The World Bank

Technology and Growth Series:
Chilean Salmon Exports

In Chile, seeding of a nascent sector by some foreign firms, reinforced by strategic partnerships between public and private development organizations, facilitated the adaptation of superior foreign technologies and led to the development of a highly dynamic salmon export sector. The Chilean salmon sector evolved from a quasi-artisan, family-based industry to a world class export-oriented industry in two decades, with nearly half of its capacity now controlled by leading global firms. Although it is technologically more sophisticated and efficient now, it still depends on knowledge developed in other countries. The government organizations that were quick to provide the required regulatory and development services continue to support local firms to keep abreast of global developments and to promote local knowledge development. Today, Chile is one of the three major salmon farming countries in the world, along with Norway and Scotland.

In the last two decades, Chile has emerged as the third largest producer of farmed or synthetic salmon in the world, contributing to rapid growth in the global industry. Chilean salmon and trout exports increased from less than US$50 million in 1989 to around US$1.2 billion in 2003, accounting for nearly 6 percent of the country’s exports. Chile’s share in global salmon and trout production increased from about 1.5 percent in 1987 to 35 percent in 2002. During the same period, Chile’s salmon farming growth coincided with a dramatic growth in global production, from 136,000 to 1,439,000 tons.

Chile is endowed with natural resources ideal for salmon farming, including pristine, fresh water lakes and ocean temperatures off southern Chile that remain between 48 and 60 degrees Fahrenheit, which provide an ideal climate for salmon, whose metabolism and growth rates are reduced by seasonal extremes. Salmon farming involves three stages: hatchery, cultivation, and processing. The first two stages require specific aquatic conditions. The hatchery stage involves eggs hatching into alevins that grow into smolts over a period of nearly six months in the fresh water lakes. In the second stage, the smolts are cultivated in salt water pens off the coast until they are ready for harvest in about a year. An abundant supply of anchovies, mackerel, and other species of fish off its coasts also gives Chile an advantage in salmon production; it requires three to five kilograms of fish to produce a kilogram of salmon, a carnivore. The accumulation of omega 3 fatty acids in salmon, a feature that makes it an attractive health food, is affected if fish meal is replaced by other forms of protein in salmon feed.

Government was a catalyst in seeding the industry

The Chilean salmon sector evolved from a quasi-artisan, family based industry. The foundation for this nascent sector was laid with the successful inception of salmon into the Chilean environment, using imported genetic material and intermediate inputs. The government acted as a catalyst during this stage, starting the first commercial salmon farming operation in the country with the help of CORFO ( Corporacion de Fomento), a public development agency of the Chilean government, and Fundacion Chile, a private

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nongovernmental organization (NGO). The latter resulted from a cooperative agreement between the Innovation and Technology Transfer (ITT) institute and the Chilean Government, and was created to facilitate innovation and technology transfer. Chile entered the global salmon market in 1974, when Domsea Farms Chile, a subsidiary of Union Carbide, started production. A second venture was launched around the same time by CORFO. After four years, this firm was exporting small quantities of trout and salmon to France. Later, it was sold to the private sector. In 1981, Fundacion Chile bought Domsea Farms and created Salmones Antartica, one of the biggest firms in the industry today. A Japanese firm, Nichiro, started to cultivate salmon in Chile for the Japanese market, using genetic material imported from the United States. Other institutions, such as the University of Washington at Seattle, also contributed to the development of the industry. The Instituto de Fomento Pesquero (IFOP), a Public Sector Institute for the fishing industry, as well as the Fishing and Hunting Division of the Secretaria de Agricultura y Ganaderia (SAG), helped set up the initial foundation of a global regulatory framework. This framework has strongly influenced the behavior of individual firms and the industry in the last two decades.

In the foundation stage, the industry was dominated by public sector firms and foreign companies. Once the industry was established and became profitable, local firms started to gain a rudimentary understanding of farming processes and entered the market. A large number of small- and medium-sized Chilean salmon farming operations, mostly family undertakings, emerged in the 1980s. They often pooled and coordinated their activities to benefit from economies of scale. They rapidly expanded their operations, some multiplying their capacities five or six fold, funded largely out of savings. The production costs were only one-third of international prices in the late 1970s and 1980s. It was during this period that Chile faced dumping charges from U.S. producers. The efforts and cost of fighting the charges and lobbying in Washington, DC, united Chilean producers and promoted cohesion within the industry.

In the late 1990s, as the world price of salmon fell, converging on long-term production costs, the structure of the industry changed significantly. Larger firms with technologically more complex operations emerged from mergers and integration, both horizontal and vertical, combining hatchery, cultivation, and processing. These firms were more capital intensive and sophisticated, and catered to niche markets. Many family-owned firms left the industry due to lack of resources and technology to compete globally. Some of the leading Norwegian and Danish firms acquired smaller Chilean firms. The number of firms in the industry declined, but the industry as a whole expanded during this period as leading salmon farming companies in the world came to control nearly half of the capacity in Chile. Beginning with sales through agents and some collective marketing, the industry graduated to direct sales to large international retailers such as Wal-Mart. Increased capital intensity in the industry reflected technological sophistication. The ratio of skilled-to-unskilled workers in the country also increased.

**Technological adaptation was critical in scaling-up a nascent sector**

Production practices in the early years were quasi-artisan and strongly dependant on imported intermediate inputs, genetic material, salmon eggs, cultivation tanks, and processing machinery. Salmon food was prepared locally by firms using fresh raw materials. In the initial stages, food conversion from cultivation, an important efficiency indicator, was close to 3 to 1, compared to nearly 1 to 1 in leading fish producing operations of the world. The cultivation tanks used in Chile were made of wood and were smaller than those used globally. Gradually, these smaller wooden tanks were replaced by larger tanks made of galvanized steel. These changes were made by small and medium firms that expanded their capacity in the 1980s and the 1990s.

A local service sector gradually developed to serve the growing industry. The services that are now available locally include the supply of vaccines, nets, packaging material, transport services, software design, net maintenance, and veterinary services. Initially, eggs, smolts, food, and processing equipment were imported. The production of salmon food is knowledge-intensive and requires con-
siderable research and development; now, these products and services are available locally. A number of local and foreign firms have been successful in mastering the technology and are now supplying salmon food. The food production industry has also undergone consolidation—today, a single Norwegian firm accounts for nearly 40 percent of the market.

Salmon farming requires natural resources, intermediary inputs that can be imported, and situation-specific knowledge. The hatcheries need to be established in uncontaminated water and favorable climatic conditions. In the second stage of cultivation, the critical ingredients are the quality of tanks, feeding equipment, and food. The food conversion rate is important. Food accounts for nearly 45 percent of the total production costs, with eggs and smolts accounting for another 18 percent. In processing, meeting international standards for phyto-sanitary conditions and creating products that are of value are important.

Salmon farming began in Chile with only rudimentary knowledge because the producers had an imperfect and incomplete understanding of the ecological, environmental, and technological parameters of their operations. The success of salmon farming depends on acquiring knowledge and the development of technologies specific to local conditions. There are no two completely similar salmon operations, as ecological and environmental parameters such as water quality, temperature, salinity, and ecological variables related to microorganisms found in the lakes vary across locations. The production process can be perfected by experimenting with changes in raw material, production conditions, and consumer tastes. Each firm needs to move through a firm-specific learning curve, acquiring knowledge through trial and error.

Salmon eggs are now produced in Chile, with the help of local research organizations. In recent years, there has been a significant reduction in imports from Ireland, Scotland, the United States, and Norway. Local egg production is helping to reduce costs and also contain the spread of certain diseases from other production centers. In 1996, nearly 40 percent of the eggs used in the country were locally produced. Some of the public organizations, such as CORFO, INFOP, and SERNAPESCA, worked with the University of Chile to facilitate local production. Although eggs are locally produced, local research in biotechnology and ictiopathology, the two important areas for technological advancement in egg production, is not as advanced as in the more developed countries.

The industry has been able to improve the food conversion rate and also make a few other technological changes, which may not be as important for competitiveness. The food conversion rate in the industry has fallen from nearly 3 in the 1980s to 1.2–1.3, a little higher than in Norway. This has been achieved through richer diet, food in the form of more digestible pellets, and the addition of vitamins. Other changes include the use of larger cultivation tanks, automatic feeding systems, and computerized monitoring systems. Many of these developments are labor-saving and may or may not contribute to competitiveness. Compared to other salmon producing countries, because the wages are lower in Chile, the local industry employs twice as many workers as the Norwegian operations. Tanks are now produced locally. Process improvements have taken place with the help of public organizations. The quality and sophistication of packaging has improved in recent years with a number of foreign and local firms supplying packaging materials.

**Government’s changing role—from facilitator to regulator—in developing a world class export industry**

In the early stage, when the industry was dominated by public sector and foreign firms, and a number of small- and medium-sized local firms, the Chilean government played an active catalytic role and helped disseminate salmon farming technology. The public sector, including CORFO and Fundacion Chile, was also involved in designing and erecting new production units that were later transferred to the private sector. The government acted as a facilitator in the foundation stage of the sector development. As more firms entered the market, the government assumed the role of regulator and coordinator. It was quick to establish the legal foundation for regulation and to develop...
organizations with the power and capability to offer regulatory and developmental services by the early 1980s. Government agencies, such as SERNAPESCA and Conama, established the regulatory framework needed for the issuance of salmon cultivation permits, evaluation of environmental impact studies, surveillance of imported salmon eggs, and so forth. The required legal infrastructure supporting these regulatory functions was in place in the 1980s and was considerably improved thereafter, complying with international standards as required by the U.S. Food and Drug Administration (FDA), the UN Food and Agriculture Organization (FAO), and, lately, the WTO Organizacion Mundial del Comercio (OMC) (Acuanoticias, November 1997).

Today, the plants that process fish for export seek certification from different sources, depending on their destination. They are usually required to follow the Hazard Analysis and Critical Control Points (HAACP) norms, regardless of the destination. The treatment of solid and liquid wastes, hygiene, worker training, and traceability are some of the factors that are considered by government agencies such as Servicio Nacional de Pesca (SERNAPESCA) in issuing compliance certificates. The Comision Nacional del Medio Ambiente deals with environmental assessments, and Intesal monitors waste treatment practices. Fundacion Chile and the association of producers (APSTCH) help firms upgrade their practices to comply with various regulations and certification requirements.

**Government’s enduring support in preserving a globally competitive edge**

The Chilean public organizations continue to be engaged in the development and transfer of superior technologies; several public organizations fund research and public universities and the Instituto de Fomento Pesquero (IFOP) conduct research. The annual research and development expenditures amount to nearly US$10 million, about a quarter of which comes from the salmon firms. Fish farming is 1 of 10 industries receiving support from a fund created to promote scientific and technological developments of major economic sectors. Organized trips to technologically more advanced operations in Norway, Scotland, England, and the United States constitute one of the major channels through which firms, regulatory agencies, and research institutions gain access to production know-how developed elsewhere. Institutions such as Fundacion Chile, CORFO, and local firms organize regular visits to Scotland and Norway.

**Future prospects**

Chile’s position among leading global exporters of farmed salmon is strong largely because of large firms and the government’s role in fostering the imitation of superior technologies. Its world-class industry continues to depend on imported machinery and equipment and disembodied know-how developed overseas. Although there is some local knowledge generation, it is still a weak aspect of an otherwise successful natural resource-based industry. The industry, which is expected to grow to become the largest in the world, has not matured to the same extent as its European competitors. It will take more time and intensive effort to reach a stage when it will be able to produce capital goods for itself or offer technical assistance to other countries.

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**Further reading**