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Transfer of Technology for Successful Integration into the Global Economy

A Case Study of the Salmon Industry in Chile

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NOTE

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Preface

UNCTAD's series *Transfer of Technology for Successful Integration into the Global Economy* consists of case studies on transfer of technology issues in individual industries in selected developing countries. These studies draw lessons from national experiences with the transfer and diffusion of technology through various channels.

The studies highlight the crucial role that successful transfer of technology can play in the integration of countries into the global economy. They focus on the modes of technology transfer, and the adaptation, diffusion and further development of the acquired technology in the wider economy.

The studies also look at the interplay between technology transfer and development. They focus on the contribution of technology transfer to employment creation, export competitiveness and national innovative capacity. Thus, they provide lessons to other developing countries on building technological capacity and promoting development.

The studies deal with sectors where the selected developing countries have demonstrated their ability to create new productive capacities and successfully integrate into the world economy. They provide examples of cases in which a country's factor endowments were modified through investment in physical capital, human resources and the building up of capacities required to develop and use new technologies.

The present study is part of the second round of case studies in this series. The first round included a case study of Embraer in Brazil, a case study of the pharmaceutical industry in India and a case study of the automotive industry in South Africa. The second round will also include case studies on the automobile components industry in Tunisia and the electronics industry in Thailand.

The identification of firm-level factors as well as government policies and institutions that enable firms to thrive, grow and compete in the world market is vital to understanding the catch-up process and the building of technological capacity. These case studies seek to identify the conditions under which industries developed and some of the key institutions that played a role in this process.

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Abbreviations

APSTC	Association of Producers of Salmon and Trout in Chile
CORFO	Corporación de Fomento de la Producción
FDI	foreign direct investment
FIP	Fund for Fisheries Research
FONTEC	National Fund for Technological and Productive Development
IFOP	Fisheries Development Institute
Intesal	Instituto Tecnológico del Salmón
JICA	Japanese International Cooperation Agency
R&D	research and development
SERPLAC	Secretaría Regional de Planificación y Coordinación
TNC	transnational corporation
TOT	transfer of technology
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development

Executive summary

The emergence and the development of the Chilean salmon industry demonstrate the important role of technology transfer in industrial development. Technology transfer has enabled Chile to build a globally competitive and innovative salmon industry over the last two decades. The industry has become one of Chile's main export sectors and a significant contributor to regional development. Today, Chile is the second largest salmon producer in the world and develops technology for the production of other fish species.

The successful development of the industry highlights Chile's approach to industrial and economic development. Chile promotes scientific and technological innovation that adds value to or generates industries based on its natural resource endowment. In this case, the long coastline, abundant freshwater sources and islands, and good climatic conditions are part of its natural endowments, which, with the appropriate technologies, have played a vital role in the development of the salmon industry.

The development of the industry was a painstaking process and success was not assured. Chile undertook several trials, including attempts to stock rivers and lakes, spanning several decades in order to master fish-farming technologies. It solicited technical support from several international institutions with experience in fish breeding and farming and used its national institutions to acquire, assimilate, develop and diffuse fish farming technologies. Some of the early firms were created by public institutions and researchers that had accumulated some basic operational knowledge and skills in fish farming.

Several prominent national players that promote the development of firms and technologies facilitated the diffusion of salmon farming technologies. Among others, Fundación Chile, Corporación de Fomento de la Producción (CORFO) and Instituto Tecnológico del Salmón (Intesal) played very prominent roles in the development of the industry in Chile. Fundación Chile established Salmones Antártica as a limited company, which demonstrated the commercial viability of large-scale farming, breeding and production of salmon. In addition, the firm carried out research activities on farming procedures and provided technical assistance to small and emerging producers. The rapid growth of Salmones Antártica stimulated private interest and led to the expansion of the industry.

The close cooperation between government agencies and the salmon producers played a vital role in the growth of the industry, especially in the development of licensing regulations, sanitary standards and supporting research and development activities (R&D). Similarly, R&D institutions have worked closely with the national fishing agency, the National Commission for Science and Technology and the salmon industry.

The industry has also been successful in the assimilation of foreign technologies and development of indigenous technological capability. Some of the major accomplishments include the acquisition and development of technologies used in the production of wellboats, sequencing of salmon pathogen genomes, development of vaccines to control some salmon infections and replacement of fishmeal ingredients by vegetable-derived alternatives in the formulation of salmon feed. Furthermore, the

experience gained so far is now being used to develop technologies needed to farm other fish species.

As a result of these measures, salmon production in Chile grew about 17-fold between 1990 and 2002. Its share in the global production of farmed salmon and trout increased from about 10% in 1990 to about 35% within the same period. Indeed, Chile has moved from being a learner to a major player in the production and marketing of salmon products. The industry's exports increased from about $291 million in 1993 to about $1.4 billion in 2004. Chilean salmon is now being exported to new markets in Asia and Eastern Europe.

The export products have also evolved from mainly frozen tailless and beheaded salmon that were easier to process, store and transport to the export of value-added products. As technologies for processing and packaging various fish products were acquired and/or developed, the ratio of value-added product increased from about 23% to 69% of total salmon industry exports between 1994 and 2004.

FDI played a marginal role in the early development phases of the industry. However, the entry of large foreign firms into the Chilean salmon industry in the last two decades has facilitated the introduction of new technologies and the expansion of production, fostered vertical integration and increased the average size of firms. It is estimated that about $300 million of FDI was invested in the industry between 1989 and 2004.

The industry has also contributed to the general development of the region. Currently, it employs about 45,000 workers directly and indirectly, and has brought about a general improvement in regional infrastructure and services. More importantly, the poverty index of Region X decreased from 40% to 13% between 1990 and 2000 while the index of extreme poverty decreased from 24% to 7% over the same period.

These development gains may partly be explained by the nature of salmon industry expenditure. About 53% of the industry's expenditure goes to goods and the remainder goes to services. This means that a large proportion of the money raised is spent in the producing regions. This has led to the emergence of egg producers, feed manufacturers and providers of services. Many of these subsectors have attracted young professionals seeking employment opportunities in the once rural community. Taken together, they have contributed to the development of the region.

Although the industry has performed well over the last two decades, Chile still lacks advanced production and harvesting technologies. For instance, the industry relies mainly on the use of drugs to control diseases, which prevents Chile from meeting the requirement for the production of "ecological" salmon and "bio-salmon" owing to the shortage of vaccines and lack of advanced waste handling and water treatment and recycling techniques.

Despite these difficulties, Chile remains one of the countries likely to meet future global demand for salmon products. The country has plenty of natural resources that remain untapped and is developing technologies to expand salmon production in other regions of the countries and/or enable all salmon production phases (i.e. from hatchery to harvesting) to occur in the same place.

Introduction

The emergence and the growth of the Chilean salmon farming industry demonstrate the importance of technology transfer in industrial development. Other than Chile, the major producers of farmed salmon are developed countries with strong technological bases and vast experience in fisheries and marine research. In addition, Chile remains the main salmon-producing country in the Southern hemisphere.

Technology is transferred through various channels, such as technology licensing, foreign direct investment, trade, and participation in technology exhibitions, demonstrations and projects. Irrespective of the channel used, successful transfer of technology involves several innovative processes needed to adapt the technology to local operational conditions. Such activities may include "trial and error" steps, imitations, minor modifications, and upgrade steps needed to improve productivity and efficiency or reduce the cost of the transfer process.

Technology transfer is often said to be costly and complex, especially if it entails the introduction of a new industry in a country with limited experience and skills. This may involve the transfer, adaptation and upgrading production, processing, distribution and marketing technologies needed to develop an economically viable and internationally competitive industry.

In the early stages of industrial development, countries can rely on imported technology and simple modifications, but success may depend upon local capacity to assimilate foreign technology as well as to upgrade and adapt it to local needs and the local environment. This may involve "learning by doing" or "trial and error".

All countries borrow ideas and information from others that have more advanced knowledge in the field of interest in order to quickly raise their technological standards. Countries use public scientific and technological institutions to acquire, adapt and diffuse technologies in the early stages. As the industry develops, complex relationships develop between knowledge developer, specialized technology suppliers, marketing agents and distributors. At this stage, technology is needed not only to boost productivity but also to meet the demands of distribution channels and international markets.

This paper attempts to highlight some of the factors that enabled the emergence and development of the Chilean salmon industry. It addresses the major efforts that were made to acquire the knowledge to farm salmons. The first chapter addresses the evolution of the industry from its inception to its current status and the development of public and private support organizations in order to identify the role they played.

The second chapter looks at the structure of the salmon industry, and the major technological developments and challenges it faces. Chapter two also highlights some of the major technological achievements and some of the industry-related organizations involved in knowledge and technology generation. The third chapter highlights the performance of the industry in terms of production, exports, employment and its impact on the general development of the region.

Chapter 1. Development of the salmon industry in Chile

1.1. Evolution of the industry

The establishment of a new industry often requires the development of various support subsectors, such as production, processing, distribution and marketing channels, which are vital to the success of the industry. Each of these subsectors has different technological, financial and regulatory needs. The overall performance of the industry may depend on the efficiency and productivity of the various subsectors. The development of the Chilean salmon industry provides a good example of the sequencing and the technological needs of these subsectors during the development process.

At least four major phases in the industrial development of the salmon farming industry can be identified: the experimentation phase, the development phase, the industrial expansion phase and the market expansion phase. Each of these stages involved the development of various support institutions, as well as stakeholders and technological needs.

A. Experimentation phase (up to 1973)

Salmon fish were introduced into Chile by the Fisheries Development Institute (IFOP*)*, a not-for-profit institute controlled by the Agency for Economic Development (CORFO),[1] in 1921. Government institutions made several attempts to introduce and develop domestic salmon fish production. The Government used national and foreign institutions to acquire, adapt and develop technologies needed to establish a salmon fish industry. Government institutions signed a number of international agreements with foreign research centres.

During this phase, two cooperation agreements were signed between two United States universities (Oregon State University and the University of Washington) and two Chilean agencies (the Agency for Agriculture and Fishing, and CORFO). The objectives of the two agreements were to assess the feasibility of fish farming, identify appropriate locations for fish farms and develop the appropriate conditions for aquaculture. These activities focused on conditions for seeding salmon avelines (young salmon) and for setting up salmon incubation facilities.

In 1969, the National Fishing Agency (SERNAP) signed a cooperation agreement with the Japanese International Cooperation Agency (JICA) to introduce Pacific salmon into Chile. The cooperation focused on human resource development and feasibility studies of the technical and economic viability of salmon fish farming in Chile.

JICA donated a fish exploration boat and agreed to introduce Pacific salmon.[2] Approximately 40 million eggs were imported and 26 million avelines were seeded.

[1] Corporación de Fomento de la Producción (CORFO) is the government agency that promotes industrial development. See <htpp://www.corfo.cl>.
[2] See http://www.chile.or.jp/c/cecooperig.htm.

The initial goal was to stock Pacific salmon in the hope that they would return to breed. However, no salmon returned and the project was abandoned to focus on salmon farming (Petr, 1998). Overall, the project concluded that salmon farming was technically feasible, but its economic viability remained unknown. However, this project had succeeded in exposing Chilean scientists and technicians to Japanese technologies. Several Chilean officials were offered scholarships to visit the Japanese salmon centre through the technical exchange programme.

B. Industrial initiation phase (1974-1984)

This period was characterized by the emergence of public and private salmon- and trout-farming activities. For instance, Domsea Farms Chile, an affiliate of the United States firm Union Carbide, started production of salmon in 1974. The firm used imported salmon eggs and operated an open cultivation system called *ranching*. However, low returns and poor weather discouraged further investment in salmon farming and it was eventually abandoned.

Salmon farming during this phase benefited from the successful commercial farming of trout. Lago Llanquihue Ltd, a Chilean firm, developed with the support of CORFO, managed to produce and export trout to France in 1978 and later to other European countries and the United States. Furthermore, the emergence of foreign firms in the salmon-farming business stimulated interest among local entrepreneurs and firms in the commercial viability of the industry. Some of the early enterprises were founded by biologists, veterinarians and marine experts, among others. Many of them had acquired substantial experience and know-how about fish farming, management of foreign species and production of fish eggs.

The first joint ventures were also established in this period. For example, the Chilean company Nishiro and Pesquera Mytilus merged with Marine Harvest, owned by the Dutch company Nutreco. Nutreco is a multinational food company that operates several distribution and sales outlets for fish, chicken and pork, with facilities in Chile, Ireland, Norway and Scotland.

C. Industrial expansion phase (1985-1995)

This period witnessed an increase in industrial growth in various areas such as fish handling and cold chain management.[3] These activities were geared towards production and market expansion. For instance, about 36 firms were running salmon farms in 1985, but by 1987 the number had increased to 56 firms, which were running about 117 farms. By 1991, there were about 471 Atlantic salmon farms and 523 Pacific salmon farms.

The private sector developed very quickly during this period. Private-sector-led salmon associations and institutes began to play a major role. For example, some firms formed the Association of Producers of Salmon and Trout in Chile (APSTC) to promote the adoption of technological innovations and quality assurance standards. In addition, Fundación Chile had international representatives in Japan, Norway,

[3] Where the processing, packaging and distribution take place at low temperature in order to preserve the quality of the product.

Scotland and the United States to promote and market Chilean-farmed salmon. As a result, exports grew rapidly during this period.

The early success in salmon farming, the relatively low initial fixed costs and the favourable export market stimulated private-sector interest. Chile earned about $500 million from exports of most of its salmon produced in 1989. Although the prices of salmon fell by about 17%, a fall that led other salmon-producing countries to accuse Chile of dumping practices, Chile pursued other export markets, such as other Latin American countries, to limit dependence on its traditional salmon markets.

D. Market expansion phase (1996–to date)

In the late 1990s, the industry's growth was driven by market needs. The fall in salmon fish prices on the international market in the late 1980s and early 1990s led to the exit of smaller firms and to industrial consolidation. The increase in mergers and acquisitions was driven by foreign investors attracted to Chile's salmon industry in search of new production sites.

Several large firms moved towards vertical integration, including feed and egg production, to make use of economies of scale and reduce production costs. Such development led to the emergence of internationally competitive firms and brought the industry closer to the standards of other leading countries.

During this phase the salmon industry emerged as a mature cluster, with several firms undertaking different aspects of salmon production and marketing. For instance, there were 22 firms that produced net-pens (cages used in salmon farming), 13 provided painting and maintenance services, 18 produced and maintained cultivation tanks and 10 provided pathological services in Region X (also known as the Lake Region) alone. Furthermore, several firms and institutions emerged to handle logistics, fish processing and manpower development.

The expansion of the farmed salmon industry was also driven by the decrease in the wild salmon catch, partly due to overfishing and the growing demand for fish as a substitute for red meat by health-conscious consumers in developed countries and emerging economies. In addition, fish consumption has increased with the increasing wealth of households. The average consumption of fish per person has doubled over the last century, although the price of seafood has increased in real terms, unlike that of animal products, which has fallen drastically over the last 30 years (*Economist*, 2003). Furthermore, the fall in the international salmon fish prices led to an increase in consumption. The world production of farmed salmon surpassed 1 million tons at the end of the 1990s, largely superseding wild salmon production, and has kept growing.

1.2. Evolution of salmon industry support institutions

The development and expansion of the salmon industry is largely attributed to the central role played by various public and private support institutions. In many cases, these institutions played overlapping and complementary roles. For example, public institutions developed firms while some private-sector institutions developed and enforced regulatory measures (such as standards). Therefore, it may be useful to

classify support institutions on the basis of their roles rather than on whether they are in the public or private sector.

As the industry developed, the role of some of the key support institutions evolved to meet new challenges and take advantage of emerging opportunities. This is demonstrated by the shift in government policies over the period. As summarized in table 1, the Government utilized technical cooperation to demonstrate technical viability but slowly shifted to enabling Chilean salmon products to compete in the global market.

Table 1. Evolution of some of the salmon industry support institutions

	1960-1973	1974-1984	1985-1995	1996-2004
Government policy	International cooperation	Development of industries	Positioning the industry in the global market	Seeking new markets and industrial sustainability
Achievements	Technical viability determined	Demonstration of economic viability	Production and trade increases	Trade agreements with some major markets
Major actors	Government	Government, Fundación Chile, foreign firms	Fundación Chile, local producers, government, market	Government, producer associations
Association of producers and institutes	–	–	APSTC and Intesal formed	Association expands, and renamed SalmonChile

Source: Lizuka (2004).

A. Technology development and regulatory institutions

There are several public and private institutions that either support or carry out technology development in the salmon industry. The Fisheries Development Institute (IFOP), created in 1965, is a not-for-profit research institute that conducts research and development (R&D) activities. Most of its work is focused on technology development and data analysis for the fishing industry, such as fish stock assessment. IFOP collects and prepares data needed by the Government to design policies. In addition, the Ministry of Economy's Fund for Fisheries Research (FIP) funds research in conservation of marine resources and aquaculture. Most of its output is intended to help the Government to set policies.

CORFO, another public agency, manages funds for the promotion of scientific and technological development. It funds areas with great potential for the emergence of new product and business opportunities. In addition, it promotes and markets the technological products or outcomes of other agencies to attract private-sector interest.

Currently, there are several public and private universities that develop new technologies and human resources for the salmon industry. Many of these projects are co-funded with private and public institutions. For example, the remote sensing system for seabed cleaning was developed by University of Concepción with funds from FONDEF.

There are also private-sector players that are involved in funding and carrying scientific research and technological development, such as Fundación Chile. However, the Instituto Tecnológico del Salmón is one of the main dedicated training institutes for the salmon industry.

The role of the Instituto Tecnológico del Salmón

The Instituto Tecnológico del Salmón (or Salmon Technology Institute) (Intesal) was established in 1994 by SalmonChile to develop and diffuse food safety and quality control technologies in the salmon industry, as well as to represent the views of producers. The Institute monitors the technology needs of the industry as it evolves and provides technical assistance or training in sanitary and quality control standards for its members. It undertakes research projects to promote competitiveness, skills and industry sustainability, as well as to provide information for policymakers. The Institute has implemented several research projects on the environmental impact of the industry and fish diseases. It works mainly as a training institution for salmon industry workers. At present, it supports the institutional consolidation of the cluster and the introduction of quality control management systems.

Intesal has played a major role in capacity building, and in the development and enforcement of salmon-farming quality standards. Almost all aspects of the industry, such as surveillance of imported eggs, treatment of solid and liquid waste, processing, hygiene and traceability, are required to be in conformity with international standards. Salmon products exported to the United States are expected to meet or follow the United States Food and Drug Administration (FDA) standards. Most plants follow the FDA, and the Hazard Analysis and Critical Control Point Protocol (HACCP) on food safety developed by Codex Alimentarius.[4]

Intesal provides training in quality control and issues certificates on waste treatment practices of firms in the industry. This is important, as SalmonChile requires its members to implement the agreed standards. For compliance purposes, SalmonChile helps firms in the industry to upgrade their production, processing and waste management standards, among others, in order to enable them to obtain certification from Intesal. These efforts played an important role in ensuring that the industry met international standards and developed in a sustainable manner.

The Government recognized early in the development of the industry the need for regulatory institutions. In 1976, it created the Office of the Undersecretary for Fisheries and in 1978 the Fishing and Hunting Division of Servicio Agricola y Ganadero (SAG), under the Ministry of Agriculture, was replaced by the Fisheries and Protection Division to strengthen the development and regulation of fisheries.

B. Institutions supporting the emergence of firms

One of the main goals of technology transfer is to facilitate the emergence of firms or the upgrade of their production, marketing and design standards. This often

[4] HACCP is the basic international reference standard used for settling international trade disputes under the WTO Agreement on the Application of Sanitary and Phytosanitary Measures with regard to fish products.

requires support in order to enable entrepreneurs to utilize the knowledge acquired in the production of goods and services.

Chile provides a unique model for the establishment of firms, based on its natural resources and the technologies it has acquired and mastered. Several public and private institutions have played an important role in the emergence of the salmon industry in Chile. These include Fundación Chile, Secretaría Regional de Planificación y Coordinación (SERPLAC) and CORFO.

The role of Fundación Chile

Fundación Chile was created in 1976 by the Chilean Government and the United States' ITT Corporation to develop ways of diversifying the Chilean economy by creating new companies based on natural resources. Fundación Chile creates firms to demonstrate new technologies and to serve as vehicles for technology transfer. Once the firms have grown, they are sold to the private sector. In the process, the Foundation recoups its investment and moves on to the next sector or stage of development. Since its inception, Fundación Chile has established more than 40 enterprises, of which about 30 have been sold to the private sector.

Among these firms is Salmones Antártica, which started the farming of Pacific salmon in fish cages in Region XI. Fundación Chile bought the company Domsea Pesquera Chile Ltd and established Salmones Antártica as a limited company in 1982 to demonstrate the technical and commercial feasibility of the large-scale farming, breeding and production of salmon. The firm carried out research activities on farming procedures, artificial reproduction and genetic manipulation, and established salmon-farming marine centres.

The rapid growth of Salmones Antártica led to the construction of new farming plants and the expansion of fishmeal production and processing plants. In addition, Salmones Antártica provided technical assistance to small and emerging producers. Between 1985 and 1987, Fundación Chile created three other firms:

1. Salmones Huillinco S.A., to produce and sell Atlantic smolts (young salmon);
2. Salmotec S.A., to develop hatchery and ranching techniques; and
3. Finamar S.A., to specialize in the export of smoked salmon.

All these firms have since been commercialized.

Fundación Chile has contributed to the development and consolidation of aquaculture by continuously searching for appropriate foreign technologies and new fish-farming opportunities, and providing technical assistance to local producers. It has also worked with other national and regional institutions and supported the specialization of Chilean professionals in the different disciplines related to aquaculture in American training centres.

Fundación Chile also facilitated the formation of the producers' association, the Association of Producers of Salmon and Trout. The association has played a major role in enabling Chilean producers to gain access to the international markets, establishing production and product standards for Chilean salmon and developing the "quality seal" that is now adopted by its members as a tool to promote salmon exports.

The Fundación Chile[5] remains one of the major players and supporters of aquaculture. Currently, it supports diversification, technology development in several areas and upscaling and sale of some of its aquaculture projects.

Fundación Chile also worked closely with SERPLAC in several salmon-farming trials. The national agency for fishing activities and the regional planning agencies promoted feasibility studies and performance evaluations of salmon activity at the small-, medium- and large-scale levels. Initially, the main role of the support institutions was to identify the best geographical areas for salmon farming and the establishment of sanitary regulations. Of late, the producers have been asking for public support to position Chilean salmon supply in the global market.

C. Role of professional institutions and partnerships

The case of SalmonChile

Other private-sector institutions have also contributed to the development of the salmon industry. In particular, organizations that represent the interests of the salmon industry in the national and international trade or marketing of salmon have played an important role. Among these is SalmonChile.

SalmonChile was established in 1986 as the Association of Producers of Salmon and Trout, and renamed SalmonChile in 2002 to include supplier firms. SalmonChile plays a key role in linking entrepreneurs and national authorities. The association submits proposals to the authorities on ways to improve regulations and facilitate the operation of firms. It also provides trade information to its members and cooperates with other international salmon-farming firms and authorities in providing data on biomass to prevent overproduction or destabilization of international salmon fish prices.

SalmonChile also represents its members in discussions with public authorities on regulatory issues, such as modification of the licence-granting system, and defending the industry on the international stage, for example against dumping allegations by American and European (Scottish and Irish) salmon producers.

For instance, the association played a major role in determining the margin of dumping and helped establish that the European investigation team was comparing the production costs of two different goods, namely fresh and frozen salmon, thus contradicting the Anti-dumping Agreement of the WTO.[6] The product under investigation (fresh salmon) and the exported product (frozen salmon) were not considered to be the same products. Chilean producers export only frozen salmon to the European market, while the Scottish, Irish and Norwegian producers export mostly fresh salmon to that market. Furthermore, frozen salmon accounts for only 10% of the total demand for salmon in the European market, and the Chilean exports represented 50% (or 5% of the total salmon market in Europe).

[5] Other major successes of Fundación Chile include the development of technologies used to vacuum-pack or seal beef, the implementation of quality control and certification of export fruit, the introduction of berries into Chile and the creation and diffusion of technology in the forestry sector (www.fundacionchile.cl).

[6] Officially known as the Agreement on Implementation of Article VI of the General Agreement on Tariffs and Trade 1994; http://www.wto.org/english/tratop_e/adp_e/antidum2_e.htm .

SalmonChile helped provide data that convinced the investigating team that any actual or potential injury to the EU salmon industry caused by the imports of Chilean salmon was negligible, and no measures were imposed.[7] Similarly, the United States dumping allegations were terminated in 2003 with favourable findings for the Chilean producers.[8] The termination of these two investigations contributed to the strengthening of the position of the Chilean salmon industry in the international market and demonstrated the value of national producer associations.

In recent years, the association has changed from being an institution focused on quality standards and marketing strategy to one focused on the diffusion of know-how. It also promotes private-sector approaches to environmental protection, improvement in working conditions and social responsibility.

The case of ProChile

ProChile, the Chilean Trade Commission within the Ministry of Foreign Affairs, has assisted in identifying effective commercialization channels and promoted Chilean goods abroad. The main roles of ProChile are to:

- Support and advance Chilean business interests in the global marketplace;
- Facilitate exports by providing data on and identifying export regulations;
- Develop international business relationships;
- Facilitate formation of strategic alliances;
- Provide information on international trade; and
- Stimulate diversification of Chile's exports.

ProChile has about 56 global offices in major and emerging markets and 13 national offices in the various regions of Chile. It also monitors the development of legislation and customs regulations in order to keep exporters informed and advises Chilean exporters on market trends concerning future developments in the economies of interest. The organization is dedicated to the promotion of successful business relations between Chilean enterprises and foreign partners.

[7] In 2002, the European Commission initiated an antidumping investigation against Chilean farmed salmon exports. The investigation was terminated as the causal link between the dumped imports and the alleged injury to the Community industry could not be established, in accordance with Article 3, "Determination of Injury", and Article 5, "Initiation and Subsequent Investigation", of the WTO Anti-dumping Agreement. See Commission of the European Communities, COM(2003) 224 final; <htpp://www.europa.eu.int>.

[8] In 2003, the Department of Commerce of the United States (DOC) removed the antidumping order applied to Chilean exports of fresh Atlantic salmon since 1998, as a result of the review carried out under Article 11, "Duration and Review of Antidumping Duties and Price Undertakings", of the WTO Antidumping Agreement. See <htpp://www.commerce.gov/international trade administration> and <htpp://www.wto.org/legal texts>.

Chapter 2. Industrial structure and technological development

2.1. Salmon production phase

The Chilean salmon industry produces two main varieties of salmon: the Atlantic salmon (*Salar*) and the Pacific salmon (*Coho*). The production of the *Coho* variety is adapted to follow a unique seasonal cycle and takes place only in Chile. *Coho* production is mainly oriented to the Japanese market. The Atlantic salmon is produced all year round and its production is mainly designed for the United States market.

The production of salmon can be divided into three main phases: aquaculture and hatchery, farming and harvesting, and processing and distribution. Each of these phases has different technological, financial and labour needs. In terms of production costs, the first phase (hatchery) accounts for about 5%, the second phase (farming and harvest) for about 49% and the third phase for about 46% (18% processing and 28% transport and distribution) of total production costs.

In terms of inputs, fishmeal accounts for about 45% of the total cost of production and labour accounts for about 27% (Vidal, 2002). In terms of technology intensity, the hatchery phase is more technology-intensive than the other phases.

A. The hatchery phase

The hatchery stage involves the artificial fertilization and hatching of eggs, and rearing of the young salmon until they are ready to go to the salty ocean water. In brief, eggs are collected from the female salmon and then artificially fertilized by adding "milt" from the male salmon. The eggs are then hatched in incubators under controlled conditions. The hatched salmon, sometimes referred to as fry, are reared until they are big enough to transfer to the cultivation facilities.

The farmed salmon are bred from lines that have been carefully selected over time for productivity, quality of product (e.g. colour) and the ability to resist diseases. Like all breeding activities, the genetic improvement of parental lines is time-consuming but critical to the overall performance of the industry. In addition, the hatchery requires very high sanitary standards to ensure that the smolts (young salmon) do not become infected before they leave the hatchery and are synchronized to ensure they are of about the same size and age.

In the early stages of development, Chilean hatcheries relied on imported salmon eggs. It is estimated that about 51 million units of salmon eggs were imported in 1991 and the number rapidly rose to reach 62 million units in 1992, 73 million in 1993 and 114 million in 1994 (Katz, 2004). However, by 1995, about 40% of the salmon eggs used (74 million units) were locally produced. This was an indication of the increasingly important role of local salmon egg production, partly to reduce production costs and limit the import of infectious micro-organisms. In 2000, the Chilean fishing agency (Subsecretaría de Pesca) imposed an import ban on salmon eggs from countries where cases of infectious anaemia (ISA) had been suspected or

detected.[9] The ban accelerated the development of domestic salmon egg production. Although local R&D in biotechnology and diseases control in the hatchery phase is still insufficient, significant investments have been made, largely in quality control and waste management.

Hatcheries are generally located in remote areas near sources of fresh water. The need for and location of hatcheries close to fresh water sources present environmental challenges since they could contaminate fresh waters. For this reason, firms are required to submit environmental impact assessment studies to the local authorities. However, local official inspections have not kept pace with the rapid industrial expansion.

B. Farming phase

The farming phase is the production stage of the salmon industry. The young salmon are reared in pens until they reach market size, at which time they are harvested. The advances in hatchery management and feeding techniques have enabled more homogeneous growth of fish.

Several technologies have been acquired, adapted and developed for the farming stage. For example, the size of cultivation tanks has increased from about 7 by 7 metres to about 20 by 20 metres. In the 1980s and 1990s, the cultivation tanks were made of wood. Now they are made of aluminium and/or high-impact plastic. Also, firms are adopting automatic feeders, computerized sensing and monitoring of the environment, among other technologies.

Some of the costly inputs and activities at this stage include expenditure on fishmeal and R&D activities to develop feeds with higher conversion rates (i.e. kilograms of fishmeal per kilogram of fish). The conversion rate in Chile has increased from 3:1 (3 kg of feed to 1 kg of salmon fish) in the 1980s to about 1.3:1 in recent years. Globally, the ratio of fishmeal in fish feed fell from 70% in 1972 to 35% in 2002 and the amount of feed required to grow salmon to maturity fell by 44% over the same period (*Economist*, 2003; Aerni, 2004). This remarkable achievement – over a period of three decades – was due to R&D investments in the field of feed development, fish-breeding programmes and improvement in fish health management.

C. Processing and transportation

Harvesting starts once the fish have grown to market size. Speed and accuracy are important in quality assurance at this stage. The facilities have to ensure that the product weight, colour, size, shape and packaging, all of which are important to consumers, are of the required standards. Well-trained workers and equipment are required in order to ensure product quality.

Different products, such as boneless, smoked and fresh salmon, impose different requirements and different markets may have unique requirements. All these may need different equipment and skills. Furthermore, the processing facilities will have to be certified by US and EU authorities if they are to export to those markets.

[9] "Squeeze is on for salmon-egg firms" (27 October 2000), Puget Sound Business Journal, *American City Business Journals Inc* (http://www.bizjournals.com/).

Most processing facilities maintain solid cold chains, international standards of germ control (HACCP) certification and efficient systems of waste management.

The cost of labour in Chile is lower than that in competitors such as Norway and Scotland. For this reason, processing facilities in Chile employ almost twice as many workers as equivalent facilities in developed countries. This gives Chile a comparative advantage in labour-intensive activities that cannot be automated, such as the production of fillets and boneless portions of salmon.

For smoked salmon, packaging is crucial both for marketing and conservation purposes. To meet market requirements, several specialized firms have emerged to support local producers. In the early stages, processing plants used imported technology from Canada, Norway and Scotland. Currently, a variety of new materials and packaging systems have been developed to satisfy local needs and habits.

Transportation and logistics are an integral part of the salmon-farming industry. Feed, medical supplies and other inputs have to be synchronized or coordinated to avoid any disruptions that could cause delays in the production chain or result in serious costs to the industry. Currently, the transportation service is fully subcontracted to specialized firms. This allows the firms to concentrate on their core businesses by practising just-in-time management. Transport companies incorporate advanced technologies and management techniques in order to meet the requirements of increasingly sophisticated international standards and to reduce the overall costs of salmon products.

2.2. Major technological developments

The industry relied heavily on imported technologies and imitation of foreign technology for its growth in the early stages of development. For instance, Chile used international institutions, such as the Japanese International Cooperation Agency, United States universities and the United States Peace Corps, to establish hatchery conditions and quality control and management. As firms emerged, several institutions and firms adapted imported technologies and, in some cases, developed their own technologies to meet their unique challenges and environment.

Although the technological needs of firms in the industry were not similar (since salmon production is affected by environmental and ecological parameters, such as water quality, salinity and temperature, which differ widely from one farm to another), it is possible to identify the key common technological developments. These include innovation that affects the industry at large or determines the competitiveness of salmon products and services.

A. Development of wellboats

Wellboats are specialized ships that serve as floating beds (with good circulation of oxygenated water) used to transport live fish. The technology was imported from abroad, but the boats are now produced locally. The existence of firms with extensive experience in ship design and production facilitated the adaptation and assimilation of the technology.

For instance, ASENAV (Valdivia, Chile), a manufacturer of boats and ships, has built several wellboats with the capacity to hold up to 800 tons of fish, using its in-house designs, as well as the Vik-Sandvik design (under a licence arrangement with Vik-Sandvik of Norway). The firm, founded in 1973, specialized in production of roll-on and roll-off ferries, patrol boats for the Chilean navy and industrial fishing boats. It also builds luxury sport fishing boats, aluminium catamarans, tugs and cruise ships for customers in the Faroe Islands, Fiji, Norway, Peru and the United States; and has built Offshore Support AHT (Anchor-Handling Tug) supply vessels. The experience and expertise gained allowed ASENAV to develop wellboats for the salmon industry.

Wellboats enable the production facilities to harvest fish and transport them alive over a long distance to the processing facilities, thereby reducing the manpower needed to harvest salmon. The use of wellboats eliminates contamination of the water at the production facilities with fish blood (if the fish were killed) during harvesting and enables processing facilities to consistently produce salmon products of a high quality (the fish maintain their colour and texture since they are delivered alive).

There have also been technological developments relating to the design of ships. The design of vessels has been modified to adapt ship structures to the geography or morphology of the Chilean coasts. These projects were financed by FONTEC.[10]

Currently, a research team from the University of Chile, with the support of CORFO, is studying the risks associated with the use of wellboats. The objective of the project is to determine the sanitary and environmental impact of wellboats and to propose the necessary measures required to improve their efficiency and limit any potential negative environmental impacts. The risk arises from the fish they carry rather than the wellboats themselves, especially for areas of the ship that come into direct contact with the fish, such as pumps and intake and outlet grids. These areas of the ship may be difficult to clean and could spread diseases.

B. Genome sequencing and vaccine development

The farming of fish, like all farming ventures, often involves the use of prophylactic and therapeutic compounds to control diseases. One of the major tools for preventing and controlling diseases in aquaculture is the use of vaccines. The development and use of vaccines are also good for the environment as it reduces the use of drugs (see section 2.3).

The sequencing of the genome of the bacterium *Piscirickettsia salmonis*, a bacterium that greatly affects salmon production in Chile and causes a devastating disease, Salmon Rickettsial Syndrome (SRS), is one of the major steps towards understanding how the disease develops and towards the development of vaccines. The disease causes annual losses estimated at about $100 million to the salmon industry in Chile (Argandoña, 2004).

[10] FONTEC is the Chilean fund for technological and productive development that finances and co-finances technology innovation and transfer of technology; see <htpp://www.fontec.cl>.

Chilean scientists from 11 institutions identified about 16 possible candidate genes for the control of the disease and developed a vaccine against it by 2004. In addition, a joint project involving the University of Concepción, CORFO and some fishmeal-producing firms resulted in the development of a recombinant vaccine against another infectious viral disease known as infectious pancreatic necrosis.

C. Development of alternative salmon feed formulations

One of the main advantages of fish farming is the reduction of pressure on natural resources imposed by hunting wild fish. However, the use of fish and fish oil in the preparation of salmon feed is often seen as putting pressure on other marine resources. For this reason, research in the development of alternative feed ingredients is regarded as important in improving environmental sustainability, reducing the costs of feed production and diversifying the feed resources. The use of vegetable resources in the formulation of salmon fishmeal is complicated by the fact that salmon are carnivorous (Aerni, 2004).

To reduce the use of animal proteins and oils, a project was carried out by the University of Valparaíso to develop vegetable substitutes – in particular, canola oil and flour – for use in the composition of fishmeal. This project, among others, has helped the salmon industry to reduce the use of fish ingredients in feed formulation from about 90% to 50% over the last two decades.

D. Experimental development of new farming species

The experience and expertise accumulated in the farming of salmon and trout are now being employed to develop new technologies for the farming of other species. Fundación Chile is providing management and financial support for the development of technologies needed to farm other fish species, for example cod fish (hake), in the country.

This initiative involves technology that has been developed in Chile. The preliminary stages of the project have been completed (i.e. development of farming, reproduction and feeding technologies) and production is expected to start in 2005.

2.3. Technological challenges

The Chilean salmon industry underwent an incremental process of technology upgrading – from the technology transfer, imitation and adaptation stages (which resulted in the local production and adaptation of wellboats, or of different kinds of fishmeal) to the development of endogenous innovation capabilities (resulting in the development of new vaccines and technologies for the farming of other fish species), as shown in table 2. While these few identifiable technological achievements may be important, the collective learning path which has influenced or led to a new approach to business management of a complex system and production of high-value-added salmon products is perhaps of greater importance.

Table 2. Summary of technology upgrading and innovation

Type of change	Technology	Phase/stage	Determinant	Innovating agent
Imitation	Wellboats made in Chile	Harvesting	Labour costs Quality	Private firms
Adaptation	Vegetable substitute for fish flour	Farming	Scarcity of natural resources	Researchers
Endogenous Innovation	Genome sequencing of *Piscirickettsia salmonis*	Product (vaccine) development	Economic losses caused by SRS	Researchers
	Hake farming	Product development	Diversification of production	Public/private institutions

Source: UNCTAD, based on survey.

Among others, the development of technology for egg production, the breeding of improved parental lines, the handling of different production phases that are spatially scattered and the monitoring of consumers' preferences in the export markets have been part of the collective learning curve of the industry. The industry has mastered and developed distribution and supply chains to meet production and market needs.

Such a collective learning process would not have been possible without a set of networks and linkages among key local authorities, domestic firms and foreign partners that facilitated the process of acquiring, adapting and disseminating new technologies. Although the technical requirements imposed by salmon production forced the industry to generate the necessary human capacities and networks needed to manage a complex system, the existence of local support institutions that work closely with industry and universities has played a major role. Most of the technology developed has involved these three core players that are part of Chile's national innovation system.

Although the industry has performed well over the last few decades, it now faces the challenge of improving production and handling methods to meet international levels of efficiency. Chile lacks advanced technology, especially for the production and harvesting phases. For example, owing to the insufficient supply of vaccines, diseases are treated with drugs, especially antibiotics. This prevents the Chilean industry from meeting the requirement to produce "bio-salmon" (salmon produced without excessive use of hormones, antibiotics or others drugs). Above all, the production of "bio-salmon" would require, in addition to the above conditions, the use of waste-handling, water treatment and recycling techniques that are still unavailable or just emerging in Chile.

The environmental impact of salmon farming remains another area of concern as it may negatively affect the industry unless measures are adopted. The industry would greatly benefit from the development of technologies for the control of foreign pathologies (imported), the management and selection of the varieties which are most appropriate to local conditions, and strengthening of the inspectorate arms of local authorities.

2.4. Overall assessment

The initial success of the industry was dependent on its natural resources endowment, cheap labour and import and adaptation of foreign technology. The industry soon realized, however, that in order to achieve sustained exports and increase the value added of exported products, Chile had to develop an innovation capacity in salmon farming. The industry had to develop a local capability to absorb, adapt and master the transferred technologies and develop more advanced technologies to take advantage of its unique opportunities and meet its challenges. In addition, successful integration of the Chilean salmon industry supply into the global economy required development of international networks and reduction in production costs in comparison with the other main competitors.

To achieve the above, Chile developed a set of support measures that were critical to technology development, improving production and marketing of salmon fish products. Among these were a friendly regulatory framework, promotion of standards and international networks, facilitating the emergence of a producer association and enhancing cooperation between technology development institutions and industry. For example, the licensing system opened up the market to foreign and domestic investors.

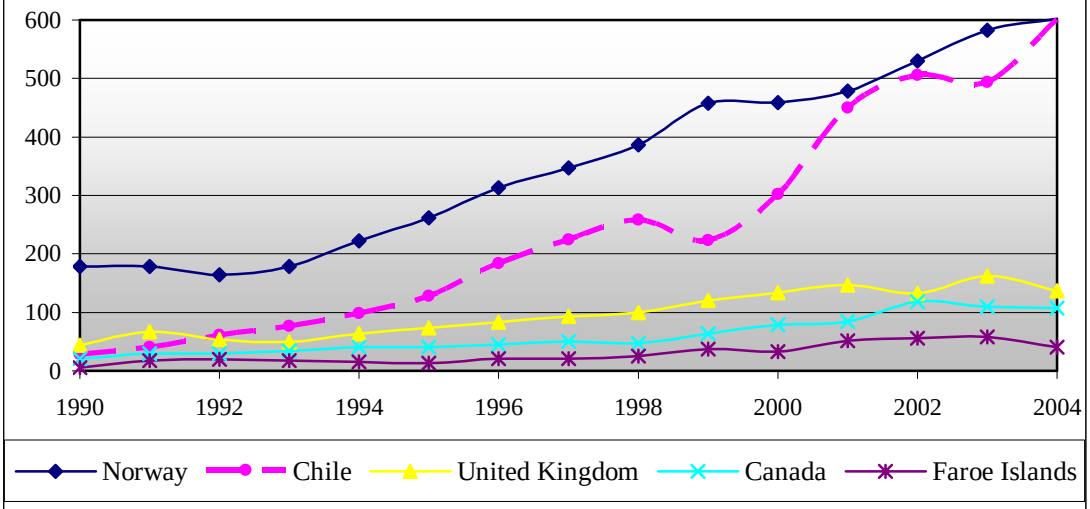
Furthermore, Chilean firms soon realized that their interests were best served if they organized themselves into a business association (the Salmon Industry Association) to articulate the needs and advocate for the industry. This proved very important in dealing with international disputes, marketing and technology development.

Chapter 3. Performance and impact of the industry

3.1. Production and export growth of farmed salmon

The main producers of farmed salmon are Norway, Chile and Scotland, which (together) account for about 80% of global production. Chile's salmon production has grown tremendously since 1990 – about 17-fold between 1990 and 2002. Consequently, its share of global production of farmed salmon and trout increased from about 10% in 1990 to about 35% by 2002 (figure 1). Within two decades, Chile has moved from being a learner to a major player in the production and marketing of salmon fish products (Alivial, 2003).

Figure 1. Production trend of major salmon and trout producers
(in thousand tons**)**



Source : SalmonChile (2005).

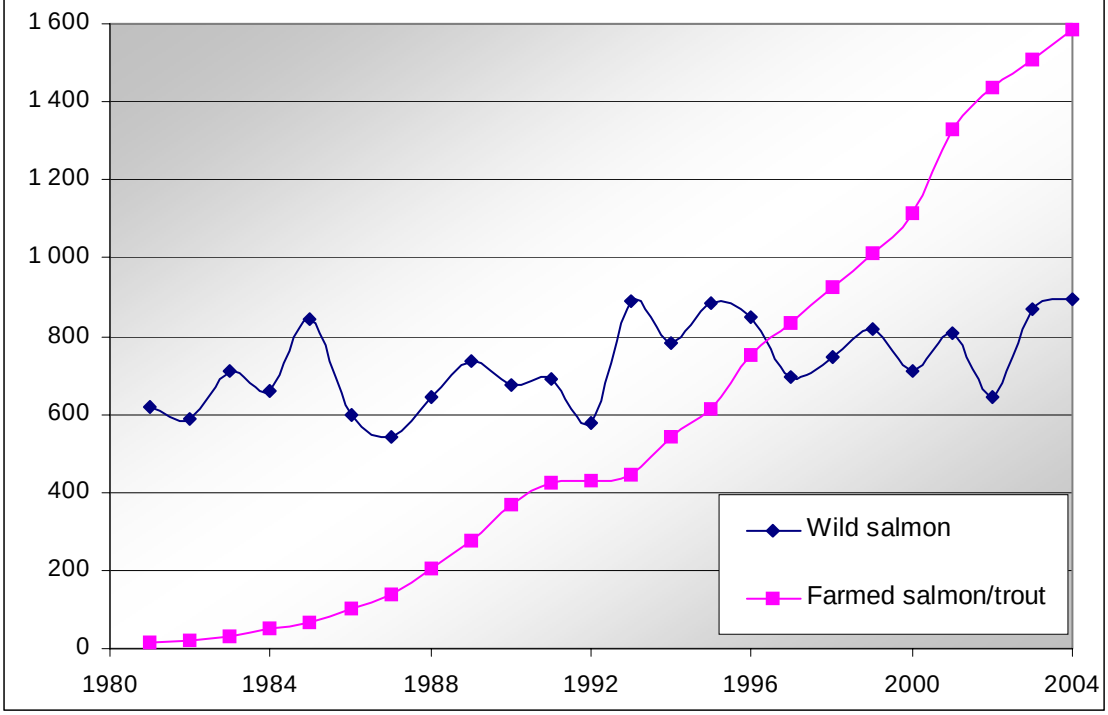
The production of farmed salmon and trout has grown rapidly during the decade, as shown in figure 1. This has altered the consumption patterns of salmon fish products. Prior to the mid-1980s, consumption of salmon was confined to high-income segments of the population, largely in traditional fish-consuming countries such as Japan and the countries of the European Union. The varieties consumed were wild Atlantic salmon and silver (Alaska) salmon.

Since then, the sustained expansion of farmed salmon supply has caused a continuous decline in the international price of salmon products. For example, prices fell from $8-9 in 1988 to $4-4.5 per kilogram in 1993[11] and had further declined by the end of the 1990s. This fall in prices was driven by increased production of farmed salmon and lifestyle changes. There was also an increasing desire among diet-conscious individuals to consume fish as a substitute for red meat.

[11] Fresh salmon from Norway at Rungis, the wholesale market near Paris (Achurra, 1995).

The increased demand is in turn stimulating increased interest in salmon farming. Most of the salmon fish consumed is farmed, as the growth of wild salmon has not grown substantially since the 1980s (figure 2). Indeed, the global aquaculture industry has been growing at an average of about 10% per annum, and food produced in this way is possibly the fastest-growing form of food. By contrast, farmed meat production is estimated to grow at about 3% annually (Aerni, 2004).

Figure 2. Comparison of wild salmon catch and farmed salmon and trout (in metric tons)

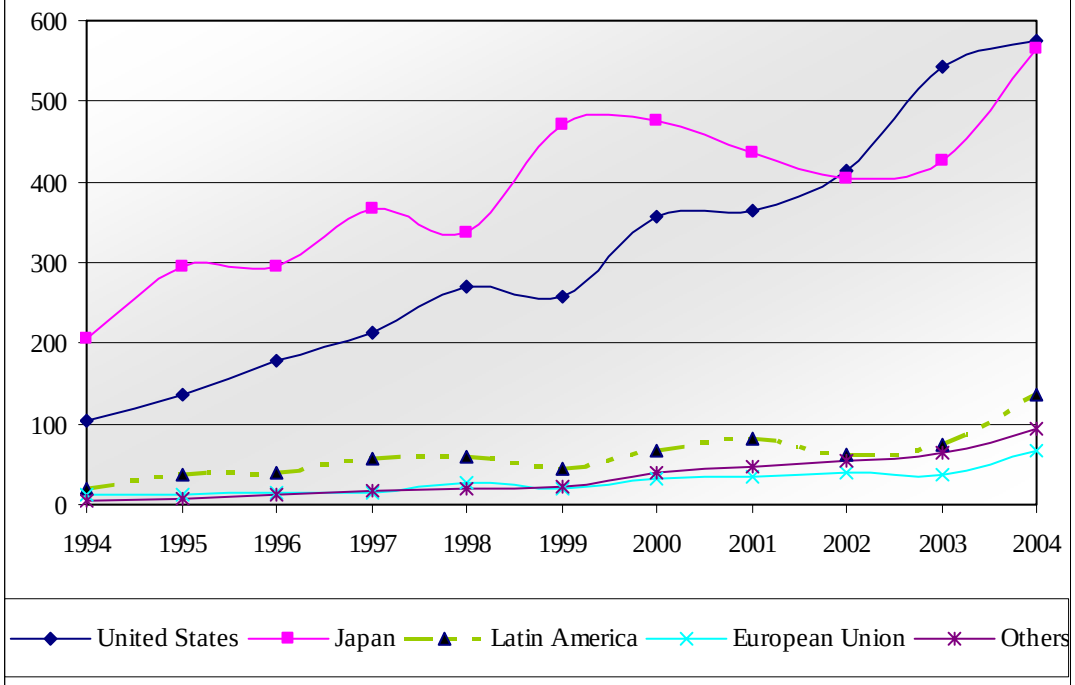


Source: *Aquanoticias*, nos. 74, 75, 76, 78, 79, 80 and 82; Fundación Chile (ed.), <http://www.fundacionchile.cl>. See also <htpp:// www.aqua.cl> and <htpp://www.prochile.cl>.

These factors (increased production, increasing demand and falling prices) led to the introduction of salmon fish products into mass distribution channels, such as supermarket chains, which made such products accessible to a wider consumer base. As a result, the industry started to provide a wide variety of products, including whole fresh salmon, fillets, portions, frozen salmon, smoked salmon and ready-to-serve meals.

The market for Chilean farmed salmon has also evolved over the last decade. Japan was the main export market for Chilean salmon products, accounting for about half of the total (up to the year 2000), followed by the United States (about a third) and the European Union (less than one tenth). However, by 2002, the United States had become the main market of destination, with a share of 43% of total exports (figure 3).

Figure 3. Main markets for Chilean exports of salmon and trout
(In million $, FOB Chile)



Source: SalmonChile database (2005).

In general, Chilean salmon and trout exports increased from about $291 million in 1993 to about $1.4 billion in 2004. This is an increase of approximately 500% in a decade. By 2004, salmon and trout farming had become the fourth main export sector of the country.

There is also a shift in the export products of the Chilean salmon industry. Salmon exports are gradually shifting towards products that are easy to use and ready to eat, and high-value in terms of varieties and production processes, to meet consumer needs. This is evident from the gradual upward trend in the total value of exports since 1994. The proportion of value-added products to total exports increased from 23% in 1994 to 69% in 2004 (table 3).

Table 3. Evolution of value-added salmon export products
(As percentage of total salmon exports, 1994-2004)

	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Fresh fillet	11	12	17	21	28	25	29	29	31	31	26
Frozen fillet	7	11	13	14	15	15	18	21	20	19	25
Salted	1	2	4	6	3	2	2	2	2	2	1
Smoked	2	3	2	2	1	2	2	2	3	3	3
Canned	1	1	1	0	1	1	1	1	1	2	2
Other products	1	1	2	3	4	4	6	6	7	11	12
Total	**23**	**29**	**39**	**47**	**52**	**48**	**56**	**60**	**64**	**67**	**69**
Total exports (in $000)	349	489	538	668	714	818	973	964	973	1 147	1 439

Source: SalmonChile database (2005).

Initially, the industry exported mainly frozen tailless and beheaded salmon that were easier to process, store and transport. The export of value-added products increased as the industry acquired and developed technologies for processing and packaging various fish products. In addition, some value-added products require a well-established distribution chain. For instance, fresh cooled products are produced and delivered to the destination market, largely the United States, in a few hours. By contrast, frozen products are easily exported to their destination market by sea. In 2002, the volume of smoked salmon exports increased by about 40% over that of 2001.

This increase in exports was also fuelled by a general increase in the average price of salmon (from $2.7 to $4 per kg in one year) and the relative growth in higher-value-added products exported (e.g. smoked salmon, fillets and boneless portions). However, it is worth noting that about 90% of the production is still exported as chilled-fresh or frozen (table 3).

Norway and Chile are among other countries most likely to meet future expansion of the world demand for salmon products, because of the availability of natural sites for salmon production.[12] In the case of Chile, production is expanding to the South into the XI Region, Aysén, and to offshore platforms. Also, it is expected that improving the quality of water will lead to a reduction in pathogens and improvement in the overall quality and cost of Chilean salmon products.

However, the EU Commission adopted fresh anti-dumping measures against Norway (which supplies about 60% of the EU salmon market). The measures imposed on 6 February 2005 include a minimum import price of €2,700 per tonne of whole fish and €2,592 for frozen salmon, and tariff quotas that limit duty-free imports to 10% above 2004 volumes, with additional duty being imposed on exports exceeding that limit.[13] Chile feared that such measures might limit investment, production growth and export volumes and filed a request for consultation in the WTO, which was later dropped following the decision by the EC to withdraw its safeguard measures on salmon originating from Chile.[14]

3.2. Foreign direct investment in the fishing industry

Foreign direct investment (FDI) has played a role in the development of the salmon industry. The first major firm to farm salmon (in 1974), Domsea Farms Chile, was owned by the United States firm Union Carbide. However, it was not until the mid-1980s that mergers with foreign firms and joint ventures started to play a greater role.

In general, FDI played a marginal role in the early development phases of the industry. However, the good perfomance and success of the industry have attracted

[12] Statement by Wouk Dekker, CEO of Nutreco, Santiago, 16/01/2004; see <htpp://www.elmercurio.cl>. Operating through Marine Harvest, Nutreco is the main producer in the Chilean domestic market.

[13] The Commission of the European Communities (2005), Imposing definitive safeguard measures against imports of farmed salmon, Commission Regulation (EC) No 206/2005 of 4 February 2005, L 33/8, *Official Journal of the European Union*, 5.2.2005.

[14] See http://www.wto.org/english/news_e/news05_e/dsb_20june05_e.htm.

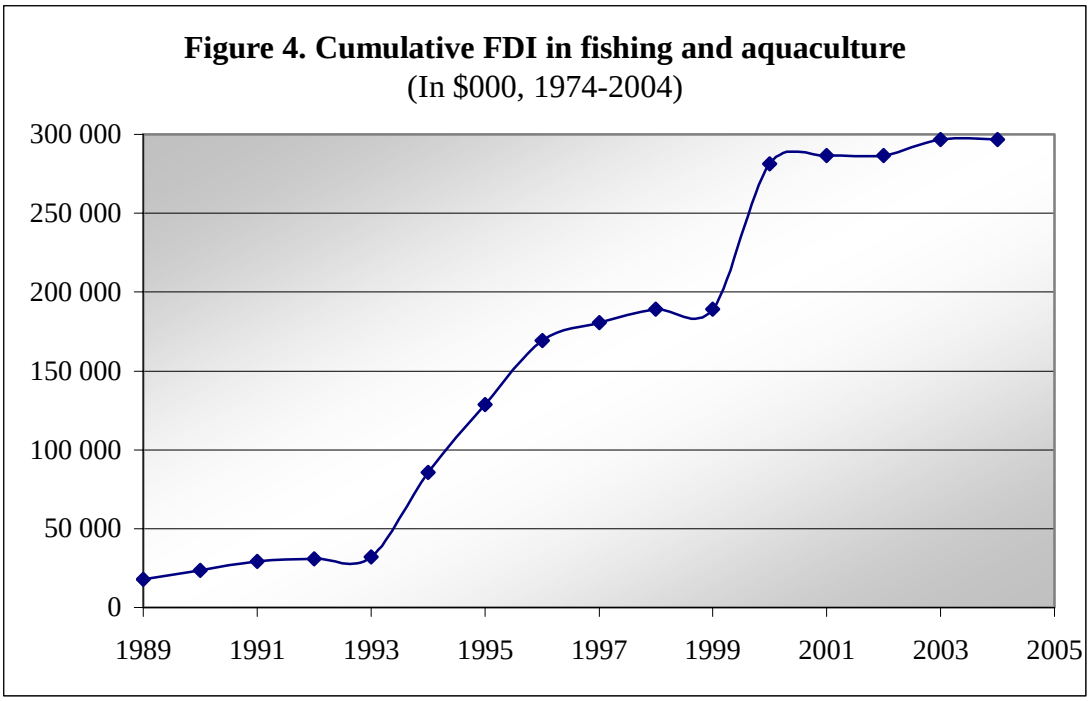
many foreign firms seeking to expand salmon production or provide inputs and support services. The entry of large firms into the Chilean salmon industry has facilitated the introduction of new technologies and practices such as automated feeding and fish-counting systems. It has also facilitated expansion of production, fostered vertical integration and increased the average size of firms.

For instance, Nutreco – which owns Marine Harvest and Skretting – is estimated to have invested about $250 million in its Chilean operations. Marine Harvest is the largest producer of farmed salmon in the world and has grown the fastest in Chile through mergers and acquisitions. The firm, Marine Harvest Chile, produced about 2,900 tons of farmed salmon in 1992. By 2004, the firm's production had increased to 72,000 tons, most of which is exported to the United States and Japan, earning about $180 million.

Similarly, Skretting is a fish feed producer and one of the major salmon feed suppliers in Chile. In 2004, the firm inaugurated a $25 million feed production plant, the largest it owns in the world. Altogether, it employs about 3,000 workers. Nutreco expects to continue investing about $9 million annually in its production facilities in Chile.

FDI flows into the fishing and aquaculture sector of the economy increased substantially between 1993 and 1996 and between 1999 and 2000 (figure 4). Consequently, the number of firms grew from 5 in 1985 to 22 in 1997 and then fell to 17 in 1999 (Katz, 2004). The increase in acquisitions and mergers that characterized the late 1990s led to a reduction in the number of firms but an increase in the average firm size.

Figure 4. Cumulative FDI in fishing and aquaculture
(In $000, 1974-2004)



Source: Chile Foreign Investment Committee database (2005).

However, there are fears that the increase in joint ventures between relatively smaller Chilean salmon firms and larger international producers may be affecting the existing linkages between R&D and support institutions on the one hand, and industry on the other hand (Enright, 1998). The TNCs are likely to focus on R&D that is in line with their interests rather than with national development goals. This may weaken the linkages that have played a vital role in the development of the industry (Enright and Ffowcs-Williams, 2000).

However, this is not unexpected since the salmon industry in Chile is now maturing and may be more interested in consolidating its market position rather than focusing on production (Humphrey and Schmitz, 2000). One way of positioning itself in an increasingly sophisticated global marketplace is to enter into partnerships and alliances that enable Chilean firms to penetrate new markets.

3.3. Employment

About 90% of salmon production is located in Region X, which is about 1,000 km from the capital, Santiago. The Region has a population of about one million. The main urban pole of Region X is the city of Puerto Montt. The expansion of the farmed salmon industry has given new dynamism to the regional economy, initially based on traditional and semi-industrial fishing, farming and harvesting of molluscs, small-scale production of potatoes, and tourism during summer. To expand production, the industry is extending to the south into Region XI.

In 2002 the industry employed about 24,800 workers (directly), while supplier firms employed 12,000 additional workers. Total employment by the sector in the region increased almost threefold between 1992 (10,200 workers) and 2002 (40,500 workers). The 2004 employment estimates by SalmonChile suggest about 45,000 workers are directly or indirectly employed by the sector. These changes may partly explain the improvement in the social indicators of the region. The poverty index in Region X decreased from 40% in 1990 to 24% in 2000, and the index of extreme poverty decreased in the same period from 13% to 7%.

3.4. Human capital development

The Government and the private sector have invested significant resources to produce trained and specialized professionals needed by the industry. The Government facilitated the development of training programmes in biochemistry, pathology, engineering, business administration and aquaculture, among others, at local universities. It has also established new research centres.

Since the 1990s, universities have supplied the labour market with professionals in aquaculture production and aquaculture business administration. Most of these professionals are graduates of universities located in the region, such as Universidad Austral en Valdivia and Universidad Los Lagos.

Similarly, Intesal joined the national training system (SENCE) in 1996. Since then, it has become the main institution for human capital development in the region, especially in training in quality control management. The number of persons trained has increased by 500%. In 2002, Intesal graduated 2,060 workers, 18% more than in 2001.

Firms in the industry are offered tax exemption on expenditures incurred in training their workers. This fiscal incentive, administered by the national labour agency, enables firms to claim a tax deduction on expenses incurred in training their workers that qualify under this scheme. Furthermore, some salmon firms have also established school programmes to support the public education system in the region.

The industry has increased the education levels of workers and those of the regional population. Migration to the region has increased and has contributed to boosting the supply of educated workers and economic activities. A number of young professionals (aquaculture-related engineers, architects, veterinarians, biochemists and technicians, as well as medical practitioners, among others) and their families have moved to the area attracted by the employment opportunities in the salmon industry and the supplier firms.

3.5. Socioeconomic development of the region

The economic impact on infrastructure is more evident: road investments aimed at connecting the region with the north of the country, including the construction of a bridge to link Chiloé Island to the continent, and the modernization of the regional airport. The city of Puerto Montt is now an economic and cultural centre. Banks and insurance companies, consultancy and engineering services, research centres and universities have been developed in the region to support the industry.

This is partly explained by the nature of the salmon industry's expenditure. It is estimated that about 53% of it is on goods and the remainder on services. This has led to the emergence of egg producers, feed manufacturers and service providers. Some of these sectors have emerged as major exporters in their own right. For instance, Chile is one of the major producers and exporters of fishmeal. Together with Peru, it accounts for about one third of global fishmeal production.

Conclusion

The rapid development of the salmon industry in Chile demonstrates the critical role that technology transfer plays in industrial and national development. Chile used international experts and institutions to expose its professionals to advanced salmon-farming techniques and employed its national institutions to adapt and diffuse the technology acquired.

The role of support institutions, such as CORFO and Fundación Chile, in facilitating technology development and formation of firms played a central role in the early development phase of the industry. For instance, the rapid growth of Salmones Antártica – the firm established by Fundación Chile – stimulated private interest in salmon farming. Also, the firm served as an experimental development centre and as a technology transfer agent. It experimented with new production technologies, identified possible farming centres and provided technical assistance to emerging salmon farms.

Although it is often argued that technology transfer is purely a private-sector activity, the development of the salmon industry shows that the public sectors of technology-exporting and technology-importing countries play an important role. Public institutions such as government agencies, not-for-profit private institutions and international development agencies (e.g. JICA) facilitated the transfer and development of technology. Private interest largely emerged after the industry had begun to grow.

The successful development of the salmon industry was also due to the existence of innovative entrepreneurs in local institutions that develop and diffuse technologies and invest in or support the emergence of private firms. Some of the early firms were developed by entrepreneurial aquaculture scientists, engineers and business management experts. The capacity to adapt and further develop the technology acquired was as vital to the development of the industry as were differences in climatic and environmental conditions. In addition, regulatory and logistical support institutions in Chile and countries that had advanced salmon farming technologies imposed technological challenges.

Although adaptation and imitations played a role in the emergence of the industry, domestic innovative capacity was needed for it to become competitive in the global market. For instance, the replacement of fish-derived ingredients by vegetable-based ingredients in salmon feed, together with the sequencing of salmon pathogen genomes and the development of vaccines, helped reduce production costs and improved farming conditions and market acceptance of Chilean salmon products.

As a result of its continuous investment, Chile's farmed salmon industry grew 17-fold between 1990 and 2002 and has reshaped the global trade in salmon. Chile has gone, within a period of two decades, from being a learner and follower to being a major producer and global player in salmon production. The country now exports salmon products to all the major markets – Japan, the United States and the European Union.

The increase in Chile's exports is partly attributed the promotion and enforcement of international sanitary standards as well as the promotion of its

products abroad. For instance, the use of international representatives and institutions (e.g. ProChile) to market and promote Chilean products has played an important role in market penetration. In recent years, inter-firm cooperation between Chilean producers and established firms abroad has played a role in marketing Chilean salmon products.

Although FDI has had only a marginal role in the development of the salmon industry, it is important to note that the major firm to farm salmon, Domsea Farms Chile, was foreign. However, since the mid-1980s FDI flows into the fishing and aquaculture sector have increased but remain a small fraction of total FDI inflows (about 0.1%). FDI facilitated the introduction of new technologies and practices that are still emerging, and led to the consolidation of firms. Also, Chilean salmon firms are increasingly developing joint ventures with other international producers. Three of the top ten producers of farmed salmon – Marine Harvest, Nutreco and Aqua Chile – have operations in Chile.

The development of the industry has improved the economic status of Region X. The infrastructure (e.g. roads and bridges) in the region has improved, several services (e.g. insurance and banking) have been established and a number of R&D and training facilities have emerged. More importantly, there has been a major improvement in the general living standards. For instance, the number of people employed by the industry has increased threefold and the poverty index has almost been halved in the region.

The Chilean salmon industry has yet to attain the efficiency and environmental standards of competitor countries such as Norway. The technologies needed to handle waste, reduce the use of antibiotics and improve the harvesting of fish are just emerging. Similarly, the regulatory agencies have not kept pace with the rapid expansion of the industry. This is important in ensuring that environmental standards are maintained for the future development of the industry.

Overall, the development of support measures and institutions has played a crucial role in technology transfer, adaptation and development, and in improving production and marketing of salmon fish products. The opening up the industry to foreign and domestic investors has promoted the emergence and expansion of firms. It has also encouraged close cooperation between public and private institutions and the emergence of producer associations. This has in turn promoted understanding among the different actors, as well as identification of needs and promotion of the industry in the international market.

References

Achurra, Manuel (1995). *El caso de un producto de exportación exitoso: El Salmón*. Colección Estudios Cieplan.

Aerni, P. (2004). "Risk, regulation and innovation: The case of aquaculture and transgenic fish", *Aquatic Science,* 66.

Alivial, A. (2003). "Evolución de la Industria, Cluster y Competitividad, *Seminario Cluster Salmón X Región*, INE-X Región.

Altenburg, T. and Meyer Stamer J. (1999). "How to promote clusters: Policy experiences from Latin America", *World Development*, vol. 27, no. 9.

Aquanoticias. Technopress, Santiago, (2002, 2000, 1999, 1998), <htpp://www.aqua.cl>.

Argandoña, G. (2004). "Vaccine 'could save Chile's salmon industry millions'", SciDev.

Asociación de la Industria del Salmón A.G. (2000). "Evolución de la industria del salmón: Chile y el mundo en el 2000", *Informe*, www.salmonchile.cl.

Banco Central de Chile (2002). *Anuario de Cuentas Nacionales*.

Economist (2003). "The promise of a blue revolution: Fish farming", *The Economist*, 7 August.

Enright, M. (1998). *Regional Clusters and Multinational Enterprises: Independence, Dependence or Interdependence?* International Studies of Management & Organisation.

Enright, M. and Ffowcs-Williams, I. (2000). "Local partnership, clusters and SME Globalisation", paper presented at OECD meeting on Enhancing the Competitiveness of SMEs in the Global Economy, 14-15 June, Bologna, Italy.

Fundación Chile (1990). *El Libro del Salmón*, Fundación Chile, Santiago.

Fundación Chile (1998). *Compendio de la Acuicultura en Chile*, Santiago.

Fundación Chile (1998). *Anuario Fundación Chile*, Santiago.

Humphrey, J. and Schmitz, H. (2000). "Governance and upgrading: Linking industrial cluster and global value chain research", Working Paper No. 120, Institute for Development Studies, Sussex.

Katz, J. (2004). "Economic, institutional and technological forces inducing the successful inception of salmon farming in Chile", World Bank.

Lizuka, M. (2004) "Organizational capability and export performance: The salmon industry in Chile", paper presented at the 2004 Druid Winter Conference, University of Aalborg, Denmark.

Petr, T. (ed.) (1998). "Inland fishery enhancements", paper presented at the FAO/DFID Expert Consultation on Inland Fishery Enhancements, Dhaka, Bangladesh, 7-11 April 1997. FAO Fisheries Technical Paper No. 374, Rome, FAO.

SalmonChile (2003). "La Acuicultura en Chile", Santiago, <htpp://www.salmonchile.cl>.

Vidal, L. (2002). *Oportunidades de inversión para la acuicultura en la región de Aysén.* ILPES/CEPAL, Santiago.

Annex

UNCTAD's work in the area of technology transfer and intellectual property rights

Responding to the mandate received from member States at UNCTAD XI in São Paolo, as well as from the Bangkok Plan of Action, the UNCTAD secretariat is implementing a transfer of technology and intellectual property rights (TOT-IP) work plan under its international arrangements programme (covering issues related to investment, as well as technology and intellectual property). The TOT-IP initiative seeks to help developing countries participate effectively in international discussions on technology transfer and intellectual property, and to identify policy options for successfully integrating developing countries into the world economy. The programme conducts research and policy analysis, technical assistance and policy dialogues with negotiators, diplomats and policymakers.

A. Work in the area of technology transfer

The TOT study series addresses government officials, international organizations and agencies, and researchers. It draws lessons from successful experiences with technology transfer and diffusion in developing countries and the effectiveness of the different modes of technology transfer.

- ***Case studies on TOT in developing countries.*** UNCTAD's series *Transfer of Technology for Successful Integration in the Global Economy* consists of a number of case studies on TOT issues in individual industries in selected developing countries. These studies draw lessons from successful experiences with the transfer and diffusion of technology through various channels.

- ***Home-country measures in promoting TOT.*** The paper presents an overview of initiatives and measures as well as incentives provided to industry and public institutions in developed countries to facilitate the transfer of technology to developing countries. It covers measures that promote technology transfer through investment, training, matchmaking services, financing and development of the technological absorptive capacity of developing countries.

- ***Compendium of international TOT arrangements.*** To provide an overview of existing technology-related provisions in international instruments, UNCTAD has compiled a *Compendium of International Arrangements on Transfer of Technology: Selected Instruments*.[15] This compendium contains a selection of TOT-related provisions drawn from international instruments. It includes relevant excerpts from international instruments at the multilateral, regional, interregional and bilateral levels. The technology-related provisions contained in such instruments follow different approaches, depending on the purpose of the instruments. They all aim at promoting access to technologies and, in some cases, the development of local capabilities in developing countries, particularly least developed countries.

[15] UNCTAD/ITE/IPC/Misc.5.

B. Work in the area of intellectual property rights

The UNCTAD-ICTSD[16] Project on Intellectual Property Rights and Sustainable Development is intended to address the concerns voiced by developing countries with respect to implementation of the TRIPS Agreement and new developments brought about in the area of IPRs by multilateral treaties and regional and bilateral free trade agreements.

The project aims at improving understanding of the development implications of IPRs and facilitating informed participation in ongoing multilateral, regional and bilateral negotiations, as well as assisting national authorities in the implementation and adoption of forward-looking IPR policies.

The project consists of three interrelated components:

1. Policy-oriented interdisciplinary research. Highlights of the project's research outputs include:

- A *Resource Book on TRIPS and Development* providing a development-oriented analysis of each provision of the TRIPS Agreement, taking into account economic and social implications and IPR trends in non-WTO forums. The entire book is available on the project website (*www.iprsonline.org*) and was published as a revised version by Cambridge University Press in late 2004.

- Studies on various topical IPR issues, including transfer of technology, public health, geographical indications, nutrition, traditional knowledge, TRIPS-plus in bilateral and regional agreements, technical assistance, innovation, competition and computer software.

- *A Policy Discussion Paper*: *Intellectual Property Rights: Implications for Development*, intended to be a synthesis of the main issues to help policymakers, stakeholders and the public in developing and developed countries to understand the development impact of IPRs and different policy positions regarding TRIPS.

2. Enhancing policy formulation. The project places considerable emphasis on assisting developing countries in enhancing IP policy formulation through establishing and supporting networks. The overall objective is to facilitate the emergence of a critical mass of well-informed stakeholders that could play an active role in future policymaking.

- *At the international levels*, the project has convened a series of dialogues involving key policymakers and stakeholders at the Rockefeller Foundation facilities in Bellagio, Italy, in order to build and promote a development-oriented agenda on IPRs.

- *At the regional and national levels*, the project works closely with selected centres of excellence based in established universities and research institutions

[16] International Centre for Trade and Sustainable Development.

in developing countries, as well as with NGOs, the media and parliamentarians. The main means of collaboration are joint research and regional dialogues, which draw *inter alia* on the existing and ongoing research described above.

3. Outreach and dissemination. Outreach and dissemination are carried out both through traditional channels and, in particular, through the continuous updating and maintenance of the project website (*www.iprsonline.org*). Regular informal encounters with stakeholders in Geneva are organized to continue raising awareness and to keep Geneva-based delegations properly informed of the project's activities, including the regional dialogues.

Since 2001, the project has benefited from the financial support of the Department for International Development (United Kingdom), the Swedish International Development Cooperation Agency and the Rockefeller Foundation.