the Uruguayan Chamber of the Software Industry (CUTI).

In the early 1990s, ARTech's search for new ways of expanding its commercialization channels coincided with a change in IBM's commercial strategy, consisting in opening itself up to partners to expand its business. With the launching of its new AS400 platform, IBM needed a network of partners to develop applications, and ARTech became one of the partners. IBM's reputation and marketing channels facilitated the diffusion of GeneXus as a product easily used for business applications development with this new platform. Later, when Microsoft consolidated its position as dominant supplier in the PC world and PC servers became an alternative for business applications, ARTech developed a closer relation with Microsoft.

ARTech opened offices in Chicago (1994), Mexico (2002), and São Paulo and Shanghai (2003); in 2004, ARTech participated in a joint venture with Japanese entrepreneurs for the distribution of its product. On the whole, ARTech's distributor network now comprises 28

countries. Carefully thought out commercial alliances are a basic part of the firm's strategy and, at times, ARTech hired specialized consultancies to help choose a foreign partner, as was the case in Brazil. Results are sometimes slow to appear: ARTech worked for about four years with its distributor in China to acquire know-how on business negotiation in China (how to negotiate, deal and work with people, gain confidence, develop projects, etc.) before getting a very important contract in 2005 to provide "GXHealth," a comprehensive administration system for the WantWant Hospital in the province of Hunan. Moving toward the East also implied moving to multi-language versions of the product.

Summing up, the exporting learning curve included different and successive approaches to internationalization: direct sales abroad; taking advantage of IBM's development strategy; establishing a network of distributors and sales agents abroad; selling through the Internet; establishing a commercial joint venture; and opting for a multi-language product. As ARTech moved from regional to extra-regional markets (the United States, Asia), uncertainty was increasingly related to cultural factors and the firm had to dedicate substantial efforts to adapt in each case.

A second source of uncertainty concerned the extent to which profit-eroding diffusion could be avoided or postponed. This is a two-fold issue: What should be done in terms of product upgrading and which alliances should be created to generate and internalize network economies?

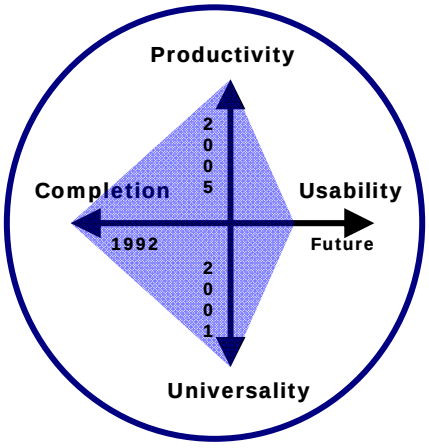
a. Product Strategy

The GeneXus discovery is a typical case of exploitation of a proprietary knowledge niche that was generated and maintained through intensive R&D and a clear, long-term product strategy.[18] Since its creation, ARTech has been heavily involved in R&D, in the area of relational databases, applications development, Computer Aided Software Engineering (CASE), and artificial intelligence. The R&D team now includes 30 engineers, some of them part-time.[19] The following were essential to attain the product objectives that were fixed at an early stage, before technology had developed sufficiently at the global level to fully attain them (Gonda and Jodal, 2006):

[18] GeneXus provides an integrated toolset for developing complex mission-critical applications with large databases. A license for the GeneXus development environment costs about US$5,000 and an additional US$2,000 for each generator. Maintenance fees in the following years (15 percent of the initial price) give the right to updated versions.
[19] University-level professionals represent 80 percent of the current total of 110 employees (90 in 1998).

- Completion. GeneXus generated not only the user database, but also all the application programs so as to allow the automatic maintenance of the whole user system with ensuing drastic cost-savings.[20] The goal was achieved in 1992 through innovation with high-level procedural language (Graph 4.2.3).

Graph 4.2.3 – GeneXus objectives and achievements



Source: Adapted from Gonda and Jodal (2006).

- Universality. This enabled GeneXus to develop applications for any existing relevant platform.[21] Applications can now be designed with independence of the construction platform. This in turn allows the software developers to *reuse* knowledge bases in different environments, an advantage that increases the longer the relation of the software firm with ARTech. High flexibility is one of the product's great strengths. According to one of the ARTech directors, there

[20] It has been estimated that, in conventional environments, 80 percent of the resources supposedly assigned to development are in fact dedicated to the maintenance of applications.

[21] Initially, GeneXus basically generated applications for one platform (IBM AS/400 computer). In the mid-1990s, the strong expansion of the client/server architecture led ARTech to release the client/server generators for the most relevant database management systems, which substantially increased universality. In the mid-1990s, in response to the worldwide spread of the Internet for business purposes, ARTech released its first Web generator that would be further refined. GeneXus users also increasingly requested the automated updating of the PC version of the programs, which was done in 2001 with the release of GeneXus generators for Java and .NET. In the following years, the firm added support to different platforms that became relevant in the market.

is no other product on the global market with this multi-platform feature and the capacity to capture knowledge at such a level of abstraction. Platform compatibility has been a way to widen the network of GeneXus users.

- Usability. ARTech has made the tool usable by anyone with a solid general background. Up to now, usability has been limited to professional developers. Removing this limitation should enable a much greater contribution from non-IT professionals in the construction of a firm's system because those are the ones with specific knowledge of the business or sector in which they are involved. "Knowledge of the problem to be solved will be increasingly more important than knowledge of the technology needed to solve it. … in the near future, business systems based on accounting, purchases, sales, payroll, stocks or ERPs, CRMs, etc. will become a minor part of the applications that users need. Where does the knowledge to build the new applications lie? Well, much more in the latter than in the professional developers." (Gonda and Jodal, 2006)
- Productivity. A fivefold increase in productivity—compared with manually using common programming languages—was the initial goal and was achieved with the 2005 version of GeneXus. A major increase is expected with the 2007 version number ten, which was totally rewritten based on the current state of knowledge, instead of building on the previous version.

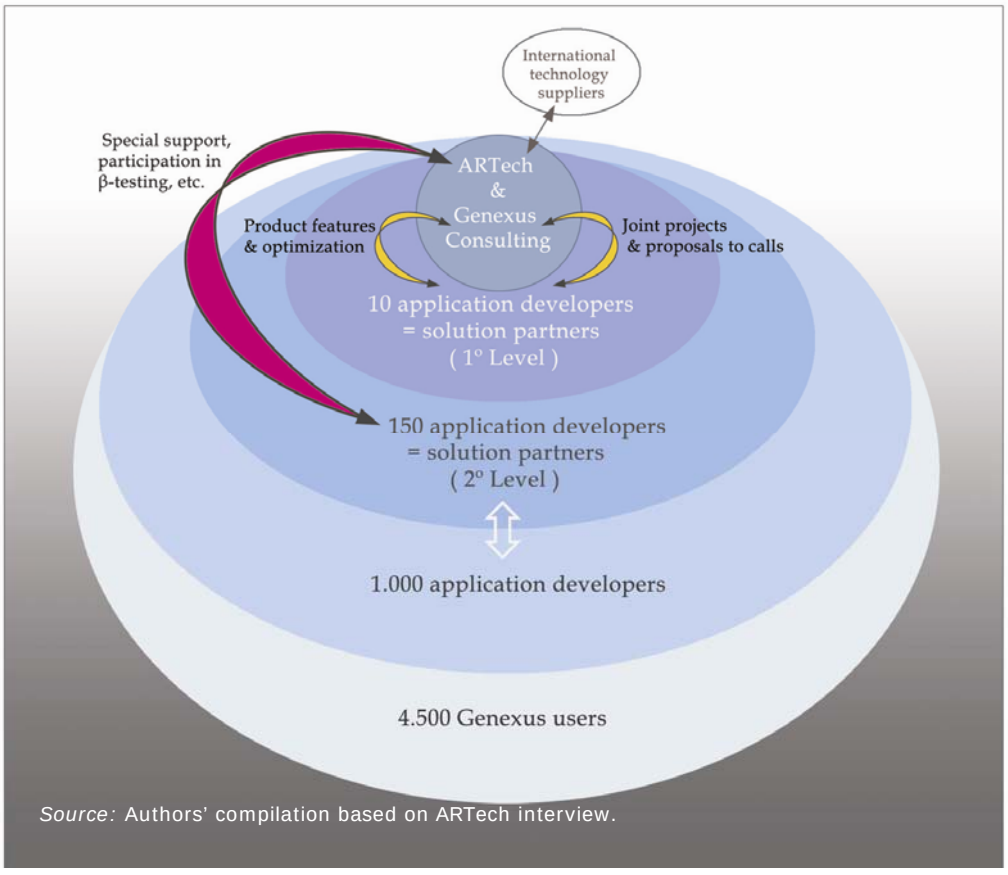
ARTech's strategy aimed at anticipating upcoming coordination difficulties, on the one hand, from rapid changes in computer sciences and, on the other hand, from customers' reluctance to changes that they do not perceive yet as unavoidable. According to ARTech's partners, each of these changes meant a moment of profound crisis for the firm (Valverde et al., 2006).[22]

b. Alliances to Benefit from Network Economies

[22] Software tools have a particularly high rate of obsolescence if they do not adapt to changes in operation systems, languages, databases, etc. In the words of one of the firm's partners: "In this industry, to survive you need to ship a new version every year, at least… Your product could be great one year, but if it is not better next year, you are dead." (Valverde et al., 2006)

As was argued, ARTech has a temporary monopoly that is regularly renovated through improved versions of its copyright-protected product, and this operates as a barrier against imitative entry. But this is only one part of the story; the other is about what has to be done so that network externalities will favor the new technology. Equally important as designing a good product is creating a network for it: finding firms that are willing to collaborate, building strategic alliances, knowing how to put the network to work, and managing it so as to internalize ensuing externalities. This was achieved through the promotion of the "GeneXus Community" (Graph 4.2.4).

Graph 4.2.4 – The Genexus Community



Source: Authors' compilation based on ARTech interview.

Since GeneXus is a tool for software developers (somewhat similar to a capital good in a traditional industry), developing close ties with the latter was of the utmost importance. Indeed, the diffusion of GeneXus among end-users needed the intermediary link of a strong user-producer relationship at the previous level of the chain. The main instrument used to develop this relationship has been ARTech's Solution Partners Program, which in fact promotes a community of practices.[23] Solution Partners are developers of GeneXus-based solutions for their own clients, with whom ARTech establishes privileged information channels. The nature of the information flows defines the intensity of the links (levels 1 and 2 in Graph 4.2.4). When a developer of GeneXus-based applications starts to deal with large clients, he is offered privileged treatment, such as special prices and technical support, participation in beta-testing, etc. In exchange, feedback information flows toward ARTech on aspects that could be improved, error detection, etc. This is the way ARTech internalizes network externalities. There are about 150 Solution Partners, of which 100 are in Uruguay and the rest in other countries. All clients of Solution Partners have to acquire a GeneXus license for program maintenance, becoming thereby also part of the GeneXus Community and increasing network economies.

With a distinguished group of close to ten Solution Partners, ARTech shares strategic knowledge (level 1): engineers of these firms work together with ARTech to increase complementary functions of the product on the basis of their own experiences and needs.[24] Collaboration helps to optimize the product:

> "If a local firm – for example, a GeneXus user specialized in the development of distribution and logistics applications – has a problem in Malaysia with its beverage distribution system, we send a person, or work in Zonamerica, to solve that precise problem. And this helps us to achieve GeneXus product optimization because it shows us a shortcoming. Despite our internal tests, with thousands of users, unexpected events can appear; this is the market filter." (Interview with one of ARTech's managers)

[23] The concept of community of practice refers to the process of social learning that occurs when people who have a common interest in some subject or problem collaborate over an extended period to share ideas, find solutions, and build innovations.

[24] Firms closest to ARTech usually develop applications in a niche or market segment: banking software (DL&A), enterprise resource planning (ERP) solutions (Datalogic, INSIS, Concepto), distribution and logistics (Solur), maintenance (BCN), etc. GeneXus is thus put into competition through firms acting in a same market segment.

ARTech also implicitly provided technological surveillance service to its partners because the latter were confident that ARTech would take care of any technological breakthrough or upgrading need. This meant lower R&D investment levels for small and medium partners. For ARTech it implies the challenge of maintaining a mainstream position at the world level in the future.

Other members of the GeneXus Community include the network of distributors and individual sales agents who sell the product in their country and deliver complementary solutions and services, and a great number of software developers (about 1,000) who use GeneXus without being Solution Partners. Alliances have also been established with international technology providers that set the industry standard at the global level, such as IBM, Microsoft, Hewlett Packard, and Oracle. In this case, it is ARTech that operates as a solution partner for the latter.

The community meets regularly at the national, regional, and international levels to review and share the state of the art concerning GeneXus. ARTech also sponsors "collaborative projects" aimed at fostering integration and knowledge transfer within the Community.[25] An important diffusion channel has been the integration of courses on GeneXus in the curricula of informatics education in the public and private universities of the country. This is another way to enlarge the network and create positive feedback (strong gets stronger) because it increases the dependency of potential software users on GeneXus.

On the whole, the GeneXus Community is an open network where ARTech differentiates among different types of allies and maintains property rights on a key technological component of that network. Looking back at the evolution of the pioneer, ARTech showed several of the characteristics usually associated with a market leader: substantial domestic market share in its segment (software development tools); extensive distribution arrangements; leadership in developing a new business model and a new family of products; a forefront position in a new technology; and some market power in determining its products prices.

Summing up, a product strategy and diffusion pattern was set up to avoid profit erosion. But was profit eroded by imitators? GeneXus never had a direct rival product in the domestic market. At the global level, competition derived less from other products offering the same

[25] An interesting feature is that university students with basic knowledge of GeneXus can propose and participate in collaborative projects, which gives them an opportunity to learn, meet the community members, and demonstrate their skills and knowledge.

integrated solutions than from the barrier to entry for a small producer from an unknown country.[26] But the lack of imitation must be associated with the specific software segment of ARTech: there are few players in the software tools world.

However, GeneXus Consulting, ARTech's sister firm, carries out joint projects with its closest partners and, in calls for tender, competes against other firms also using GeneXus. ARTech's profitability depends to a certain extent on the development of services alongside products.

First Mover Externalities

Information externalities generated for subsequent entrants into the software industry had the following characteristics: i) they were market revealing, by establishing a reputation for Uruguayan software goods and services in foreign markets (country image); and ii) they had a demonstration effect in the domestic market. In the context of a country with no risk-taking culture and with scarce entrepreneurship resources, ARTech's role was important in showing that it was possible for Uruguay to export world-scale software technology and to establish partnerships with the world's leading firms in the software industry.

The GeneXus innovation entered the pool of technological knowledge and thereby benefited society as a whole. Examples of how these *knowledge spillovers* were internalized include the framework agreement signed in 2004 between ARTech and the computer research center (InCo) of the public university, for collaboration in fields related to software development and education. Recently, they implemented together a testing center in Zonamerica, with the support of Microsoft. Cooperation has also developed between ARTech and private universities.

Finally, *network externalities* have developed through the GeneXus Community. This is a clear case of how private bargaining can internalize externalities, resulting in efficient solutions.

[26] Nowadays, the alternatives to using GeneXus include: i) developing a more traditional database system, which requires the use of several tools because no one provides an overall solution; and ii) buying the relatively recent Microsoft "Visual Studio Team System," an integrated development platform for building mission-critical applications for businesses. Although the latter is different from GeneXus because it uses a different technology, it aims at resolving the same type of problems.

Public Support

In its early stages, the discovery did not benefit from any special public support or incentives. However, the public sector was important to the extent that it adopted the product for some of its entities. In a later stage, ARTech benefited from the advantages of operating in a technological free trade zone, with state of the art infrastructure and services and a package of fiscal benefits. Considering that operational costs are high in Zonamerica, an important issue in deciding to move there was the expected benefit in terms of ARTech's image abroad.

4.2.3 Diffusion Process

It is now clear that ARTech played a first-mover role in the "human resources (H-R) model" sense because it revealed to other potential investors the relatively local cost structure and the profitability of a new activity at the country level. The basic logic of the self-discovery model indicates that once this information becomes known, imitation appears, the pioneer's gains vanish, and a new sector arises. However, in the present case there was no successful imitation of GeneXus, a rather normal feature in the software tools segment. How then did an exporting software sector emerge and develop in Uruguay?

We consider the following issues: i) the available public goods for the development of a local software sector; ii) a series of conditions that triggered exports and gave rise to different internationalization strategies; and iii) the extent to which the community of practice model promoted by the first mover was replicated. Then we turn toward some coordination failures and the way they have been tackled. Lastly, we comment on the public response to the discovery, summing up the impact of the public policies and instruments described throughout this chapter.

Public Goods

a. Education and Research in IT-Related Fields

The dramatic growth of ICT in the advanced industrial nations had two features that were of great importance for follower countries: the decoupling of hardware from software and the pronounced human capital intensity of software. This, together with rapid improvements in data communication (and communications more generally) and the steady increase of globalization, opened a window of opportunity for countries well below the technology frontier, but rich in human capital relative to the opportunities for that human capital (Arora et al., 2001). This is the great opportunity that has been seized by the three "I's"—Ireland, India, and Israel – which all

exhibited an "excess" supply of human capital in the 1980s and early 1990s and, specifically, an excess supply of engineers and technology graduates. Although this last condition does not hold in the Uruguayan case, the country fits the model in as far as it had a high share of university graduates compared with its level of technological development. There was no wide and diversified industrial base demanding these resources. The opportunity cost for professionals to work in the software industry was therefore not too significant and the window of opportunity that opened in the 1980s for late-coming countries in IT could be seized.

The initial availability of very qualified human resources was the product of long-term investment in education and R&D in that particular field. In Uruguay, the only public university (Universidad de la Republica, UDELAR) created graduate studies in computing sciences at its Engineering School in 1967, when it also created a research oriented Computer Institute (InCo) with the advice or collaboration of foreign researchers. After the dictatorship period (1973-84), UDELAR's Engineering School sent computer engineers to train abroad at the postgraduate level as a way to strengthen the dismantled computer center. Computer sciences were also included in the post-dictatorship Program for the Development of Basic Sciences (PEDECIBA), which among other measures proved highly successful in bringing researchers and teachers back to Uruguay.

In the 1990s, the expansion of private universities, which was particularly noticeable in informatics, provided the additional human resources that the software sector growth required. The latter's curriculum tends to be pragmatic, aiming at facilitating the rapid incorporation of graduates into the software industry. In contrast, the sound theoretical base provided at the state university is crucial for developing the capacity for resolving complex systems problems and generating technological innovations in a field where specific knowledge is particularly prone to become rapidly obsolete.

Education in ICT was thus the result of public and private efforts. During the past 15 years, there has been a positive response to the supply of graduates. Employment in the IT sector grew from around 800 at the beginning of the 1990s to 4,900 in 2004 (González, 2007). An additional 1,600 people work individually or are hired on a short-term basis by software firms; and hardware related employment absorbs another 2,200 workers (CUTI, 2004).

b. Telecommunications Infrastructure

During the past two decades, the state-owned telecommunications enterprise, ANTEL, developed a 100 percent digital telecommunications network covering the whole country, and an extended optic fiber network for data transmission. Uruguay has a good relative position in Latin America in terms of ICT infrastructure, with some indicators comparing favorably with other emerging software nations (Table 4.2.1). However, the recent economic recession deeply affected ANTEL's revenue and investment, and the country also lost the opportunity to hook up to the optic fiber loop for Latin America and now has to connect to the Argentine hub, a more expensive alternative.

Table 4.2.1 – ICT indicators, Uruguay and selected countries, 2005 and 2004

Countries	Tel. lines	Mobile cel.	PCs	Internet hosts	Internet users
	per 100 inhabitants (2005)		per 100 inh.(2004)	per 10,000 inh.(2004)	per 100 inhab.(2004)
Uruguay	*30.9*	*18.5*	*13.3*	*333.8*	*21.0*
Average 5 LA countries*	23.7	48.2	13.0	149.8	14.8
Ukraine	25.2	37.0	2.8	27.0	7.8
Bulgaria	32.1	80.8	5.9	84.7	15.9
Korea	49.2	79.4	54.5	1,130.1	65.7
Ireland	49.0	101.5	49.7	421.0	29.6

*Argentina, Brazil, Chile, Mexico and Costa Rica.
Source: Based on data from www.itu.int.

c. Quality of Life

Although the link between quality of life and software development and exporting may not seem evident, the quality of life is important for attracting FDI and making the country attractive as a regional software hub, as well as for preventing the relocation of successful national firms in more vibrant business environments.[27] Some researchers have found that the type of talent sought by multinationals tends to reside in clusters typified by high quality of life standards, i.e., locations in which there is: quality of place, a thick labor market, and high levels of

[27] ARTech's partners and other successful entrepreneurs have all declined proposals to install their main offices in the United States. Although this is a complex issue involving several factors, the quality of life in Uruguay was not the least of them.

environmental quality (Florida, 2000, in Carmel, 2003). Environmental conditions are excellent in Uruguay, a peaceful country with an educated population and no racial problems.[28] The country also shows a good ranking in indexes of government stability, democracy, corruption level, etc. On the downside, labor and other markets lack dynamism, and air connections are sometimes awkward even for some Latin American destinations.

It was only around the turn of the century, as the software sector consolidated, that a few important foreign firms appeared, in particular the Indian multinational Tata Consulting, in 2002.[29]

d. Legal and Regulatory Framework

Until 2003, software products were implicitly copyright protected by the intellectual property law of 1937. Law 17.616, issued in that year, now takes specifically into account the informatics programs and the developer has the exclusive right to authorize their reproduction, distribution, transformation, and communication.

No other laws or regulations were specifically directed toward the software industry during the export take-off period. It was only after exports had experienced a substantial rate of growth that a series of fiscal benefits were established. In 1999, this industry was declared "of national interest" (Decree 84/999),[30] which provided it with some fiscal benefits, mainly: exemption from the 1.5 percent capital tax (Impuesto al Patrimonio); exemption from the value-added tax (VAT, 23 percent) associated with imported capital goods; and refund of VAT in the case of local purchasing of these goods. In 2000, two decrees (No. 387/000 and successive renovations, and No. 386/000) exempted the sector from the 30 percent industry and trade income tax (IRIC) until December 2006 and from VAT on exports of software and informatics services.[31]

[28] According to a 2005 study by IBRD/IMF/ECLAC, Uruguay is the third country in Latin America in terms of population welfare indicators (El País, 05/07/06).

[29] In the software development segment, the Irish multinational Trinchet (2000), which acquired a local firm, is the most relevant example. In the consultancy services segment, foreign capital is more important but still not preponderant; there are some firms from the region (like Sonda from Chile) and from the United States (Unisys) and Europe (Soluziona, Spain). On the whole, the weight of transnational companies in software exports was only 3.7 percent in 2004, according to a CUTI survey. Firms like Bull and IBM have operated since long back in Uruguay but mainly in the domestic market.

[30] Several other sectors benefit from national interest status. See Chapter 1.

[31] Previously, only exported *goods* benefited from VAT exemptions (as all exported goods do); the decree extended the exemption to consultancy services and licenses sold abroad.

Finally, in 2002, a decree (No. 144/02) eliminated withholding at source for the income tax when importing software.

Other promotional measures will be analyzed in the section on coordination failures and the public response.

Milestones and Comparative Advantage in the Development of Exports

Lower labor costs than in the developed world are a basic advantage of all software emerging nations in the developing world. But in an international comparison, Uruguay lies far from the cheap labor countries. Other factors must have combined in the building up of Uruguay's comparative advantage. Similarities in the trajectories of software firms in the early period of the discovery appear to be revealing in this regard, besides illustrating some typical features of the sector's development.

a. From Niche Strategy and Customized Solutions to Internationalization Strategies

From the outset, the perception concerning software demand was that there were some market niches of no interest to large IT companies. Indeed, in some areas it was only possible to find either standard programs that would perform multiple but not in-depth functions, or highly specialized but very expensive applications. A demand thus existed for reasonably priced applications that would perform some functions better than the former programs but would disregard certain functions of the latter that were useless for the concerned client.

Therefore, specific market opportunities emerging from IT development were at the origin of the local firms. Many of these firms grew from links with related sectors that originated demand and became a source of competence (i.e., through the knowledge and skills the latter possess, their willingness to experiment, and their ability to engage in an active dialogue). Unattended needs were detected in both vertical and horizontal markets. To take advantage of these opportunities, firms developed a strong capacity for customized solutions, and the industry further evolved from tailor-made applications or solutions to: i) customized adaptations, integration, or implementation of standard programs and tools; and ii) products developed as open packages that support customized adaptation. Accumulated experience in attending local specificities or conditions was a major condition for reaching foreign markets.

Different business models progressively developed to enable sustained export growth. A paradigmatic example is Memory Computación. When software programs started to spread in

Uruguay in the mid and late 1980s, few of them took into account the specific characteristics and needs of the administration of small firms. Memory targeted the SME segment as a way to avoid competition from commercial, standardized programs; it ended up with a packaged program that integrated common modules with country specific components. The firm had an early vision that accountancy systems would substitute for accountants and that there was a wide market in Latin America for this new "commodity." However, Memory went through several experiments before finding the right internationalization strategy: a franchise system (see the Annex to this chapter).

Other firms developed competencies in a vertical market, which enabled them to latch onto a global value chain when the opportunity arose. An example is SOLUR, a firm that started building up knowledge in the field of distribution and logistics. At some point on the learning curve, its system was noticed by a multinational (Pepsico) in search of a new distribution solution. This was SOLUR's opportunity to develop a strategic alliance with a world player.

In the service sector, an outstanding example is GRUPO QUANAM, a firm that provides specialized consultancy services in information technology to enhance the competitiveness of very large companies.[32] In the late 1990s, QUANAM specialized in implementing or adapting People Soft packages in different business environments, developing its own methodology adapted to the specific needs of the Latin-American market. When People Soft was acquired by Oracle (2004), QUANAM organized a team of 400 Latin American consultants in nine Latin American countries, all specialized in Oracle's products. The firm is currently implementing a contract with a multinational on the "Fortune 500" list.

b. Compelled to Export

Although software firms initially used the domestic market as a testing ground for their products and services, they rapidly had to look for foreign markets to achieve a better return on their investment and reap the benefits of their apprenticeship. The limitations of the domestic market,

[32] The firm was founded in 1978 by a group of computer engineers who decided to provide technical support to a program generating applications for mainframe equipment, at a time when mainframe hardware was sold together with the software it would use. For many years, consultancies were carried out to develop IT management systems according to the needs of national clients such as the central bank, the public port administration, a main supermarket chain, etc. In the late 1990s, Quanam established a formal alliance with People Soft, a leading firm in enterprise resource planning and, later, customer relationship management, and specialized in implementing solutions in these fields. (See interviews with E. Cotelo and V. Ganón).

both in terms of size and sophistication, made it impossible to reach high business levels without exporting.[33]

Although Uruguayan exports were growing, countries such as Argentina, Brazil, and Chile were still focusing on their own, larger domestic markets and their exports were slower to develop. So, for some time, Uruguay benefited from a comparative advantage deriving from its insertion in regional markets before hard competition would start from other larger Latin American nations. In 2002, Uruguay was exporting more than any other country in the region.[34]

Soon after, the financial crisis in Argentina drastically restricted its investment rate and imports, which in the field of software represented 30 percent of Uruguay's exports. This had the effect of compelling Uruguayan firms to diversify their markets to take advantage of the competitive price of their software products and services outside MERCOSUR.

The export propensity of Uruguay was close to 40 percent in 2004, reaching 71 percent for the segment of product developers. This share is far from the figures observed for the three "I's" in Table 4.2.2 but is quite high in comparison with other software exporting nations.

Table 4.2.2 – Export Propensity of Software Latecomers

Country (2003)	**Turnover** (US$ millions)	**Exports** (US$ millions)	**Exp./turn.** (%)
Ireland	14,000	13,000	93
India	12,500	9,500	76
Israel	4,100	3,000	73
Uruguay (2004)	240	80	**39**
Singapore	1,660	476	29
Argentina	1,100	180	16
Chile	200	15	8
China	13,300	700	5
Korea	7,700	240	< 3
Brazil	7,700	100	1

Source: MEP (2004) and CUTI.

[33] Of the 300 firms, 75 are exporting, but exports are extremely concentrated in a dozen of them. In 2005, 37 firms (50 percent) exported less than US$100,000 each and only 13 exported more than US$1 million each (PAC, 2006).

[34] From that year on, the Argentine currency depreciation boosted its software exports, which grew from US$35 million in 2000 to US$250 million in 2005 (according to data from CESSI, the chamber of the software industry in Argentina).

c. A Sophisticated First Client

In contrast with the first-mover case, many start-ups in the diffusion process were spurred by a sophisticated first client (often referred to as a "godfather") that helped to resolve uncertainties and reduce the cost of experimentation. In this sense, externalities were generated by clients that opted to hire a local firm where there was no recognized national experience.

A good illustration of this process is provided by the development of software for the financial sector. In the 1990s, new software firms took advantage of the presence of multinational banks in Montevideo—a dynamic financial place—because of the inadequacy of their administration systems to handle specific and complex requirements in Uruguay and Latin America in general (e.g., concerning hyperinflation, national taxes, credit procedures, etc.). The standardized European or North American systems often did not have the needed flexibility to adapt to such needs. Some of these banks assumed the risk of hiring Uruguayan firms to redesign their systems. After successful implementation, new opportunities appeared in other foreign branches of these banks. The difference in costs between Uruguayan professionals and European or North American consultants (that otherwise would have been required by the multinationals to adapt their own systems) played a very significant part in the decision to acquire a Uruguayan product in *ceteris paribus* conditions. Nowadays, there are at least 14 firms in Uruguay developing software for the financial sector (banking and credit card administration). Some examples include DL&A with its product "Bantotal," implemented in 12 Latin American countries and the United States, and Top Systems with its "Topaz" family of products.

Picking up the right first client was thus essential not only to have a technically proficient interlocutor, but also because it could mean a bridge toward markets where Uruguay lacked a reputation or a country image.

d. Low Initial Investment and Comparative Advantage in Labor Costs

Capital requirements are fairly low to develop software applications or provide services, as compared with other sectors of the economy (e.g., electronics). This, combined with little rewarding employment alternatives (mainly the public sector or working abroad) in the early 1990s, spurred the creation of start-ups by graduates who "tried their luck."

In the late 1990s it was estimated that wages for IT professionals in Uruguay were about 65 percent lower than in the United States and 25 percent lower than in Argentina.[35] Significant wage increases have not been reported in the past decade. Nowadays, a department manager or project coordinator usually does not earn more than US$2,000/month (gross); a senior analyst, between US$800 and $1,500/month; and a programmer, between US$400 and $725/month (CUTI, 2005). More generally, the labor cost of management is very low in Uruguay compared with other Latin American countries (Table 4.2.3).

Table 4.2.3 - Wages of Executive Officers in Firms with Turnover Less Than US$50 million (2004)*

	General Manager	Financial Manager	Commercial Manager	Production Manager	HHRR Manager
Brazil	14.161	8.076	6.493	6.607	5.589
Mexico	13.778	9.999	7.931	9.797	10.301
Chile	8.601	5.126	6.115	5.490	5.368
Argentina	6.839	3.480	3.558	4.672	4.385
Uruguay	**4.214**	**1.921**	**2.306**	**1.896**	**1.292**

* Net monthly wages in US $, calculated on the basis of annual wages, including bonus. For each category: median or second percentile.
Source: América Economía (2005), nr. 43, Jun 24-jul 14, based on data from Price Water House Coopers and Mercer Human Resources Consulting.

e. Portfolio Diversification to Face Lack of Capital

Venture capital has always been a scarce resource in Uruguay, even more so in the case of this "intangible" sector.[36] So, for many firms, the complementary sale of imported hardware acted as a source of financing and insurance against failure in their new endeavor. However, most product developers also provided services (related to their products) that contributed substantially to their overall turnover. In general, the tendency of the firms to engage simultaneously in different types of activities has persisted: they maintain a diversified portfolio for protection against fluctuations and to gain maximization strategy.

[35] These estimations were gathered from interviews at software firms before the industry was surveyed.
[36] As was typically expressed in the early 1990s by entrepreneurs taking part in a software round table: "We all know somebody who, in the last five years, said he would be willing to invest some US$200,000 in a business related to livestock, banking, or [real estate] in Punta del Este. We don't know anybody, though, who would agree to invest a similar sum in a software project made in Uruguay." (Snoeck, Sutz, and Vigorito, 1992, p. 268)

Replication of the Community of Practice Model

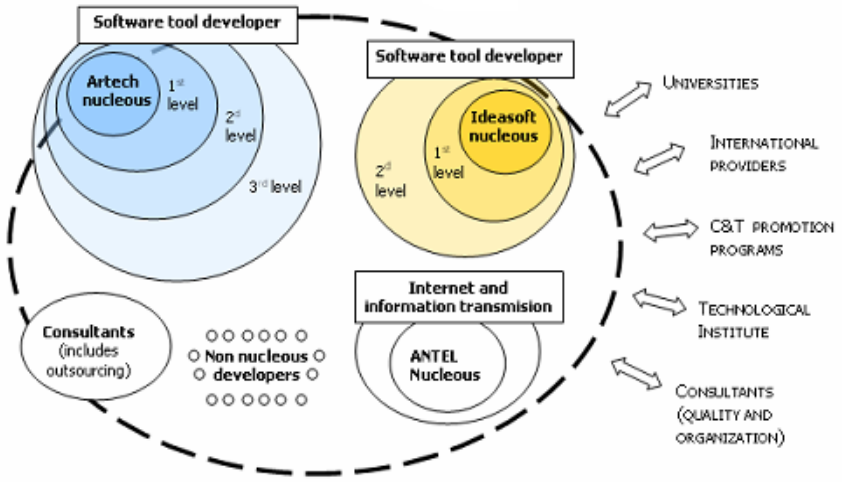
In the same way as ARTech became the core of an agglomeration of firms linked together through different ties, which would progressively lead to a community of practice, another software tool developer emerged intending to develop a similar virtual organization in the 1990s. "O3" of Ideasoft is a different product than GeneXus but it belongs to the same "business intelligence" category of software products.[37] A third nucleus also exists around ANTEL in the field of Internet and data transmission (Graph 4.2.5)[38]. Both cases require further inquiry to establish whether they effectively became communities of practice.

However interesting this model might be, it is not the pattern by which the software sector as a whole developed in Uruguay. But, in a more general way, these examples show how a final IT system applied in a non-IT firm (end-user) is the product of complex, nonlinear relationships between different types of agents. At all levels, user-producer relations are a strong ingredient and are based on formal or informal agreements. An end-user can even become part of a solution that is then supplied to other customers, when this final end-user was heavily involved in the building up of his system, as has sometimes occurred. At the same time, it seems clear that the search for network externalities and economies of scale stimulated producers to look for product diffusion patterns that would also enable complementary benefits for them, such as a greater capacity to upgrade products.

[37] GeneXus and O3 do not compete with each other because both are very specialized.

[38] The figure is based on a knowledge flow diagram from previous research (PNUD, 2005), which surveyed: 38 innovative software firms and informatics service providers, representing a considerable proportion of the sector's turnover and exports in 2003; 90 client firms, and three R&D entities.

Graph 4.2.5 – Nucleus Type of Diffusion in the Software Industry



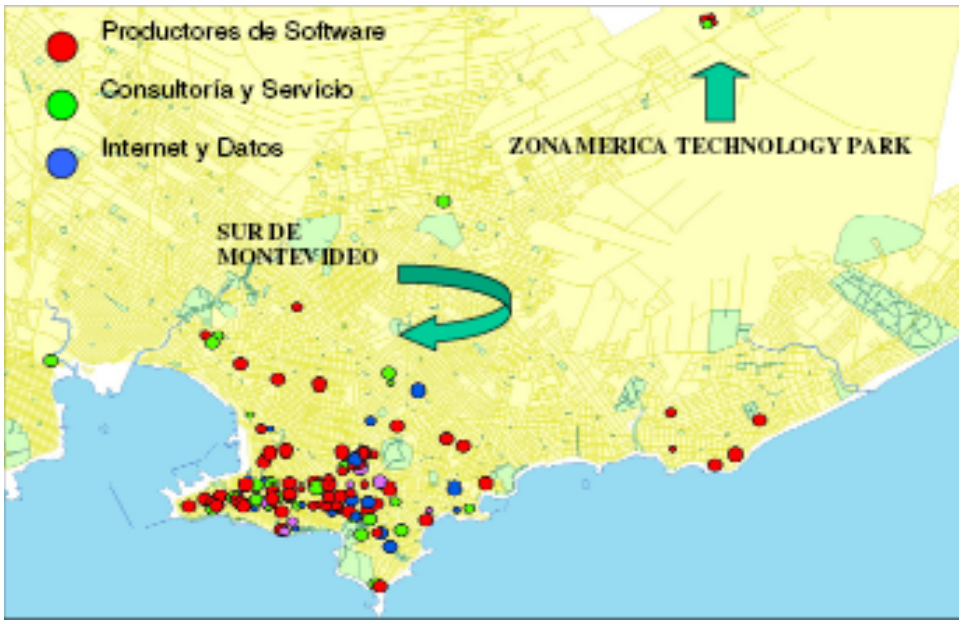
Source: Adapted from PNUD, 2005.

Coordination Failures and Their Solutions

The previous review of several of the sector's main features leads us to detect a series of market failures.

a. Limited Agglomeration Economies and Synergies

Is the growth of the software sector related to benefits deriving from the geographical concentration of the software firms in Uruguay, as shown on the map? A survey carried out in 2004 on 97 firms of Montevideo sought to clarify this issue (Kesidou and Romij, 2005). The study was based on territorial theories that identify the agglomeration of economic activity as a possible generator of benefits related to economies of scale, labor market concentration, and rapid diffusion of knowledge.



Three mechanisms by which local knowledge spillovers (LKS, i.e., unpaid-for knowledge flows) occur were analyzed: spin-off, labor mobility, and interaction. No significant results were obtained concerning spin-off, but the other two mechanisms—LKS through interaction and labor mobility—appeared to play a significant role in innovation and learning at the firm level in the geographic agglomeration. Their statistical results demonstrate that LKS are an important mechanism through which knowledge circulates among actors in the software sector, and that they are more important for innovation than other types of knowledge flow (market based). The study concludes that the argument—found in theoretical and empirical works in developed countries—of LKS fostering innovation in high-tech clusters, holds for the Uruguayan case.

However, evidence of such agglomeration effects is not clear-cut. Other studies emphasize the juxtaposition of firms rather than their organization in clusters to take advantage of mutual benefits. A study conducted in 2003 concluded that in the Uruguayan software sector, firms depend exclusively on their individual effort to generate the competitive advantages that allow them to compete (UCUDAL, 2003). According to another study, software firms are not prepared to combine efforts when there is a risk of real competition among them (CAE, 2003). Cooperation, which to some extent exists in the software sector, develops mainly when complementing capacities does not imply competing for the same market or product.

Summing up, local knowledge spillovers exist and this market failure could be restraining firms from assigning the required resources to develop endogenous efforts in a systematic way

because they perceive they will not internalize all the social benefit that their investment will generate. This limitation was somehow recognized in the 1990s, when several initiatives to foster joint activities were debated but did not materialize.

It is only now—about two decades after the sector's birth—that complementary, collective actions have begun to produce synergies in the sector. It is noteworthy that public involvement (virtually inexistent for the discovery and early diffusion process) is high in the present phase. The main undertakings currently under implementation include the following:

- Actions to strengthen the *academy-industry linkages*. A couple years ago, a software testing center was set up with a European Union grant. CES (Centro de Ensayos de Software) is a public-private consortium between the Engineering School of the public university and CUTI. It is the only non-private center of its kind in the region and it is about to become self-funded. It provides services and infrastructure to perform testing and platforms for software products, as well as a technological observatory.[39]
- Actions to foster *innovation and quality upgrading*. Since 2001, PDT, the Technology Development Program headed the Ministry of Education and co-financed by the IDB, has granted competitive funds for up to 50 percent of the cost of projects aimed at developing an innovation or improving quality management. The software sector has been by far the most demanding sector, usually by way of individual projects, although recently a project aimed at international certification was presented and selected for financing.
- Actions to spur *entrepreneurship* by reducing risks inherent to start-ups. The incubator Ingenio (2002), a joint undertaking of LATU (a public sector entity for the promotion of industrial technology) and ORT (a private university), with the financial support of the IDB, does not grant financial support to IT start-ups but different types of services. Some of the incubated firms are now

[39] By contrast, and prior to CES, CAITI (Centro Académico Industrial de Tecnologías de la Información) was created in 2004 and integrates all universities (public and private), the software industry through the business association CUTI, and the government (Ministry of Industry). It is supposed to work as a round-table (*mesa*) to establish priorities in R&D in fields of common interest. However, CAITI has not shown significant results yet.

exporting and Ingenio is starting to incubate projects from other knowledge intensive sectors (such as life sciences).

- Actions to facilitate *internationalization*. Grupo Integro (2004), an Economic Interest Group was set up by 25 software firms, including many of the most important ones, with the objective of creating synergies in their internationalization process. This is an entirely private initiative, with the support of CUTI (the industry association of software firms). At the same time, Ingenio and CUTI (2006) are jointly promoting internationalization through public calls for associative projects aimed at foreign market penetration. The IDB is supporting this initiative.
- Actions to promote *clustering*. In 2006, the software industry requested that it be considered among the sectors that will benefit from a new government program, PACC (co-financed by theIDB) aimed at developing the competitiveness of local clusters. This program is being implemented in parallel with a program co-financed by the European Union, also fostering the building-up of clusters but in other sectors.

Most of these initiatives are highly dependent on external financing. They are indicative of consistency in the present public support for the software discovery process. They could result in the needed public-private coordination to define a coherent long-term vision and a focused strategy, a feature that has proved essential in most emerging software exporting nations but that is still to be defined in Uruguay.

b. Limited Linkages with Other Sectors

The software industry has only partly benefited from the demand-pull action of other sectors of the economy. Tough links have been strong with some sectors (e.g., the financial and distribution sectors). It is common knowledge that the national agricultural, livestock, and agro-industrial sectors have not fully taken advantage of the opportunities offered by IT. When observing the fields using IT intensively in the United States, it is striking that in Uruguay most of these sectors are low IT users (Table 4.2.4). This coordination failure is due, on the one hand, to the small size of the great majority of local firms. Many of them do not count on professionals who can properly identify the benefits of investing in IT; and association—which

could counteract this tendency—is uncommon.[40] On the other hand, it has been stated that in the past:

> "Local software was systematically discriminated by public enterprises that did not assume the risks inherent in hiring local development, opting for including clauses in tenders that made it impossible for Uruguayan firms to participate. Among others, the following examples can be cited: several international banks used, both in Uruguay and other countries, software developed locally, but the [public] Banco de la Republica acquired a banking system developed by a (foreign) multinational; the call for tender for the informatics system of ANTEL practically excluded potential local providers and the system was acquired from a multinational corporation." (CARE, 2002)

Table 4.2.4 – Use of IT in USA and Uruguay

Sectors using intensively IT in USA	Intensity of use in Uruguay
Depository institutions	Intense use
Business services	Intense use
Wholesale trade	Intense use
Petroleum/coal products	Intense use
Health services	Intense or limited use
Security and commodity brokers	Limited use
Holding and investment offices	Limited use
Real estate	Limited use
Telecommunications	Limited use
Radio and TV broadcasting	Very limited use
Motion pictures	Almost no use
Legal services	Almost no use
Insurance carriers	Almost no use
Instruments and related products	Almost no use
Pipelines, except natural gas	Almost no use
Chemicals and allied products	Almost no use
Insurance agents and brokers	Almost no use

Source: Edelman et al. (2002).

[40] An exception is Scantech for retailers.

State actors argue that the main risk in awarding a contract to a local firm was the possibility that the firm would disappear once the product or system had been developed, thereby creating maintenance problems (UDELAR, 2003). Currently, and mainly as a consequence of the reputation acquired by software exporters in the international arena, public entities and programs are more prone to take advantage of local capacity in some of their undertakings, such as in the recent Program for Animal Products Traceability.

The fact that public purchases have, in general, not been used as an instrument to foster the development of technology intensive sectors in Uruguay has been an effect of these industries.[41] A policy proposal is now being prepared by a special commission of CUTI because the government has shown interest in using this instrument as part of its strategy to strengthen the National Innovation System.

c. Low Connectivity to Global Markets

Connectivity with the high-tech world is essential but full of obstacles for a developing country.[42] Among others, globalization compels investment in certification and cooperation. Yet in this regard, the situation of the Uruguayan software industry is not too bright.

Evidence is provided by data on connectivity from the previously mentioned local survey of the 38 most innovative software and informatics service firms.[43] The bulk of these firms (76 percent) reported that they participated in one or more networks, an instrument that they considered of strategic importance. However, less than a quarter of the firms were integrated in networks that included companies from developed countries; only 15 percent of them participated in MERCOSUR networks; and about 20 percent were integrated with networks in other Latin American countries. Considering that the survey concentrated on the most dynamic software firms and the main exporters, it can be asserted that, from the 300 firms that make up the sector, an extremely low proportion had the capacity to invest in developing connectivity with the high-

[41] In many software emerging nations, public purchases play an important role in promoting the sector. In China, for example, "the government has been another big player, with national and regional governments often favoring domestic vendors for a variety of PC based software, from the operating system to application software" (Arora et al., 2004).

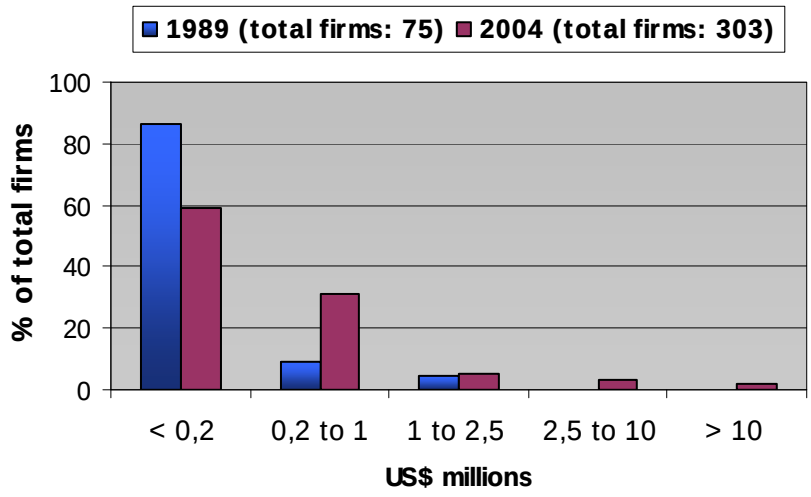
[42] See Brum (1999) for a useful "soapy stick" metaphor describing the relations between the developed and underdeveloped world.

[43] This group of firms represented 72 percent of the sector's turnover in 2002, 85 percent of exports, and 62 percent of employment (excluding independent professionals). See PNUD (2005).

tech world, in the early years of the present decade. An overwhelming majority of them do not have partners from developed countries that better *connect* to global networks.

An initial limitation for entering the global market is the small size of most of local software firms, in the first place because there is a minimum turnover level to be considered reliable and credible. A firm selling at or below US$1 million is easily disregarded for being potentially unstable (CARE, 2002) and most Uruguayan firms are below this threshold (Graph 4.2.6). However, producers increasingly have to meet international standards that are continuously renovated and enhanced. The problem for small firms is that the fixed costs of auditing compliance with the standards are high and thus scale intensive.

Graph 4.2.6 - Number of firms by turnover size



* Excludes firms mainly dedicated to HW/SW marketing and independent professionals (1.600 in 2004). Source: CUTI 2004 survey and Snoeck et al., op.

Meeting standards and certification requirements is an essential way of upgrading processes (UNIDO, 2001). In this sense, upgrading started only recently in the Uruguayan software sector. Of the 38 innovative firms surveyed in 2002, only nine had certified a product or a service, and only five of them in a developed nation entity (PNUD, 2005). According to the more comprehensive CUTI survey of 2004, 24 firms had an ISO-9001 or similar certification and another 13 were working on it. Two firms had achieved CMM level-five certification (one of them Tata), the highest industry standard. Very recently eight firms presented a joint project to the Technology Development Program aimed at preparing collectively for CMM certification.

Summing up, the situation in international networking and certification reflects poor connectivity of the software sector as a whole and vulnerable insertion in global markets.

d. Elasticity of Labor Supply

Several issues are at stake concerning the future supply of human capital for the software industry. In the past 15 years, an annual *average* of 300 students have been graduated in informatics (engineers, analysts, programmers, etc.), roughly half of them from private universities.[44] This is a very low figure in comparison with other emerging software exporting nations: in computer disciplines, there are 3,000 annual graduates in Bangladesh; 2,500 in Vietnam; and 5,000 in Indonesia (Carmel, 2003). Furthermore, the share of science, math, and engineering students in total tertiary level students is also lower in Uruguay (24 percent) than in Argentina (30 percent) and Chile (43 percent) (Rivero, 2004). More generally, the Uruguayan tertiary education budget is extremely low compared with what other countries, such as Finland, Ireland, and the Bangalore region, invest in education to foster their IT sectors.

There is another underlying coordination failure that is expressed in the very high dropout rate in the first years of engineering studies at the public and some private universities.[45] Dropouts and delays in obtaining computer science degrees are attributed to severe deficiencies in math education in secondary (public) school, as well as to vocational problems and the hiring of advanced students by the software firms. Overcoming the dropout problem should be a priority if the country wishes to support actively the diffusion of exports.

Thus, there have been some concerns on how to increase the provision of software professionals if the industry continues to grow. Tata Consulting opted for on-the-job training of non-IT graduates when it had to increase employment from 340 to 600 in 2005-06. Were Tata to have a demonstration effect of Uruguay's adequacy for offshore outsourcing, the arrival of new multinationals would imply a strong pressure on the labor market.

In Argentina, an anticipated labor shortage in this field has been tackled through a vast promotional campaign coupled with a scholarship program in IT education. This was not the case

[44] The number of IT graduates each year fluctuates but the trend indicates a very slow rate of increase (Darscht, 2005).

[45] The dropout rate is very high at the public university as a whole: the official figure is that, from a yearly intake of 17,000 students, only 4,000 graduate. In basic sciences, the relation is one to 10. At the private ORT University, dropout rates of up to 70-80 percent are registered during the first year of the engineering degree (UDELAR, 2006).

in Uruguay, but the initiative of "recycling" university graduates from different schools and disciplines into software professionals is gaining impetus, especially considering the lack of employment opportunities in other science related fields (UdelaR, 2006). A first step in this direction again was taken by Tata Consulting, by investing in a regional training center, located in the Laboratorio Tecnológico del Uruguay (LATU), that was recently inaugurated (2007). This center will cover the needs of local software firms, among others.

Human capital with entrepreneurship and management skills is a scarce resource in the country and is a crucial need for the expansion of the sector and, especially, its insertion in global value chains. It was only in 1988 that the first business school was established in Uruguay, by the private ORT University. Since then, universities have increased their offerings in business-related fields and obtained a good response. However, at the School of Engineering at the state university, entrepreneurship and management are still considered "second rate" skills.[46] Regarding foreign language skills—especially English, which is a must for the internationalization of the sector—some shortcomings at the country level became evident when Tata Consulting could not find enough bilingual candidates to fill the posts offered.[47]

The intention exists at the policy level to make better use of Uruguay's important "Diaspora," a factor that has proved relevant in other software exporting countries to help connect to foreign markets.

Public Response

The question of public response has been addressed throughout the study. The software industry emerged and developed in Uruguay without a state-defined or collective strategy. In the early period, when asked about the role of the government, software entrepreneurs would indicate that their main request was no government interference with their business, which had a twofold meaning. On the one hand, they proudly distinguished themselves from the typical state-dependent entrepreneurs of the import-substitution industrialization of earlier decades. On the

[46] InCo's director recently expressed: "There are some initiatives at the School of Engineering, such as a postgraduate degree in technology management, but it is not considered essential at the "political" level … it does not have the hierarchical status of engineering studies or other postgraduate studies. It is a subject … on which there is no general consensus. (…) Some people have a manager or a business profile, distinct from the hard scientific profile, and we are filtering these people: if they are not good in hard science and technology, we reject them through the existing mechanisms. This is an aspect we have to correct." (Udelar, 2006)

[47] First-mover ARTech also experienced language as a barrier to shifting from Latin American to global markets and has found it necessary to systematically generate (and not translate) all technical documentation in English.

other hand, the other underlying connotation referred to the fact that "a weak and inefficient bureaucratic structure works best when it attempts not to do too much" (Arora et al., 2004).

At the turn of the century, the remarkable dynamism of Uruguayan software exports and, more generally, the need to foster the development of ICT in the country, led to several public debates on how to consolidate this area. Some initiatives were launched with varying degrees of success. An early initiative, which did not prosper, consisted of the creation of a National Committee for the Information Society (Decree 225/2000), with broader purposes than just fostering the software industry. But in recent years, a set of fiscal incentives has been decreed and the government is backing up programs financed by international agencies.

Finally, the sector's competitiveness has been affected by macroeconomic monetary policies. Real exchange rate appreciation between 1990 and 1995 affected negatively all exporting sectors of the country, just as the 2003 devaluation of the local currency boosted export competitiveness outside the region.

Summing up, in spite of recent measures of a collective nature, there has not been a coherent, articulated state policy to promote software development and its insertion at the global level. However, as argued by Rivero (2004), assuming that the state played no role during the development phase of the IT industry would be a mistake. Indeed, the state had a key role in the creation of certain preconditions and public goods that later made the software sector achievements possible. The early creation of high-level tertiary education in informatics and good public telecommunication infrastructure are the most distinctive of these preconditions.

4.2.4 Comparator Case: The Electronics Sector

Introduction

In Uruguay, some segments of the professional electronics industry started to develop in the 1970s, stimulated by the decreasing price of basic components in the world market and by miniaturization, which widened the field for local design and production. Researchers at the Electrical Engineering Institute (IIE) of the public university set up some of the firms. They were looking for new ways to subsist after the public university intervention during the dictatorship period. The sector showed some dynamism throughout the 1980s (40 firms in 1989, mostly small; 45 types of products), mainly associated with the strong increase in electronic capital goods imports (Snoeck, Sutz, and Vigorito, 1992). Their integration into different economic activities required knowledge and skills in the field of electronics in order to adapt to local needs.

The *potential* market for national electronics consisted of applying these recent technologies and goods to specific problems of other productive sectors—at a reasonable cost—thereby enhancing the productivity and export capacity of the latter. However, Uruguay did not have a strong industrial sector, and most firms did not count on expertise to detect upgrading options through accessible electronic devices. *Real* market niches did not emerge abundantly as in software and/or were not fully exploited. This and other factors prevented the electronics sector from evolving from some local market niches and customization skills toward successful internationalization strategies.[48]

In regard to the initial development of the electronics sector in Uruguay, the most decisive condition was the availability of highly skilled human resources. The IIE of the public university has a long tradition and it started dealing with modern electronic issues such as digital techniques in the mid-1960s. As in the case of software, the state takeover of the university in the 1970s had a severe disruptive effect on research at the IIE, but strong capacity was rebuilt after the dictatorship period. Difficulties in consolidating full-time research and teaching teams (mainly due to the very low salaries at the public university) led to the multiplication of agreements and contracts between the Engineering School and the private sector, providing extra revenue to researchers. This was a general feature of the Engineering School, including the IIE.

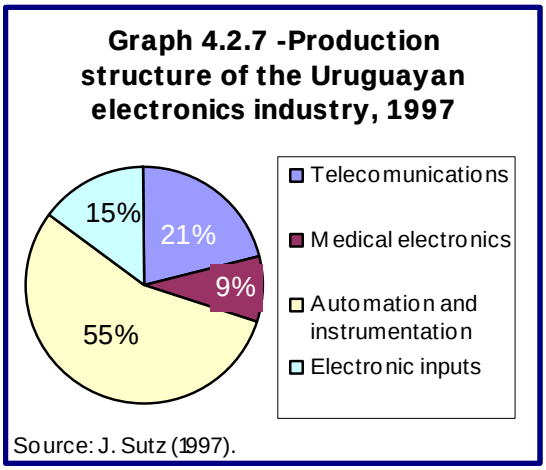
It was also in the 1960s that linkages developed between the Engineering School and public entities, mainly ANTEL. The implementation of a telex system in the country by a local firm, in 1976, consolidated a relationship that was decisive for the initial development of the electronics sector.[49]

It has been estimated that national production of electronics increased roughly from US$10 million in 1988 to US$30 million in the mid-1990s and developed around four segments (Graph 4.2.7). No recent data on the sector are available but the number of electronic firms has decreased substantially. Currently there are probably no more than 10 firms developing their main

[48] Interesting enough, interviews with entrepreneurs show that three features identified in software discovery can be found in some electronics cases: a) the cost of the first experience was shared among different actors; b) an externality was generated by the client who decided to hire a local firm with no recognized national experience; and c) the local firm was propelled to foreign markets hand-in-hand with its first client. A good example of this was the automation of wool processes in Uruguay, described in Sutz (2000).

[49] This relationship started with the hire of electrical engineers by ANTEL in the 1960s. Previously, ANTEL only hired civil engineers, with no skills in electronics and no knowledge of the local capacity in this field.

production activity in the field of electronics. Moreover, some electrical engineers migrated toward the software industry.



On the whole, the attempt to develop an export sector failed. But two cases are worth mentioning as first movers with a late export take-off and no diffusion process.

First Movers

In the *automation and instrumentation segment*, in 1973, three engineers created CONTROLES S.A.[50] It is a now a medium-size firm (around 40 employees; turnover exceeds US$1 million) dedicated to the design, production, and sale of electronic equipment. It developed some niches in the domestic market, such as elevator controllers, industrial automatisms, power converters, different types of scoreboards and alarm systems, and SCADA systems. Particularly important was the de-concentration and de-verticalization process of the elevator controller market in the late 1980s, a market previously dominated by OTIS. This provided CONTROLES with a technical and commercial opportunity to specialize in this segment, taking advantage of the broad range of elevators in Uruguay and Argentina that needed remodeling in order to comply with stricter municipal norms. This niche was thus exploited at the domestic and regional levels. Exports of different products began tentatively in the early 1990s, attained US$0.4 million at the

[50] From 1973 to 1979, it developed from a workshop into a small factory with 15 employees. The initial partners are each in charge of a specific area.

turn of the century, and then experienced a strong decrease during Argentina's crisis.[51] Export dependence on Argentina has been reduced from 79 percent (2000) to 18 percent (2005).

Although initially there were several other Uruguayan firms operating in the field of automation and instrumentation, few survived; the ones who did focus mainly on domestic niches (e.g., weighting systems).

One of the CONTROLES managers described some of the difficulties in penetrating foreign markets (Sutz interviews, 1997; and MIEM, 1999):

- To some extent, exporting electronic goods to MERCOSUR countries was slowed down due to procedures related to the Certificate of Origin norm (60 percent of the good must be of regional origin; see Introduction, section 1.2). The norm was designed for unitary products and not for products like electronics that integrate dozens of elements. To get the Certificate, each of these elements needed to be described, with its code, its specific tariff, etc.; this made the overall procedure extremely troublesome and time consuming.[52]
- The cost of an aggressive export strategy was very high for a single firm and there was no adequate support from Uruguay's representation offices abroad.
- The need to possess the right quality certifications to enter foreign markets, especially beyond the region, implied not only high costs, but also a series of testing that was not provided by LATU, the industrial technology institute.
- Some instruments implemented to promote the development of priority sectors had contradictory effects on others. Tourism, for instance, was declared "of national interest" and different inputs for hotel building could be imported duty free, like alarm systems or intelligent door systems, thereby hindering the (price) competitiveness of locally designed systems.

It must be stressed that these comments were not complaints from unsuccessful exporters but from a firm that was able to overcome the initial export barriers. Almost a decade later, most of these coordination failures at the national level are still valid. Although some also applied to

[51] This is according to data from the Customs Office.
[52] In addition, some inputs for the electronics sector were subject to high tariffs, a fact that tends to lower the price competitiveness of Uruguayan products integrating these inputs, with respect to imported goods.

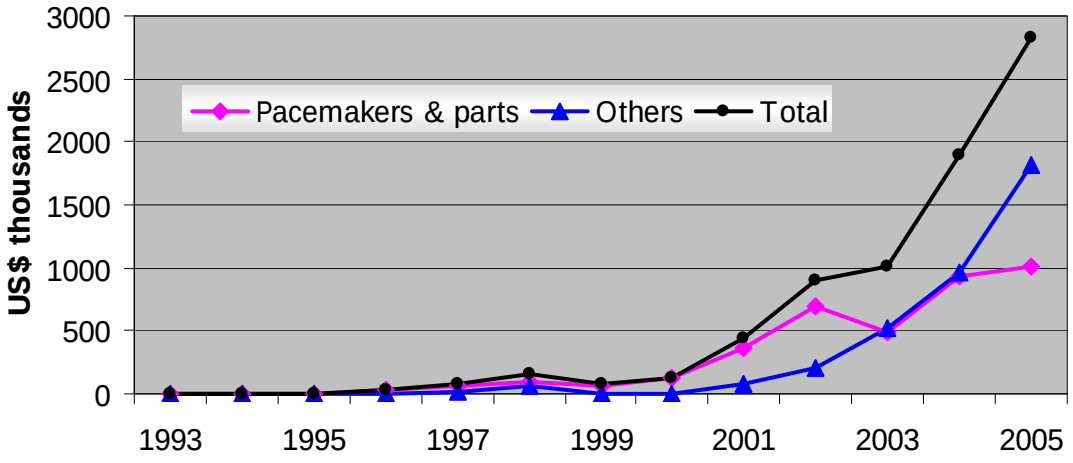
the software sector, the latter has been more successful in organizing collective actions to tackle them, at least in recent times. In the electronics sector, an early attempt to organize an Economic Interest Group did not prosper.

The other pioneer worth mentioning belongs to the *medical electronics segment*: Centro de Construcción de Cardioestimuladores (CCC), one of the seven largest pacemaker producers in the world.[53] CCC, founded in 1969, develops and manufactures real-time systems, including active implantable medical devices such as cardiac stimulators, as well as other medical electronic devices. Just as ARTech offers a world-class product to develop complex mission-critical systems, CCC develops world-class safety-critical systems.

The interesting point, as far as the present study is concerned, is that 30 years after its foundation, CCC exports suddenly boomed, from US$126,000 in 2000 to US$2.826 million in 2005 (Graph 4.2.8). CCC's production started in the 1970s, in the framework of an import-substitution strategy. Previously, few implantations were performed in Uruguay because of the high costs of imported pacemakers, but the foundation of the Institute for Highly Specialized Medicine helped create a domestic market for pacemakers by covering implantation costs for anyone who lacked medical coverage. The choice of the pacemaker to be implanted (imported or local) was open to the doctors.

[53] In 1960, in Uruguay, Drs. Fiandra and Rubio achieved the first pacemaker effective implant in a human in the world, with a device developed in Sweden. The Uruguayan implant operated for nine months, until the patient's death.

Graph 4.2.8 - CCC: Exports of pacemakers and other appliances



Source: Customs Office.

Later, when the electronic sophistication of pacemakers increased and exceeded CCC's capacity, the firm went into partnership with a U.S. company that provided the designs for CCC production. Around 1992, a group of engineers providing services to CCC in programming and maintenance presented a project to the firm to develop pacemakers completely in Uruguay. The project was approved, and the first locally produced pacemaker was implanted in 1994. Since then, technology has been constantly updated, with a new generation of pacemakers appearing periodically.[54]

Product upgrading was parallel to a no less demanding commercialization strategy. Different types of initiatives were launched, with varying levels of success.[55] The internationalization strategy was not only directed toward selling pacemakers and related devices, but also aimed at finding R&D enterprises demanding engineering services. The relevance of this strategy can be appreciated in Graph 4.2.8, which distinguishes between exports of pacemakers

[54] CCC's personnel increased from 55 employees in 2002 to 110 in 2006, 40 of whom are engineers.
[55] These are illustrated in Darscht (2005) and in Interviews by Sutz for Uruguay XXI (1997).

and of other devices, mainly a variety of electro-diagnostic appliances. The latter embedded customized engineering design ordered by clients mainly for clinical testing purposes.[56]

The firm now exports to 20 developed and developing countries. In the global market, CCC products compete in the intermediate price range. In the domestic market, CCC provides about 35 percent of the implanted pacemakers.

As was clearly synthesized in a case study of CCC:

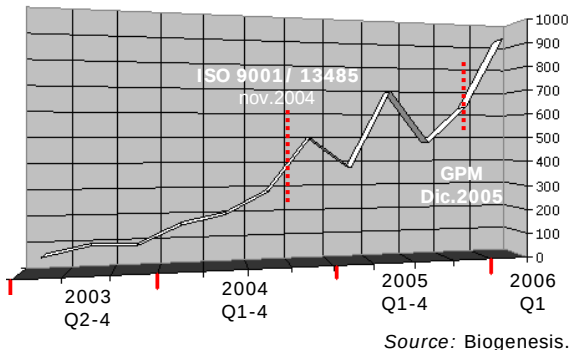
> "When CCC history is examined carefully, a constant factor can be identified that characterizes each of its development phases: the new phase would not have been possible without the capacities generated in the previous ones. Indeed, Dr. Fiandra created a small firm to produce pacemakers because he had participated in the development of this forefront technology in Sweden; he therefore knew the technology and achieved the first successful implantations in humans of these devices. CCC could assemble third-party pacemakers because it had knowledge of the market for these medical devices and a name in the domestic market. Years later, CCC could again design and develop its own devices because the firm had remained in the market and maintained its management, production, and marketing capacity. Further on, it penetrated the global business of biomedical engineering services because its products, designed by its engineering department, testified to its recognized experience and quality. Today CCC gains markets in the field of pacemakers because it is well known that its engineering capacity has been hired by prestigious firms in biomedical research, which in turn entrust it with the production of implantable devices designed by CCC itself." (Darscht, 2005)

CCC developed close ties with the Engineering School. A Micro-electronic Group was created within the Electrical Engineering Department in the early 1990s, at a time when future demand for local research in this field was highly uncertain. The Group consolidated and was hired in the mid-1990s by CCC to develop an ASIC (Application Specific Integration Circuit) for a new generation of pacemakers, which was successfully completed. In the field of medicine, linkages with the academy developed with an Argentine research center.

[56] Unembedded services are not included because the Customs Office only registers exports of products.

There was no diffusion process following this discovery, as far as we circumscribe the analysis to the electronics sector. However, when looking at CCC as a first mover in biomedical devices, some firms started to appear in that segment around the time CCC exports took off. BIOGENESIS S.R.L., for instance, was created in 2002 and produces temperature sensors (probes) for incubators, neonatal open care systems, monitors, etc. Its exports to 20 countries now represent 92 percent of its total sales, compared with 30 percent in 2003, and they seem to have been stimulated by international certifications (GMP and ISO) (Graph 4.2.9).

Graph 4.2.9 – Number of sensors sold by Biogenesis, 2003-2006 (Quarters)



Source: Biogenesis.

BIOLOGÍSTICA S.A. recently patented in Uruguay and the United States two blood-collecting devices, which were developed with the support of the already mentioned Technology Development Program. The firm is now looking for strategic alliances to position these devices in foreign markets. Finally, MEDICAA—a recently created firm that focuses on R&D in neuroscience and neuro-otology—develops products and services for vestibular rehabilitation of patients with balance disorders. It was selected for support by the brand-new venture capital fund in Uruguay, Prosperitas.[57] There are also two successful catheter producers.

It could thus be argued that some diffusion is tentatively taking place in biomedical devices, and that this process reveals certain recent changes in the environment. Some government support for innovation projects tends to reduce experimentation costs, and at least one public-private partnership has started providing venture capital to technology intensive start-

[57] Investors in Prosperitas include the MIF, the CAF, Prosperitas' partners, and private investors (www.prosperitascp.com).

ups. Investing at a very early stage in international certifications is perceived by recent start-ups as a requirement to reduce uncertainty in foreign market penetration. To some extent, these firms take advantage of externalities from the first mover: a reputation for Uruguayan biomedical device exports in foreign markets; and some labor mobility between firms.

But the question remains: Why was there no diffusion process in the field of electronics?

Differences with the Software Case

According to a prominent actor in the electronics and software fields, these two sectors faced very different market opportunities, which to a large extent determined distinct trajectories.[58] When looking back at the paradigmatic examples of export take-off in the software sector, no similar experiences can be found in the electronics case:

- No producer developed an innovative tool for design in electronics in a similar way as ARTech.
- No producer succeeded in integrating a global value chain through customized services, as QUANAM did. There possibly were not many global value chains in search of value-added services as in the software field.
- Specialization in a vertical market did not become a springboard for alliances with multinationals, as in the case of SOLUR.
- No one discovered and seized an opportunity to develop a future commodity adapted to Latin American market characteristics, like Memory.
- A similar experience as the local learning curve in financial software, through sophisticated, multinational clients, did not repeat in the electronics sector.

On the supply side, according to the head of the Industrial Electronics Department (School of Engineering, IIE), a decisive factor differentiating software and electronics is that the orders of magnitude are totally different: investment requirements in microelectronics can be 100 times larger than in software, while demand can be 100 times less. The high fixed-cost structure of electronics operations is a major issue for small-scale firms because industrial scale is needed for the business to be profitable.

[58] Based on an interview with F. Brum (Feb. 05, 2007) and his comments on a draft of this study.

A strong barrier to entry thus stems from the combination of the following factors:

- Demand must be large enough to justify investment. Software firms can start from scratch with a very limited investment in physical capital, which is not the case in electronics.
- The production process in microelectronics is complex and requires several stages and inputs. Many of these inputs have to be imported because the size of the domestic market and the rapid obsolescence of components make their local production unprofitable.[59] Importing components has been plagued with difficulties (according to qualified interlocutors) that reflect, among others, a serious coordination failure around customs procedures.[60]
- Seed capital and working capital loans are practically nonexistent in the country and it is doubtful that an unknown Uruguayan firm could obtain venture capital from foreign sources. There are several cases of failed start-ups in electronics (that often emerged as spin-offs from the university), mainly because the founder had to dedicate too much of his time to another, remunerated job. This difficulty also appears in other technology intensive sectors but it is reinforced when combined with the previous factors.

In previous decades, reaching the required quality level entailed accessing technologies that were practically out of reach of hardware developers in Uruguay: it was economically nonviable to apply technologies like customized integrated circuits or surface mounting due to low demand; it was difficult to obtain updated technical information; and design programs were very expensive and only ran in workstations (Pérez et al., 1997). In contrast to the software case, electronics goods need to meet presentation and robustness standards, which implies the use of specific boxes, ironworks, good quality connectors, etc. Again, low volumes of production of these components were of little interest to the local industry.

These difficulties explain why, in spite of relevant antecedents in the country, hardware design and implementation by local firms were often discarded as alternatives for solving specific

[59] Stock costs, in turn, make it unprofitable for local providers to keep components with the required variety, quality, and continuity.
[60] Relations with international providers were also difficult because of their lack of interest in a low volume of demand.

problems. Public purchases, because of their size and recurrence, could have been a way to support long-term projects in electronics, where continuity allows knowledge and capacity to develop and update in some specific fields. But public purchases have not been used to promote local learning processes.

In recent times, some of these shortcomings have been overcome. State-of-the-art technologies have become more accessible: fixed costs in prototyping and production have decreased; CAD stations are now affordable and more powerful; the Internet offers easy access to information from providers and manufacturers; components can be acquired in small lots directly from international providers (although importing is still cumbersome); foreign producers of printed circuits admit prototyping and low-scale production at affordable prices (designs are sent via the Internet and the printed circuits are received a few days later); and there are firms in the region offering welding services for surface mounting (Pérez et al., 1997). These new trends imply renovated opportunities for the development of certain types of applications, like the ones that integrate standard and customized products, i.e., the integration of existing electronic devices and eventually software into more complex systems. Market niches exist in the fields of industrial control, data acquisition, communication, automation, and biomedical engineering.

In short, comparative advantage did not develop in the Uruguayan electronics industry despite of some apparently favorable initial conditions. Because of its complexity, this industry would have required a great deal of coordination at different levels of the economy to prosper; this did not happen and partial attempts were truncated. Most important, the market did not evolve as in the software industry, where different types of windows of opportunity appeared and were seized by local producers.

Naturally, important knowledge and other externalities derived from the local trajectory in electronics and have contributed to the development of some critical mass in knowledge-intensive sectors in the country.

4.2.5 Conclusions

Software discovery in Uruguay was based on the existence of qualified human resources, the R&D tradition in computer sciences, and good telecommunications infrastructure. These public goods proved essential for taking advantage of market opportunities that emerged in the fast development of IT in the 1980s and 1990s. Firms took advantage of these opportunities by following a niche strategy, focusing on one or a few target markets, small enough to be ignored

by the major industry players. In short, this discovery was about: (i) identifying an activity (rather than a product) that the country could develop thanks to some preconditions and low capital requirements; and (ii) overcoming barriers to entry in foreign markets for a country only known for exports based on natural resources.

The firm ARTech played a first-mover role, although some other pioneers with different products also paved the way for followers. ARTech's partners were savvy investors: they used to work as consultants in a more sophisticated context than the Uruguayan environment, and this helped them to find a niche beyond the local market. They opted for a highly differentiated product, with a well defined and "limited" scope that enabled the high productivity of their product. ARTech's trajectory shows an ability to assume large challenges on the basis of a long-term vision of the development of IT and globalization trends.

A major problem faced by the first mover in exporting derives from the inexistence of an image of Uruguay as a software producing nation and from the usual distrust in the North of technology-based products coming from the South. This was probably the main cost of the discovery. Overcoming this barrier to entry (by ARTech but also by other pioneers) resulted in an important positive externality for followers.

ARTech's growth relied heavily on different types of alliances. By developing the GeneXus Community—a network integrating application developers, end users, distributors, and technology suppliers—ARTech limited the non-appropriability problem associated with knowledge spillovers. It has been a way to diffuse ARTech's product and to reach network economies, while providing a fertile environment to the members to upgrade their knowledge and develop activities around the product.

The extent to which this *intra*-nucleus type of diffusion led to *inter*-nucleus imitation is not clear. Two core firms have been identified as intending to develop their own "community" but how far they succeeded in creating a community of practice remains to be investigated.

The way firms insert into global value chains is important because it tends to determine upgrading opportunities. Empirical evidence shows that chains characterized by "network relationships" offer ideal upgrading conditions but are the least likely for developing country producers because of the high level of complementary competencies required (Humphrey, 2003). The organization set up by the first mover appears to have favored the development of complementary competencies. ARTech and its closest software developers represent a (small)

cluster with such competencies, which in turn offers greater strength for incorporating into foreign markets.

The diffusion process in the software sector extended well beyond this first-mover pattern, since there are presently about 300 firms producing applications and/or services. Difficulties observed at the firm level usually related to financial, management, commercial, and scaling-up issues. In short, the critical point has been how to make the transition from a "one man in a garage" undertaking to an export oriented business through product and marketing upgrading.

Coordination difficulties in the sector subsisted for a long time and some still do, in part due to the inexistence of a national vision concerning the perspectives of the Uruguayan software sector. Coordination failures included:

- Rigidities at the policy level to adapt laws and regulations to the software business, which is different in many ways from traditional industrial business.
- Failure to experience, so far, significant agglomeration economies from geographical concentration. The agglomeration of most of the software firms in Montevideo was the result of the usual centralization of productive activities in the capital city and its surrounding area, rather than the organization of a cluster aimed at taking advantage of mutual benefits.
- Limited linkages and synergies between the software industry and other sectors of the economy, with the exception of some specific vertical or horizontal activities involved in the emergence of the software industry. Consequently, spillover effects of the software industry on the economy as a whole are more restricted than they could be.
- Difficulties in integrating into global networks. The bulk of software exports are, more than ever, highly concentrated in a few firms. In 2001, the 10 largest exporting firms concentrated 54 percent of total exports (US$80 million); by 2005, this figure reached 80 percent of the US$104 million exported. Several of these exporters were created in the early period, which could be an indication of the length of the learning curve.
- A too slow rate of increase of IT graduates. In spite of some diversification of educational institutions for computer sciences in the past 15 years, there is

little flexibility at the university level to respond to further significant export growth. For instance, a fivefold export increase (US$500 million) would require, roughly, some 2,400 additional graduates in informatics, when the yearly average has been around 300 in the past decade. “Recycling” of graduates is now considered as an alternative strategy.

Once the software sector demonstrated its export capacity, about a decade after the beginning of exports, the convenience of policy measures to promote the development of the software industry started to be debated, as recognition of the presumed relevance for the country of the development of a high tech and thus high value-added exporting sector. The ensuing government intervention thus occurred once a market failure concerning the diffusion of the export discovery had been explicitly identified. The most directly impacting measure was the exemption of the 30-percent income tax for software firms at the turn of the century. It was supposedly a temporary measure aimed at stimulating the growth of the industry and its penetration in foreign markets. The foundation of this sector-specific subsidy is now again being debated in the context of the present government strategy to strengthen the productive sector. The strategy, still mostly in its declarative stage, includes IT as one of five sectors to be given priority (agro-industrial systems, biotechnology, cultural industries, tourism, and software and information technologies). However, it also has to be stressed that, as the sector developed, software entrepreneurs increasingly backed up the Uruguayan Chamber for Information Technologies, CUTI. The latter is now very active in promoting collective actions to resolve coordination failures.

Public response has not been restricted to fiscal measures (see Table 3.2.8). External financing (grants and loans), channeled through the government, has been allocated to the strengthening of this industry. The most recent of these initiatives seeks to foster clustering effects. Different public entities also participate in collective actions aimed at developing synergies in the sector, often by means of public-private partnerships. However, on the whole, collective actions have been slow to develop.

There are some opportunities for the Uruguayan software industry that have been little explored yet. Among others, Uruguay could take advantage of its geographic, linguistic, and cultural linkages with Latin America to become a “near-shore” destination, i.e., a variation

onoffshore outsourcing with higher value-added services and where geographic and cultural proximity between the provider and the buyer are considered important.[61] The free trade zone, Zonamerica, could become a gateway to Latin America for multinationals, although there will be tough competition in this regard with other software producing countries of the region. In this respect, the installation in 2002 by the Indian multinational Tata Consulting Services of an operations center in Uruguay to provide services throughout Latin America is a good precedent to make known the advantages of the country for outsourcing.

As far as a comparator for software discovery, the emergence of the local electronics sector showed similarities with the software discovery (skilled human resources, research capacity, potential market niches, etc.) and there were some successful pioneers in certain market segments. However the diffusion process was truncated. As a whole, this industry could not take advantage of some local market niches and customization skills to implement successful internationalization strategies. There were barriers both on the demand and the supply sides.

Table 4.2.5 outlines the public goods, market failures, and instruments involved in the software discovery process.

[61] For example, Mexico takes advantage of a geographic linkage to advertise itself as a near-shore destination for offshore outsourcing, notably through its software cluster in Monterrey, which is very close to the border with the United States. Others software emerging nations use time-zone linkages (Carmel, 2003).

Table 4.2.5 – Key Factors of the Software Discovery

Public goods	Market failures		Public & private Instruments (and starting date)	Impact
	Externalities	Coordination failures		
-IT education at public university (PRE*)	-Local knowledge spill-overs	-Rigidity at the policy level to adapt laws and regulations to the software business (different from traditional industrial business)	-Fiscal incentives: exemption of income tax and of VAT on capital goods and exports, 1999-2000.	High
-IT education at private universities	-In communities of practice (2): network and scale economies		-Free trade technology park: Zonamerica, 2000	Medium
-Public research at InCo (PRE)	-Reputation for Uruguayan software goods and services in global market	-Failure to experience significant agglomeration economies from geographical concentration	-Public program to foster up-grading (innovation and quality management), applied research & postgraduate education: PDT, 2001	High
- Telecommunication infrastructure (PRE)	- Demonstration effect in domestic market	-Limited linkages with other sectors	-PPP** to foster entrepreneurship: incubator Ingenio, 2002	High
-Intellectual property law (2003)		-Limited integration into global networks	-PPP to define R&D priorities: CAITI, 2004	Low
-Quality of life for FDI & outsourcing (PRE)		-Too slow rate of increase of IT and management graduates	-PPP for software testing: CES, 2004	Still none
			-Economic Interest Group for export: Grupo Integro, 2004	Still none
			-Public program to foster clustering effects (PACC), 2006	
			-PPP to foster foreign market insertion: public calls for associative projects, 2006	

* PRE: available at pre-discovery stage.
** PPP Public-Private Partnership

Annex: An Example of a Product and Marketing Upgrade toward an Export Business Model

In 1985 a university student successfully developed a software program to handle the accounting and management needs of a classmate's family business. He then decided to dedicate himself to commercializing that product through a promotional campaign among acquaintances, retail companies, and accounting firms, and founded the firm Memory Computación, playing a one-man orchestra role in the early stage. Tough competition from locally established companies, such as IBM, Sun Microsystems, Unisys, and others, caused him to target small firms that were not even looking for enterprise resource planning (ERP) technology. To that end he developed a strategy to stimulate ERP demand from that business segment. Part of this strategy was to adapt the Memory program to the needs of individual accounting consultants (and their way of thinking) because they would then convince their clients (SMEs) to acquire the program.

In 1991 Memory began to explore the Chilean and Argentine markets, looking for distributors with technical skills to facilitate product support and integration (value added resellers). But foreign sales grew slowly: Memory software was only one among various products of the distributors, who lacked the incentives and skills to provide specific support and training as had happened in Uruguay. In the mid-1990s, Memory decided to open commercial offices in Santiago and Buenos Aires, with weekly trips by its management team to assist local staff in developing these markets. By replicating the Uruguayan business model, foreign sales increased but did not reach Memory's goal. Barriers to entry included: different codes and norms in each country, lack of knowledge of the local markets, difficulties in penetrating these markets without a relationship network, and lack of structure and resources (human and capital) to take advantage of business opportunities arising in other geographical areas.

In the early 2000s, Memory's product was upgraded to take into account country specificities (legal and tax systems, idiosyncrasies, etc.); it now includes common modules and country- specific components. Simultaneously, a new commercial strategy was defined to overcome barriers to entry into foreign markets. A franchise model was selected, which first required the reorganization of Memory's business according to best practice management. Next, an independent business unit was created to transfer Memory's know-how to franchisees. Franchisees contributed with capital and their knowledge of the local market. On the management

side, the typical "founder's dilemma" was faced by creating an advisory board comprising top professionals with management experience either in multinational technology businesses or franchising models.

Memory Computación is now a business integrating two types of companies: a network of distribution franchisees throughout Latin America (11 in 2005) and "the franchiser," a company that concentrates on finding investors for new franchisees.

Source: Based on the case study by Mordezki (2004).

4.3 The Forestry Case

4.3.1 Introduction

Forestry has a long tradition in Uruguay. The country has an important area covered by native forest (hardwood and shrub) that has been traditionally used as firewood and is now protected by law. The first plantations had two main purposes: to protect livestock and to protect sand dunes on the coast. For the first purpose, different kinds of eucalyptus species (*globulus, tereticornis, camaldulensis, saligna, robusta, diversicolor,* and *cinerea*) were planted. For the second purpose, pines were the principal species used.

Until the mid-1950s, these two types of plantations prevailed, both unrelated to large-scale wood production. In the second half of the 20th century, however, two factors gave a push to a different use. First, an important and persistent balance of payments deficit made it necessary to substitute national inputs for imported raw materials in the wood and furniture industry. Second, the oil crisis in the 1970s led to an increase in the use of wood as an energy source (gasified wood fuel).

In the 1960s, studies prepared by the national Committee for Investment and Economic Development (CIDE) and the Food and Agriculture Organization (FAO) concluded that the development of a forestry sector was viable in Uruguay and that it offered possibilities to make rural areas more dynamic. The first forestry law, approved in 1968, aimed at stimulating conditions for planting species for industrial use. The tax exemption scheme allowed farmers to reinvest the "IMPROME" tax (a tax on some cattle establishments) but, as the main beneficiaries were not interested in forestation, the planted area only increased by 1,100 hectares per year. By the end of the 1980s, just before a new forestry law would be promulgated, a relatively modest total of 31,000 hectares had been planted (17,000 ha. of eucalyptus, 11,000 of pines, and 3,000 of other species). The forestry areas were concentrated in four departments in the North and Northwest of the country.

Wood extraction showed more dynamic behavior in the 1980s than in the past. As a whole, industrial roundwood production doubled in the second half of that decade, reaching an extraction level of 2.4 million tons per year.[62]

[62] From 1980 to 1988, firewood consumption grew from 0.6 to 1.7 million tons, as manufacturing activities demanded alternative energy sources. Sawn wood extraction modestly increased from about 220,000 tons at the

The activities undertaken within the framework of the first forestry law were not export oriented. Those who took advantage of the benefits, such as pension funds (Caja de Jubilaciones y Pensiones Bancarias, Caja Notarial) and firms such as Balerio-FYMSA and Industrias Forestales Puerto Arazatí built up forests and sawmills mainly for the domestic market. Some manufacturing firms developed plantations in the 1980s as a source of energy for their factories, like the beer producer, Norteña, and the ceramic producer, Metzen & Sena. FANAPEL produced pulp and paper for the country but also for the region. By the end of the 1980s, wood exports were extremely limited. Argentina was the destination of most of them, 83 percent of which was pulp from FANAPEL, and Uruguay was a net importer of wood products.

At the world level in the mid-1980s, wood demand was largely unsatisfied in the Northern hemisphere and wood was still coming predominantly from natural forests. Half of the rough wood production was used in the manufacturing industry and consisted principally of pine wood (60 percent). The main producers were the United States and Canada (50 percent) and the European Union (23 percent). The other 40 percent of rough wood came mainly from the United States (25 percent), Brazil (8 percent), and Malaysia, Cambodia, and the former Soviet Union countries (7 percent each).

Meanwhile, in a context of accelerated deforestation at the global level, policies to preserve the natural forest were strengthening in several countries, which resulted in a significant decrease of the worldwide wood supply. Some Southern countries with natural conditions for forestry and a favorable investment climate emerged as new forestry nations. Such was the case of New Zealand, South Africa, Brazil, and Chile, where plantations extended in very productive land for forestry, especially for fast-growing species (e.g., eucalyptus). In the Northern hemisphere, the growing paper industry demanded an increasing amount of cellulose, provoking producers to search for new sources of pulpwood supply.

This was the international context Uruguay entered in the 1990s. In what follows, we will analyze how the export discovery took place, from the first-mover experience to the build-up of a new exporting sector.

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beginning of the 1980s to 300,000 tons in 1986. The extraction of wood for pulp as an input for local paper plants (FANAPEL, PALMER, CICSA, and IPUSA) was less dynamic (120,000 tons per year).

The analysis does not take into account the paper branch of the forestry chain,[63] which has been an exporting sector since the beginning of the 1980s (more than US$10 million annually). Paper exports have increased fivefold since then and are highly concentrated in one firm (nearly 60 percent). And the study does not consider such manufactured goods as frames, boxes, wood packages, wood tools, and other similar articles for domestic use and furniture. Exports of these goods are negligible in Uruguay.

4.3.2 First Mover: Grupo Otegui

The initial discovery was startling: trees could be planted in Uruguay with a view to exporting pulpwood to Europe. It all started in 1988 with a local business group, Otegui, discovering an opportunity to export eucalyptus roundwood to Finland for pulp processing. Otegui was until then mainly dedicated to wool commercialization and industrialization, in addition to participating in other activities (farming, banking, and trading). Otegui used to receive orders from different origins and fields through its trading activities and it thereby detected a permanent and steady demand for pulpwood in Finland. It then decided to create a wood trading company, TILE S.A., which became the first to export significant amounts of roundwood (Table 4.3.1).

Table 4.3.1 - Exports of Wood and Pulp, 1981-1991
(US$ thousands)

EXPORTING FIRMS	1981-87*	1988	1989	1990	1991
Rough and sawn wood	_	1,943	4,511	1,634	5,300
TILE S.A.	_	_	_	1,826	165
EUCALOG S.A.	14	_	_	_	_
Caja de Jubilaciones y Pensiones Bancarias	3	_	_	_	_
Industrias For.Puerto Arazatí	20	11	32	210	646
Others					
Wood pulp					
FANAPEL S.A.	166	338	1,791	846	143

*Annual average
Source: Customs Office.

[63] Corresponding to Chapter Nr. 48 of the MERCOSUR Trade Classification.

The firm investigated international prices, the possibility of buying roundwood from Uruguayan producers, and the logistical costs of exporting it. Once the viability of the business was established, two shipments were sent as trials.

Uncertainty was high and concerned several issues, such as the following:

- Montevideo's port was in no condition to operate such large-volume shipments. This new activity at the port required specialized management. This matter finally led to a reform of the National Port Administration (ANP) in the 1990s that allowed the participation of private service providers in the port. Some firms then specialized in wood freight movements, in ports in both Montevideo and Nueva Palmira. Facilities were also built around the port to prepare the shipments (log bindings to move them in bundles). Special equipment was required to move these large volumes.
- Initially, neither Otegui nor its client had established clearly how the wood volume measurement was to be done, at either the origin or the destination. Volumes may vary during transportation, with a consequent impact on the final unit price. After some time, it was established that measurement would take place at the destination, by displacement of water at large ponds.
- Otegui had no previous experience in wood harvesting, and there was no specialized equipment in the country to manage logs in the field (e.g., elevators with clamps).

The discovery thus arose from a window of opportunity in the global market that was exploited by a local non-forestry firm on the basis of its commercial ability and experience in international trading. However, this would not have been possible without the previous development of some local wood supply, because wood shipments imply large volumes. As we mentioned, two pension funds and a few other firms had been planting with the benefits of the first forestry law and some other incentives related to the substitution of renewable energy sources for fossil energy. They had been exporting very small amounts of posts and sawn wood to Argentina (Table 4.3.1). For its first exports, TILE thus succeeded in gathering wood from local forest owners.

While Otegui started its export experiment, some other players, including the Spanish group ENCE, were analyzing the profitability of investing in forest plantations in the Southern

Cone countries. Their interest stemmed from wood scarcity in the Northern hemisphere and the favorable forestry conditions offered by Argentina, Brazil, Paraguay, and Uruguay. In Chile, which had already developed a forestry sector thanks to its favorable investment climate, the price of land was higher.

After the initial trial shipments, Otegui decided to implement a large-scale project centered on forest plantations for export. COFUSA (Compañía Forestal Uruguaya S.A.) was created to that end in 1988. A joint venture was established with EUFORES, the brand-new forest firm of ENCE in Uruguay. Forestation began in the country's Northeastern (Tacuarembó and Rivera) and Western (Litoral) regions. Otegui benefited from ENCE's long experience in forestry. Some years later, this association split and Otegui kept the Northeastern plantations. Over time, COFUSA's planted area grew to 23,000 hectares. The prevailing species is *Eucalyptus grandis*, with a production cycle of 16 to 18 years. COFUSA plantations are certified by the Forest Stewardship Council (FSC),[64] having been granted the environmental quality seal by the Qualifor Program (SGS.).

The skills and abilities of Otegui, prior to the wood discovery, were probably essential to the latter. The wool branch of the group, Barraca Otegui, was the leader in Uruguay in purchasing wool directly from farmers. It was thus used to deal directly with primary producers as well as with a number of brokers all over the country. As a business group also involved in banking, Otegui had access to bank loans.

Otegui additionally had experience in technology management and innovation. Wool handling in one of their factories had been completely automated in the 1980s through specific technological adaptation by a Uruguayan software engineer allied with a local electronics firm. This contributed to generating interest by a French industrial group in Otegui's factory, which was finally sold in 1987 to the French. But management was partially kept in the hands of Otegui's people. Through this experience, Otegui accumulated knowledge in innovation processes, technology development and subcontracting, and, not the least, international business negotiation.

[64] FSC promotes the responsible management of the world's forests, in environmental, social, and economic terms. Its standards are based on 10 principles that involve: compliance with laws, tenure and use rights, indigenous peoples' rights, workers' rights and community relations, benefits from the forest, environmental impact, management planning, monitoring and assessment, and maintenance of high conservation value forests (www.fsc.org).

Otegui's technological strategy involved setting up a nursery farm to ensure maximum care for the genetic material in a similar way as the other large firms in Uruguay. But in fields where Otegui had no experience, subcontracting was the solution. This favored the creation of small firms to respond to those needs by grouping together existing skilled labor.

Soon after Otegui started buying land, it began experimenting with simultaneous cattle raising in the forested area. This would later develop into a "silvopastoral system"[65] that combines on the same farm tree plantations with land for cattle. In a 100-hectare farm, 60 hectares are used for forestry and fireguard areas, and the rest for cattle pasture.

Once Otegui separated from the Spanish group, it started experimenting with the production of sawn wood. Producing high-quality sawn wood required (i) planting species (or sub-species) adequate for such use, (ii) reducing planting density with respect to pulpwood production, (iii) intensifying the silvicultural regime in order to obtain even and straight logs of a larger diameter and free of knots, and (iv) assuming longer production cycles.

This new activity reinforced Otegui's vertical integration process in forestry: URUFOR S.A. was created in 1992 to process sawn wood. Located close to Otegui's *Eucalyptus grandis* plantations in the Northeast of the country, URUFOR progressively acquired the needed knowledge and skills to process eucalyptus wood. It now exports most of its production to Europe and Asia through commercial agents.[66]

URUFOR has two registered trademarks. The first (Batovi) applies to basic products for the furniture manufacturing market (kiln-dried boards, EGS panels, and FGP panels). The second (Eucanova) is for construction materials, such as finger-joint floors, beams, frames, and moldings.

The arrival in Uruguay of the Finnish forest group, Metsä-Botnia, was a new opportunity for Otegui Group to evolve. In 2003 Otegui sold half of the TILE stocks to Metsä-Botnia, and in 2006 the latter totally absorbed the former. This was part of a broader association between both groups, aiming at ensuring an adequate supply of raw material for the Metsä-Botnia pulp plant, now under construction. Otegui has a 9 percent share in the Finnish group.

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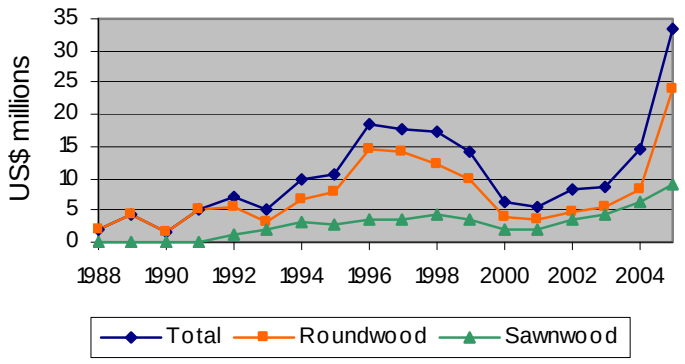
[65] One of the oldest agro-forestry systems used in the temperate regions of the world, where forages and/or livestock and trees are cultivated together on the same unit of land.

[66] URUFOR's sawmill has a processing capacity of 35,000 m^3/year to produce green boards, and a modern remanufacturing plant with the latest technology in kilns and equipment, with a production capacity of 6,000 m^3/year of dry boards. It employs about 150 people including in-house staff and hired personnel.

As a result of the first-mover development, its exports increased from US$2 million to $33 million in the 1988- 2005 period (Graph 4.3.1). The main markets for roundwood are still Norway and Finland, although in the past years exports to Morocco and Vietnam exceeded those to Finland. Sawn wood exports are more diversified and now include the United States (70 percent in 2005), Italy, France, Belgium, Japan, China, Taiwan, and Vietnam.

Graph 4.3.1 - Otegui wood exports, 1988-2005



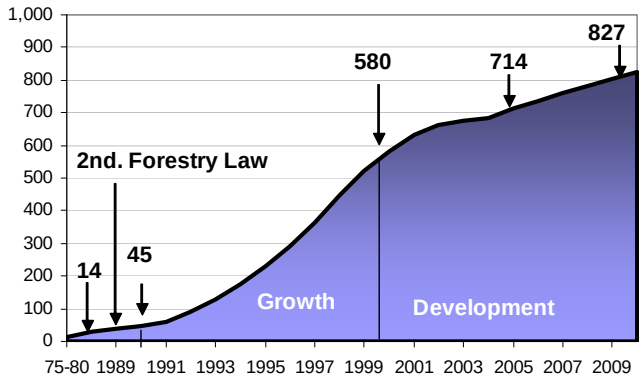
Source: Own elaboration with BROU and Custom

4.3.3 Diffusion Process

The Forestation Process

Three stages can be clearly distinguished in the forestation process (Graph 4.3.2). In the first stage, wood production increased moderately and was absorbed by the domestic market. In this phase, some knowledge accumulated in planting techniques and species selection. The second Forestry Law (1987) marked the beginning of the second phase, which was characterized by a sharp increase in the number of hectares planted and the appearance of foreign investment in the sector.

Graph 4.3.2
Uruguay: Forestry Development Phases
(thousands of hectares)



Source: MGAP, Forestry Department.

The third phase started in 1998, when the yearly growth rate of hectares planted slowed down somewhat, especially in the years following the economic crisis of 2002. At present, forested land in Uruguay amounts to 1.6 million hectares, 50 percent of which are artificial plantations.[67] These 800,000 hectares represent 5 percent of the country's total surface and, on this basis, it has been estimated that around the years 2010-15 harvesting might reach 20 million m^3 of wood, a volume far superior to the present level.

Indeed, in 2005 the volume of wood extraction was 5.7 million m^3; the average annual increase was 4 percent in the past 15 years (Table 4.3.2). Firewood still represents an important part of this volume, although its share decreased from 90 percent in 1980 to 65 percent in 1998 and 34 percent in 2005. Wood extracted for industrial use is mainly pulpwood (83 percent in 2000, 84 percent in 2005). Production grew from 0.2 million m^3 in 1992 to 3.13 million in 2005.

[67] Eucalyptus is the principal species, covering about 71 percent of the planted area. *Eucalyptus globulus* (used to produce pulp) represents 61 percent of that species and *Eucalyptus grandis* (used to produce pulp as well as sawn wood), 33 percent. Different pine species, used to produce sawn wood, account for 27 percent of the forestry area. Forestation can only take place in soils that are not suitable for agriculture; all soils in Uruguay are classified according to their exploitation potential.

Table 4.3.2 - Wood in Rough Extraction(m^3)

Extraction (in m^3)	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Total	**2,933**	**2,984**	**3,439**	**3,739**	**5,084**	**5,702**
Coniferous	263	262	304	177	213	221
Other	2,670	2,722	3,135	3,562	4,871	5,481
Firewood - total	**1,423**	**1,387**	**1,607**	**1,607**	**1,760**	**1,973**
Coniferous	-	-	-	-	-	-
Other	1,423	1,387	1,607	1,607	1,760	1,973
Industrial wood - total	**1,511**	**1,597**	**1,832**	**2,132**	**3,324**	**3,729**
Coniferous	263	262	304	177	213	221
Other	1,248	1,335	1,528	1,955	3,111	3,508
Sawn wood & veneer-total	547	547	591	485	536	580
Coniferous	208	208	250	171	189	197
Other	339	339	341	314	347	383
Wood for pulp - total	893	960	1,151	1,637	2,770	3,128
Coniferous	54	54	54	6	24	24
Other	839	906	1,097	1,631	2,746	3,104
Other industrial - total	70	90	90	10	18	21
Coniferous	-	-	-	-	-	-
Other	70	90	90	10	18	21

Source: MGAP, Forestry Department.

A better knowledge of the international scene has led a number of producers to manage plantations for high-quality wood to be used in higher-value-added products, a strategy that the first mover applied in the 1990s. However, this trend is still incipient, as can be observed in Table 4.3.2.

Production Diversification

Ideally, the forestry chain should be considered as an integrated system, from seed production to high-value-added manufacture.[68] In Uruguay, the chain development process involved product and market diversification, although no such integrated system exists yet. The growth process in the sawn wood sector is slow because it needs to start from plant selection and management, implying long production cycles, as was already mentioned. Sawn wood of a higher quality is

[68] This kind of structure would allow, for example, the sawn wood industry to place its by-products in the production of energy for the pulp factories, and would determine a loss of competitiveness for sawmills that would not sell their by-products.

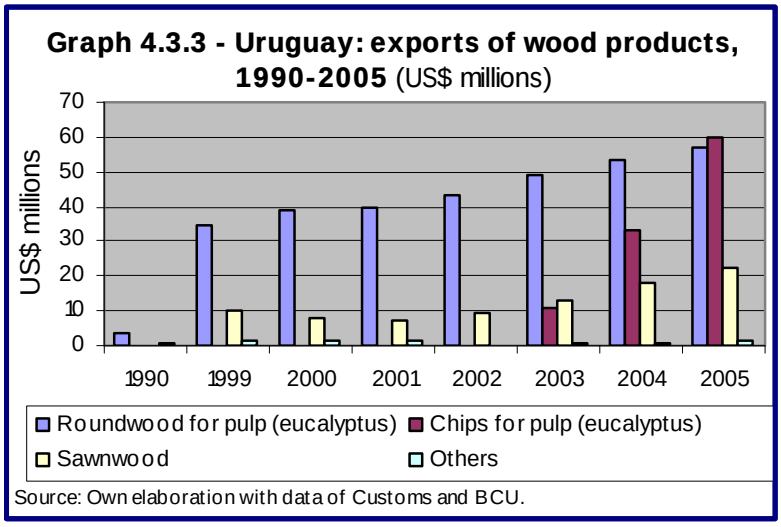
now beginning to become available, so firms that recently invested in building sawmills or upgrading existing sawmills can now offer higher-quality products in the international market. Secondary transformation is still incipient.

Some facilities for the production of chips have been recently incorporated. The transformation of pulp logs into chips improves transportation efficiency (more tons per shipment). It also opens up new markets, because few firms in the world buy logs due to logistical difficulties.

Substantial investments are now assigned to a new sub-sector: paper pulp for export. Mëtsa-Botnia is already building a pulp mill, and two others (Stora Enso from Sweden and ENCE from Spain) are planning to build cellulose pulp mills.

Exports

Roundwood exports have grown rapidly since the 1990s (Graph 4.3.3); about half of the industrial roundwood production (800,000 tons/year) is sold abroad. Chips appeared in 2003 and now exceed roundwood exports.[69] The growth in sawn wood production, especially in the past few years, has also implied new export flows that exceeded 100,000 m^3 in 2005 (more than 20 percent of the national production).



[69] The first mover in exporting wood chips was a local enterprise (Juan Balerio), followed by a few other firms. But in 2003 EUFORES began to export chips, which caused this product to emerge as the dominant one in exports.

Although wood board exports are still insignificant, two important forest enterprises are developing this sub-sector for export (URUPANEL and Colonvade S.A., an affiliate of Weyerhaeuser Forestlands International).

Total wood exports (excluding paper) increased from US$4.5 million in 1990 to US$141 million in 2005. In the same period, their share in Uruguay's total exports increased from 0.2 to 4.1 percent. Wood exports are expected to multiply fivefold in the next 5 years (several sources estimate that exports will reach between 600 and 750 million dollars a year). A structural change in their composition is anticipated after Botnia begins operating. Pulp will substitute part of the roundwood exports.

The presence of foreign enterprises in the sector has helped to diversify markets and clients. In addition to the Scandinavian countries, markets now include: other European countries, some Asian and African countries, the United States, and the countries of MERCOSUR (see the Annex to this chapter). Destinations were less concentrated in 2005 than in 2000. Spain and Norway reduced their relative share, while Japan and the United States increased theirs.

Prices behaved differently according to the product. Wood in rough and sawn wood, in particular, has shown a decrease in export prices, which is an incentive to produce more high-value-added products.

Analysis of Followers

There were 816 firms with commercial plantations in 2000. Most of them (57.7 percent) had plantations of less than 300 hectares, which altogether represented 14.4 percent of the total forested area. However, about 55.5 percent of the total forested area was concentrated in units of more than 1,000 hectares each (only 9 percent of the total number of farms). High concentration of forestry areas thus coexisted with a diffusion process in small and medium-size units.

The sector's accumulated investment was estimated at US$900 million in 2004, with the following distribution: 42 percent in land, 39 percent in plantations, 13 percent in plants, and 6 percent in infrastructure. Domestic capital originated about 55 percent of the investment and foreign capital, 45 percent. Foreign direct investment thus played a very important role in the diffusion process.

The structure of capital assets changed drastically in 2006, with the investment of the Finnish group Metsä-Botnia in a pulp mill, the acquisition of land and plantations by Stora-Enso (a Swedish firm), and other foreign capital.

In 2005, the main players in the forestry sector were the following (shown in Graph 4.3.4):

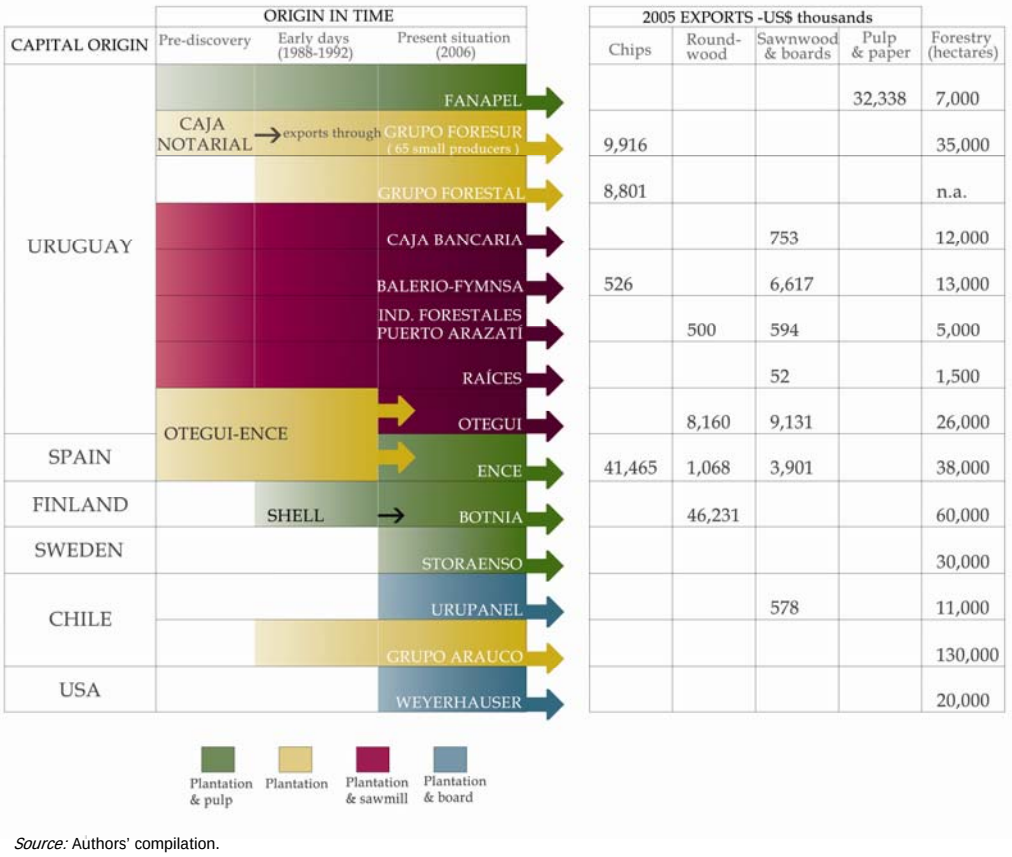
1. *Domestic enterprises owning forest plantations since before 1988:*
   FANAPEL
   Caja de Jubilaciones y Pensiones Bancarias
   Caja Notarial
   Industrias Forestales Puerto Arazatí S.A.
   Juan C. Balerio S.A. (FYMNSA)
   Raíces S.R.L.
2. *Domestic enterprises emerging during the diffusion process:*
   Idalen
   Grupo Mascolo
   Paso Alto, Fondo Forestal and Valle Flor (forestry investment funds)
3. *Multinational firms:*
   ENCE (Spanish)
   Metsä-Botnia (Finish)
   Weyerhaeuser Forestlands International (USA)
   Stora Enso (Swedish)
   Arauco S.A. (Chilean)
   URUPANEL- ex Delamonte (Chilean)

DOMESTIC OWNERSHIP ENTERPRISES

Domestic enterprises owing forestry plantations before 1988 followed, in general, a process of vertical integration. Plants were installed near the forests, particularly sawmills owned by the same forest owners (Balerio-FYMNSA, Caja de Jubilaciones y Pensiones Bancarias, Industrias Forestales Puerto Arazatí, Raíces S.A) as well as other industrial plants for higher-value-added products (board wood).

Although at the beginning of the diffusion process a great number of firms emerged as new plantation owners, in the past few years a concentration process developed. This was due to the main multinational firms buying plantations from domestic producers.

Graph 4.3.4
Main Firms in the Uruguayan Forestry Sector



2005 EXPORTS -US$ thousands				
Chips	Round-wood	Sawnwood & boards	Pulp & paper	Forestry (hectares)
			32,338	7,000
9,916				35,000
8,801				n.a.
		753		12,000
526		6,617		13,000
	500	594		5,000
		52		1,500
	8,160	9,131		26,000
41,465	1,068	3,901		38,000
	46,231			60,000
				30,000
		578		11,000
				130,000
				20,000

Source: Authors' compilation.

Some local forestry firms that emerged in the early diffusion phase got into financial difficulties. This happened mainly to firms managing forestry investment funds. They ran into problems in the planting process several years after starting, mainly due to the use of varieties that did not adapt well to the soil and climate of the planted zone. As a consequence, their investments were not profitable and they went out of business, selling their venture.

Some medium and small-size producers associated in order to obtain better results (and a larger scale), principally in roundwood commercialization. Producers from the Southern region integrated FORESUR and established alliances with other firms to install a chip plant in

Montevideo. These firms started exporting as a spillover effect of the first mover, taking advantage of the opening up of the market by the latter as well as other information externalities.

FANAPEL is a different case. Founded in 1898, it is the only national firm with a vertical integration process in the paper industry. It has its own forestry plantations and produces pulp and paper. In 2000, FANAPEL acquired Celulosa Argentina S.A, the largest cellulose plant in Argentina. Since the 1980s, FANAPEL has exported pulp to Argentina in the framework of the bilateral CAUCE trade agreement, but its main business is in the paper industry. The firm has taken advantage of the growth in the forestry sector to undertake a regional expansion strategy. It concentrates in the production of stuccoed papers, selling them to Argentina, Brazil, Chile, and Uruguay.

MULTINATIONAL ENTERPRISES

The Uruguayan forestry sector was attractive for foreign investment since the beginning. It was previously mentioned that incentives also existed in other countries of the region, but Uruguay probably provided a more reliable environment (macroeconomic stability and institutional framework). The diffusion process was led by some of the leading multinationals in the forestry industry:

- *ENCE*

ENCE (Spain), through its Uruguayan firm EUFORES, started planting in the country in 1990 after evaluating locations in Argentina, Chile, Costa Rica, Venezuela, and Uruguay. The firm stated that Uruguay was selected for its forestry policy and its macroeconomic stability.

In 2002, the firm bought the Southern Cross Timber saw mill (presently MASERLIT). In 2003, it inaugurated its logistics terminal M'Bopicuá on the river shore (Litoral), as the first private harbor in Uruguay, which it uses to export to Spain. It has a wood chip plant installed there, in addition to one in Montevideo.

ENCE's strategic plan consists of focusing on the production of eucalyptus cellulose at a competitive global cost level. To this end, ENCE plans to install a cellulose pulp mill in the West of the country, with a yearly capacity of one million tons. Fifty percent of the raw material will be supplied by the firm's own plantations. Total investment is estimated at 930 million euros.

- *Mëtsa-Botnia*

In 2006, this Finnish firm started building a pulp mill in the city of Fray Bentos in Western Uruguay (Litoral). The mill will produce high-quality bleached hardwood pulp for export to Europe, Asia, and North America. Full capacity will be one million tons/year, which will require 3.5 million m^3 of pulpwood. Investment will amount to at least US$1,100 million, including a very large amount of construction work.

With this project in mind, in 2003 Mëtsa-Botnia acquired the Royal Dutch/Shell stock in Compañía Forestal Oriental S.A. (COFOSA), which had been planting since 1991. It also acquired TILE S.A. (Otegui's wood trading company), which is now in charge of acquiring raw material from other forestry firms (including Argentine ones) to feed the pulp mill.

- *Weyerhaeuser Forestlands International*

Colonvade S.A. is an affiliate of Weyerhaeuser Forestlands International from the United States and it started planting in 1997. It now owns more than 37,000 planted hectares, principally with pines. The firm aims at obtaining a minimum of 2 million m^3 of wood per year. It acquired a total area of about 100,000 hectares. It also bought Los Piques, a firm owned by Canadians and Uruguayans (27,500 hectares). The firm expects to have facilities in operation by 2008 to manufacture appearance-grade solid wood products for export. Plans include the building of five to eight different wood factories, with an estimated investment of US$20 million to $130 million each.

- *Stora Enso*

The Swedish firm Stora Enso began buying land and plantations relatively recently. It plans to acquire about 100,000 hectares of land to plant *Eucalyptus dunii* and pine, and to build a pulp mill near the Baigorria Dam, with a production capacity of about one million tons per year.

- *Other Players in the Sector*

Service firms have played an important role in the development of the forestry sector. Initially the services offered related to tree nurseries, plantation, pruning, transportation, and trading activities.

Later, some medium and small-size firms developed specialized forestry services for the different phases of the forestry chain; even the most vertically integrated firms engaged in systematic strategies of subcontracting supporting services.

Other firms related to pulp processing are setting up. They will supply raw inputs for the pulp plants, such as Kemira, which produces sodium chlorate, chlorine dioxide, and oxygen, all required for pulp bleaching. It will invest in a new plant in the same town where Metsa-Botnia is building the pulp mill, with an estimated investment of 60 million euros.

The Role of Government

Uruguay has developed and maintained a forestry policy since 1968, when the first forestry law was promulgated. Prior to this, in 1964, the National Forestry Department was created in the Ministry of Agriculture, Cattle Raising, and Fisheries (MGAP), thereby institutionalizing all issues related to the forestry system (San Román, n/d). This office is still in charge of forestry policy.

In 1985, the government submitted to the Parliament a project for a new forestry law. Its objectives were to preserve natural forests and promote forestation. The first forestry law had been derogated in the 1970s during the military dictatorship and a large deficit in wood supply for domestic consumption emerged in the 1980s.[70] When the law was under discussion, although exports were not regarded as a main objective, the possibility of exporting processed materials—mainly cellulose pulp from pine—was considered. The law project considered initial financing equivalent to the cost of 10,000 hectares of plantations per year. The Parliamentary procedure took two years, and in the final report to the Senate, the possibility that Uruguay could become a "wood materials exporter" (particularly pulp) appeared as a new explicit objective.

The Japan International Cooperation Agency (JICA), which had been advising on different forestry-related issues in Uruguay, developed and published a sector study during debate on the law.[71] The impact of the study was important in enhancing the credibility of a forestry development model among national and foreign investors, as well as with the World Bank, which collaborated with in financing for the sector.

The Law of Forestry Development (No. 15,939) was finally passed in December 1987. It established tax exemptions and subsidies for development in zones declared "forestry priority." It

[70] In those years, wood production reached 1,300,000 tons/year while domestic consumption was estimated at 2,011,000 tons: firewood for residential consumption, 1,260,000 tons; firewood for industry, 509,000 tons; wood for sawn wood, 129,000 tons; wood for posts, 33,000 tons; and wood for pulp 82,000 tons.

[71] "Informe para el estudio del plan maestro para el establecimiento de plantaciones de árboles y utilización de la Madera plantada en la República Oriental del Uruguay."

included national tax exemptions, import tariff exemption for inputs and capital goods, subsidies up to 50 percent of the cost of planting, and soft credit to finance investment in forestry. Another relevant point was that the law authorized stock companies to own forestry assets and to use them as a guarantee when requesting loans. Most important was that the law enhanced the benefits established in the first law, allowing the use of the debt capitalization instrument. The first mover, among others, used this instrument. Later, other measures were added, such as the establishment of export processing zones and private ports (as M'Bopicuá in Fray Bentos). In order to access tax and financial benefits, firms must present a management plan for forest operation and renewal works. This plan has to be approved by government authorities. The law and its application acted as a clear signal to foreign capital of public support of the sector and the continuity of the promotional policy.

At the same time, the Uruguayan government negotiated sector financing with the World Bank. In 1989, the World Bank approved a US$65 million loan to finance the Second Agricultural Development Project. Around US$27 million were assigned to the forestry sector. The purpose was to plant 100,000 hectares of eucalyptus to produce Kraft pulp for export, and 60,000 hectares of pines to supply raw material for one sawmill and one chemical-thermo-mechanical pulp plant. The World Bank supported three lines of action: i) financing wood product exports; ii) supplying credit for planting, harvesting, and developing small forestry industries, with the participation of the Uruguayan public bank, BROU; and iii) assisting the government in implementing the financial incentives established in the forestry law (World Bank, 1989).

In September 2005, law No. 17905 was passed to eliminate subsidies to forest plantations (Table 4.3.3). The law does not seem to have had any negative effects. Since 2004, the sector has shown a tendency to recover from the reduced levels of the previous crisis years.

The specific instruments to promote the forestry sector were complemented with general investment incentives defined in Law No. 16.906 passed in 1998 (Investment Law, see Chapter 2). This law establishes non-discriminatory treatment of foreign with respect to domestic firms. The general investment incentives include exemptions from the net worth taxes, the value-added tax, and IMESI applied on imports, and the value-added tax on inputs and equipment destined for the productive cycle.

Table 4.3.3- Forestry subsidies in Uruguay

Year	Hectares	US$ thousand
1990	1,156	161
1991	3,710	341
1992	9,493	1,284
1993	14,826	2,608
1994	18,315	3,498
1995	23,783	5,312
1996	20,070	4,726
1997	21,984	4,637
1998	16,460	3,317
1999	29,416	5,273
2000	8,769	1,516
2001	28,744	4,825
2002	21,277	2,505
2003	11,866	1,154
2004	12,117	1,543

Source: MGAP-DGF: Anuario Estadístico, 2005

This set of institutional factors caused production and export in the forestry sector to increase sharply with an important participation of foreign direct investment. Nowadays, effective and projected investment in the sector indicates the prevailing presence of transnational corporations. These actors are the main exporters and the ones responsible for new, large-scale projects.

Other tax incentives are related to two special regimes: (i) the import of inputs and equipment free of tax, and (ii) export free zones, where income and net worth taxes do not apply, and neither will eventual new taxes. In October 2004, the government granted an export free zone regime to Metsä-Botnia and ENCE in Rio Negro. The regime applies to the production by these firms of pulp, paper, and other cellulose products, the installation of other wood industries, the production of inputs for the cellulose plants, electrical energy generation, and port operations. Other reforms supporting development of the forestry industry included the port reform which, among other measures, enabled the private sector to operate ports in the country. The forestry law established a one-third reduction in port tariffs for wood exports.

In 1997, the World Bank and the IDB approved new projects to improve public roads, bridges, and ports used by the forestry sector. In turn, the government elected in 2004 is projecting railway transport and public roads improvements with the participation of the private sector. In spite of these measures, infrastructure is still a bottleneck for the development of the sector.

In addition to the National Forestry Department, the National Environmental Department (DINAMA) also has some control over the sector because all wood processing projects must be submitted to that agency.

4.3.4 Export Triggers and Obstacles

By the 1970s the possibility of producing cellulose pulp in Uruguay had been studied by FAO, ECLAC, and JICA. It was known that the eucalyptus growth rate in Uruguay was upper 25 m^3 per hectares per year, a very high rate compared with those of Northern countries, although lower than the Brazilian one. When the first mover discovered the possibility of exporting pulpwood from Uruguay, all the wood available in the country at the time was insufficient to cover the client's demand. Planting yield forests was needed to obtain a sustainable business and, local growth rates indicated favorable local conditions.

However, at the end of the 1980s, there were high barriers to entry in the forestry sector: large amounts of resources were required to invest in land and capital; the production cycle (from initial investment to revenue) was long; tree nurseries enabling a high increase in planted areas were scarce; there was a lack of transportation for getting heavy products to destination markets (distance and type of product); and infrastructure to allow the development of the sector was poor. Public policy had an important role in lifting some of those restrictions. Subsidies represented about two-fifths of the investment needed to develop a plantation, and the forestry policy had a remarkable continuity through different governments.

Other factors that promoted the diffusion process were related to Uruguay's natural and market conditions. At the beginning of the 1990s, land value was low in comparison with international prices. There were few profitable alternatives for agricultural and farming business investments (the international price for Uruguayan meat was very low in those years). Uruguay also has a comparative advantage in forestry according to its natural resource endowment (climate—temperature and rain regime—topography, and soils) and population distribution (non-

inhabited land availability). Different species, such as pine, eucalyptus, and poplar, have adapted successfully to Uruguayan forest soil.

During the 1990s, various supporting activities developed. First, private tree nurseries began to produce and sell great amounts of seedlings, and their cost decreased during the decade. Second, a standard technology was adopted in all processes: nursery, forestry management, and harvesting. Genetic improvement was undertaken; in particular, clonal seedlings started to be used to get trees better adapted to the Uruguayan weather and soil conditions. Third, tree crops started to be used in plantations, by sprout management or replanting with high-productivity varieties (cloned and selected seed plantations).

The development of subcontracting in sowing, management, and harvest sustained the diffusion process and allowed small and medium firms to be competitive. The forestry chain slowly integrated logistics and other service firms, enabling scale and network economies. The regulatory reform of the National Port Administration additionally played a significant role in reducing logistical costs.

The development of industrial, higher-value-added processes, like pulp plants and wood board factories, is capital intensive. Only with the entrance of foreign firms was it possible to go beyond the capital restrictions and integrate forestry production vertically. In Uruguay, private enterprises of national capital do not have the capacity to invest 1,000 million dollars, the amount that would be required to install an integrated enterprise in the forestry sector. The single national enterprise that has an integrated vertical process (FANAPEL) only processes the wood produced on 7,000 hectares.

The entry of foreign capital pushed the sector forward and gave credibility to its growth process. There were spillovers because foreign firms defined the technological process in planting and this process was imitated by local firms. They also established links with local firms that became their suppliers of wood, inputs, and services.

A market spillover process does not seem to have taken place. In general, foreign firms tend to export to their countries of origin, while domestic firms try to open up new market destinations, particularly in Asia. The forestry boom showed that there were technological limits that, as a consequence of the length of the biological cycle of trees, caused a lag between the economic growth of the sector and forestry research.

The public institutions related to the sector research are the National Institute of Agricultural Research (INIA), which has an experimental facility in Tacuarembo, specialized in forestry research; and the School of Agronomics, which has a research department specialized in forestry. These institutions develop local R&D jointly with the private sector. Funds allocated by INIA to R&D in the wood sector have been scarce, because the institute estimates the R&D funding to be allocated to each sector based on its contribution to an export tax that is not applied to the wood sector.

At present INIA is in charge of the National Forestry Program (Programa Nacional Forestal), which aims at developing the sector via cutting-edge technologies in the main links in the wood product chain, seeking quality, and attempting to overcome the commodity exporting stage while respecting natural resource sustainability. The specific objectives of the National Forestry Program are to improve in the following areas: genetic improvement of rapid-growth species (*Eucalyptus and Pinus*), silvicultural management of the most-used species, and control and assessment of the environmental impact of forestry.

In recent years, the main research activity has taken place on environmental and sanitary issues, seeking to obtain better technologies to transform the wood produced. BROU has also financed some research activities and studies in the framework of the PRENADER (a program for natural resources and irrigation development). Hence, forestry R&D has been related principally to private enterprises, in particular multinational enterprises whose R&D generates spillovers for local firms. In the primary sector, small local firms take advantage of technological packages while other local firms copy the procedures of foreign firms.

The curriculum of the School of Agronomics of the public university (UDELAR) has included since 1963 the option of specializing in forestry, but the number of graduates with this specialization has been limited (maximum 40 per year). Thus, a specific weakness of the sector is the deficit of specialized professionals and researchers in the forestry sector.

Moreover, Coordination among research institutions and enterprises has been weak. During the early stages of the diffusion process, some types of *eucalyptus globulus* were planted in zones that were not proved to have adequate conditions (soil and climate). Later, poor tree growth was observed in those zones and it was necessary to replant with a more appropriate variety.

In 2005, seven firms had plantations certified by the Forest Stewardship Council (FSC). The total certified area was 133,771 hectares and was owned by: EUFORES (ENCE), COFOSA (Metsä-Botnia), COFUSA (Grupo Otegui), FYMNSA (Balerio), Industrias Forestales Puerto Arazatí, and two small firms (Guillermo Gómez Platero/Gabriela Carriquiry Bocage and Grupo Forestal San Gregorio). However, some environmental organizations have criticized the certification on the grounds that it does not take into account key aspects of the effects of forestry on water resources and local flora.

LATU, in association with JICA, researched the quality and properties of wood as well as industrial processes for obtaining quality sawn wood products. This institution focused its research on the eucalyptus drying process to avoid problems that affect products due to eucalyptus fiber movement.

4.3.5 Comparator Case: The Wine Sector

INTRODUCTION

Wine is a traditional activity in Uruguay. At present, wine production hovers around 100 million liters per year. Due to changes in Uruguay's economic policies in the mid-1970s, related to increased openness, wine firms felt threatened by foreign competition, especially from Argentina. This concern, jointly with other factors, caused the sector to adopt strategic changes in order to be competitive in the global market. Today some trade protection remains in the domestic market.

Although initially restructuring of the industry was exclusively private and limited to a few firms, the ensuing diffusion of technological changes to a larger part of the sector benefited from strong public support. The National Vitivinicultural Institute (INAVI),[72] a public-private support organization for the wine sector, played a significant role in the sector's restructuring and, once exports started, contributed to the internationalization process of the sector.

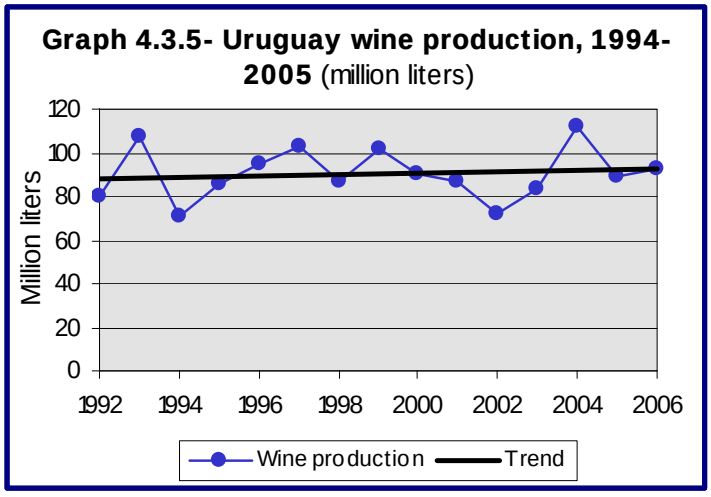
Restructuring the industry implied progressive reduction in the number of wineries and vines, and in vineyard area (Table 4.3.4). Total wine production has varied within a certain range since the early 1990s, mainly due to climatic factors (mostly rain), as shown in Graph 4.3.5.

[72] INAVI was created by law (No. 15.903, art. 141 to 154) in 1988 to control wine grape production. See https://www.inavi.com.uy.

Table 4.3.4 – Evolution of Wineries, Vines and Vineyard Area in Uruguay

	Vines (plants x 1,000)	Area (Ha)	Wineries (Nr.)
1992	46,926	12,131	404
1995	37,063	10,900	353
2000	31,852	9,146	313
2005	29,503	8,484	275
2006	n.a.	n.a.	272

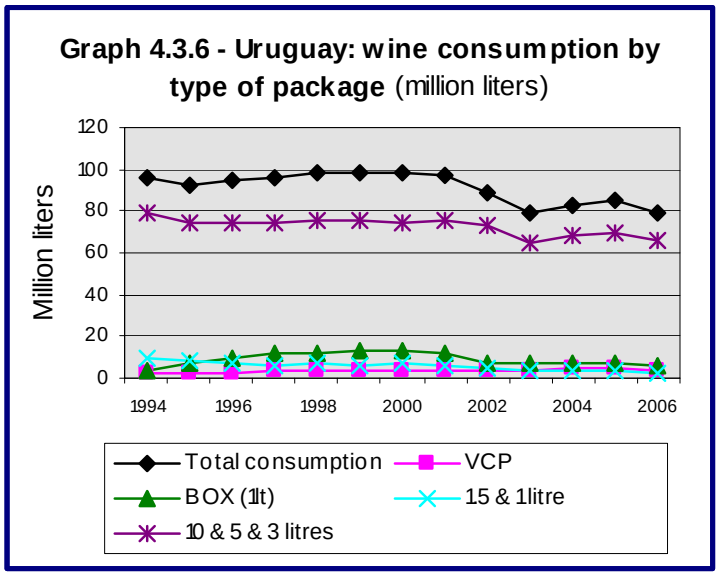
Source: Authors' compilation based on INAVI data.



The wine sector offers a wide set of product options, from table wines (packaged in 10, 5, 3, 1.5, and 1-liter bottles, and TetraPack boxes) to fine wines (VCP,[73] 0.75-liter bottles). In the past 10 years, wine packed in 10, 5, and 3-liter bottles represented 80 percent of total consumption, on average (Graph 4.3.6). This evolution reflects the importance of cheap wines, mostly associated with popular consumption practices: people used to buy "non-packaged" wine, which is sold by wineries to retailers in 10-liter bottles; consumers, in turn, provide their own containers (usually

[73] Quality wines are labeled "Vino de Calidad Preferente" (VCP) in Uruguay to distinguish them from common or table wines.

glass bottles) to be refilled by the retail seller. Younger people used to buy TetraPack boxes (table wine) for personal consumption at night.



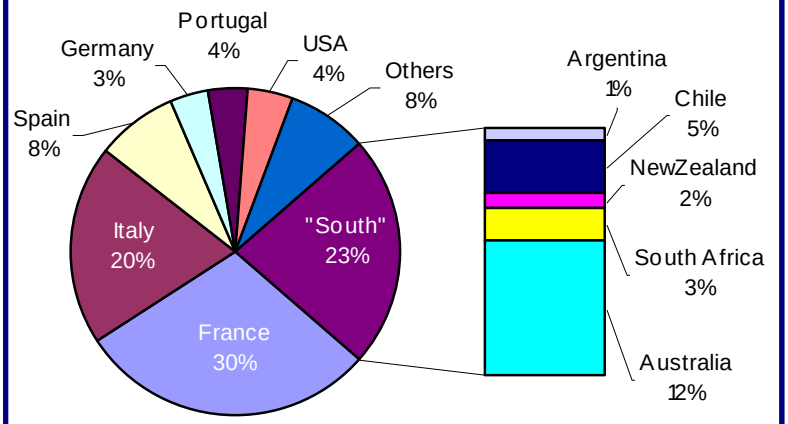
VCP consumption does not fully reflect production capacity. Wineries package wine and make production decisions, such as vineyard management and industrial processing, according to market segmentation, and this decision can change from one crop to the next. Some wineries emphasize volume, while others prefer quality. Total consumption has been on a declining trend since 2002, coinciding with the economic crisis. In Uruguay, wineries with an average production of 350,000 liters per year are considered very small. Larger enterprises produce about 5 million liters, but these scales are indeed very small in the international context.

World consumption is about 23,520 million liters, and world production is around 28,000 million liters. It is a mature market, with a declining consumption trend over the past 20 years (-0.2 percent per year, 1986-2003).The European Union (EU), by far the largest producer, has been reducing its vine area and discussing its subsidy policy. Meanwhile, countries in the Southern hemisphere have increased their plantations (especially during the 1990s) and their global market share. The EU still provides 60 percent of production, with France, Italy, and Spain at the top. Outside the EU, the United States, Australia, and Argentina are the countries with a share greater than 5 percent of global production.

Imports and exports are growing in the global market. This indicates the presence of more sophisticated consumers, who wish to try a variety of tastes. Thus, competition is increasing over time.

Chile took advantage of a window of opportunity in the international market and has become an important player. Although during 1986-90 Chile only exported 4 percent of its wine production, in 2004 exports represented 60 percent of its production, generating US$712 million in revenue. Chile is now the fifth world exporter. Currently, 5 of the 11 top exporters are from the Southern hemisphere (Graph 4.3.7).

Graph 4.3.7 - World exports of wine, 2004



Total = US$ 14.591

Source: own elaboration with FAO data.

FIRST MOVER

Exports were initiated in the mid-1990s by the few firms that undertook the modernization of their vineyards and wineries some 15 years ago. Among these, the first mover can be identified as Bodegas Carrau, a family firm with a long and interesting trajectory in vine growing and processing. In 1997, this firm was the second in terms of export value (a quarter of total exports).[74] Its markets included Scandinavian countries, the United Kingdom, Holland, and Canada. Exports further increased and markets extended to China, Poland, and the United States.

[74] In fact, the firm developed an export project as soon as 1977, which was declared "of national interest" by the government because its purpose was, among others, to export and make Uruguayan wines known in international markets. For various reasons, the export project had to be postponed.

It is still one of the dominant exporters. Interestingly enough, Bodegas Carrau is one of the few private firms in Uruguay carrying out R&D. In 1985, it created an internal R&D laboratory and its main researcher—one of the owners of Bodegas Carrau—has since then contributed to the research on different aspects of enology at the Chemical School of the public university.

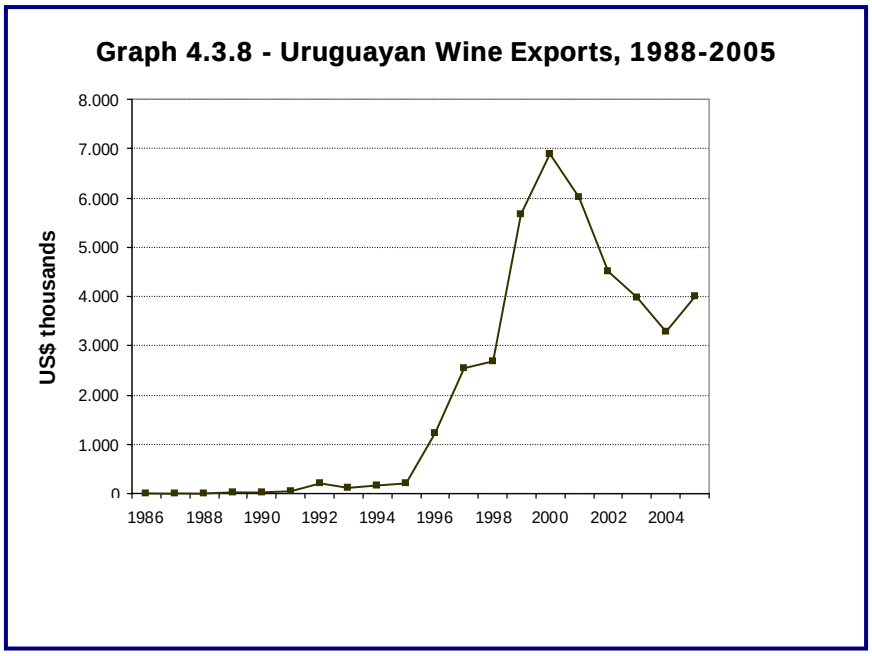
Bodegas Carrau used to produce 500,000 liters per year when it began to export. When the winery was started in 1976, its objective was to produce and export high-quality wine. Previously, the Carrau Family was associated with another winery. In 1974-75, Carrau had researched vineyard production zones in the South of Brazil with support from the University of California. This led Carrau to install its main vineyard in a new zone, close to the Brazilian frontier in the Northeast of the country (Rivera).

The main hurdle was related to the lack of recognition by the world market of Uruguay as a quality wine producer. In addition, Carrau was too small to create by itself an image in such competitive market.

Diffusion Process

Until the end of the 1980s, wine exports from Uruguay were virtually nonexistent. The common expectation was that wine production would disappear in the country due to the end of import tariff protection: the flood of cheap wine from Argentina would impede the survival of Uruguayan viticulture. In fact, important protection of domestic production is still in force: imports are forbidden for "non-packaged" or more than one-liter bottles, and domestic taxes are higher for imported wines.

Uruguayan exports started in the mid-1990s (Graph 4.3.8) thanks to some key elements that had been brewing over the previous 15 years: a small number of innovating firms restructuring first their vineyard and later their wineries, according to world standards, and a supporting institutional framework.



Several other factors have to be taken into account to explain why exports could start at that precise time; most of them are of a local dimension, although some relate to particular global conditions. But there is one factor that happens to be particularly important. Uruguay has succeeded in developing a VCP from "Tannat cépage," a variety that has long been cultivated in the country. Tannat was known by specialists but was previously only known to exist in a small region of France.[75]

After the export peak in 2000, the sector suffered the consequences of the financial and economic crisis of the country and the region. Cheap Argentine wines were difficult to compete with in the Brazilian market, while the foreign trade strategy to conquer European and other markets experienced a drastic reduction in funds. This seems to reflect Uruguay's difficulties in exporting large volumes of wine to countries other than MERCOSUR members. This is particularly striking if one takes into account the aggressive market diversification strategy that has been followed: Uruguay has been exporting wine to a total of 55 countries in the past decade and to 35 countries in 2004 and 2005. Its wines have earned awards in a variety of worldwide competitions.

[75] In fact, Tannat vine stocks have always been grown in the country, but used to bear the name of the person who imported it at the end of the 19th century, Pascual Harriague. Over time, the origin of the stock was lost and its identity was rediscovered in the 1970s through laboratory analyses in France.

In the very competitive and traditional world wine markets, it is extremely difficult to compete with well-established varieties. Although Uruguay is producing and exporting several types of wines, it is through the Tannat variety that it was able to "make a name" for itself. This by no means has been a panacea but rather the starting point of a complex R&D path in order to build the sector's future, partly based on this opportunity. And it has not been the only or main determinant in making wine exports feasible; but it shows a particular match between local and global conditions.

Uruguayan exports are 90 percent red wines, and a third of them are Tannat. Wineries introduced in the markets by Tannat as a symbol can show and sell other varieties (mixed or not with Tannat). In 2005, 30 firms were exporting to 35 countries. Four wineries accounted for more than 50 percent of exports (Carrau, Castillo Viejo, Juanicó, and Pisano). The amounts have not been sizeable: US$690,000 is the total value of exports of these top firms.

Export Triggers and Hurdles

After the early phase led by a handful of "elite" wineries, institutional support actively promoted diffusion: subsidized credits for vineyards and winery restructuring; INAVI support to the setting up of the country's wine image; and research projects financed through public programs. Public institutions intervened to deal with two typical market failures derived from the public good nature of both research and country image (associated with wines).

Before the wine industry was restructured, a number of firms used to participate in non-governmental groupings of agricultural producers (CREA[76]) that shared their experiences and problems as well as hired part-time consultants to help find solutions. This was an important channel for getting in touch with foreign specialists in viticulture, starting a program to rejuvenate viticulture (with the passing of time, grapevines had become subject to viral infections), and moving on to an investment and innovation process in wineries. Had these selected wineries not started the move toward higher-quality grapevines in the 1970s, it is unlikely that the sector would have resisted trade liberalization in the 1990s because of the long biological times implied in vine growing.

[76] Centros Regionales de Experimentación Agrícola.

INAVI played a coordination role in the diffusion process, including the promotion of Uruguayan wines in wine and export shows. When exports started, there was a window of opportunity for Uruguayan wines due to foreign retailers being attracted by the introduction of a new country of origin. This opportunity was open while "wine of Uruguay" was news. From the moment the news is acknowledged by the most active consumers, Uruguay is just another competitor in the market.

Uruguayan firms are small in the global market. Thus, none of them was able to compete far from a boutique-winery position, and INAVI's role in promoting the Tannat "concept," plus some coordination of wineries was required for success. At different stages, some wineries learned to cooperate, acting as a group in the export market, after some failed experiences. In the local market, rivalry has always been difficult. Thus, collaboration among firms is fragile.

The domestic market, for its part, has evolved favorably toward more sophisticated demand by consumers with higher standards. Ten years ago, Carrau created a Wine Club (Cava Privada) with the intention to promote the "Wine Ritual." Nowadays it is common to hear wine conversations among "non-professional" consumers or to see wine accessories bought as gifts. New restaurants within a gourmet culture contribute to this trend. This is used by wineries creating Wine Routes, including reception facilities for winery visitors (tourists can take a tour including a "winery walk and taste" from Montevideo Harbor for a small fee).

The wine sector is still threatened by foreign competition. Wines produced in Argentina or Chile by firms that are many times larger than the Uruguayan ones can produce "good wines" at lower cost (grape production, packaging, and labels). The Uruguayan vineyards are still changing and reducing in size. Traditional table-wine varieties are diminishing while modern "market value" varieties are growing (Table 4.3.5). A net reduction of 1 million vine plants from 2002 to 2005 hides growth of 2 million plants in red wine varieties such as Tannat, Cabernet, and Merlot.

The sector's transformation in recent decades clearly improved its competitiveness. However, wine exports did not grow as expected, and they are only remarkable in the Tannat niche.

Table 4.3.5 - Uruguay: Number of Plants by Variety, 2002–2005

VARIETY	2002	2005	Difference
Moscatel Hamburgo (wine)	5,067,041	4,834,032	-233,009
Folle Noire (vidiella)	409,188	282,775	-126,413
Frutilla	3,087,255	1,962,399	-1,124,856
Red hybrids	4,266,226	3,092,396	-1,173,830
Other decreasing red varieties	340,563	161,806	-178,757
Sub total			**-2,836,865**
Tannat (Harriague)	5,003,292	5,421,532	418,240
Merlot	2,179,584	2,573,964	394,380
Cabernet Franc	789,917	969,178	179,261
Cabernet Sauvignon	1,723,248	2,223,056	499,808
Red blending	100,321	349,850	249,529
Others (“tintas de vino”)	16,740	184,316	167,576
Other increasing red varieties	406,430	529,454	123,024
Sub total			**2,031,818**
TOTAL RED VARIETIES			-805,047
Riesling	140,801	49,342	-91,459
Semillon	324,150	177,674	-146,476
White hybrids	2,600,112	2,306,895	-293,217
Other decreasing white varieties	881,807	692,562	-189,245
Sub total			**-720,397**
Chardonnay	371,792	392,252	20,460
Ugni blanc	1,771,471	2,093,192	321,721
Other increasing white varieties	116,855	165,967	49,112
Sub total			**391,293**
TOTAL WHITE VARIETIES			-329,104
TOTAL*			**-1,134,151**

* 362 hectares reduction.

Source: INAVI.

Comparison with the Forestry Case

The wine sector, like the forestry sector, has a long tradition in the country; it is a primary inputs processing industry and it has a long time-span between planting the vineyards and completed production of quality wine (eight years). The firms are also commonly vertically integrated and have their own plantations. Similar to the forestry sector, wineries had government support for undertaking the restructuring process and maintaining sales in the internal market.

In the wine sector, exports have not grown as expected, and domestic market protection has been sizeable. There was fear of imports from Argentina (basic quality wine, cheaper than Uruguayan wines due to better climate, large firms, scale economies, and clustering and networking of suppliers). The situation in the older forestry sector was not very different. Cheap wood imports came from Brazil and Paraguay, with long-established forestry sectors in both sawn wood and paper.

In both the wine and forestry sectors, a worldwide reallocation of production has taken place toward countries in the South. This has been based on relatively more freely functioning of world markets, because comparative advantage is present in those countries. European countries continue to provide subsidies for vineyards. The opportunity created by the move toward the South has been seized by the wood sector in Uruguay; in wine this has not happened to a similar extent. By contrast, first Chile and then Argentina have profited from this opportunity for their wines.

Differences between the two sectors include the following:

- Wine is a differentiated product. Origin is important and might be even more important than brand; this is not the case for wood. Uruguayan wine was previously unknown and this implies a strong disadvantage when competing with Chilean or Argentine wines. This might also influence the location of FDI.
- Climate in Uruguay is not ideal. It is adequate, but it lacks the extremely dry summers of Mendoza or Chile (where water supply to the vineyards can be totally programmed by irrigation).
- Land prices (low in Uruguay) are not significant in wine production because relatively less land is required than in the case of forestry.

- The wine sector is still protected (in Uruguay as well as in other countries); the forestry sector had a relatively "fresh start" that involved modern solutions in many fields.
- In the wine sector, the domestic market (protected) is important for the firms. Thus, domestic orientation is strategically attractive and enhances profitability, which could reduce export competitiveness.
- The world demand in the wine market is less dynamic than it is in the wood market, and there is no clearly determined and significant unsatisfied demand.
- Firm size and profitability are important for accessing technology updates, which is dynamic in the wine sector as a differentiation generator.
- Uruguay could however identify a market niche with the Tannat variety, which may possibly keep growing.
- Because foreign direct investment has not come forward in the wine sector (as it did in Chile and Argentina), spillover effects of the type observed for forestry were not observed.
- As Brazil was the relevant export destination and Argentina the main competitor, the wine sector has suffered more from the regional macro instability, which has harmed trade flows; this has not affected the wood sector.

4.3.6 Conclusions

The beginning of Uruguay's forestry sector renewal is identified with the first Forestry Law (1968), which generated an increase in the planted area. This experience was relevant to show the capacity to produce wood in the country, but it did not establish an export flow. However, some enterprises that started planting in those years are now important actors in the sector.

The Otegui Group, previously known for its participation in wool commercialization and manufacturing, identified and took a commercial opportunity to provide wood to the European cellulose-paper industry. It was the first firm to export a non-negligible amount of roundwood to Europe, in 1988. To reach an exportable volume, Otegui bought roundwood from farmers established under the first Forestry Law.

When the second Forestry Law was approved (1988), the Otegui Group, in association with the Spanish forestry group ENCE, pioneered massive forest planting in Uruguay. After these first moves, Otegui decided that sawn wood would be a more promising business, then split from the Spanish firm and started specializing in sawn wood. Nowadays, Otegui is a most relevant player in the forestry industry: it owns two enterprises and has a strategic association with Metsä-Botnia (a pulp mill).

For its part, ENCE, after analyzing the viability of producing wood in the region as an input for its Spanish mills, decided that Uruguay would be the most convenient location. Once the decision was taken, the firm chose to associate with Otegui. This process seems to indicate that the Spanish firm would have invested in forestry in Uruguay even without Otegui's first move.

A strong diffusion process took place, first at the planting stage. In this process, Uruguay benefited from the situation of the global forestry resources in the 1990s: a contraction of the industrial forest surface in North America, an unsustainable felling level of tropical wood in the Pacific Asia region, and a growing preoccupation with protecting natural forests. This caused the forestry chain to de-localize its first links toward regions where land was cheap and high-growth species adapted well. Uruguay showed higher growth rates than the world average, indicating a comparative advantage.

Uruguay has been more successful than other countries in the region in capturing forestry investments due to a clear promotional policy that was given continuity over the past 20 years, and also because of relative macroeconomic stability. The promotional benefits granted by this policy, however important, were nonetheless similar to those observed in other countries; hence they must not be regarded as the only explanation for the sector' success. Nowadays the sector continues developing in spite of the recent elimination of planting subsidies.

Another factor that made Uruguay attractive for forestry was the relatively low cost of land and the lack of profitable investment alternatives at the time the sector started its development. The presence of multinational firms in the Uruguayan forestry sector is at the same time an indicator of its success and one of its causes.

At least three stages may be recognized in the diffusion process. In the first stage (1990-2003), the most important element was the forestation of 650,000 hectares (around 4 percent of all rural land); firms' revenue was scarce or nil, and exports were at a minimum.

The second stage, corresponding to recent years, was characterized by the development of primary wood processing once massive harvesting started. When transportation costs were reduced, wood manufacturing became profitable and exports grew.

In the third and present stage, it is expected that the sector will gain in strength and competitiveness through optimization of the various sub-systems and their interrelations: products and sub-products would be exploited in their best alternative uses and optimized for each market segment; resource allocation and use would be improved; and unsolved coordination failures would be tackled. It has been estimated that this stage would be completed about 15 years from now.

Products presently sold are commodities and reflect the current development stage. Initially, high-density pulp wood plantations were targeted, entailing low-cost silviculture management and higher yields. But later on, sawn wood started to gain importance and this implied more demanding management systems (weeding, breeching, etc.) and longer growth cycles. Costs increased in the forestation phase but higher prices are obtained for the processed products. In this second stage, although the sector still moves in commodity markets, new products have appeared, such as wood boards on the one hand and pulp on the other. It is only in the third phase that high-value-added products, possibly differentiated, will be processed.

Development of the sector was spurred by the presence of multinational firms that incorporated capital and knowledge. Together with significant public support, this contributed to solve uncertainties and lift some barriers to entry. Among others, it became obvious that an export market existed, the technological package was evident, and service firms emerged. This led to a number of local imitators entering the sector. About 40 percent of the plantations were the outcome of local small and medium-size projects.

The largest firms, especially multinationals, followed a vertical integration strategy, installing plants for primary and/or secondary wood processing (pulp mills, sawmills) near their plantations. From the start, these enterprises developed subcontracting, thereby stimulating the diffusion process. Agglomeration economies started to appear from this practice.

Once the plantations reached maturity, exports increased rapidly (reaching a 4 percent share in the country's total exports in 2005). On the basis of the expected wood volumes for the coming years, this share should be growing and impact significantly the structure of Uruguayan exports. The significance of the forestry sector in the economy is already noticeable in the use of land,

transport and port infrastructure, regional development, and social impact. Forest plantations have changed the landscape in several regions of the country and issues related to the sector are debated daily. A "forestry culture" is also developing in the plantation zones.

Naturally, a learning process took place along this evolution. The series of operations involved in planting – tree nursery, soil preparation, planting, plague control, branching, thinning, felling, etc. – improved and caused the real cost per hectare of planting to diminish. Knowledge accumulated on the varieties and species that better adapt to each location, type of soil, or topographical location. Another important factor was the strengthening of a "silvopastoral" regime that allows joint wood and meat production (cattle breeding) in a same area. In short, the sector's productivity increased and higher prices can now be faced for the new areas to be planted.

Productivity in the transportation system also improved. Transport is one of the most important elements in production costs. Internal transportation improved significantly; basic equipment did not even exist previously. Some measures applied by the government had a significant impact on the sector's operations, such as regulatory changes in ports, road maintenance, and railroad improvements. However, in the present second stage of development, the new processed products mean lower volumes to transport (chips or pulp instead of logs), which results in a more efficient transportation system in the sector as a whole.

Different visions of the social and environmental effects of forestry coexist. Although "green" certification was obtained for a significant portion of the main plantations, some groups have denounced their inadequacy and insist on the negative impact of eucalyptus on soils and water supply. Recently, a similar controversy has arisen concerning the installation of some industrial facilities.

Some plantations (including some of the largest firms) have suffered reduced productivity due to the inadequate selection of varieties at some locations, particularly *Eucalyptus globulus* in the Northern and Northwest areas. Such difficulties might be attributed to a lack of coordination between development of the sector and research requirements. The fast diffusion process has meant that public and private research has lagged, particularly given the context of scarce research resources and long production cycles.

The public sector played a key role in the discovery. To a certain extent, government agencies pioneered changes prior to the pioneer's first steps. The first forestry laws and some

limited public research were starting points even if they were not outward oriented and rather modest. Afterward, the state kept a clear and continuous policy through different government administrations, maintaining the necessary stability for the installation of large firms.

In the forestry sector as well as in the wine sector, public intervention was strong, aiming at restructuring of the sector in each case. Its impact was limited in terms of achieving a sustained growth path in wine exports. Some relevant features that might explain the different export paths in forestry and wine include: the dependence on domestic and regional markets (wine), the grade of product differentiation (origin and brand), and the presence of FDI (negligible in the wine sector). FDI in the wine sector probably could have contributed to its international insertion.

A conclusion appears to be that it is not enough to have a natural comparative advantage with respect to the destination markets. Competitive advantage is also relevant, particularly in the case of differentiated products. And the previous existence of a domestic market might not always be an advantage.

Finally, Table 4.3.6 outlines the main market failures, public goods, and incentives associated with the forestry discovery.

Table 4.3.6
Market Failures, Public Goods and Incentives in the Forestry Discovery

Public Goods	Market Failures: Externalities	Market Failures: Coordination Failures	Public & Private Instruments (and starting date)	Impact
- Natural conditions (PRE)*	- Agglomeration economies	-Limited infrastructure (roads)	- Second Forestry Law, 1988 (subsidies and tax exemptions).	High
- Macroeconomic stability (PRE)	-Local knowledge spill-over	- Deficit of specialized professionals and researchers	- Forestry General Direction,	Medium
- Agronomy Faculty research and specialized professionals (PRE)	-Silvopastoral system	- Week coordination among research institutions and the enterprises	-Forestry policies continuity	High
-Knowledge from previous forestry (PRE)	-Demonstration effect and spill-over from FDI	- Scarcity of long-term financial resources	- PACPYMES, wood industry cluster, 2006	Still none
- Infrastructure (roads, port, railways)	-Potential environmental impact (negative)		-Specific benefits to cellulose pulp mills, 2004 (free trade regime)	High
- Reform of the National Port Administration			- PRENADER	Low
- INIA research			- Different studies and advisories about sector development, 1963	Medium
- Investment Law			-IO' support, 1989 (BROU loans)	Medium
			- LATU-JICA's research on forestry products and industrial process, 1996	Low
			-PPP** National Port Administration reform, 1991 (specialized port operators)	High
			- Vertical integration, 1990	High
			- Forest R&D by MNCs, 1990s	Medium
			- Suppliers network development (sowing, management, harvest and logistic), 1990	High
			- Environmental certifications (FSC), 2005	Low

* Pre = available at pre-discovery stage. ** PPP: Public-Private Partnership

Table A.4.1- Uruguayan Wood Exports by Country
(US$ thousand)

	1990	1999	2000	2001	2002	2003	2004	2005
					RAW LUMBER			
European Union	**2,872**	**32,284**	**36,451**	**37,159**	**40,198**	**52,527**	**70,667**	**82,441**
- Spain	958	21,537	27,759	27,506	24,448	26,947	30,366	33,553
- Finland, Norway and Sweden	0	8,769	8,690	9,650	12,798	17,063	27,040	39,554
NAFTA	**0**	**0**	**3**	**0**	**20**	**32**	**4**	**1,092**
- USA	0	0	3	0	3	6	1	1,092
Asia and Africa	**588**	**604**	**1,459**	**1,001**	**3,156**	**7,204**	**15,912**	**33,892**
- Japan	0	0	0	6	0	0	6,123	22,104
- Viet Nam	0	0	0	0	14	89	1,824	4,427
- Morocco	588	604	1,459	995	3,028	6,020	7,942	7,357
Latin America and Caribbean	**0**	**1,208**	**2,261**	**2,505**	**241**	**699**	**589**	**687**
- MERCOSUR	0	1,208	2,261	2,398	216	635	532	687
Export Free Zones	**0**	**0**	**0**	**1**	**0**	**0**	**5**	**0**
TOTAL RAW LUMBER	**3,460**	**35,870**	**40,174**	**40,666**	**43,615**	**60,462**	**87,177**	**118,112**
					SAWN WOOD			
European Union	**210**	**2,893**	**1,465**	**884**	**1,657**	**1,768**	**1,933**	**1,765**
NAFTA		**5,563**	**4,106**	**3,671**	**4,090**	**7,367**	**11,975**	**16,947**
- USA		5,212	3,768	3,400	3,726	6,243	10,506	1,544
Asia and Africa		**849**	**1,605**	**1,774**	**2,395**	**2,375**	**3,133**	**2,102**
Latin America and Caribbean		**168**	**520**	**900**	**1,253**	**1,321**	**1,254**	**2,376**
- MERCOSUR		168	117	16	60	49	51	571
Export Free Zones		**0**	**1**	**1**	**214**	**0**	**18**	**80**
TOTAL SAWN WOOD	**210**	**10,109**	**7,697**	**7,230**	**9,609**	**12,831**	**18,313**	**23,270**

Source: Customs export data.

Table A.4.2- Uruguayan Wood Exports by Firm
(thousands of dollars)

	1990	1999	2000	2001	2002	2003	2004	2005
				RAW LUMBER				
Balerio		53	340	680	127	683	479	526
Foresur		8,729	8,799	2,899	2,063	2,141	3,048	9,916
Grupo Forestal		-	-	-	-	-	2,032	8,801
Grupo Otegui	1,634	10,711	9,548	7,784	10,493	14,958	24,370	25,214
ENCE		12,850	17,329	20,264	20,572	26,943	32,417	42,532
Metsä-Botnia						15,094	24,533	29,177
Other	1,826	3,526	4,158	9,039	10,360	643	298	1,946
TOTAL WOOD IN ROUGH	**3,460**	**35,870**	**40,174**	**40,666**	**43,615**	**60,462**	**87,177**	**118,112**
				SAWN WOOD				
Balerio		5,454	4,200	3,879	4,158	4,991	6,959	6,617
Industrias Forestales Arazatí		285	153	267	711	755	854	594
Grupo Otegui	210	26	2,116	1,956	3,517	4,258	6,308	9,131
ENCE		3,514	79	16	50	710	1,794	3,901
Other		830	1,149	1,112	1,173	2,117	2,398	3,027
TOTAL SAWN WOOD	**210**	**10,109**	**7,697**	**7,230**	**9,609**	**12,831**	**18,313**	**23,270**

Source: Customs export data.

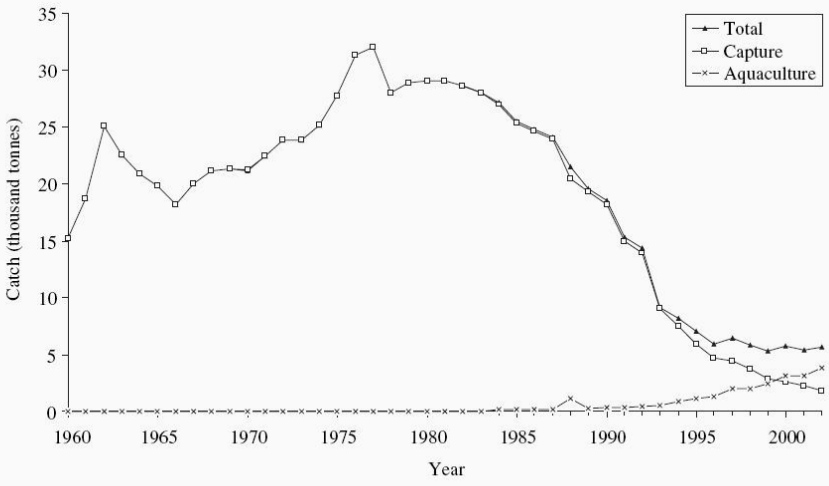
4.4 The Caviar and Sturgeon Case

4.4.1 Introduction

Sturgeon farming is a new activity in Uruguay. Black River Sturgeons S.A. proudly claims to be the only farm producing legitimate Osetra Malossol Caviar and sturgeon meat in the southern hemisphere. Created in 1995, the firm is now growing fast and developing a new project that is expected to increase tenfold the firm's present production level. At least another two firms are waiting for the authorization of the governmental agency for agricultural resources (Dirección Nacional de Recursos Acuáticos, DINARA) to start their own farms.

The main processed product from sturgeon fishery is caviar.[77] The other important processed product is sturgeon meat (smoked, frozen, or marinated). The evolution of the world catch volume of sturgeon and paddlefish (from fisheries and aquaculture) has shown a constant and remarkable decrease since 1978 (Graph 4.4.1).

Graph 4.4.1
World Catch of Sturgeon and Paddlefish, 1960-2002



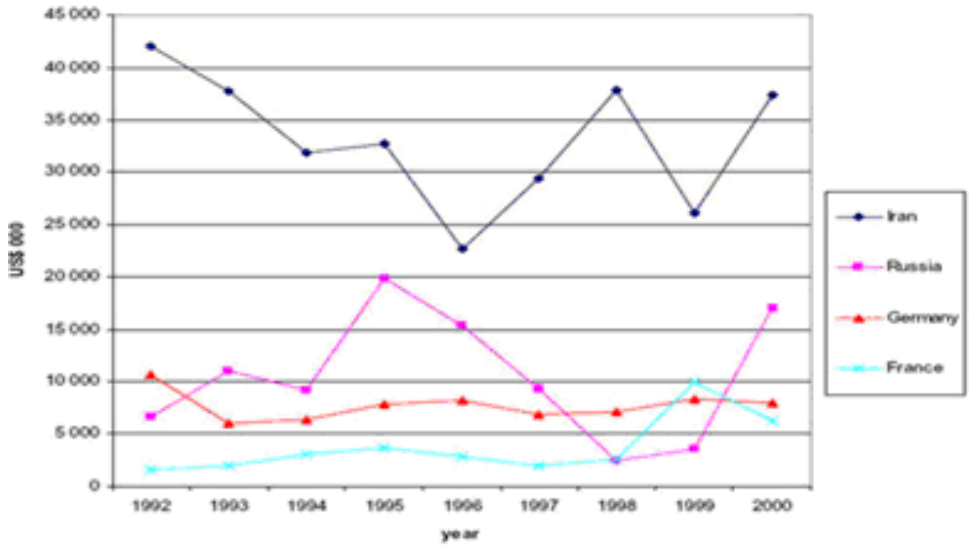
World catch of sturgeon and paddlefish (Source: FISHSTAT Plus, Fisheries Data Analysis Software for Windows, FAO, Rome).

[77] Caviar is the processed salted roe of various species of fish, most notably sturgeon. It is sold throughout the world as a delicacy. The name "caviar" comes from the Persian word "Khāg-āvar," which means "the roe-generator." In Persian this name means both the sturgeon and its product, the roe. Today, the best caviar comes from sturgeon fished from the Caspian Sea by Azerbaijan, Iran, and Russia. The highest prices are paid for the Beluga, Osetra, and Sevruga varieties. The Russian word "malossol" on the label ("little salt") indicates that it has been processed with a minimum amount of salt. Caviar contains typically 4–8 percent salt, and less in the best varieties (http://en.wikipedia.org/wiki/Caviar).

Many years of river pollution and overfishing have caused the sturgeon to become an endangered species. Since 1997 this species has been protected and export quotas have been set in the framework of the Convention on International Trade in Endangered Species (CITES).

The main caviar producers in the world are four states bordering the Caspian Sea: Russia, Iran, Azerbaijan, and Kazakhstan. The main exporters are shown in Graph 4.4.2.

Graph 4.4.2
Export of Caviar by Main Countries, 1999-2002
(US$ thousand)



Sturgeon are farmed mainly in Russia, Iran, the United States, France, Italy, and China, and there are at least 12 farms worldwide. Production is rising by substitution of farm-raised for fished sturgeon.

Total world imports of caviar increased from 243 metric tons (MT), representing a value of some US$13.8 million in 1976, to 488 MT (US$80.95 million) in 2000 (FAO, no date). The main importing countries in 2000 were:

- United States, with 90 MT (US$22.1 million)
- France, with 36 MT (US$15.9 million)
- Germany, with 34 MT (US$15.7 million).

There are differences between global production and import records, mostly due to non-reported fisheries. Some reports indicate non-reported captures to be about five times those officially reported.

In spite of large increases in imports, caviar demand exceeds supply and scarcity has caused prices to rise. Prices also differ according to the type and quality of species (Table 4.4.1). Today, the market has incorporated yet another parameter that takes into account whether the caviar comes from captured or farmed fish.

Table 4.4.1
Caviar Prices in 2004, from an Internet Survey
(US$)

Product name	Species	Price (US$/oz)
Beluga	Huso huso	50-150
Osetra	Acipenser guedenstaedtii	37-90
Sevruga	Acipenser stellatus	25-80
White	Acipenser transmontanus	28-32
Paddlefish	Polyodon spathula	11-38
Hackleback	S. platorynchus	11-38
Baerii	Acipenser baerii	30-40
Persian	Acipenser persicus	75
Salmon		2-14
Whitefish		2-10
Trout		4-16
Bowfin		17

Source: Pikich et al. (2005).

Uruguay is rich in fresh water resources such as rivers and lagoons, many of which are used for agriculture. A non-polluted environment with a temperate climate also contributes to a favorable scenario for aquaculture. There have been several government resolutions to promote aquaculture as a productive activity and some public research has also been undertaken in this field. Nevertheless, this sector is not yet well known or attractive to local entrepreneurs.

Uruguayan agricultural firms are conservative in many ways. New kinds of businesses and innovations are not always welcome, and a long demonstration period is often required. Traditional activities are mostly of an extensive nature and involve low-skilled labor. In contrast, aquaculture is capital intensive and requires specific technologies and skills, and the return on investment is to be expected in the long run.

In 1975, the National Fisheries Institute (INAPE) was created (law 14.484[78]); it was later reformed as DINARA, a department of the Ministry of Cattle, Agriculture, and Fisheries (MGAP). Among other objectives, INAPE was expected to study and promote all forms of aquaculture. The law stated that fisheries should comply with health and quality regulations, both in products and processes. Aquaculture, including all kinds of related activities and species, was decreed to be "of national interest" in 1996, a condition that provides investment projects with a series of tax exemptions (see Investment Promotion, Section 2.4). Any firm with a commercial purpose must present a detailed project to DINARA for evaluation.

DINARA owns two aquaculture facilities where it researches and breeds some species as a way to promote this activity:

- "Centro de Investigaciones Pesqueras y Piscicultura" in Villa Constitución in Salto
- "Estación de piscicultura de Laguna del Sauce" in Maldonado.

The bred species, which are sold to private firms, include: Catfish (*Rhamdia quelen*), Carp (*Cyprinus carpio* and *Ctenopharyngodon idella*), Pejerrey (*Odonthestes bonariensis*), "Madrecita de agua" (*Cnesterodon decenmaculatus*), Yacare (*Caiman latirostris*), and Australian blue lobster (*Cherax cuadricarinatus*).

The Veterinary School of the public university (UDELAR) also has a fishery research center (Instituto de Investigaciones Pesqueras, IIP) that hosts an aquaculture area. Breeding, reproduction, and farming processes of selected species are studied, as well as products and production methods. Some work on sturgeon reproduction and sturgeon meat industrialization has been done, the results of which were published after the first mover had started production.

[78] See http://www.parlamento.gub.uy/Leyes/Ley14484.htm.

4.4.2 First-Mover Black River Sturgeons

Esturiones del Río Negro S.A. (trademark: Black River Sturgeons, BRS) began its activity in 1992 on behalf of Mr. Walter Alcalde (1933–2003). At present, his four sons manage the company. The Alcalde family also owns another company, Marplatense S.A, which is located in the Port of Montevideo and has been operating for about 40 years. In addition to selling sea products, this company used to provide catering to the Russian fishing fleet and take care of their scientific boats while they were in Montevideo. One day, at the end of the 1980s, an officer of one of these boats told Mr. Alcalde that a satellite study undertaken by Russian scientists showed that Uruguay was the best location in the world outside Russia for sturgeon breeding. The relevant characteristics in support of this result were latitude, water temperatures, climate, and, mainly, water quality.

Mr. Alcalde, motivated by this opportunity and the coincidence of several favorable factors, started to look for possible locations in the country as well as for Russian breeding technology. He found Baygorria, on the Rio Negro River, to be the best place in Uruguay to locate a sturgeon farm. He then hired Russian professional advisers and opted for breeding the Siberian Sturgeon (*acipenser baerii*). Experimentation started in 1990.

The selected location gave the project an almost perfect environment for sturgeon breeding, with the following key elements:

- Water came from Baygorria's Dam, with basaltic ground, free of all kinds of contamination and pollution.
- Water flowed with no energy requirement. Sturgeon need well oxygenated (flowing) water and a farm needs a significant water flow. If that flow were energy-consuming, costs would be too high.
- BRS's water consumption was marginal compared with the river flow.

In the words of Mr. Alcalde's son: "After the fall of the Soviet Union, the KGB-controlled technology for producing caviar finally emerged from Russia in the early 1990s" (http://www.caviaruruguay.com.uy). This, together with the natural resource endowment and the initial satellite information, were the key factors that opened a window of opportunity for the discovery.

There were also some reinforcing elements, such as:

- The former Soviet Union countries offered by that time assets and materials at prices more affordable than ever.
- The availability of experienced technicians.

BRS imported sturgeon farm equipment from Russia. The complete equipment for breeding sturgeon, from the egg to the adult phase, was bought from a former Russian aquaculture farm. The farm was finally set up in 1995 with the assistance of technicians from a Russian laboratory in Astrakhan. The Alcaldes learned almost all there was to know about sturgeon farming, including their dietary habits and how biopsies determine the best time to extract the roe.

Commercial caviar production began in 2001, and exports have grown rapidly since then (Table 4.4.2). DINARA reported 12-month production of 180 kg of caviar in 2000-01, while in 2002 production reached 1,200 kg for the whole year.

Table 4.4.2 - Evolution of BRS Exports

		2000	2001	2002	2003	2004	2005
Caviar-roes	US$	0	6,000	154,892	117,038	516,489	907,133
Meat	US$	3,150	6,900	6,115	10,193	0	3,850
Caviar-roes	Kg	0	13	343	236	999	1,621
Meat	Kg	300	850	555	1,312	0	500
Caviar-roes	US$/ Kg	-	461.5	451.6	495.9	516.8	559.3
Meat	US$/ Kg	10.5	8.1	11.0	7.8	-	7.7

Source: Processed data from Customs (DNA) – Uruguay.

Main Uncertainties Faced and Solved by BRS

Despite these favorable conditions, the pioneer firm faced a number of problems and risks in project implementation. Uncertainty and experimentation costs were significant. BRS progressed step by step, finding a solution for each problem that emerged:

- The initial investment had to be undertaken without any prior sturgeon farming experience because all the farm equipment had to be properly installed before the arrival of the first eggs.
- Sturgeon females were expected to need 12 or 15 years to mature in terms of reproductive capacity to produce roe. This was a long waiting period, especially considering that it involved handling a breed that was completely new, not just to the Alcalde family but to all of the Southern hemisphere. Walter Alcalde decided to face that risk. Later, it turned out that female Siberian sturgeon in the Uruguayan environment were able to produce caviar at a younger age than their counterparts in the Caspian Sea. Five-years-old females now reach 8-10 kg, which means about a kilo of caviar.
- Equipment imported from Russia was not initially fully functional in the Uruguayan environment (due to weather conditions, local predators, etc.). An adaptation period (and investment) was required.
- There was no local provider of food of a guaranteed quality level for the sturgeon. To lower the risks associated with feeding requirements and specifications, BRS decided to build its own mill, located in Durazno, the closest medium-size city to the farm. Of course, this increased the complexity of the project, the capital needs, and thus the risk assumed.
- All alevins (i.e., young fishes) obtained from the first eggs imported died because of air micro-bubbles in the water. These bubbles caused the alevins to float, preventing them from feeding themselves. This problem needed to be properly understood and solved before new imports could be ordered. A solution was found from an inexpensive Canadian method.
- Sturgeon must be managed with care; stress can kill them. It is also necessary to classify them regularly by size to give slower-growing sturgeon the

opportunity to eat. This required a learning period, as well as motivated and trained people.

- Early sturgeon classification by sex is also very important. Males are only used for their meat, while females will produce caviar and meat as a by-product. Mature females will produce caviar that represents about 10 percent of their live weight.
- A critical problem was that sturgeon did not reproduce in Uruguay's natural environment. Research was needed to find the hormonal supply, which finally succeeded.

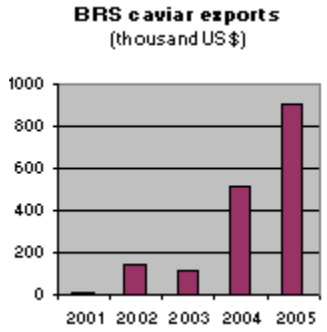
Finally, the sturgeon species was new to DINARA, and its introduction to the Uruguayan waters was seen as entailing a potential risk. The first step taken by DINARA when evaluating the project was to consult with other regional authorities. Initially the result was not favorable for BRS and the authorization was thus delayed. Finally, DINARA approved the importation of sturgeon eggs. Subsequent authorizations were time-consuming as well. For example, the request for industrial and commercial activities was submitted by BSR in August 2000 and was resolved by DINARA only in July 2002 (http:// www.presidencia.gub.uy/resoluciones/2002071904.htm).

BRS's Strategy

Mr. Alcalde's determination was strong, and he pursued an aggressive strategy (Graph 4.4.3). BRS, his dream, would not only be an experiment to reproduce a fish or produce any kind of caviar: it was created to produce top-level caviar in a high-quality, sustainable environment. And indeed, BRS proved to be a great success. Demanding caviar consumers and retailers consider Uruguayan caviar an excellent product. However, by the early 1990s, total investment—before any commercial result was obtained—had already climbed to some US$3 million.

Graph 4.4.3
BRS project development

2006 new 10 Tons project
2003 Management improves
2001 First caviar exports
1998-2000 International promotional campaign
1995 Creation of BRS and farm
1990-1994 Feasibility study, extensive learning in Russia and hiring of Russian experts



The pioneer had to make decisions and undertake a number of activities and procedures to develop a high-quality product. It was decided to harvest caviar by killing the fish (instead of by caesarian) to ensure top-quality roe, while selling the sturgeon meat as a by-product. To the same end, BRS does not store caviar but produces it according to demand. BRS's production process standards have been approved by the U.S. government (HACCP), the European Union (PP-34), DIPOA in Brazil, SENASA in Argentina, and authorities from Chile, Japan, and other regions, including DINARA (C-34) in Uruguay. All BRS exports comply with the CITES control standards.

BRS also defined an unusual marketing strategy in the Uruguayan context, because it was based on establishing a brand of its own. The product would be distributed by top-line caviar sellers. According to Alcalde's son: "Getting the American market to accept caviar made in Uruguay took a while, but now it's considered the world's best farmed caviar." A milestone was when the prestigious firm Petrossian was unable to distinguish BRS from the best Russian caviar in a blind taste test.

The Internet is used extensively to promote and sell the Uruguayan caviar. There are several Web pages offering BRS caviar in the United States and Europe; most of them stress the quality and sustainability of BRS production (Graph 4.4.4). Prices are similar to the best farmed osetra caviar.

Graph 4.4.4 - Selected Examples of BRS Commercial Offers on the Web

This magnificent Caviar has a fresh nutty taste, medium roe size, and color ranging from light to dark brown. Black River Sturgeon Farms produces this natural Osetra Caviar under strict environmental quality control. Utilizing the expertise of famed Russian Caviar masters, Black River Sturgeon Farms yields an Osetra Malossol Caviar just right in fit, finish, and taste so find that special moment to enjoy.
http://www.costco.com/Browse/Product.aspx?Prodid =11099227&whse=&topnav=&browse=

Farmed Osetra Black River (Uruguay)
This caviar is produced by farmed Siberian Osetra Baerii. This unique sturgeon farm (Esturiones Del Rio Negro) is tucked away in Uruguay in the middle of a perfect eco-system, about a two and a half hour drive from the capital of Montevideo. The excellent environment and strict control during production give this caviar unique freshness and unparalleled quality. The caviar is hand selected/graded for its medium to large grain size, dark to light brown color and fresh nutty flavor. This graded Caviar is the closest thing to Wild Caspian Osetra, a credit to this family-run farm that embodies pride and passion.
http://www.plazadecaviar.com/farmed/index.html
price: 1 oz. USD 70

Baerii Caviar (Uruguay) or "Esturiones Del Rio Negro" is a Siberian sturgeon caviar that has been farmed in Uruguay, and is both beautiful and flavorful. This caviar is part of the Osetra caviar family, but is slightly smaller in size. Being farm raised, this caviar offers a flavor that is both pure and delicate.
http://www.daily-tangents.com/Store/Caviar.shtml
http://www.caviaretc.com/category.php?page=3&id=1
price: 1 oz. USD 72,50

BRS defined a growth strategy that required facing new investment and managerial needs. In 2003, the firm established a strategic alliance with a Swiss investor, Mr. Jacques Olle, who entered the business as a minority associate (20 percent). The management structure was also

reinforced with a professional and experienced general manager, who was entrusted with coordinating the functional/operational managers, Alcalde's sons.

At present, BRS is implementing a project to renew the breeding technology and significantly increase production capacity. Caviar production is expected to increase to about 3,000 kg in 2007 and 7,000 kg in 2008, and to continue growing until it reaches 12,000 kg/year. The project will turn BRS into the world's largest sturgeon farm. The pioneer firm does not anticipate that selling such large quantities of caviar in the future might be a problem, considering that demand is increasing.

The enlargement project, with an estimated investment of US$600,000, was declared "of national interest" in 2006. It includes the building of 40 raceways[79] that are fed by water pipes from the dam lake with a siphon system. A new breed will also be incorporated: the Caspian sturgeon, which is larger than the Siberian sturgeon.

BRS knows that some costs need to be reduced through improved performance in fields such as plant control, food-to-meat conversion rates, and energy utilization. An area to be developed is sturgeon meat processing, particularly the lines of smoked and packaged meat to reach demanding markets. Nowadays, BRS sells the meat mainly in the domestic market (30,000 kilos/year), but smoking technologies are being tested in a joint project with the Veterinary School of the public University with a view to exporting.

The company's future includes both challenges and opportunities. On the one hand, BRS faces a growing demand with a unique product. Up to now, the company had the resources to successfully position itself in the global market. On the other hand, a growing number of farms are being established in different countries and will compete in the future with BRS.

Has BRS built enough strength to face such competition? Its partners see the future with optimism. They consider that a next step in their growth strategy is technology franchising in the breeding stage, while caviar production technology, quality control, branding, and marketing will remain in their hands.

[79] Raceways are a series of tanks or ponds through which water flows continuously without being recycled. Most freshwater fish cultures employ some type of raceway.

4.4.3 Followers

In view of the success of BRS in sturgeon farming and caviar commercialization, other firms are now becoming interested in this activity. Externalities from the first-mover experience include the spread of information on the favorable environmental conditions in Uruguay for aquaculture, and the existence of a proven technology. Particularly important is the Uruguayan origin now associated with a quality product. Followers will be able to take advantage of these public goods, but they also will have to take care of them. Part of the technology (caviar production in itself) stays outside the public dominion and this could delay the diffusion process.

It is clear that a diffusion process has not yet occurred. In 2002, DINARA reported the existence of one single commercial aquaculture firm (BRS) that coexisted with other non-fully-commercial experiences, including some research activities. But there are signals indicating that the demonstration effect of BRS will soon lead to imitation.

There was one failed experiment in 2003, when another entrepreneur imported sturgeon in order to investigate the potential for breeding and reproducing the species in Uruguay's climatic conditions. Located in Maldonado, he made an agreement with a researcher from the School of Sciences of UDELAR to experiment with sturgeon reproduction. They succeeded almost at the same time as BRS did, by using a similar hormonal methodology, but some coordination failures among parties led to the sturgeon's death and put an end to the experiment.

When looking at emerging projects, there are three cases of sturgeon farming. Two of them are waiting for DINARA's approval. Apparently, their key issue is finding a location with flowing freshwater. As was mentioned, an optimal location will have pure flowing water provided by gravity force. The newly presented projects should be located in places that ensure such supply.

One of these projects is meant to be even larger than BRS. The proposal comes from experienced Iranian entrepreneurs, who plan to breed sturgeon in Uruguay because of the climatic and water conditions. Their idea is to nurse a sturgeon variety with a longer maturity period (Beluga).[80] At least 10 years will be required before commercial caviar will be produced.

[80] There exist 27 sturgeon species in the world, many of them farmed in countries with longer breeding experience than Uruguay.

The other two projects are somehow related to BRS. One of them is promoted by an ex-BRS employee. The other is backed by Swiss capital through a partner of BRS. The latter's idea is to install a farm near BRS, use the BRS breeding technology, buy BRS supplies, and process caviar in BRS's plant. The farm will obtain pure flowing water by pump.

How do these diffusion expectations affect BRS? BRS is willing to collaborate and transfer technology to other entrepreneurs in Uruguay so as to preserve the quality associated with Uruguayan caviar. Alcalde's idea is "to join forces in order to maintain a country image associated with quality." However, BRS is not willing to transfer the caviar production know-how.

In the broader field of aquaculture, two species are soon to be commercially bred in the country:

- The Australian blue lobster (*Cherax cuadricarinatus*). There are two projects in an early stage of implementation. One of them is located in Montevideo and intends to breed this lobster in waters that are warmed with energy supplied by ceramic oven cooling. The other project, Acuicultura Punta Negra (APN) in Maldonado (Piriapolis), obtained a US$50,000 subsidy (50 percent of the project cost) from the Technology Development Program (PDT) to develop an intensive system to breed this tropical lobster in Uruguayan climatic conditions.[81] APN's current production (1 metric ton/year) is being consumed in the restaurant of one of APN's owners. But the objective is to increase production in order to commercialize lobsters. Exporting know-how is among their objectives: Brazil has been seeking their advice and there is demand for alevins and breeders in Latin America because no farm has been authorized yet in the region to export this fish.

[81] APN's partners are a biologist who specializes in hydrobiology, and a gastronome who is the owner of a well known restaurant in Piriapolis. In 2000, they started looking for an aquaculture species with commercial potential in Uruguay and the region, as an alternative to emigrating from Uruguay in view of the unfavorable economic conditions. A friend told them about a TV documentary that showed a breeding farm of the Australian Blue Lobster somewhere in the region. It happened to be in Cordoba, Argentina. In the next two years, they studied the local conditions, identified a location for a pilot project, got through the legal procedures, and built the first facilities. At the end of 2002, the first breeders were imported from Miami and experimentation began with different farming methods. This entailed the adaptation and building of the required equipment because there are no suppliers of aquaculture equipment in Uruguay, and importing it is costly. APN's facilities include: 24 outdoor ponds for breeding lobsters; 300 m^2 of hothouse with sinks for lobster reproduction; a water quality analysis lab; and a small mill for producing food. See MEC/DICYT/PDT (2006).

- Tilapia, a tropical species that is bred for its meat. Industrias Serranas is investigating the viability of producing this low-cost, hardy and productive species. Alevins are imported from Brazil. The reproduction of Tilapia will soon begin as a first stage toward commercial breeding.

Perspectives for diffusion were adequately summarized by APN's biologist:

> "Non-polluted waters are abundant, as well as soils that are not suited for agriculture but adequate for aquaculture. However, the country lacks the necessary technological knowledge to take advantage of these conditions. Aquaculture is an incipient activity in Uruguay and the extent of its economic potential has not been seen yet. There are no advanced academic activities in this field. As a consequence, the local state of the art is precarious."

4.4.4 Public Response

The caviar discovery was essentially a private undertaking. However, the pioneer benefited from the general investment promotion law that provides some tax benefits for projects considered of national interest. Although most sound projects can request that status in Uruguay, it is probably easier when the sector as a whole has been declared of national interest, as in the case of aquaculture.

The public response to the BRS project, if not exactly pro-active, was at least "enabling." Indeed, implementation of the project depended critically on DINARA's approval, and use of the Baygorria Dam water supply required authorization from the state-owned energy enterprise (UTE, the owner of the dam). The government acknowledged the importance of BRS's undertaking for the country by having the Vice President inaugurate the plant.

Professional advice from DINARA was also useful in the project's early days. DINARA is responsible for most of the research on the new species to be introduced and it is now evaluating the growth pattern of Tilapia in a natural thermal water environment in the North of the country (Salto). DINARA is thus expected to be a relevant actor in the diffusion process. However, it is a fact that DINARA had been promoting aquaculture production for a long time and it was only after the success of BRS that new commercial projects have been presented to this government agency.

IIP, the research center of the Veterinary School, has carried out some applied research directly related to the caviar discovery, specifically concerning the process of smoked sturgeon meat. This should enhance BRS's capacity to introduce this high-valued, gourmet product in export markets. Meanwhile, the School of Sciences has been involved in biological issues, namely sturgeon reproduction in Uruguayan conditions. This shows some research capacities in this field, even if BRS finally solved this uncertainty on its own.

Finally, the environmental authorities are in charge of protecting the quality of Uruguayan waters. All projects with a potential environmental impact must be evaluated and eventually approved by national and local authorities. At the national level, the Environmental Department (DINAMA) of the Ministry of Housing, Public Works, and Environment (MVOPT) is the one in charge. This is essential at the country level, but also specifically to protect BRS's undertaking because a pulp mill project has been proposed for the shore of the Black River; in this case, the location will be downriver from BRS's farm with no impact on it.

4.4.5 Comparator Case in Aquaculture: The Frog Experience

Frog legs, considered a delicacy, are consumed mainly in France, Canada and the United States. By the end of the 1980s, environmental restrictions caused wild frog capture to decrease, especially in Southern Asia, the traditional capture zone. Prices thus increased and farming was seen as a business opportunity. Commercial farming of the bullfrog species[82] was undertaken in Mexico, Guatemala, El Salvador, Panama, Ecuador, Argentina, Thailand, Indonesia, Laos, Vietnam, and Malaysia, while experimental farms were set up in the United States, Cuba, and Puerto Rico.[83]

In Brazil, bullfrog farming gained popularity in the mid-1970s, when many small ventures emerged. Academic groups became involved in research in the late 1980s and developed a range of alternatives for breeding facilities and techniques.[84] These techniques were also applied in small ventures in Argentina in the 1980s, but without giving due consideration to the need to

[82] This is the species bred in Uruguay (*rana catesbeiana*).
[83] This introduction is partly based on the FAO Web site (http://www.fao.org/fi/website/FIRetrieveAction.do?dom=culturespecies&xml=Rana_catesbeiana.xml#tcN110076).
[84] Feeding was one of the main difficulties to be tackled in breeding farms because frogs instinctively hunt insects and do not feed from immovable objects, which becomes a problem when commercial volumes of production are considered. The use of flooded places with floating food supplies has now been acknowledged as the best breeding system: floating pellets move, so frogs are attracted to eat them. Supplies must have a 33 percent protein content and their origin and quality must be strictly controlled.

adapt them to the temperate climate of the Buenos Aires province where most of the farms were installed. There was no specialized agency to support these new investors, and technical advisors were not specifically educated in frog farming. By the mid-1990s, many of these small farms had disappeared. In 2005, there were six large-scale producers, with production systems that had been adapted to the specific climatic conditions through water heating equipment and air conditioning facilities.

In Mexico between 1991 and 2001, a research center (CINVESTAV) carried out a comprehensive applied research program for frog cultivation, which resulted in significant advances in reproductive physiology, nutrition, pathology, and ecophysiology. This led to the development of an inundated-type culture system that is currently in commercial use in a number of regions in Mexico and Central America.

Meanwhile, a strong frog industry developed in Asia: Indonesia and Taiwan (China) are the largest suppliers in the world (both in capture and aquaculture).[85] Brazil (200 metric tons/year) and Mexico are also among the main producers. Production in Argentina amounted to 50 metric tons in 2000, while in Uruguay it was only two metric tons. The international market is about 10,000 metric tons/year.

In Uruguay, frog breeding started in 1986, when INAPE (later DINARA) initiated studies to establish the viability of such breeding in the country. A specific project, jointly undertaken with the IIP of the Veterinary School (UDELAR), showed that frog breeding in template climate regions was technically feasible (Mazzoni & Carnevia, 1989).

First Mover

On the basis of the results obtained from the above-mentioned project, in the late 1980s a local entrepreneur decided to breed frogs and process the meat. He believed he could take advantage of exclusive technology and knowledge to grant franchises to frog breeders while he himself would concentrate on the industrialization and commercialization part of the business. Franchisees would be frog meat suppliers (with reduced bargaining power).

A farm was installed in the Northeast of Montevideo (Manga), where small amounts of frog meat (2,000 kg/year) were produced and sold in the domestic market and, to some extent, to

[85] In 2002, 15 percent of the global frog market was supplied by aquaculture as compared with 3 percent in 1980, although market statistics are reportedly scarce and unreliable.

Argentina. The producer owned two or three freezers in supermarkets and, at this low-scale production level, he was rather successful. However, he lacked the financial resources to develop his whole plan. The story eventually ended when contaminated supplies killed all the frogs. The pioneer sued the supplier for the damage and decided to retire from this business.

Similar to the sturgeon case, this pioneer had been running another firm, which gave him business experience and some financial means. But in this case, the pioneer did not solve the main uncertainties related to frog breeding and meat processing, namely:

- The non-existence of off-the-shelf technology
- The unavailability of specific inputs
- No frog slaughterhouse was set up yet
- There were no tanning capacities to process frog skins as by-products
- The production scale was very limited
- The pioneer could not franchise the breeding technology because followers could not catch up with the first mover.

Perhaps it was too early to develop the frog industry in the specific climatic conditions of Uruguay, at least without the support of technological research focusing on adapting existing technology to the domestic conditions. Perhaps the pioneer not only lacked capital, but also lacked a strategy to face and solve uncertainties. But it is a fact that the caviar pioneer faced at least the same number and type of difficulties, which he succeeded in solving, step by step. He could count on substantial family capital but when he "ran out of it," he looked for, and found, a foreign partner.

Analysis of the Followers

In spite of the meager results of the first mover, a diffusion process developed during the 1990s. Twenty-three frog farms were authorized by DINARA, and two slaughterhouses were built, one of them with the required authorization to export products. While exports from that firm to Argentina began in 1997,[86] most of Uruguay's frog failed during the 1999-2003 period. The

[86] Argentina had a similar price level as Uruguay in 2001, although the Argentine crisis of 2002 surely changed these conditions.

followers were similar to the first mover: small-scale firms using the same technology and targeting the domestic/regional market.

A first problem was climate. Bred frogs ideally grow at constant 25º to 28º temperature. Uruguayan natural conditions, with relatively cold winters, are quite different. More recent farms solved that problem by incorporating heating equipment.

Other problems faced by the first frog producers were pinpointed by DINARA in the Frog Farming Investment Guide it published in 2001. In the first place, it was stated that frog breeding was still a new activity with no common knowledge yet of the production system:

> "Though accumulated experience from the last ten years has generated abundant knowledge and proven results have been achieved at large scale and in different productive situations, the available technology has been little spread and only a very limited number of professionals know it and are able to apply it [in the country]. These difficulties are worsened due to the lack of local support services, adapted to the needs of an industrial breeding activity that implies the handling of aquatic organisms."

Specific problems included the following:

- Lack of capital to install farms of a viable production capacity. Most farms started with the minimum investment needed to acquire some experience in frog handling. After this initial phase, they had no capital to grow. And small size implies an improper balance between fixed costs and incomes.
- Lack of initial investment in a quality water supply and heating system, and underestimation of the annual operating costs.
- Underestimation of the technology and know-how needed. Frog breeding includes two very different cycles (tadpoles and frogs), each with its own complexities and risks.
- Lack of qualified human resources and underestimation of the man-hours needed. Firms also frequently recruited people with little motivation and without training.

In short, frog breeding was often considered as a handicraft business when, in fact, its specificities and requirements restrict success to undertakings based on relatively high investment[87] (and production scale), demanding technology and in-depth knowledge of the business.

In addition, the currency depreciation in Brazil in 1999 reduced production costs in dollars to one-third in that country, diminishing dramatically the competitiveness of the Uruguayan product. So, in 2001, while production costs in Uruguay were estimated at about US$9/kg for frog carcass with a selling price of about 14 US$14/kg, the Brazilian price was only US$5/kg.

At the same time, increased production in Asia caused international prices of frog legs to fall from US$10-12/kg to $5-6/kg. The Asian product also reached a high quality level, making it even more difficult for Uruguayan exports to compete. International demand existed but with certain conditions: supply must be of an excellent quality, including good packaging, sanitary compliance, certification, cold chain handling, and supply continuity. These were difficult barriers to entry to overcome for small enterprises.

Nowadays there are only six or seven frog farms in Uruguay. They produced 4 metric tons of bullfrog in 2003 and 2 metric tons in 2004, according to FAO records. In spite of this low production level and the remaining barriers to entry in foreign markets, DINARA reported a somewhat improved or healthier situation than in the early 2000s:

> "… as time passed and experience built up, frog farms installed at the end of the 1990s have been luckier than the previous ones. Several animal food importers have registered requests for frog food and there is one food producing plant in the Department of Durazno that could eventually process food for frogs. From the technological point of view, the updating of breeding systems that were developed at the pilot level, as well as the production experience acquired in the first decade of frog breeding in the country, have been helpful for those that recently integrated this activity. Frog breeders also achieved a reasonable level of coordination and

[87] In Mexico, where frog breeding developed successfully, fixed investment costs for a 36 MT/year bullfrog farm have been estimated at US$130,000 (land: US$20,000; infrastructure: US$90,000; equipment: US$16,000; and initial brood stock US$4,000); and annual operating costs, at US$67,500 (41 percent food, 31 percent labor).

cooperation, both in the productive and commercial areas, which represents a very relevant progress." (DINARA, 2001)

Public Response

The public sector played a relevant role in promoting this activity. DINARA and the Veterinary School have researched breeding system requirements and other issues. In spite of this, frog production has not yet demonstrated economic viability.

4.4.6 Conclusions

The first mover in caviar production and export found an attractive opportunity by obtaining information about the ideal conditions in Uruguay for breeding sturgeon. Walter Alcalde worked many years and invested heavily in developing a sturgeon and caviar business. Risks were assumed and a flexible and creative attitude was adopted to solve problems. Walter Alcalde's background and entrepreneurship were critical in starting up the firm.

Professional management, including strategic planning, was acknowledged as a priority to sustain growth and develop marketing. The first mover developed a growth strategy and built up an image for BRS. It uses SWOT analysis[88] and has an "image of the future" guiding it. Walter Alcalde, the firm's founder, was a leader with managerial skills developed on the basis of his previous experience. People working in BRS are motivated and dedicated.

BRS bought the best available technology and services. But it also had to adapt and develop specific procedures to breed sturgeon in Uruguay's climate conditions. BRS selected an optimal location. The state played an important role conceding land and use of the Baygorria Dam's water.

BRS is a company with family equity; but when it needed additional funding to grow at a pace to match its strategy, it did not hesitate to build up a strategic alliance. BRS is successful in exporting, but its financial surplus is not yet clear when comparing export incomes and accumulated investment during 16 years. Although the firm's investment needs were not insurmountable, they were a severe and critical condition for the pioneer's undertaking to be successful. The alliance with a foreign partner was therefore very important, providing both financial resources and market experience.

[88] SWOT: strengths, weaknesses, opportunities, and threats.

Caviar is a much differentiated product with strong marketing requirements. BRS owns its brand and has pursued an independent marketing strategy, with quality and origin as differentiation features. It probably would have been easier for BRS "to make the first move" through distributor brands, but its future would then not look so promising. BRS succeeded in penetrating the U.S. caviar market, one of the largest and most important in the world, and Uruguayan osetra is now well recognized.

BRS demonstrated that sturgeon can be bred in Uruguay with notable commercial success. The resolution of a great number of uncertainties paved the way for diffusion, which was expected to materialize in 2007. Of the three other sturgeon projects, one is directly associated with BRS and will benefit from its experience and solutions, buying specific inputs from the pioneer. However, it will take about six years or more for these new caviar projects to reach the market, due to the long breeding cycle of sturgeon. Other aquaculture species (Australian Blue Lobster and Tilapia) recently started to be bred in the country, but neither has reached the commercial stage yet.

The main triggers for the caviar discovery were Uruguay's climate and water quality. World caviar demand is in short supply because the capture of sturgeon was regulated. This provided the commercial opportunity for the discovery. The main hurdle derived from the long cycle before the market could be reached. In other aquaculture projects, the risk was in introducing foreign species, due to the need to research better breeding conditions and protect the natural environment from invasion. At this stage of the diffusion process, vertically integrated projects with know-how of their own are required.

The state did not play a pro-active role, but neither did it become an obstacle to the discovery. DINARA and the Veterinary School contributed with technical assistance and specific research.

Frog and caviar farming in Uruguay presented or faced a number of similar conditions: a new activity at the country level; a gourmet food; global market scarcity largely due to environmental restrictions; some technological research and other public goods (water supply, specialized government agency, and some research); and some investment incentives. But when at the end of the 1980s a window of opportunity opened for exporting frog meat to the global market, local producers failed to make the most of it. Among the reasons for this failure are the following:

- Lack of resources, at least for a first mover facing many uncertainties.
- Poor management and labor skills.
- Insufficient technological research to adapt existing technologies.
- Prevalent high costs, probably due to low productivity and small-scale production, which redounded in high market prices. Production should have been allocated in zones with more favorable climatic conditions.
- A marketing strategy that made frog farms dependant on domestic and regional markets. The severe contraction of the domestic and Argentine markets in the 1999-2003 crises, and the pronounced decline of Brazilian frog meat prices after the 1999 devaluation showed the limits of this strategy.
- No brands were established, no associated services, and no differentiation.
- International trends did not validate the perception of long-term scarcity. Asia's response almost closed the opportunity window, at least on the dimension it was expected to have.

The comparator case shows that enterprises must have minimum capacities related to production and technology, firm organization, and marketing in order to be able to take advantage of emerging opportunities for self-discovery.

Finally, the following table summarizes the market failures, public goods, and incentives associated with the caviar discovery.

Table 4.4.3
Public Goods, Market Failures and Incentives in the Caviar Discovery

Public goods	**Market failures**		**Public and Private Instruments** (and starting date)	**Impact**
	Externalities	**Coordination failures**		
-Water quality -Climate -DINARA (and DINAMA) regulations -Some research capacity in aquaculture and industrial processing (DINARA and Veterinary School)	-Local knowledge spill-over -Reputation of Uruguayan caviar -Demonstration effect	-Limited linkage with other sectors -Monopoly rent from caviar production technology (first mover)	-Aquaculture sector status of "National interest," 1996 - Environmental regulations, 1990 -Public-private partnership for research, 2004-2006 -Public concession of land and water use, 1994 - Vertical integration, 1995	Low High Medium High High

4.5 Biotechnology Applied to Animal Health: The Vaccines Case

One of the most significant drivers of value in the vaccine market has been the development and commercialization of biotechnology advances applied to animal health, particularly, to vaccines. This has been critical in the development of new animal vaccines and in the improvement of current ones, and it still holds great potential (Wesley, 2005).[89]

In the present decade, sales of veterinary vaccines have grown at a higher rate than that of the whole market of animal health products. In 2004, sales of veterinary vaccines represented 20 percent (US$3.2 billion) of the sector's revenue. The largest national markets are the United States (US$935 million), Japan (US$236 million), France (US$220 million), and Brazil (US$221 million). The Brazilian vaccine market is dominated by foot-and-mouth disease (FMD) products, which account for 40 percent (Wesley, 2005).

International trade of animal vaccines amounted to US$1.26 million in 2004 and has risen by 13 percent per year since 2000. The largest importers are Europe (54 percent) and Asia (15 percent). NAFTA countries (7 percent) and Latin America (6 percent) are next, while Africa (2 percent) is far behind. Exporters are concentrated in developed countries: Europe accounts for 73 percent of global sales and the United States, 19 percent (International Trade Center (ITC) of UNCTAD/WTO).

Sales are also highly concentrated at the firm level: six companies account for more than 70 percent of the market. The leader is Intervet, with sales of almost US$600 million in 2004. Trends in ownership of the global veterinary vaccine market indicate a rapid consolidation of manufacturers over the past 10 years. That trend has been driven partly by corporate restructuring

[89] "Vaccines developed using traditional approaches have had a major impact on the control of foot-and-mouth disease, rinderpest, and other epidemia viral diseases that affect livestock. But there are many other important diseases, notably parasitic diseases, for which attempts to develop vaccines have been unsuccessful. Rapid advances in biotechnology and immunology over the past two decades have created new opportunities to develop vaccines for parasitic diseases. Initial optimism in the early 1980s that vaccine products would quickly emerge from applications of recombinant DNA technology has not been fully realized. Subsequent experience has demonstrated that, unlike traditional approaches to vaccine development, effective exploitation of recombinant DNA technology requires knowledge of the target pathogens and the immune responses they induce, and an understanding of how immune responses can be manipulated. Since the early 1980s, a series of fundamental discoveries in immunology have led to a detailed understanding of how the immune system processes and recognizes pathogenic organisms, and the different ways that immune responses control infections. These advances, coupled with further developments in the application of DNA technology, now provide a strong conceptual framework for the rational development of new vaccines." (Morrison, 1999)

and, significantly, by the rising costs associated with the development and commercialization of new immunological technologies (Wesley, 2005).

Bright global prospects have been forecasted for the second half of the current decade, with sales growing at a compound annual rate of 4.8 percent between 2004 and 2009, when they are expected to exceed US$4 billion. A double-digit growth rate is anticipated for Brazil, the strongest rate among the seven major markets, while in Germany, for example, sales are expected to rise only by 1 percent (Wesley, 2005).

It is in the context of this dynamic global market for animal vaccines that a new successful activity emerged in Uruguay: the export of bacterial vaccines. The determinants of this discovery will be analyzed in what follows. We will first describe the evolution of exports and justify why we consider them a discovery (4.5.1); second, we will focus on the unsettled issue of who has been the pioneer and which uncertainties had to be solved in order to initiate exports (4.5.2.); we will then focus on the preconditions for this discovery and the public goods used (4.5.3), as well as the barriers to enter global markets (4.5.4). Finally, we will examine the coordination failures not yet overcome and the extent to which these might explain the absence of a diffusion process (4.5.5). A comparator in the form of "new biotechnological firms" will further allow checking the consistency of some of our discovery findings (4.5.6). And last, conclusions will be drawn (4.5.7).

4.5.1 A Uruguayan Export Discovery: Bacterial Vaccines

Uruguay's specific needs in animal health, namely against foot-and-mouth disease (FMD), have been an incentive to produce vaccines as early as the 1950s. The accumulation of local scientific and technical capacities in animal health and the presence in Uruguay of two of the largest multinationals in this field generated the conditions under which this demand for vaccines could be met. Although some limited exports took place in the 1970s and 1980s,[90] as long as domestic demand existed for FMD vaccines, there were no real incentives to export. Indeed, in a country with 10 million heads of cattle to be vaccinated regularly, FMD represented a huge and safe market, providing very high returns on capital. It is probably one of the few cases in which the Uruguayan domestic market was not limited in size. Furthermore, the absence of exports can be

[90] Some exports of FMD vaccines musts have taken place in the 1970s because Chile used, for its eradication campaign, "an aqueous vaccine of guaranteed quality, mainly produced in Uruguay" (Sutmoller et al., 2003).

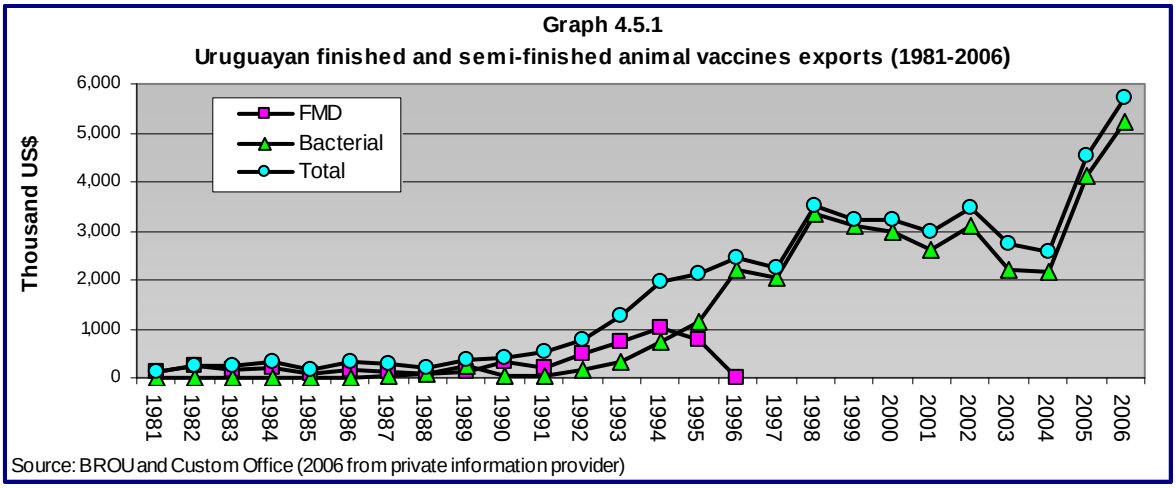
related to the multinational strategies at the time—a subsidiary for each domestic market—and to the untimeliness of an export-oriented investment of a local company as will be further explained.

In 1996 Uruguay was declared "free of FMD without vaccination" by the International Organization for Animal Health, a very important label in the global meat markets. In order to obtain this status, the government had decided two years earlier to discontinue vaccination. Simultaneously, handling the disease's live virus was prohibited for security reasons,[91] which meant the end of FMD vaccine production in the country.

These events contributed to a turning point in the mid-1990s in the shaping of the present Uruguayan vaccine sector, as can be observed from the evolution of exports in Graph 4.5.1. On the one hand, multinationals lost interest in Uruguay with the disappearance of the domestic FMD market. However, the closing down of multinational subsidiaries in the country was not an isolated fact in the vaccine sector. It was rather in line with the strategy applied by the pharmaceutical multinationals in a period in which MERCOSUR had changed some of the rules of the game:

> "Around the end of the 1980s and the mid-1990s, the macroeconomic situation brought about a change in the multinational companies' strategy. The increasing openness of the markets and the need to undertake technology investments, in addition to the limited size of the national market, led to the relocation of production plants at the regional level. Transnational firms closed down their plants in the local market and limited their operations in the country to selling products that were imported from neighboring markets (Argentina and Brazil)." (Bértola et al., 2004, p. A-20)

[91] The decision followed an international technical assessment of the existing bio-safe conditions in the country for handling the FMD virus.



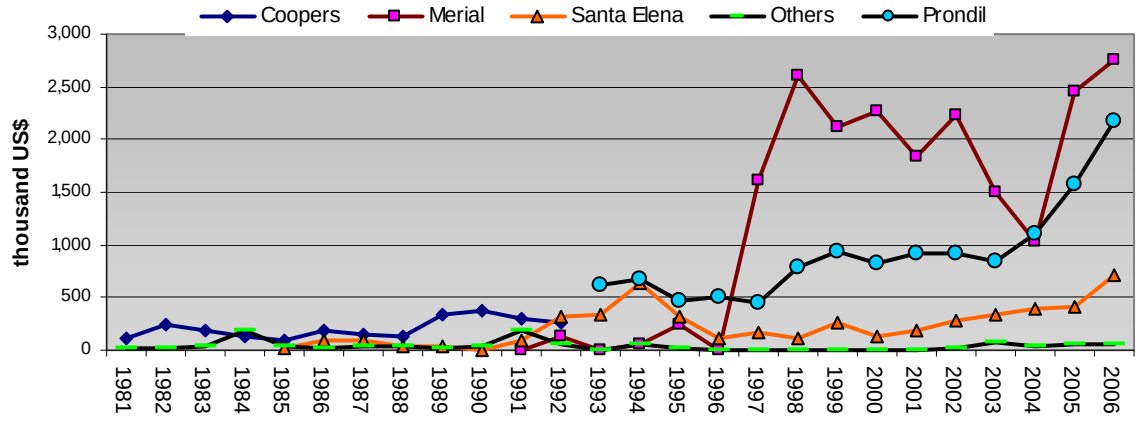
On the other hand, projects to produce other animal vaccines took shape and led to an "export discovery." Between 1995 and 2006, exports grew at a cumulative annual rate of 9 percent, reaching US$5.5 million, mainly including bacterial vaccines (Graph 4.5.1). These booming exports show how the country took advantage of technological, productive, and commercial capacities to respond to a negative demand shock (caused by the suspension of FMD vaccination) by seizing opportunities in a related field, although with different technological features and markets.

Market opportunities in different developing regions—Africa, the Middle East, Asia, and Latin America and the Caribbean—were an essential export trigger. These opportunities were strongly related to the lower price of Uruguayan vaccines in comparison with more-developed-country vaccines. Considering that regulations (norms, product trials) in the importing countries supposedly guarantee the effectiveness of the product, lower production costs mean a substantial advantage for Uruguayan producers, at least when exporting to those countries that cannot afford the prices fixed by multinationals.

Only three firms located in Uruguay have produced and exported bacterial vaccines in the past ten years: a branch of a multinational firm and two local companies (Graph 4.5.2). One of them is Laboratorios Santa Elena. It was created in 1957 by a small group of researchers of the Veterinary School of the public university, to produce animal health products, including vaccines. In spite of poor managerial skills, this family enterprise quickly found its way in a market with

little competition at the time. Its clients were veterinarians, cattle breeders, and traders from the countryside.[92] Although primarily focused on the domestic market, the firm developed its first export project in the mid-1980s. But it is from 1995 to the present that exports intensified. Bacterial vaccines, namely against anthrax and clostridia diseases, and viral vaccines (against rabies and eye diseases among illnesses) were exported to Latin America and the Caribbean. Bacterial vaccines now account for the main share of Santa Elena's vaccines exports, which reached US$720,000 in 2006. Since 2004, small amounts of them are sold to Middle Eastern markets. Santa Elena recently invested US$2 million to recycle an earlier "FMD laboratory" with a view to substantially increase exports.[93]

Graph 4.5.2
Uruguayan finished and semi-finished animal vaccines exports by firm, 1981-2006



Source: BROU and Custom Office (2006 from private information provider)

The other local firm is Prondil. It was created in 1992 by a group of former employers of the local subsidiary of the world leader in animal health multinationals, Coopers, which withdrew from the Uruguayan market in 1991. Prondil's capital is entirely national and totally independent of the multinational. The firm immediately targeted the global market, knowing that the national market could not on its own justify production. FMD vaccine production, the previous bulk of Coopers' production, was no longer an alternative. Initially, Prondil built on earlier marginal

[92] Santa Elena's history is related in Snoeck, Sutz, and Vigorito (1991).
[93] The firm's annual turnover exceeds US$3 million (US$3.4 million in 2002) and biological products now represent about 60 percent of it.

businesses of Coopers in South Africa and maintained some commercial relations with Coopers' head office. But the firm quickly developed new products so as to generate an independent business. A strategic decision was made to specialize in two lines of bacterial vaccines (clostridia and anthrax vaccines) on which it would focus its technological and commercial efforts. Total vaccine exports reached US$2.2 million in 2006 and represent around 85-90 percent of Prondil's sales. Destinations include the Latin American and Caribbean region as well as African markets (82 and 68 percent of total exports in 2003 and 2005, respectively[94]). There are, as well, additional prospects for development of export markets.

The third producer is Merial-Uruguay (formerly Interifa).[95] Atypically, this multinational subsidiary survived the wave of closures of most of the regional branches of multinationals in the 1990s. In 2006, its vaccine exports amounted to US$2.8 million, about 50 percent of the firm's turnover. Export destination often responds to inter-company agreements. Latin America (mainly Brazil) is the main market, but Africa has also been targeted. Merial-Uruguay has been exporting for several years to Botswana and is now ready to enter the North African market and some Asian countries. The increasing external demand for the firm's vaccines led to a recent US$2 million investment to expand production capacity (up to 50 million hexavalent doses per year). The export share in the firm's turnover is expected to increase from 50 to 60 percent in the near future.

These domestic perspectives of increasing exports seem to line up with the global situation of the vaccine sector. The literature points out that, in the future, many vaccines are likely to be produced in developing countries, or at least will be region-specific, which will in turn impact decisions on capacity and market size. The vaccine industry is changing, moving from consolidated global manufacturers to a new breed of developing country manufacturers that reach high standards of excellence (Milstein and Candries, 2001).

[94] Although the firm exports to six African countries (South Africa, Morocco, Kenya, Zimbabwe, Zambia, and Rwanda), its main market is South Africa. The latter represented 54 percent of total exports in 2003-05, and Prondil has a majority market share in this country for the type of vaccines it produces.

[95] Merial-Uruguay, created in 1962, is a subsidiary of the French animal health multinational of the same name. In the early 1960s, attracted by the potential FMD vaccine market in this cattle raising part of the world, the multinational Rhône Merieux (later Merial) decided to be present in Argentina, Brazil, and Uruguay. From the 11 FMD vaccine producers in the country in the 1960s, only four survived in the 1970s and 1980s, all subsidiaries of foreign companies. Merial was one of them.

Summing up, the new bacterial vaccine exports of Uruguay are a "discovery" because they represent a successful export activity that recently emerged and experienced strong growth, going from basically zero to becoming significant for the country, considering that figures are observed at the 6-digit classification. The key reason for targeting these exports arose from the need and low opportunity cost to replace FMD vaccines when local production of these vaccines was prohibited. The choice of this new export activity was made easier by the prior technological, productive, and commercial knowledge about animal vaccines accumulated by the former FMD vaccine manufacturers. Uncertainties concerning local production costs were thus considerably reduced and, as we will see in the next section, this heritage played an important role in the success of the new activity; however, it did not spare firms from facing other ex-ante uncertainties regarding the profitability of exporting bacterial vaccines.

In more general terms, what the country discovered was the capacity to continue exploiting a comparative advantage indirectly related to the important livestock of the country. Indeed, comparative advantage in FMD vaccine production was closely linked to Uruguay's competitive meat production, and bacterial vaccine production internalized the benefits from the learning trajectory of the former.

4.5.2 The Pioneer Issue and Uncertainties to Be Solved

According to Hausmann and Rodrik (2003), the discovery process for new export activities requires a "…pioneer investor who signals to other investors the profitability of these new activities." The present case is not a typical discovery of that kind because there was not a single firm that discovered the underlying cost structure of the new activity. Instead, three firms discovered simultaneously the profitability of producing bacterial vaccines for export. Indeed, the vaccine exports of Merial, Santa Elena, and Prondil started at the same time, i.e., in 1996 (see Graph 4.5.2), and the products belonged to the same production line, namely, bacterial vaccines. However, the destination markets were different: the first two exported mainly to countries in Latin America and the Caribbean, and the latter additionally to South Africa.

In this case, the pioneers were not savvy investors looking for broad opportunities but rather prudential discoverers looking to exploit close and accessible opportunities. Discovery thus entailed low-cost activities, as firms jumped from one product to another with no need for a knowledge breakthrough at the firm level. However, even if bacterial vaccines were not new

developments, their production and export involved a degree of uncertainty. What uncertainties were resolved in the discovery process? Did each firm accomplish the discovery separately? Or was it the result of synergy and collaboration between firms? To answer these questions, it is necessary to inquire into the individual responses to the negative demand shock associated with FMD eradication.

Until 1995, Merial-Uruguay focused on the domestic market, but things changed drastically with the prohibition on producing FMD vaccines in the country:

> "When production had to be stopped, we experienced the same as any company that would lose its 'battle horse': production had to be completely restructured since we had no product, neither biological nor chemical, with the same weight as the FMD vaccine. At that critical moment, we laid a wager on our professional background in biology and bacteriology. We had some experience in the production of bacterial vaccines, but it was still of a craft industry type. So we asked for financial and technological resources from Merial's headquarters to shift to the industrial production of bacterial vaccines. Quality was the factor that helped us gain the confidence of headquarters. The (quality) control system we use led us to become important not only in Uruguay, but also in the regional market. Merial closed its biological production plants in Argentina and Chile and only kept the Brazilian and Uruguayan plants, the latter one to produce for the whole region." (Interview with Merial-Uruguay's manager, July 25, 2006)

Bacterial vaccine production was not totally new to the firm at that critical moment. A former manager of Merial-Uruguay, now retired,[96] stressed the knowledge accumulated by the firm in that field since the 1980s:

> "In the mid-1980s, we sent a vet of the firm (the present manager) to study biology in France. After his master's degree in biology in Lyon and in the Pasteur Institute, I told him that we had to deepen our knowledge about bacterial vaccines. So he prolonged his stay in Pasteur and then spent some time in Merial's laboratory in

[96] A veterinarian with a profound vocation for biology, who studied in the 1950s in the laboratories of the precursors in FMD vaccines, like Frenkel in Holland and Merieux in France, and in 1962 founded Interifa (a Merial subsidiary) in Uruguay. He developed FMD vaccines according to the French tradition.

> Toulouse where he acquired know-how on anaerobic vaccine production. We thought these vaccines were commercially profitable because they attended many disseminated diseases and were very difficult to produce." (Interview, September 20, 2006)

This was particularly relevant considering that the risk involved in biological production entails a long process of knowledge build-up:

> "Biological training is a much more complicated issue than chemical or pharmaceutical training. Several years of specialized training after the basic university education are required before one can claim to be biologically trained. This is because of the high uncertainty associated with working with living beings." (Interview with Merial-Uruguay's present manager, September 20, 2006)

Four main elements guided Merial's parent company in the decision to restructure the local firm toward the production of bacterial vaccines (mainly against anthrax diseases): regional commercial opportunities for anthrax vaccines; the good quality level of the Uruguayan local anthrax vaccine compared with the Argentine and Brazilian ones; the adequate conditions offered by the Uruguayan subsidiary to upgrade technical and productive procedures so as to replicate the French anthrax vaccine; and the thrust established between the parent company and its Uruguayan subsidiary, based on long-term relationships, technical exchanges, cultural affinities, etc.

In short, signals on bacterial vaccine profitability were provided by the parent company as well as the physical and financial resources needed to restructure Merial-Uruguay. But also important was the accumulated local knowledge that allowed the quick implementation of the new line of production once FMD vaccine production ceased.

In the case of Prondil, its director clearly referred to Coopers' legacy when asked about the initial strengths of the firm:

> "In the first place, Prondil has a solid educational base, which derives from integrating professionals who had worked with Coopers, a highly renowned leading enterprise in animal vaccines. The British were pioneers in this field and Prondil succeeded in capitalizing on Coopers' legacy through its founders who

had been working for a long time with the multinational. In addition to the human resources strength, the inherited technology also was important in the first stage. Although some of Coopers' technology still remains in the laboratory, Prondil has gone much further and has developed many things that did not exist in Coopers' time. Local developments took place, some internally and others with the assistance of external resources, like some projects carried out with the Biotechnology Department (School of Medicine of the public university). (…) On the commercial side, Prondil took advantage of having been closely related to Coopers' trajectory. This opened doors to some of Coopers' clients who already knew people at Prondil, because they were the same ones who carried out Coopers' businesses. These were the first steps, the most difficult ones." (Interview with Prondil's director)

As in the case of Merial, bacterial vaccine production was not totally new to Prondil. A retired veterinarian and former technical manager of Coopers[97] pointed out that in the late 1950s, Coopers-Uruguay hired a researcher, who was a professor in microbiology of the Veterinary School and technical assistant in the state owned *Laboratorios Rubino*, to develop bacterial vaccines. In the following years, the latter led a team that carried out important technological developments in bacterial vaccines; however, in the 1960s the main business of Coopers-Uruguay was related to the FMD vaccine, which represented 70 percent of total sales. When Coopers closed its Uruguayan subsidiary, two junior members of the "bacterial research team" participated in Prondil's creation and helped transfer the accumulated knowledge from one firm to another.

Hence, to a large extent, Prondil's discovery was based on signals it received from the multinational from which it was created. Coopers provided information on the profitability of the vaccine business and the new firm inherited the laboratory, tacit and codified technology, and some clients.[98] The main barrier to entry that Prondil initially faced in foreign markets was the

[97] He was a researcher who had been experimenting since 1946 in FMD vaccine development in the state-owned Laboratorios *Rubino*. He was hired in 1952 by Coopers-Uruguay to further develop this vaccine. He adopted Frenkel's FMD technology and developed the vaccine according to the English tradition. In 1954, the first FMD vaccine of this type was registered in Uruguay. The local branch of Coopers became in the next 15 years the main laboratory of the multinational's experiments on the vaccine's performance. (Interview, November 10, 2006)

[98] During a few years after Prondil's creation, some products (including FMD vaccines) were manufactured for Coopers and thus commercialized with Coopers' label.

lack of image and reputation. This meant hard and sustained work to promote the products (traveling to different countries) but, once the firm achieved quality and service records in several markets, doors started to open more easily. The formal registration of Prondil's vaccines in its destination markets was a very relevant factor, since it then acted as a reference to penetrate other markets.[99]

Regarding Santa Elena, in the early 1990s the firm had invested in a brand new laboratory for large-scale manufacture of first-class FMD vaccines, and it was at the verge of becoming a large exporter of these when production was prohibited.[100] The firm found a way out of the ensuing crisis by focusing on bacterial and other vaccines that were until then marginal for the firm. Investments in large-scale vaccine production are flexible enough to allow shifting from one product to another, and variable costs are not too large:

> "The large size of the fermentation tanks is what allows production on a large scale and the concomitant scale economies. Different types of vaccines cannot be produced simultaneously, but they can be produced successively in time. Between the different batches of vaccines, the tanks must be cleaned and sterilized and small technical changes must be implemented so as to ensure that there will be no contaminants from one vaccine to another." (Interview with a regional consultant in biotechnology)

Santa Elena thus received signals about the profitability of exporting bacterial vaccines from its own business, in a somewhat different way than the other two firms. They were vaccines that the firm had previously developed and produced in small quantities. Uncertainty concerned commercial issues rather than technological or productive activities. Even so, the former must not have been too important considering that the product was initially sold in the same markets where Santa Elena exported FMD vaccines in the past (Bolivia, Peru and Paraguay). From 2000 onward, destinations included new regional markets (Colombia and Brazil).

It can thus be stated that the three exporting firms found simultaneously but separately positive signals to invest in bacterial vaccines: Merial received them mainly from its parent

[99] Vaccines must first be registered in the producing country and then in each destination country.
[100] Since 1992, Santa Elena has exported FMD vaccines to Bolivia, Peru, and Paraguay, and there were talks underway with the government of Bolivia on a possible collaboration for the eradication of FMD disease. The former can be observed in Graph 4.5.2 as Santa Elena's exports grew between 1992 and 1994.

company; Prondil, from the multinational from which it emerged; and Santa Elena, from its in-house and outside previous trials. This is not really surprising because the information on commercial opportunities and technological features of bacterial vaccines appertained to the industry's "common sense" at the time, according to a regional biotechnological consultant (Interview, 17/10/2006). And each firm counted on different assets to solve uncertainties related to the concrete trading possibilities: Merial was fully integrated in a global value chain as a subsidiary of a multinational; Prondil partially participated in one since its main market intermediary was the multinational Intervet (former Coopers); and Santa Elena had established connections through its recent market prospecting for FMD vaccines.

In conclusion, several factors combined at the precise moment as veterinary vaccine firms lost their safe FMD domestic markets in the middle of the 1990s: commercial opportunities existed for bacterial vaccines and exporting costs were accessible because the targeted markets had relatively lax regulations; there were local technological and productive capacities to seize these opportunities; and, last but not least, there were people in the local industry willing to continue making their "way of living" from producing vaccines in Uruguay. In terms of the "H-R model," these combined factors provided information on expected profits being large enough to have some pioneers experimenting right away. Apparently the possibility of waiting for an information externality from other experimenting firms was disregarded. As we will see in Sections 4.5.4 and 4.5.5, these simultaneous investments, associated with individual trajectories, did not help to resolve a number of coordination failures that precluded diffusion and limited the development of the animal vaccine export sector. But we will first discuss the pre-conditions and the public goods that enabled the discovery.

4.5.3 Preconditions and Public Goods

Important preconditions existed for the development of the discovery, including the provision by the state of some critical public goods. These issues will be dealt with in this section.

Common Origin in Biological Production

Historically, Uruguay has been part of a very important stockbreeding region in the world. This spurred the local development of veterinarian products and services. In previous periods, the decentralization strategy pursued by multinationals led them to install subsidiaries in this part of the world, so as to take advantage of the animal health market that was developing rapidly and of

the availability of human and other resources, like diagnosis services, national laboratories, trained human resources, etc. Within this framework, the production of FMD vaccines proved to be a particularly profitable and highly secure business. The domestic market for this vaccine was so large in countries like Argentina and Uruguay that export strategies were not developed or were marginal.

Once FMD was eradicated in Uruguay (1993), a natural course of events would have been to use the installed capacity to produce vaccines for countries still facing the disease. But the prohibition on handling the FMD virus in Uruguay made this impossible and production was suspended.[101] At that moment, it seemed that the local vaccine industry would be driven to extinction. What were the factors that reversed the expected evolution and triggered this new export phase?

A first factor was the legacy of this historical period, in terms of learning economies in the field of animal vaccines. The second one relates to the trigger that the prohibition of FMD vaccine production meant for the development of a new vaccine sector, this time geared toward exports.

As previously stated, the three producers of animal vaccines share a common background: the huge market that the FMD eradication policies meant for the animal health sector in the second half of the 20th century, particularly in the River Plate Basin, one of the main cattle-raising regions in the world.[102]

Most of the multinationals that developed animal health products entered the country, and the regional market as a whole, by acquiring a national laboratory. They thereby took advantage of substantial local experience that had been developing in this field. Indeed, livestock breeding was the main agricultural activity in the River Plate Basin, and meat exports were the mainstay of area economies. It thus comes as no surprise that related services had been developing quite substantially, through education and research in veterinary sciences and the creation of national

[101] In recent years, FMD reappeared in the country and vaccination had to be reestablished urgently with no local production capacity. This coordination failure has, in other terms, been pointed out for the whole region by Panaftosa's experts, because the risk taken when suspending vaccination was not compensated by mitigating measures (like building up an FMD vaccine bank, as other countries do). Similar coordination failures have occurred with vaccines for other diseases such as brucellosis.

[102] Introduced in the Americas from Europe around 1870, FMD has affected the entire American continent at some time, with the exception of Central America. In the United States, the disease was eradicated in 1929.

laboratories offering products and services against the main livestock threat: infectious and parasitic diseases. In the words of the son of a prominent veterinarian of that time:

> "In animal health—in the field of biology and less so of chemistry—a world-level development focus arose in the Southern Cone in the 1950s. Looking at the history of Argentina, Uruguay, and Southern Brazil, one can find in each case about seven to eight national laboratories that were created in the 1950s and 1960s, within the framework of the import-substitution strategy. Somehow they were a kind of annex of the universities' Veterinary Departments. The technical experience of the teaching vets stimulated them to create private enterprises to develop products related to their teaching and research. Their education level was very good and there was very little difference between a national laboratory and a European or North American one. So, firms like Bayer and Hoechst—typically with a chemical base but little biological knowledge—started their biological activities in the region, acquiring one of these national laboratories. Coopers Welcome was the only one of all the multinationals coming to this region that did not start by buying a local laboratory." (Interview with one of Santa Elena's partners, July 24, 2006)

FMD became an early and indirect trigger of the vaccine export discovery in Uruguay. Although it triggered production for the domestic market, this activity gave rise to learning economies in the broader animal vaccine field through the development of abilities in research, diagnosis, industrial production, technical training, etc., related to disease eradication.

Institutional Build-up and Regulations for FMD Vaccines

Since the 1930s, the country has been fighting FMD. State laboratories were created to experiment in new animal vaccines and regulations were created. In 1946, domestic private laboratories were authorized by the government to produce FMD vaccines, but it was only around 1954 that these activities started effectively to take place. In 1967, regulations to start a national campaign against the disease were approved. In 1968, the campaign included the whole country and a governmental FMD institution (DILFA) was created to control the quality of all FMD vaccine production.

This new institutional framework contributed to the displacement from the market of several laboratories at the end of the 1960s. Of the 11 FMD vaccine producers in the country,

only four survived, all subsidiaries of foreign companies, and they would share the domestic market throughout the 1970s and 1980s. In 1974, the Ministry of Agriculture estimated that these four firms were producing all FMD doses that were consumed in the country (Astori, 1979).

The commercial regime for FMD vaccines was quite exceptional given the import-substitution regime of the time. In 1968, the government decreed tax exemption for all imports destined to prevent and fight cattle diseases.[103] Consequently, the non-existence of imports cannot be explained by high import tariffs to FMD vaccines but was more likely due to the adequate quality and quantity of local production.[104]

A relatively extensive scientific base of human resources dedicated to R&D was available for the development of this local industry at that time. The state laboratory, Laboratorios Rubino, and DILFA were in charge of transferring to private firms the researchers' technological developments. The Veterinary School of the public university was in charge of veterinary education but had very little intervention in R&D in this field.

More recently, the industry-government relation takes place mainly through the vaccine registration process at the Agricultural Department of Veterinary Laboratories (DILAVE). This department is also in charge of controlling the activity of the laboratories. Control is applied through vaccine sampling and might include the request of documentary evidence of the firm's internal controls.[105]

Scientific Base and Technological Capacities

Presently, Uruguay stands out not only for the quality of its scientists, but also for the quality of the technicians working at the laboratories. The Uruguayan biotechnology sector was analyzed in previous research (PNUD, 2005). It was based on a survey including 68 laboratories that undertake R&D in biotechnology applied to human and animal health as well as to plant and animal genetic improvements. As shown in Tables 4.5.1 and 4.5.2, the data from the survey indicate the existence of a critical mass of biotechnology scientists and technicians (the present research field in vaccines), and that almost all laboratories undertake research in applied biotechnology.

[103] This exemption also applied to inputs for local production.
[104] This disqualifies in part the infant industry protection argument for explaining FMD domestic production.
[105] The only case in which all batches were systematically controlled in Uruguay was the FMD vaccine, a practice that was part of the eradication policy in the region and that is still in force in the producing countries.

Table 4.5.1-
Number and Educational Level of Researchers and Technicians in 68 Biotechnology Laboratories in Uruguay

Highest academic degree	Total	Bachelor Degree	Master in Sc.	PhD	Post - Doc
Number of professionals	780	427	161	158	25
Number of technicians	377				

Source: PNUD, 2005.

Table 4.5.2 - R&D Activities of 68 Biotechnology Laboratories in Uruguay

R&D activity	Number of laboratories
Fundamental Research	42
Applied Research	65
Development research	49

Source: PNUD, 2005.

Educational Base and Its Cost

The often mentioned good basic education level of Uruguayans has made it relatively easy to train non-specialized people in vaccine production techniques and to obtain satisfactory results from both the employer and employee perspectives.[106] In contrast, as will be further discussed, specialized human resources in specific areas of vaccine production are difficult to find in the country due to the small size of the vaccine industry.

Vaccine production costs are substantially lower in Uruguay than in more-developed countries. This is partially due to the comparatively lower salaries in Uruguay, especially for very qualified people. It is also relatively easy and affordable to carry out tests on animals in the

[106] For example, most of Prondil's non-professional employees entered the firm at a young age, after secondary school, and were trained in the laboratory, where they acquired adequate skills.

country, a relevant advantage considering that this is a very expensive issue in industrialized countries.

4.5.4 Barriers to Entry in Global Markets

High barriers to entry characterize vaccine production because it entails high investments in R&D, production facilities, quality control, quality assurance and product registration, as well as special arrangements (like partnerships) for selling and distribution. In addition, it rests on the difficulty of acquiring know-how so that technology transfer often requires a strong cooperative relationship between partners (like joint ventures). Once the fixed costs are covered, unit costs can be reduced significantly through gains in productivity (the "learning curve") and scale economies. These barriers, together with the limited world vaccine market (less than 2 percent of the pharmaceutical market), explain the relatively low number of vaccine producers in the world as compared with other classes of pharmaceuticals (GAVI, no date).

In the following paragraphs, we will examine how Uruguay's pioneers have surmounted the various barriers to entry in global markets, including R&D, production know-how, scale economies, quality control systems, upstream and downstream production, and distribution economies, and vaccine registration in foreign countries.

The three Uruguayan firms mainly produce "traditional" vaccines by using available public knowledge. But the process of mastering, adapting, and improving this knowledge is not easy and smooth. It involves R&D and other knowledge creating activities, distinct from the production process, which have different degrees of complexity depending on the "tacitness"[107] of the adopted technology. It is now fully accepted in the literature that, because much technology is tacit, even when production techniques in the public domain and transparent to outsiders, their adoption requires significant knowledge creation and application with uncertain degrees of success (Lall, 2003).

In fact, the vaccine industry in Uruguay is highly related to specific research. Prondil and Santa Elena both have strong partnerships with local academic groups, and the Department of Biotechnology at the Instituto de Higiene (School of Medicine of the public university) is a very relevant actor. The academic teams, although very limited in number, include scientists trained in

[107] Tacitness means that a technology or product cannot be easily codified into a blueprint that would allow for easy application (Nelson and Winter, 1982).

some of the best academic institutions in developed countries. The teams maintain strong links with their academic partners in developed countries and therefore have access to state of the art scientific equipment and methodologies. Thus, they provide the needed research infrastructure to local firms.[108]

Since its start, but more intensively since 1987, Santa Elena has been very closely related to local and regional academic institutions. It has signed research contracts, mainly for molecular biology and genetic engineering projects, with the public biological research institute, Clemente Estable. It also has carried out research projects with different departments of the public university, such as the Chemical School, the Virology Department of the Sciences School, the Immunology Department of the Veterinary School, and the Biotechnology Department of the School of Medicine. Research projects have also been carried out with Argentine and Brazilian universities.

According to Santa Elena's manager, the firm focuses on diseases affecting cattle and cattle breeding because these are of little interest to multinationals:

> "We specialize in analyzing what the region needs. When the stockbreeders and the vets face a problem, they have no access to the R&D leaders of large companies, so they go to the local laboratories, and the same happens in Argentina. The problems we face in the region have nothing to do with Europe or North America. We have a pastoral system, concentrated or extensive but an outdoor system. The Europeans have a confinement system; their cattle practically do not eat grass and do not walk. So, diseases are totally different in the two systems. Our first task is to identify our problems … Then we identify the people at the university who can solve these problems, we support their R&D up to the point that they reach the development of an antigen. That is when Santa Elena takes over to develop the product at the industrial level … Industrial R&D at the laboratory never stops. The biggest investment is made inside the laboratory, and

[108] This research-industry complementarity is an essential base to build up strong national systems of innovation. As Chabalgoity (2005) points out, "There are plenty of strong academic teams spread across developing countries, were scientists are already conducing R&D in new vaccines of regional and global importance. (…) these groups are often struggling with the lack of proper funding in their own countries and therefore the relationship with the industry could be a source of fresh funds, working as a way to improve the research-building capacity in developing countries, as has traditionally been the case in industrialized nations."

each time we get better results with lower costs, with faster and safer processes." (Interview with one of Santa Elena's partners, July 24, 2006)

Since 2001, Prondil has called on the R&D capacity of the Department of Biotechnology (Medical School of the public university) to solve some of its problems. This happens when the firm does not have the required expertise and/or equipment:

> "Prondil has no intention of financing basic research. What it needs is to solve practical problems, to generate knowledge on how to solve problems that Prondil is already facing, like production problems, control issues, better performance or cost reduction needs, etc. Researchers make an important contribution. They do not always find these issues very attractive, but they certainly are interested in establishing links with the industry, in part because it is a financing source for their laboratories and the critical mass that is needed in the sector. Prondil has developed a fruitful relationship with the Instituto de Higiene and, earlier, with the university's Veterinary Department. (…) Sometimes the academic environment is somewhat slow but the industrial sector has no room for dreaming. When we have a need, it is concrete, urgent and we have to solve it." (Interview with Prondil's director, July 26, 2006)

A good example of collaboration with the Instituto de Hygiene is an ongoing project for a new cell culture, the industrial aspects of which are being carried out by Prondil with equipment from the Institute, which in turn is in charge of applying all control techniques to the product. Because Merial's technology comes from its parent company, relations with the national R&D environment are limited. Its closest tie is with the Veterinary School of the public university, which has an almost exclusively clinical orientation. Merial promotes technical talks by specialists in different biological areas, aims to foster better knowledge of the animal health productive sector, and finances one scholarship per year.

The patent system does not play a crucial role in impeding the diffusion process. Vaccines can be relatively easily copied if the required skills and knowledge exist, although the processes are not totally standardized as there are important issues related to the mix of the adjuvant and the pathogen agent to obtain the most effective vaccine. These issues are secrets of *production know-how* that act as important barriers to the entry of new firms.

In regard to *quality control and assurance* as well as *scale economies*, two recent local investments are directed at solving these fundamental issues. It is a well known fact that the quality of a product is becoming an increasingly relevant factor. As and when better control capacity develops at the government level of producing or importing countries, the smaller laboratories of emerging suppliers with no updated internal control systems will tend to disappear.[109]

One of these investments (US$2 million) concerns Santa Elena.[110] The firm completely renovated its previous "FMD laboratory" with a view toward improving the technology and quality of its products and processes, and to produce in biosafe conditions so as to respond to the most recent bio-safety regulations. The vaccines will be of a new generation and the production capacity has been designed to respond to the increasing biological demand. Santa Elena considers the application of good manufacturing practices (GMP) as the main barrier to entry used by developed countries to protect themselves.

Also with a recent US$2 million investment in a new plant for bacterial vaccines, Merial-Uruguay seeks to increase scale economies (doubling the production capacity), update the technology, and improve the quality system. The local director stresses that the parent company decided to locate this investment in Uruguay mainly because of the excellent clostridial vaccine performance attained by Merial-Uruguay.[111]

Upstream links create significant economies for the local firms. In the case of Prondil, for example, animal trials are outsourced to two veterinarians who are also cattle producers and can thus easily test new vaccines. As concerning Santa Elena, the firm is highly related with different actors of the animal health sector: diagnosis firms, local veterinarians, and cattle and other animal breeders.

Another important upstream link relates to input supplies. Prondil established a user-producer association with its two plastic bottle providers. So, while quality was inadequate and unstable initially, it was subsequently leveled through an intense learning process. Another very

[109] A similar condition could happen as with FMD, when technological progress and government regulations forced seven of the 11 laboratories to close in Uruguay. In the present case, the situation would not so much apply at the national as at the regional and global level.
[110] The firm obtained a US$1 million loan from the state development bank and the project has been declared to be of "national interest," which provides it with different tax exemptions.
[111] Interview, *Diario El País* (Montevideo), July 8, 2006.

relevant national input for Prondil production is horse meat, which is used to obtain the protein concentrates needed for antigen production. It is a tough process and Prondil is the only vaccine producer to start the production chain from this early stage. But the firm found it rewarding in terms of quality and costs as compared with the alternative of importing the protein concentrates, and despite the fact that it is a price taker in the local horse meat market, which is entirely geared toward exporting.

A *downstream production barrier* to entry derives from transportation costs. Vaccines are usually transported by plane and must be surrounded by ice, which inflates the weight.[112] Long distances to developing regions, like Africa, mean high transportation costs, which can end up being higher than the FOB price. So, large-scale shipments must compensate these costs.

A main barrier to enter export markets relates to the *norms* in force in the importing countries. Different countries apply different norms for biological products, and in developed nations these have become non-tariff barriers. Prondil's director explained this issue as follows. The firm registers its vaccines using the United States' standards; as a consequence, its vaccines fulfill these norms. But exporting to the United States or Europe also implies submitting the vaccines to very complex laboratory tests in order to prove the above-mentioned fulfillments. Complying with all the required tests and trials to export to these markets would require a very superior technical structure than the existing one, which in turn would imply huge investments.[113] Instead, the firm can use its cost advantages to export to countries that cannot afford to pay the price of vaccines produced in developed countries.[114] The firm's vaccines are registered with Prondil's trademark and these registers are the main capital of Prondil: the firm is the owner of the sanitary registers of its products in its export markets (Interview with Prondil's director, July 26, 2006).

Cost advantages are also used by Merial—within its overall multinational strategy—to sell vaccines made in Uruguay in markets that Merial-France cannot access due to its higher production costs. However, according to the firm's manager, lower production costs are not the main factor in Merial's decision regarding its subsidiaries. Much more important is the security,

[112] Only in some instances do volumes and other conditions make sea transportation possible.
[113] Naturally, this does not imply that the firm does not comply with the international control techniques, since they have to achieve the established standards to register their products locally and abroad.
[114] Some products can be made with the same performance and effectiveness as their equivalents in Europe, at up to one-tenth of the latter's prices.

from quality control and assurance, that the subsidiary will not damage the multinational image and reputation.

Finally, *selling and distribution* barriers to enter export markets were solved in different ways by the pioneers. Merial is fully integrated in a global value chain as a regional provider of a multinational; Prondil is still, in its main markets, closely linked for selling and distribution to the multinational Intervet; and Santa Elena has established regional joint-ventures to sell and distribute its products.

In conclusion, the three pioneers have overcome several barriers to entry in global markets. But during this process, some coordination failures were not resolved and, as we will see in the next section, this restrained the emergence of other local exporters.

4.5.5 A Truncated Diffusion Process

As Hausmann, Rodrik, and Rodríguez-Clare (2005) observe:

> "…the self-discovery process is rife with information externalities because the cost information discovered by an entrepreneur cannot be kept private. If the pioneer is profitable, this can be readily observable by others. Imitative entry then follows, the incumbent's rents are dissipated, and a new sector takes off. If, on the other hand, the pioneer firm goes bankrupt, the losses are borne in full by the entrepreneur. Hence entrepreneurship of this kind is not a very rewarding economic activity: the losses are private while the gains are socialized. Consequently markets under-provide entrepreneurship in new activities."

In this case, the three pioneers developed a profitable business, but this did not give rise to an imitation process by other firms. Why did these opportunities not diffuse? Answering this question requires understanding the channels through which the pioneers captured monopoly rents, because different channels have distinct implications for diffusion. Two channels were found: firms internalized an ex-ante productivity advantage acquired from prior bacterial and FMD vaccine production; and they introduced new barriers to entry.

We know from previous sections that when the three pioneers launched the bacterial vaccine discovery they were already producing the FMD vaccines with strong economies of scale and they had already developed and internalized production secrets. They thus took as a starting point prior knowledge from vaccine production and sales, which they had accumulated on their

own or inherited from a former firm. This accumulated knowledge makes up a manufacturer's secret that gives rise to proprietary knowledge, which in turn precludes externalities from spilling over, unless researchers, technicians, or other qualified workers move from one firm to another or create a new company. In this case, no flows of skilled workers can be observed; therefore, we might presume that the first channel to capture monopoly rent by the incumbent firms is an important explanation for the absence of diffusion.

We also know that the three pioneers surmounted several barriers to entry in global markets, which paved the way for imitation. But each firm developed its production environment in isolation from the others (including upstream and downstream arrangements in addition to substantial investment in R&D, infrastructure, distribution, etc.) and no common interest was identified that would give rise to collective actions. Neither was there any effective institutional arrangement in the broader biotechnology field.[115] In this way, coordination failures were not solved and no collective goods were created. These factors constitute a second channel for pioneers to capture monopoly rents, and contribute to explain why other animal vaccine companies did not appear in Uruguay.

The coordination failures restraining investment in activities that are crucial for the sector's expansion involve mainly the lack of agglomeration economies that, in other countries or environments, arise from: a thick labor market, a scientific and entrepreneurial infrastructure for emerging projects, and a network of specialized input providers.

The absence of thick labor externalities in this case was set out by a regional consultant in biotechnology in these simple terms: Uruguay does not have the required professionals in order to set up new vaccine plants (Interview, October 17, 2006). The inadequacy of the university curricula to serve that purpose and the inexistence of certain specializations at the graduate or postgraduate level are part of the explanation. For example, biological engineers, among others, to scale up processes in a vaccine plant are not available. Clearly, a coordination failure here arises because of the complementarities implied: creating a specialization might not be reasonable in the absence of firms demanding such human resources, but firms will not invest in fields where it is difficult to find specialized professionals.

[115] For example, unlike local software firms, the various attempts of the business organization Asociación Uruguaya de Empresas de Biotecnología (AUDEBIO) to coordinate the resolution of common problems has been fruitless until now.

In regard to the entrepreneurial infrastructure for emerging projects, its shortfall for the diffusion phase derives from the evolution of the biotechnology-related business. The three pioneers emerged as "traditional" firms that were then compelled to restructure as technological breakthroughs in biotechnology imposed new conditions to reach competitive advantages in the vaccine industry. In contrast, new vaccine businesses have to be created from scratch as biotechnology-based firms, with a very different profile in terms of technology requirements and business model.[116] And, of course, new firms would not inherit the signals that each pioneer received from its predecessor and/or its previous activity.

Finally, the nonexistence of a network of specialized input providers is of first importance in slowing down diffusion, because "a biotechnological endeavor in Uruguay implies the generation of the entire chain of production and distribution" (Interview with a biomedical exporter, December 13, 2006)[117]. The limited volume of biotechnological exports explains the absence of such specialized providers, and indicates once more a problem of complementarities.

Summing up, the truncated diffusion process in the veterinary vaccine sector is explained by two main elements: the accumulated knowledge transformed in manufacturers' secrets by pioneers and the process by which these firms got through the barriers to entry in global markets without resolving the basic coordination failures of the industry.

4.5.6 Comparator: New Biotechnology-based Firms

We chose as a comparator for the vaccine discovery the new Uruguayan biotechnology-based firms because they have not been able to export, or do so only marginally, in spite of enjoying the same critical public goods as vaccine pioneers.

The previously mentioned analysis of the Uruguayan biotechnology sector (PNUD, 2005) included a survey of 24 firms that apply biotechnology to services and products of human and animal health as well as to plant and animal genetic improvements, and the 68 laboratories

[116] Some ways in which diffusion could take place in the future would be:
- Spin-offs from the public university: technological developments in vaccines could lead for example to a joint venture with a local or foreign investor or even to a consortium with one of the existing firms.
- The acquisition of a local laboratory, taking advantage of accumulated know-how, with a view toward investing in it to increase its production capacity.
- The creation of a firm from scratch by an investor with the help of consultants specialized in setting up this sort of business.

[117] For example, there is only one firm in the country that produces dry ice and the only producer of foam insulated boxes does not offer products suitable for the international transportation of biomedical products.

mentioned above, which undertake biotechnology R&D. The survey results show that exports are highly concentrated in a few firms (besides the three vaccine producers previously analyzed):[118] there are three *Rhisobium leguminosarum* producers, two plant micro-propagation companies, two human vaccine laboratories, a molecular biology firm, and an exporter of animal genetic improvements. Exports of the first three groups of firms are relatively important, while the last two firms only export sporadically.

Consistent with our previous analysis, the major biotechnology exporters share with the three animal vaccine firms a restructuring process from a traditional business to a biotechnology-based one. However, the minor exporters started from scratch a modern biotechnology business and these are the ones having a hard time getting to takeoff.

It is well known that a great deal of difficulty is faced by biotechnological start-ups. Substantial connections with R&D are needed and expensive facilities and laboratories, as well as regulatory and legal knowledge (including a thorough understanding of intellectual property issues), financial expertise, and, in general, know-how to manage this particular kind of business. Access to human resources with all these qualifications may be beyond the means of such start-ups. This has much to do with the difficulties involved in developing exports in technology-intensive sectors.

In this case, connecting with R&D does not seem to be the main problem. According to the survey, the biotechnology sector in Uruguay has a particular feature compared with other knowledge intensive sectors in the country: there are well established links between firms and research laboratories.[119] Furthermore, there is a relatively strong commitment of the research laboratories to work on biotechnological-based solutions for issues related to the productive sector.

The regulation of biotechnology related issues and the legal protection of its products is one way of making modern biotechnology a business. In Uruguay a regulatory system for modern biotechnology is presently being designed by the government authorities. It is a fact that very few biotechnological related patents have been registered at the National Office for Property Rights

[118] The survey was carried out in 2003-04, and firms declared their exports until 2002.
[119] The 68 research laboratories in the survey included different schools of the public university, the public biological research center Clemente Estable, and the national institute for agriculture research INIA, which all had at least one research line in biotechnology.

(DNPI) and most of them are not from residents, a clear sign of how modern biotechnology is still not seen as a business opportunity by locals. And there is not a single lawyer specializing in biotechnological issues in the country, a strong limitation for emerging entrepreneurs.

Another major problem lies in the management side of the business. There is little experience in managing biotechnology-based undertakings, an issue that is worsened when the start-up is created by scientists, as often occurs. In Uruguay, the researcher-entrepreneur who sets up his own company usually has to learn on his own how to become and remain competitive, because support for entrepreneurship is scarce. In this context, business and strategic management is either not considered as essential as technological matters or is neglected because of limited means to hire the required expertise. The learning path is then very troublesome and limited initial gains leave little room for trial and error.

A related issue concerns the lack of sound projects emerging from the academy, with notable exceptions. Ideas are seldom developed into viable projects backed up by a business plan or a feasibility study. This comes as no surprise considering the rather traditional university curricula as far as entrepreneurship is concerned. Subjects involving intellectual property rights and other legal matters are restricted to the Law School, while entrepreneurial skills and knowledge are only developed in administration and business schools, with no such courses in the science or engineering schools. Fellowships to provide young researchers with working experience in industrial firms and laboratories are very recent. The divorce between science and business is thus still in force at the educational level.

At the world level, it is a common fact that biotechnological entrepreneurs emerge from a university, a research institution, or a company with which they have been working. In Uruguay, there exists indeed some critical mass of researchers in biotechnology and many of them work in applied research and on concrete development related issues, as was previously made clear (see Tables 4.5.1 and 4.5.2). But few of them start their own firm, in spite of the very low wages at the public university (private universities have no basic science schools) and the Clemente Estable research institute.

Until recently, no policy instruments existed to promote and support start-ups in the field of biotechnology, such as project incubators or clusters. However, recently several public and private initiatives have emerged. The successful (public-private) software oriented Ingenio incubator has now extended its field of action to include biotechnology projects, although it does

not yet offer specific infrastructure. Neither has it developed as a hub allowing easy connections to state-of-the-art research laboratories or access to expertise in the specific business models needed. BiotechPlaza, by contrast, offers a specific environment for biotechnological firms in the privately owned free trade zone, Zonamerica, but this is a costly location for national firms.[120] The Polo Tecnológico de Pando is a scientific and technological park for chemical and biotechnological firms that were established by the Chemical School of the public university, with funds from the European Union. PACPYMES, a governmental program also mainly funded by the European Union, is presently supporting a life science cluster, among other clusters. Still another initiative is AMSUD-Pasteur, a Uruguayan branch of the famous French Institute Pasteur; it will develop a regional pole anchored in biology, biomedicine, and biotechnology. Most of these undertakings are however too recent to evaluate their impact.

Finally, investors such as angels and venture capitalists have not yet appeared in the local biotechnology field, and public agencies have not provided seed capital. This seems to be part of the explanation for the very slow diffusion process. Again, two recent initiatives could make a difference in the near future,[121] assuming that adequate project profiles can be presented. Risk aversion as an idiosyncratic Uruguayan trait is a more general explanation, which deserves to be considered in a set of instruments to generate adequate incentives to create biotechnological-based firms.

In short, new biotechnology-based firms have not been able to export because—even if they share with vaccine pioneers and other traditional biotechnological exporters the local R&D infrastructure—they lack management tools and other entrepreneurial skills to enhance their global competitiveness.

[120] BiotechPlaza targets companies ranging from start-up and mid-size companies to multi-national ones that concentrate in life science areas (humans, animals, and plants) and wish to develop an international business strategy taking advantage of leading-edge infrastructure, tax benefits, and synergistic effects derived from an agglomeration of high-tech firms (see http://www.zonamerica.com/english/biotech.asp).

[121] One is led by Prosperitas Capital Partners, a financial management company that recently established the first venture capital fund in Uruguay. It seeks to identify and invest in small and medium-size companies that apply new technologies and know-how (at the country level) in the technology, service, and agribusiness sectors (www.prosperitascp.com). The other one comes from the restructured Corporación Nacional de Desarrollo (CND). In addition to providing seed/venture capital, it aims at "promoting an entrepreneurship culture of high added value, through systematic increase in the quantity and quality of new undertakings or young firms in dynamic sectors" (www.cnd.org.uy).

4.5.7 Conclusions

Three firms located in Uruguay have produced and exported bacterial vaccines in the past ten years: a branch of a multinational firm and two local companies. These exports are considered a "discovery" because they represent a successful export activity that recently emerged and experienced strong growth. The key reason for targeting bacterial exports arose from the need and low opportunity cost to replace FMD vaccines when local production of these vaccines was prohibited. The choice of this new export activity was facilitated by the prior technological, productive, and commercial knowledge of animal vaccines accumulated by the former FMD vaccine manufacturers. In other words, what the country discovered was the capacity to continue exploiting a comparative advantage indirectly related to the important livestock of the country.

The three exporting firms found simultaneously but separately positive signals to invest in bacterial vaccines: Merial received them mainly from its parent company; Prondil, from the multinational from which it emerged; and Santa Elena, from its own in-house and external previous trials. Hence, the present case is not a typical "H-R discovery" as there was no individual pioneer firm that discovered the underlying cost structure of the new activity. These three pioneers were not savvy investors looking for broad opportunities but rather prudential discoverers looking to exploit close and accessible opportunities. Discovery thus entailed low-cost activities, as firms jumped from one product to another with no need for a knowledge breakthrough at the firm level. However, even if bacterial vaccines were not new developments, their production and export involved some degree of uncertainty.

Two factors are considered to be important "preconditions" that made possible the export discovery: the three firms had a common origin in biological production, and they inherited the country's institutional set-up that was built for FMD vaccine production. They also took advantage of two critical public goods: the scientific base and the technological capacities and generally high-quality basic education. Global markets offered niche opportunities but several barriers to entry had to be overcome. The three pioneers invested in R&D activities, quality control systems, and production know-how and production capacity; they also developed upstream and downstream activities and distribution links; and they obtained vaccine registration in foreign countries.

The bacterial export discovery is truncated in the diffusion phase. Again this case withdraws from the typical "H-R discovery" because the development of the profitable bacterial

business did not give rise to an imitation process by other firms. This was because cost information discovered by the pioneers was kept private by two channels: the firms transformed an ex-ante productivity advantage acquired from prior bacterial and FMD vaccine production into a manufacturer's secret and the process by which they constructed new barriers to enter global markets did not require the resolution of the basic coordination failures of the industry.

The coordination failures that held back investments in activities that are crucial for the sector's development beyond the three pioneer firms involved mainly the lack of agglomeration economies that could have been generated by thick labor market externalities, the existence of scientific and entrepreneurial infrastructure for emerging projects, and the development of a network of specialized input providers. Government policy should attack the above coordination failures; these are, in conclusion, the policy lessons that emerge from this case study.

The modern biotechnology-based sector was used as a comparator for this discovery because it has not been able to develop exports, or only marginally, in spite of enjoying the same local R&D infrastructure as traditional biotechnological exporters. It was stated that the lack of management tools (such as for managing property rights, for example) and other entrepreneurial skills to enhance global competitiveness were essential to explain these different performances.

Finally, the following table outlines the market failures, public goods, and incentives associated with the vaccine discovery.

Table 4.5.3
Market Failures, Public Goods and Incentives in the Animal Vaccine Discovery

Public Goods	Market Failures		Public and Private Instruments (and starting date)	Impact
	Externalities	Coordination Failures		
-Common background in "biologicals" production	-Few local knowledge spillovers	-Failure to experience significant agglomeration economies: • No thick market effects • Inexistence (until recently) of scientific and entrepreneurial infrastructure for emerging projects • No network of specialized inputs providers	-Fiscal incentives: VAT exemption on capital goods	Medium
			-University-industry agreements. Public University, UdelaR, 1990	Medium
-Institutional building–up and regulation for FMD vaccines	-Few local information spillovers		-Business association AUDEBIO, 1980	Low
-Education at public university			- BiotecPlaza in free trade business and technology park (Zonamérica), 2003	Low
-Scientific base and technological capacities			-Public program to foster firms upgrading (innovation and quality management), applied research & postgraduate education: PDT, 2001	Low
-Quality basic education			-Public-private program to foster entrepreneurship in life science: Incubator Ingenio, 2005	Low
			-Public program to foster clustering effects (PACPYME), 2006	Low
			-Chemistry School Technological Park: Polo Tecnológico de Pando, 2005	Low

5. Conclusions and Policy Lessons

In this study, we explored new tradable activities that emerged in Uruguay in recent times, with a view to reaching a better understanding of the drivers of export growth. A consistent export database at the firm and product levels was constructed for the period 1981-2005, which allowed us to observe long-term trends. The clearest findings so far mainly relate to the *evolution* of: the number of exporting firms and their sales value; the concentration by firm size; the flows of entry and exit of exporting firms; the relative contribution of long-lasting firms and new entrants to export growth; the number of products; the concentration by product; the flows of entry and exit of products; and export specialization, diversification, and destination at the firm and product levels.

However, as far as tracking export discoveries is concerned, the statistical database showed limitations mainly due to the data sensitivity to the four changes in the product classification of the official export records throughout the period considered. In spite of constructing conversion tables to generate a unique, consistent database, there are spikes in entry and exit of products that seem to be ascribable to the change of system.

The study investigated four export discoveries as case studies, each one accompanied by a comparator to check the consistency of the analysis: software (comparator: electronics), forestry (wine), sturgeon and caviar (frogs), and animal vaccines (biotechnologicals).

Conclusions for each case were presented in the corresponding chapter. Therefore, the present concluding chapter focuses on the policy lessons that can be drawn from the research. We first discuss a number of findings that relate to the general conditions affecting investment and export discoveries in Uruguay, including several coordination issues at the national level (Section 5.1). Next, we consider how our cases contribute to the "H-R export discovery model" and some specific policy lessons. We begin by treating the following issues in some detail: public goods as preconditions for the selected discoveries (Section 5.2); uncertainties solved by pioneers and knowledge diffusion patterns (Section 5.3); and coordination failures in the diffusion phase and their eventual resolution (Section 5.4). Finally we present a systematized outline of other findings for each case according to different concepts included in the research methodology (Section 5.5).

5.1 General Conditions Affecting Export Discoveries

5.1.1 Real Exchange Rate Volatility

Microeconomic strategies to enhance competitiveness in markets, sectors, and firms should be parallel with other types of policies, namely those that assure adequate macroeconomic conditions, such as a reduced vulnerability to crises, especially in the neighboring nations. Our analysis confirms that exchange rate volatility played a significant role in hampering the development prospects of some of the sectors analyzed. This is particularly relevant for those that had a prominently regionally oriented export strategy, such as winery and frog cultivation. Sharp variations in bilateral real exchange rates, such as those experienced at the start of the 1990s, seem to create very short-term windows of opportunity for temporary exports of virtually anything to neighboring countries. The opportunities tend to disappear without a trace once macro conditions swing the other way. It is noteworthy that some of our counterfactual cases (wine, frog breeding) suffered particularly during the 2002 crisis due to marketing strategies largely focused on regional markets.

This does not mean that Uruguayan exports should not reap the benefits from the opportunities offered by the large markets of its neighbors. Obviously, the simultaneous presence of global and regional goods contributes to the stability of the Uruguayan economy. When Brazil devalued in 1999, followed by Argentina in 2001, with demand falling in both countries, Uruguay as a result depreciated its currency vis-à-vis that of the United States. This led to a financial and solvency crisis. But at the same time, the profitability of exports to the world was reestablished and the way out of the crisis was eased. When regional demand goes up, Uruguay's neighbors' real exchange rate appreciates vis-à-vis the dollar. Resources are attracted to regional goods and there are pressures for real exchange rate appreciation also in Uruguay.

There is no sound theoretical link between high real exchange rates and long-term growth, although empirical results are at best controversial.[122] However, there might be clear real exchange rate growth effects via the volatility and size of real exchange rate fluctuations. Every time Uruguay experiences such deep fluctuations, price signals are severely distorted and the profitability is dramatically altered. Discount rates increase as well as preference for the present, thus affecting saving and investment decisions.

[122] Hausmann, Pritchett, and Rodrik (2004) find some degree of correlation between real exchange rate depreciation and growth acceleration.

There are multiple effects of real exchange rate volatility on firms and their product strategy, especially in an open and small economy, with a limited domestic market. On the one hand, it is obvious that changes in the relative prices of non-differentiated products are instantaneous because buyers are more sensitive to prices than in the case of specialized products and can easily shift to different providers without altering other aspects of their management strategy. In the case of differentiated products (and services), finding another provider is usually costly and thus represents a barrier to entry. Therefore, product differentiation acts as a "defense" when reduced levels of exchange rate instability are faced.

On the other hand, exchange rate instability and even its threat lead to a lower investment level in the production of specialized goods for a certain market (for instance, regional). Commercial flows cannot be foreseen in the delays that are required for investment to mature. Obviously, market instability also acts against upgrading and optimization processes that normally emerge from extended relations between sellers and buyers, as well as against innovation discoveries in products and services.

In terms of policy lessons, less than discussing whether a high exchange rate is required for growth or how high it must be, a firm consensus is required as to which policies might smooth its fluctuations.

5.1.2 Business Conditions

Investment in activities new to the country with a view to exporting is highly dependent on the general local business climate. The main deficiencies of Uruguay in this regard have been extensively documented in recent literature on the country, namely in Fernández-Arias and Sagari (2006).

It is common knowledge that evolving from a "one man in a garage" business, or any other type of small enterprise, toward an export oriented enterprise is a complex question involving management abilities that turn out to be equally important as the technological capacity of the firm. Entrepreneurship and management skills are still a scarce resource in the country, which in part explains why export discoveries in Uruguay are often associated with the "exceptional" personal abilities of a pioneer (skills, insights, and commitment). We consequently refer to three specific aspects that are critical in Uruguay in this regard and leave room for policy intervention.

Strategic Vision

Contemporary firms need to define a strategy that guides them through their development process. The entrepreneur who only takes care of the operative aspects of his firm will rapidly face problems deriving from a constantly changing competitive environment. It is clear that the strategy depends on the firm structure (organization) and culture (value system, beliefs, and habits).

Many Uruguayan firms lack a strategic vision and their partners lead the business without a strategic orientation, in a sequence of short-term lapses. In this context, the pioneers of the software and caviar cases (ARTech and BRS) are outstanding. They started their business with a clear strategic vision and progressively built up a complete firm that evolved through different stages of development.

In designing instruments for small and medium enterprises, policy analysts should pay attention to the way firms that are granted support will develop their activities within the framework of such a medium or long-term strategy, and the way they will maintain an adequate investment level in "soft" resources. Positive habits should be promoted, such as participating in prospective seminars, exchanging information, and, more generally, integrating networks for selected activities.

A special concern is marketing strategy: very few Uruguayan firms export products with their own brand or develop activities (or associations) to position their brands in foreign markets. ARTech and BRS are again exceptions showing that this is feasible.

Firm Management

There are clear signs of a lack of professionalism in the country regarding firm management, especially in those with no foreign capital participation. This phenomenon is usually explained by a combination of several factors, including business climate, macroeconomic instability, lack of education in business administration, family-type management, etc. In recent times, the more stable macroeconomic environment in Uruguay, the emergence of business schools (essentially in private universities), and increasing requirements in terms of product and process certification have contributed to reduce the vulnerability of firms. However, firm management is still a problematic issue: to a large extent, Uruguayan firms behave with a limited rationality, settling for results that they believe to be satisfactory. It seems advisable to observe and pick up cases of

well managed firms and make successful practices known to others in different spheres, without restricting this type of exercise to the business administration curriculum.

One of the obstacles to overcome is the concealment of information, either in the private sector, as a management practice reflecting the prevailing business culture, or in the public sector, revealing bureaucratized behaviors. Public entities should foster the circulation of quality (i.e., accurate and timely) information;[123] this would, however, exclude information used for inspection and disciplinary ends. Improved information flows to firms could be an important input for promoting, for example, the development of a venture capital market, one of the country's great deficiencies in financing new activities.

Another important aspect to achieve professional management concerns the need to improve labor relations through the implementation of policies that include productivity as one of the main components.

Entrepreneurship

In the software and vaccine case studies and their respective comparators, electronics and biologicals, we referred to the educational divorce at the public university between, on the one hand, hard sciences and, on the other hand, knowledge related to entrepreneurship, science and technology management, and other soft sciences. Scientists and engineers are not prepared to move research and scientific discoveries from the lab to the market. Including in curricula topics such as how to create enterprises that combine scientific innovation with market opportunities and how financial markets value scientific knowledge is still pending.

5.1.3 Imperfect Information on Foreign Market Opportunities

In spite of the spread of Internet resources, most firms still lack information on opportunities in foreign markets. This market failure (imperfect information) was recognized at the state level long before the development of the Web, and several instruments have been launched to overcome it. According to a recent study (Zurbriggen, 2006), in 2004 there were 16 public and private entities in charge of export promotion with no formal division, specialization, or coordination between them, although informal interaction was common. That study also

[123] This now happens with export records at the firm and product levels. Firms in Uruguay are often reluctant to provide precise information on turnover, exports, etc. In the course of this study, several firms were surprised to know we had long-term series on their exports.

described the role information networks, the absence of performance indicators for evaluating promotional instruments, and the predominance of programs designed without taking due account of the demands of the private sector.

Uruguay does not possess an institutionalized and professional system to identify interests, objectives, and options for the country's international insertion.[124] The shortcomings in the development of the political-technical capacity of the state to define and negotiate the country's position in the international scene hamper the exploitation of new opportunities emerging from trade liberalization.

5.1.4 Foreign Investment

Foreign direct investment has been a most relevant factor in our four discoveries. It was essential in the first phase of the forestry chain (plantations) as well as, in a later stage, in industrial transformation (pulp mills and sawmills). In the caviar discovery, FDI provided complementary investment funds to the pioneer at a critical stage. In animal vaccines, the main exporter is a subsidiary of one of the largest animal product multinational corporations. It recently laid a wager on Uruguay as a regional supplier, investing significantly in the Uruguayan laboratory upgrading. In the software sector, the investment of Tata Consulting in Zonamerica to establish a development center for its activities in Latin America holds great potential in its demonstration effect for other outsourcing activities.

As is well known, attracting FDI may be an effective way to bring in foreign technology, increase the quality of domestic suppliers through backward linkages, or induce the local production of an advanced intermediate good by a foreign firm (Rodríguez-Clare, 2005). However, considering the national economy in general, FDI still has a limited impact in Uruguay and actions to promote investment in new activities have not been undertaken systematically or under the guidance of a strategic vision.

[124] Zurbriggen (2006) concludes that this deficiency can be ascribed to the following factors: lack of strong political leadership in commercial negotiations and in a strategic vision; ambiguous delimitation of functions, scope, and competencies between different public sector entities in charge of commercial negotiations; lack of coordination at the inter-ministerial and public-private levels; informality of the internal decision-making processes of the public administration; inexistence of systematic follow-up and evaluation mechanisms; ensuing lack of institutional memory, which implies that information and experience are essentially restricted to the authority of the moment; and delay in building up a professional and consistent bureaucratic team, due to a culture that is not prone to professionalism and sound technical capacities.

5.1.5 Recent Policy Instruments

In our case studies, we discussed various promotional instruments that are now being applied to address various market failures. They all aim to foster the development of what the international literature conceptualizes as the National Innovation System: incubators, technological and/or business parks, cluster and network promotion programs, subsidies for individual and collective innovation projects, brand-new financing available for new ventures, etc. Some of them are public-private initiatives, and most are backed up by international cooperation funds or loans.

However—as was illustrated for one field of action in Section 5.1.3—the evaluation of policy measures and program performance has traditionally been erratic in Uruguay (often restricted to the requirements of the donor of the funds) and often indulgent. Cross-program evaluation according to national benchmarks is virtually nonexistent. However, it is common knowledge that many instruments experienced shortcomings in their implementation.

Therefore, the issue now at stake in policy intervention for self-discovery is not so much about convincing on the need to attend different market failures with a number of instruments, as about identifying coordination failures in the application of the existing instruments and modifying them according to the ultimate goals pursued.[125] To this end, the country should implement (i) an "umbrella" evaluation system to address implementation failures, and (ii) a set of strategic objectives deriving from a vision for the country's future.

5.2 Public Goods as Preconditions for Discoveries

Our analysis of Uruguay's successful export experiences confirms the leading role of some public institutions and policies in providing relevant public goods that allowed the private sector to seize critical opportunities for growth. At the policy level, we might refer to the stability of the economic policy because, in spite of the 2002 crisis, it showed a significant degree of continuity among different government administrations. This stability does not only relate to the monetary, trade, fiscal, and investment policies, but also concerns continuity in the openness process. The

[125] Some progress might be expected in that sense through new institutional arrangements brought about by the present government. The creation of a National Agency for Innovation and Research (ANII) was approved by the Parliament in 2006; it will centralize the administration of all science-technology-innovation related resources. This should occur in the framework of a national strategic plan for science, technology, and innovation that is being prepared by a technical team convened by the recently created "Gabinete Ministerial de la Innovación."

case of forestry is also noteworthy because a key ingredient for the sector's development has been the longstanding forestry policy.

The existence of research units in the public university (UDELAR) and government entities has been a precondition for discovery in several of our cases. The following were mainly involved: the Institutes for Computer Sciences (InCo) and Electrical Engineering (IIE) of the School of Engineering (UDELAR) in the software and electronics cases; the School of Agronomy (UDELAR), the National Institute for Agricultural Research (INIA), and the Forestry Department of the Ministry of Agriculture, in the case of forestry; research units at the Chemical School (UDELAR) in the case of wine; the Veterinary School (UDELAR) and the Department for Aquatic Resources (DINARA) in the case of caviar; and, in the case of animal vaccines, various research units of the Schools of Sciences, Medicine, and Veterinary (UDELAR) as well as the biological public research center Clemente Estable. It is clear that the research level is extremely variable among these entities, and so was their contribution to the discoveries.

The public university's provision of highly-skilled human resources for the software and animal vaccine discoveries (as well as for the counterfactual cases of electronics and wine) was also an essential precondition.[126] The telecommunication infrastructure provided by the state enterprise ANTEL in the 1990s was indispensable for the emergence of the software and electronics sectors. The setting up of regulations and quality control for the eradication of foot-and-mouth disease in an earlier period eased the emergence of new vaccine exports.

Interestingly, the mentioned public goods were not only exploited in the successful cases, but also in some of the "unsuccessful discoveries." Obviously, it was the combination of these public goods with other factors that made them relevant for a successful discovery path. Public goods that proved relevant for the discoveries were often the result of investments carried out a long time ago. Institutions such as UDELAR and ANTEL have not always been able to sustain an investment rate allowing them to maintain their standards. Several institutions could not avoid the fact that research lagged behind the diffusion process, which occurred notably in the context of a lack of resources or when the new activity had a long production cycle (forestry).

Two observations come to mind for policy purposes. On the one hand, if the provision of adequate public goods has been an important precondition for the emergence of new export

[126] The role of private universities became increasingly relevant in the 1990s in the field of computing-related and business management education.

activities. Their upgrading process is not only an essential condition to ensure productivity in the diffusion stage, but also to allow the emergence of new discoveries.

On the other hand, in our discoveries, the role of researchers and, more generally, research capacity could easily be traced. At least in the long run, the above-mentioned research entities were able to create relevant expertise and collaboration with the private sector. Nevertheless, on the whole, the distance between science and production is still large.[127] Therefore, one way to stimulate greater spillovers from research would be to provide more support for collaborative long-term projects between the private sector and those research entities that created such expertise.

5.3 Resolution of Uncertainties by Pioneers and Information Revelation Patterns

Due to uncertainty and information externalities, a firm will only invest in developing a new export if it is possible to capture sufficient monopoly rents to avoid quick profit erosion from imitation. What do our cases reveal on innovation appropriability? And what do they show regarding diffusion patterns of the knowledge that pioneers generate when solving uncertainties entailed in the discovery? This is important because the information revelation process has essential implications for the diffusion and growth of new exports.

5.3.1 Software Case

In this case, uncertainties related to: production costs (highly uncertain for an R&D based product), upgrading costs (new versions of the product with incremental innovations), foreign demand (for a highly differentiated and technology based product coming from an unknown "southern" country), and commercialization strategies (for an intangible good). These are classical types of uncertainties and they were solved without public intervention. An interesting point concerns the information revelation process that followed their resolution: there was a combination of externalities contributing to diffusion and monopoly rents limiting profit erosion for the pioneer.

[127] This is in addition to the fact that a critical mass of researchers does not exist in all fields that are relevant for the Uruguayan economy, which is even the case for the forestry sector.

Three types of knowledge goods can be distinguished according to their diffusion pattern:

- *Proprietary knowledge*, which is generated and maintained through intensive R&D and a clear long-term product strategy. The first mover regularly renovated its temporary monopoly through improved versions of its product and this operated as a barrier against imitative entry.
- *Club goods*, i.e., non-rivalry but excludable goods. The pioneer developed a kind of community of practice around its product (a software tool for software developers), creating incentives and systems for practitioners to solve problems together. Through formal and informal collaboration mechanisms, the community generates a common, shared understanding of different types of events and an action orientation for dealing with such events the next time they arise (Sharp, 1997).
- *Public goods* derived from externalities flowing freely from the pioneer toward the economy in general. Information externalities generated for subsequent entrants into the software industry were of a market revealing nature, by establishing a reputation for Uruguayan software goods and services in foreign markets. They also had a demonstration effect in the domestic market: in the context of a country with no risk-taking culture and with scarce entrepreneurship resources, the pioneer's role was important in showing the feasibility of exporting world-scale technology and establishing partnerships with the leading firms in the world. Knowledge spillovers also occurred, notably through collaboration of the pioneer with the public and the private universities.

This paradigmatic case was paralleled by other self-discoveries in the local software industry, since the very nature of ICT opened the way to a continuum of new products or segments, once the existence of local comparative advantages had been discovered.

5.3.2 Caviar Case

Caviar exports representing an intriguing self-discovery case. A private actor decided to use original, specific information revealing the country's comparative advantage to invest in a new activity in Uruguay with a view toward exporting a differentiated product with bright perspectives in global markets. Ex-ante uncertainty about local production costs (and other costs) was high so that this pioneer had to sink capital into experimentation to learn about the costs.

Uncertainties were solved without public intervention. The pioneer reduced uncertainty by acquiring foreign technology and hiring permanent advice, as well as through a learning process in relation to species adaptation to the local environment. On the commercial side, he developed a brand of Uruguayan origin associated with a quality product. Process certification was also needed to access foreign markets. A basic policy lesson stemming from the successful strategy implemented by the pioneer is that professional management is a necessary condition to transform an innovative idea into a competitive firm, an issue that was discussed in Section 5.1.2. Considering that caviar exports are recent and diffusion is thus incipient, can we anticipate anything about innovation appropriability in this case? The pioneer is not willing to share his know-how on caviar production (i.e., the transformation of sturgeon roe into a commercial product), considering that he proposed a price out of proportion when a follower showed interest in it. This specific know-how is thus what the pioneer seems to consider as a source of temporary monopoly rent.

In contrast, the sturgeon breeding and reproduction technology appears to be more prone to imitation because another, independent experimental project got positive results at about the same time as the pioneer's. Other relevant information for potential followers is directly related to the uncertainties solved by the pioneer. Conditions thus exist for the imitation phase, despite some degree of appropriability of the pioneer's discovery that limits the extent of knowledge spillovers.

However, diffusion is not feared by the pioneer because he will benefit from the consolidation of Uruguay's image as a caviar producer. His idea is that producers "join forces in order to maintain a country image associated with quality." Furthermore, diffusion will allow him to provide services and inputs (such as special food for sturgeon breeding from the plant he built) to followers.

This discovery reveals broader opportunities for aquaculture related activities in Uruguay. This is still an incipient activity in the country and its economic potential and profitability are not yet common knowledge. Therefore, policy lessons point to accelerating the diffusion process by (i) ensuring appropriate conditions for entrepreneurship, (ii) perhaps promoting opportunities abroad to attract FDI (or joint ventures) because the aquaculture business is usually capital intensive, and (iii) stimulating research, technological development, and experimentation.

5.3.3 Vaccine Case

This case is a good illustration of how "the probability that a country will develop the capability to be good at producing one good is related to its installed capability in the production of other similar or nearby goods for which the currently existing productive capabilities can be easily adapted" (Hausmann and Klinger, 2006). In Uruguay, three firms simultaneously discovered the profitability of producing and exporting bacterial vaccines, largely as a consequence of the negative shock in demand associated with the prohibition on using and even producing the foot-and-mouth (FMD) vaccine. These firms thus jumped from a closely related product. The human, physical, and institutional capabilities needed to produce the new vaccines were close to those needed to produce the FMD vaccine.

This was not the case for other biotechnology-based firms, which have not been able to develop exports successfully in spite of the existence of R&D capacity and other preconditions. First, they could not count on the kind of positive signals that the animal vaccine firms received in one case from the parent company; in the second case, from the multinational from which it emerged; and in the third case, from its own in-house and external previous trials.

Second, the vaccine firms had some specific assets for solving the uncertainties related to foreign trade, in spite of the fact that FMD vaccines had virtually not been exported. One was fully integrated into a global value chain as a subsidiary of a multinational; the second partially participated in a global chain because it used a multinational as a market intermediary; and the third had recently established regional connections through market prospecting for another product.

Third, it appears that firms that were able to restructure from a traditional business to a biotechnology-based and export oriented business have been, in general, more successful than new undertakings starting a biotechnological business from scratch. Several factors are involved

in this, but a critical issue seems to be accumulated management skills in the former case. By contrast, biotechnology start-ups in Uruguay are often managed by "scientists" who not only lack business experience, but also a pool of skilled labor from which to draw management skills (especially strategic management, including technology and commercial issues). We previously referred to the country's shortcoming in this regard. This does not imply that start-ups are destined to fail (there are indeed a few successful experiences), but rather that exit is particularly uncertain, left to the eventual business abilities of the researcher-entrepreneur.

One policy lesson from this case study is that, to reach a critical mass of biotechnology-based firms, it is necessary to generate conditions allowing the new researcher-entrepreneurs to acquire the needed managing capacities, in addition to strengthening institutional mechanisms for a smoother transfer of R&D results from academy to production.

In our analysis, we concluded that the three pioneers solved different types of uncertainties and overcame the barriers to entry in global markets, but that during this process some coordination failures were not resolved. This restrained the emergence of imitators and diffusion did not take place. We also identified two channels by which pioneers have been capturing monopoly rents: (i) they internalized an ex-ante productivity advantage (from prior related activities) that persists even after the new activity proved profitable, and (ii) they introduced barriers to entry (scale economies, knowledge production secret, upstream and downstream arrangements, vaccine registrations in foreign countries, and quality control systems of processes and products).

5.3.3 Forestry Case

In the forestry case, the pioneer jumped to a new sector (from wool to forestry), applying his previous know-how in international trade. He reduced uncertainty by starting large-scale planting only after two ships of wood logs had been successfully sent to the interested party. He also went into partnerships with a foreign investor interested in developing plantations in Uruguay and opened up technology.

Other uncertainties concerned: large-scale harvesting costs and specialized equipment requirements; specific international contract procedures (considering all issues that can affect the final price, like volume varying according to its measurement at the departure port or at the destination); and, significantly, Montevideo's port capacity to handle large wood shipments. This

last issue was resolved through a reform of the National Port Administration that allowed private, specialized firms to participate in the freight movements.

Interestingly enough, uncertainty on tree breeding costs for the whole production cycle remained long after the forestation process began. In fact, production costs for different species and locations have only been discovered recently, when massive harvesting started. The pioneer thus did not reveal these costs to followers. Instead, planting subsidies have been the instrument used for avoiding the effects of uncertainty on the diffusion process, in addition to accelerating the sector's learning curve. Subsidies were eliminated in 2005, more than 15 years after they were introduced, with no negative effect on the diffusion process.

5.4 Coordination Failures and the Public/Private Response

This section deals with coordination failures that might hamper the diffusion phase of an export discovery. Table 5.1 synthesizes the coordination failures detected and the way they were eventually resolved. They are classified according to their relation with specific requirements for the diffusion phase. It is a "historical" look and does not include those failures that could be anticipated nowadays for the future development of the sectors considered.

Table 5.1 – Coordination Failures (Potential or Actual) in Successful Discovery Cases

SOFTWARE	FORESTRY	CAVIAR	VACCINES
1. Related to specific infrastructure needs			
Telecommunication infrastructure (potential): it was updated during the early diffusion phase, though it sometimes lagged behind the needs.	–Inadequate infrastructure for heavy load transportation of raw materials and final products. Resolution: -Public investment in basic infrastructure (port access, roads, railways). -Regulations allowing private participation in ports and railways. -Public-private cooperation for road maintenance and fire prevention. (Investment level is still well behind needs.)		Inadequate infra-structure: lack of *modern* biotechnologi-cal laboratories Resolution: -Updating of the biotechnological division in the Institute of Hygiene (School of Medicine). -Creation of Biotec-Plaza in Zonamérica -Recent private investments to upgrade two vaccines plants.

Table 5.1, continued

2. Related to capital requirements			
SOFTWARE	**FORESTRY**	**CAVIAR**	**VACCINES**
	-Inexistence of a capital market in Uruguay and limited saving capacity (this hindered the large scale development of the whole forestry chain Resolution: -Partially overcome by FDI (stable conditions offered in Uruguayan laws). -Forestry law: subsidies awarded with plantations as guarantee. -Special credit lines of public bank (BROU).	-High capital requirements Resolution: Foreign investors (pending of authorization)	
3. Related to human resources			
-Management skills to evolve from small start-ups to export businesses. -Higher requirements of graduates in computer sciences than the public university provision. Resolution: Private universities developed education in management and computing.	-Shortage or unavailability of specialized skills in different stages of the forestry chain. Unsolved The largest multinational (Botnia) opted for training Uruguayans in Finland's headquarters.		-Lack of skilled labor to sell in global markets. -Lack of biological engineers. Unsolved
4. Others (inputs/services; property rights, regulations and norms)			
-Inadequacy of (industrial) exporting procedures and norms. -Informatics property rights were not included in the intellectual property law in force. -Limited capacity to develop connectivity with the high tech world (e.g., international certification) Resolution: -The spreading of the Internet allowed selling through it instead of resorting to traditional ways. - Law 17.616 of 2003 now includes software programs as copyright protected products. -Solved in a case by case approach.	-Specialized services along the whole forestry chain Resolution -Initial subcontracting by the pioneer and foreign firms spurred the development of services firms. -Research lags well behind the sector requirements. -Week coordination in environmental issues between research institutions, entities in charge of norms and regulations, and firms. Unsolved	-No providers of quality food for sturgeon. -Week coordination between research institutions and enterprises (a joint project failed) Resolution: -Upstream integration by pioneer (building of a food plant) -Unsolved for technology.	-No providers of quality inputs (raw materials, bottling and packaging) Resolution: Solved individually by pioneers but not for newcomers.

The pattern of intervention (public or private) to resolve coordination failures appears to have been as follows:

- In the software and forestry cases, the private sector organized and asked the government for action. In the former, government was responsive because export capacity had been built in a high-tech sector and because demands were channeled through an organized body (CUTI). In the latter, the government responded because of the potential structural importance of the forestry sector.
- In the vaccine case, some coordination failures were resolved through public intervention for pre-existing activities (R&D infrastructure, quality control, and regulations) but others were not resolved at all (thin labor market, lack of specialized input providers, and lack of support for start-ups), which hindered diffusion. Firms overcame individually the barriers to entry in global markets, and created barriers to entry in the local industry.

In terms of policy lessons, the following stand out:

- Collective actions within an emerging industry are slow to develop in spite of apparent common interests.
- Public-private partnerships are less difficult to establish once there exists a private sector entity that represents the common interests and operates as a valid, non-rent-seeking interlocutor in negotiation with public entities.
- In the forestry case, the existence of an institutional framework allowed some level of public-private coordination (wine is another example), but these institutions should be more active in identifying coordination failures and in generating appropriate mechanisms to overcome them.

5.5 Other Features of the Discoveries

Finally, the following table presents several additional features of the pioneer and the diffusion process that were systemized as a result of the research undertaken.

Table 5.2 – Pioneers and Diffusion Features

SOFTWARE	FORESTRY	CAVIAR	ANIMAL VACCINES
Nature of the pioneer			
Pioneer was a savvy investor, looking for opportunities to apply accumulated knowledge in a specific field.	Pioneer used its commercial and agro-industrial abilities to jump from wool to wood.	Enterprising pioneer from fishery sector took advantage of exceptional information on the country's conditions for sturgeon breeding.	Pioneers looking for close and accessible opportunities jumped from one type of vaccines to another.
Original stimulus for the discovery			
Technological opportunity discovered abroad.	Market information from abroad.	Private, foreign information on geographical conditions of Uruguay.	Need and opportunity to use prod. capacity and knowledge of a sus-pended product (FMD vaccines).
Preconditions that made it possible for the successful discovery to take place			
Skilled human resources. Research capacity (public university). Telecommunication infrastructure.	Knowledge from previous forestry activities. Climate, soils. Low land prices. Macroeconomic stability. Forestry Law.	Climate and water quality. Institutional framework (DINARA).	Skilled human resources. Research capacity (public university). Common origin in 'biologicals' production. Institutional framework created for FMD vaccines production.
Discovery costs (activities with high or low costs)			
High: -use of fast growing technology to develop a new product through research (uncertain, by definition). -costs associated to foreign market insertion.	High: -long delays before harvesting. -experimentation costs before implementing the project (2 shipment trials).	Very high: -long production cycle. -substantial investments (fixed costs) and need to build entire farm/process before starting exports. Some information was obtained at no cost.	Low: -prior technological, productive and commercial knowledge on animal vaccines.
What exactly was discovered?			
Classic comparative advantage: possibility of competing in international markets on the basis of skilled human resources with low wages as compared to developed countries.	Classic comparative advantage, based on natural resources.	Classic comparative advantage, based on natural resources.	Related to a country classic comparative advantage based on natural resources (cattle).
Was there any international diffusion that led to the discovery?			
International diffusion of Information and Telecommunication Technologies (TICs).	Yes.	No.	International diffusion of biotechnologies.
How much diffusion has there been in the sector?			
Plenty, following first movers in different specialization niches.	Intense.	Incipient.	None (but three pioneers).
How much have exports grown (US$ millions)?			
4,5 (1993) to 104 (2005)	4,7 (1990) to 141 (2005)	0,003 (2000) to 1 (2005)	2,1 (1995) to 5,7 (2006)

Table 5.2, continued

SOFTWARE	FORESTRY	CAVIAR	ANIMAL VACCINES
Barriers to entry			
In the nucleus model: club type goods and network economies.	Long production cycle. Capital requirements. Infrastructure needs.	Long production cycle. Appropriate location (fresh water). Knowledge of caviar production process and technology.	Scale economies. Production secret. Quality control systems of processes and products Upstream agglomeration economies (medium importance). Vaccines registrations in foreign countries (medium importance).
Did the pioneer encourage diffusion?			
Yes, through the creation of community of practice with other software developers.	Yes, by going into partnerships and opening up technology.	Yes, by associating with another sturgeon farm and transferring farming technology.	No
Impact of diffusion on the pioneer?			
Network economies. Collective development of project (and capacities).	Positive impact: production costs decreased.	Positive to neutral.	n/a
Was there price erosion?			
Price of the pioneer's product remained stable over time.	No.	No. (Could happen in the future if diffusion is high)	No
Were there cost increases due to competition for inputs?			
Not yet. Labor cost could increase in the future if supply does not adjust.	In the medium run, the price of land increased.	Not in the mid-term.	No
Pioneer benefited from diffusion by supplying inputs or buying production from entrants?			
Pioneer benefited from diffusion by supplying a software tool for the development of software applications and systems.	Pioneer sells services.	Pioneer will provide food and technology to the follower, and will process caviar from roe coming from the new farm.	n/a

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Interviews and Case Studies

Software and Electronics Cases

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- N. Jodal, "GeneXus: el software uruguayo que llegó a China para quedarse" (May 23, 2005).
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- "La rentabilidad de la forestación," May 27, 2003.
- "Weyerhaeuser, otro ejemplo del desarrollo forestal," November 10, 2005.
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- "Carta de Guayubira al obudsman del Banco Mundial," November 3, 2005.
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