The Global Value Chain in the Horticultural Agro-export Enclave of Sinaloa, Mexico: Technical-Productive Structure, Industrial Organization, and Governance Modalities*

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Abstract

This research analyzes the conditioning relationships of the competitiveness of vegetable producers in the Mexican state of Sinaloa within the context of the relationships between fresh vegetable-producing companies and leading companies in the value chain in the segments of technology, inputs, and marketing. The hypothesis establishes that the integration of the producing segment implies the adoption of "technology packages" as a condition for meeting the requirements and norms, both public and private, necessary for the integration of the chain and competitiveness. The research was conducted considering the description of the

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work process and identifying the technical and productive structure of the requirements of the leading segments based on documentary research and fieldwork through interviews with actors and stakeholders. The result is the identification of oligopolistic/monopsonistic governance that ensures the formation and appropriation of "rents" of a technological, commercial, and financial type from the producing segment towards the leading or dominant links while exacerbating dependence on structural heterogeneity and extraversion in the central node, as historical features of underdevelopment. This condition is not exclusive to this enclave but expresses a modality of capital accumulation in the Mexican agro-export sector.

Keywords: horticultural global value chain; technical-productive structure; industrial organization; governance; Sinaloa; Mexico.

La cadena global de valor en el enclave agroexportador hortícola de Sinaloa, México: estructura técnico-productiva, organización industrial y modalidades de gobernanza

Resumen

Este artículo analiza las relaciones de condicionamiento de la competitividad de las empresas productoras de hortalizas en fresco y empresas líderes en la cadena de valor en los segmentos de agroquímicos y de comercialización. La hipótesis establece que la integración del segmento productor implica la adopción de determinados "paquetes tecnológicos" como condición para el cumplimiento de los requerimientos y normatividades tanto públicas como privadas necesarias para la integración y la competitividad. Este análisis se realizó considerando la descripción del proceso de trabajo e identificando la estructura técnica y productiva en relación con los requerimientos de los segmentos líderes. Lo anterior se hizo a partir de una investigación documental con entrevistas a partes interesadas. El resultado principal es la identificación de una gobernanza de tipo oligopólica/monopsónica que garantiza la apropiación de "rentas" de tipo tecnológico, comercial y financiero, desde el segmento productor hacia los eslabones líderes, al tiempo que exacerba la dependencia, heterogeneidad estructural y extraversión en el nodo central, como rasgos históricos del subdesarrollo. Una condición que no es exclusiva de este enclave, sino que expresa una modalidad de la acumulación del capital en el sector agropecuario de exportación en México.

Palabras clave: cadena global de valor hortícola; estructura técnico-productiva; organización industrial; gobernanza; Sinaloa, México.

JEL: F15; L14; L23; P13; P17.

Introduction

Due to its ideal natural conditions for producing and marketing vegetables, the state of Sinaloa stands out as a historical benchmark at the national level for the dynamic formation of a high-value agro-export enclave. The signing of the North American Free Trade Agreement (NAFTA) in 1994 marked a break in Mexico's agricultural export specialization pattern, encouraging the transition from traditional to non-traditional exports. There was a notable increase in the harvested area of commercial fruits and vegetables. At the same time, traditional crops such as corn and beans, pillars of Mexican food security, saw their cultivation areas reduced (Orozco-Ramírez et al., 2017). This change indicates that NAFTA promoted the development of export-oriented agriculture at the expense of traditional crops that constitute the basis of the local diet and economy, considering a competitive advantage approach (Hernández, 2021).

In this context, exports of fresh vegetables, mainly to the U.S. market, have seen exponential growth, with tomatoes standing out as the most dynamic product. Their export volume increased from 400 500 tons in 1993 to 1.8 million tons in 2022, positioning Mexico as the leading global exporter. By 2022, Sinaloa was the primary national producer and exporter of tomatoes, peppers, chilies, cucumbers, and pickles (USDA, n.d.).

Integrating the horticultural sector into global circuits has shaped the formation of a Global Value Chain (GVC), whose technical-productive structure is conditioned by the profitability levels and governance of the leading companies, responding to the characteristics of the new fruit and vegetable export specialization pattern. Technically, the production of vegetables for export is related to the use of improved seeds, fertilizers, and fungicides, as well as highly technified irrigation systems and temperature management, provided through the leading transnational companies in this sector.

This process involves the adoption of specific "technology packages" as a condition for complying with public and private regulatory norms in terms of quality, health, safety, social responsibility, and environmental care and leaving national producers captive in an oligopolistic/monopsonistic structure, which obeys the maximization of profit by the leading companies under top-down coordination mechanisms executed through normative requirements and imposed certifications, generating the formation of "rents" of a technological, commercial, and financial type throughout the process, as forms of property, knowledge management, and exchange restriction. This has led to the worsening of degrees of "structural heterogeneity," as only a particular segment of producers (large and, to a lesser extent, medium-sized) have adapted to the technical and productive requirements of the large companies, fostering a process of concentration in the face of increasing competitiveness standards, production costs, and stagnation dynamics in the average export prices. A condition that is not exclusive to this enclave but expresses a modality of capital accumulation at a global level.

This article aims to analyze the configuration of the fresh vegetable agro-export enclave in Sinaloa, Mexico, based on the characterization of the technical-productive structure, the modality of industrial organization, and the governance dynamics exercised by the leading companies in the GVC. It is divided into four sections. The first presents the methodology and case study. The second addresses the results obtained from the proposed method. The third discusses the implications of the findings within the research context, and the conclusions are presented as a final reflection.

Methodology and Case Study Presentation

From a methodological perspective, this article used the "Global Value Chains" (GVC) approach as a tool for top-down-bottom-up analysis, which allows the separation of segments or nodes of the chain to identify the technical-productive configuration of the work process, describing the quality and safety requirements that meet the needs of marketing agents (Cortés, 2021; Gereffi & Fernandez-Stark, 2016; Sandoval & Borja, 2023).

The study was developed in the context of fresh vegetable production, which exemplifies the dynamics of an agri export enclave with high linkages and dependence on the international market, especially the US market. Exporting companies were considered subject to the direct influence of external market requirements, which in turn pointed to the presence of companies supplying the domestic market, which are indirectly influenced by technical-productive mechanisms such as regulation and public policies (Álvarez et al., 2017; Maya-Ambía, 2011; Rosales & Lopez, 2008; Sandoval, 2011; Valenzuela & Velarde, 2024).

The participation of companies was considered from three levels. At the back is the oligopoly of input suppliers (agrochemicals, seeds, machinery, etc.); in the middle is the producer segment, comprised of indigenous or local companies that comply with technical requirements; and finally, at the front, the monopsony of marketing companies. An inductive-deductive approach was used as a methodological bridge of articulation between the theoretical-conceptual elements and the concrete processes that define the case study. This approach is efficient in describing the quality and safety requirements that meet the needs of marketing agents, identifying both the relationships between companies and the mode of governance between the various segments of the chain.

To achieve this objective, several field visits were made over several years (2007, 2010, 2021 and 2023), during which interviews were conducted with production unit managers, producers, day laborers and local public officials. Within the producer segment, 15 semi-structured interviews were conducted with key actors identified from the companies of the Confederation of Agricultural Associations of the State of Sinaloa (CAADES) as part of the certification process: "Eleven Rivers Growers", established in 2009 as a mechanism to improve the performance of producer companies in terms of food safety, social responsibility, environmental management and efficiency in traceability processes. Tables A1 and A2 from Appendix show the exporting companies included in the "Eleven Rivers Growers" certification and the stakeholders interviewed.

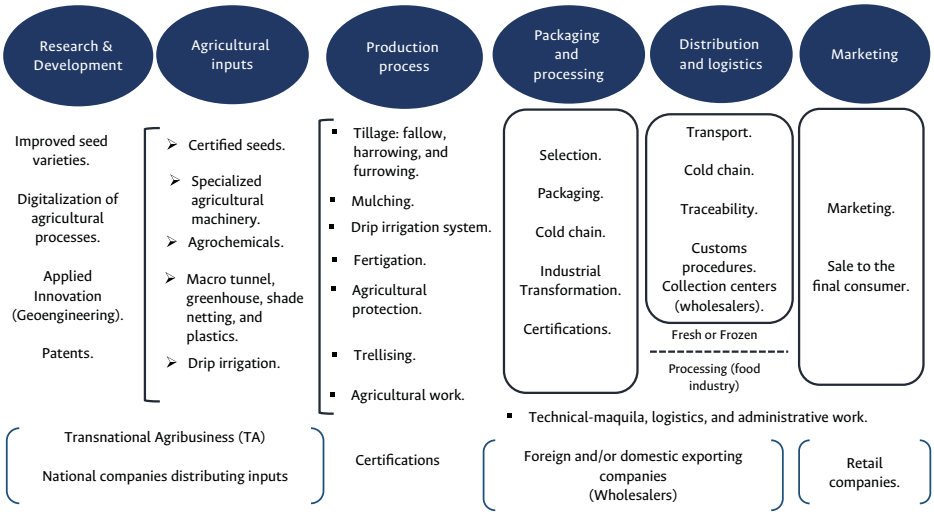
In addition, specialized literature was reviewed, consulting scientific and popular articles, theses, and manuals on good agricultural and management practices, as well as national and international certification criteria. This approach made it possible to articulate the information obtained in the field, providing an exhaustive and precise understanding of the dynamics of this subsector.

The GVC is an analytical category that describes the activities carried out by companies and workers to produce a commodity or provide a service (Gereffi, 1994; Gereffi & Fernandez-Star, 2016; Lee et al., 2012; Sturgeon, 2001). For the horticultural case, various participants were identified, describing their dynamics of integration, competitiveness, and scaling under the articulation of six "nodes" or "segments" including, first, research and development; second, agricultural inputs; third, production process; fourth, packing and processing; fifth, distribution and logistics, and sixth, marketing.

These segments are intertwined through a technical-productive modality configured under the coordination and execution of the leading companies located at the initial and final segments of the chain, articulating as the producing segment through various regulations. This process is represented in Figure 1.

A descriptive statistical analysis was conducted to treat and organize quantitative information by collecting representative data from national and international official sources. The article presents the data in calculations, tables, and charts.

Figure 1. GVC. Horticultural agro-export enclave. Technical-productive organization modality



Source: Own elaboration.

Results

The horticultural GVC in Sinaloa, Mexico: technical-productive structure

The analysis of the Global Value Chain (GVC) determined that the fresh vegetable-producing segment for export purposes appears as a link executing a prior design, which involves specific requirements in the acquisition and use of inputs, machinery, and equipment, as well as labor skills and packaging and distribution models. Production is organized through large and medium-sized local agricultural units that supply primarily foreign wholesale-exporting companies through agreements or contracts. Additionally, the presence of producer-exporter companies with large land areas subcontracting other production units to complement their offer is highlighted.

The supplier segment is characterized by the implementation of biotechnological processes, high-end innovation, and automation promoted by leading transnational companies in the biotechnological and agricultural industry (e.g., Monsanto/Bayer, Syngenta, BASF, Corteva), with financial capacities and highly profitable marketing capabilities (Amaro & Sandoval, 2019). These companies are assumed to be developers of patents in the segments of improved seeds, digitization of production processes (use of drones, automated tractors, specialized software, IoT internet), and geoengineering techniques (ETC Group, 2022).

> [...] a quarter of the improved seed market consists of horticultural crops that come almost entirely from abroad [...]. Seed-producing companies apply high-quality standards for seed production and conditioning. Controlled production in the field or greenhouse, selection, cleaning, laboratory analysis, treatments, packaging, storage, inspections, certifications, etc., are factors that ensure the quality and health of the seed (Secretary of Agriculture and Rural Development [SADER for its acronym in Spanish], 2020, pp. 34-54)[1].

The improved seed conditions the implementation of the technological package as a determining element of the entire production process from soil preparation and leveling, planting, nutrient provision, pest control, and proper crop management, as well as the inputs used: 1) fertilizers and agrochemicals; 2) specialized agricultural machinery; 3) ferti-irrigation equipment; and 4) protection systems. The scientific and technical development defining a technological package protected by various property rights ensures its realization in the producing segment through multiple means: 1) concentration of the offer of seeds, agrochemicals, machinery, and equipment; 2) preferences of the large buyer about specific brands of inputs; and 3) formal health and safety requirements referring to public and private standards and certifications. The inputs used are summarized in Table 1, highlighting the dependence on technology from leading transnational companies in these segments.

Table 1. Vegetables. Agricultural Inputs: Components, Acquisition Market, and Distributing Companies

Components	Main acquisition market	Distributing companies
Certified hybrid seeds.	• United States • Europe	• BASF [Germany]. • Monsanto/Bayer [United States/Germany]. • Limagrain [France]. • Rijk Zwaan [Netherlands]. • Syngenta [United States].
Agricultural machinery: • Tractors/Implements: discs, harrow, furrower, laser-guided levelers, seeders, transplanters, and rotovators. Automated processes.	• United States • Italy • Japan	• John Deere [United States]. • New Holland [United States]. • Kubota [Japan]. • CNH Industrial [Italy].

1 In addition to this, the global tomato seed market is controlled by just five Agrochemical Transnational Corporations (BASF, Monsanto/Bayer, Limagrain, Rijk Zwaan Zaadteelt en Zaadhandel, and Syngenta), who concentrate 57.3% of the market (Mordor Intelligence, n.d.).

Components	Main acquisition market	Distributing companies
Pesticides: • Insecticides. • Herbicides. • Fungicides. Fertilizers: • Nitrogen-based (sulfur, calcium, and potassium). Phosphates and sulfates. • Micronutrients (magnesium, zinc, iron, etc.).	• United States • China • Switzerland • Russia	• Corteva [United States]. • Monsanto/Bayer [United States/Germany]. • Syngenta [China]. • Uralchem [Russia].
Irrigation systems: • Drip irrigation (tapes, drippers, connections, valves, filters, and controllers).	• United States • Mexico	• Orbia (Netafim Limited) [United States]. • Jain Irrigation Systems [United States]. • Irridelco México S.A de C.V [Mexico/ United States]. • Valmont Industries [United States].
Protection systems: • Shade netting, greenhouses, and macro-tunnels. • Plastic mulching.	• France • United States • Mexico	• Richel Group [France]. • Rough Brothers, Inc [United States]. • Hydro Environment S.A. de C.V. [Mexico].

Source: Own elaboration based on data and information from J. Cortés, personal communication, October 14, 2023 and Mordor Intelligence (n.d.).

Implementing both "Good Agricultural Practices" (GAP) and "Good Manufacturing Practices" (GMP) and the Safety Standards for fresh agricultural products subscribed to—for the United States—by the Food Safety Modernization Act (FSMA) establishes a direct relationship with the producing segment[2].

The primary basis in the production process is the amount of labor used in various agricultural activities, ranging from sowing to post-harvest handling. The workforce is mainly unskilled, although it is combined with a smaller percentage of medium and high-skilled labor. This workforce can be classified into three areas: 1) agricultural day laborers, 2) agricultural workers, and 3) owner producers and independent labor participants. The former mostly come from rural areas with high marginalization, poverty, and low educational levels, particularly from the states of Chiapas, Oaxaca, Guerrero, Puebla, Michoacán, and Chihuahua. Their mobility adheres to the seasons and agricultural cycles of different crops. In the horticultural areas of the state of Sinaloa, between 200,000 and 400,000 agricultural workers arrive each year, of which 83% are day laborers from Guerrero, Oaxaca, Veracruz, and Chihuahua, with salaries ranging from 23 to 46 dollars per day, under piecework payment (Mimiaga, 2023; Sánchez, 2023; Elizalde cited by Sánchez, 2015).

2 GAP (Good Agricultural Practices) and GMP (Good Manufacturing Practices) are defined as the set of quality actions aimed at reducing risks; biological, physical, and chemical both in the production stage and in post-harvest handling.

Furthermore, it is highlighted that within the core tomato exporter group, made up of large companies like *El Fuerte* and *Sinalopasta*, there is increasing lobbying with high investment amounts to regulate through certifications compliance with labor requirements related to the use of child labor, acceptable conditions regarding minimum wages, working hours, social security, and health, accompanied by the construction of shelters, dining facilities, childcare, and medical facilities (J.R. Elizalde, personal communication, March 28, 2023). There is wage heterogeneity, as while export tomatoes are subject to high-quality standards advertised as free of child labor, open-field production aimed at the domestic market lacks such regulations, resulting in an intensive demand for labor that often includes children and youth, subject to no access to social security, legal benefits, and precarious living conditions (Vizcarra, 2024).

In the case of specialized agricultural workers, semi-skilled technicians, including tractor and implement operators, technical advisors (agronomic engineers, biologists, etc.), technological system operators, and quality control managers, are present. These technicians play a crucial role as coordinators and supervisors of production and post-harvest stages, and their salaries and benefits grant them certain status and permanence.

Among the agricultural producers, owners, and independents, those who incorporate as a labor force by renting their lands or signing contracts with wholesale companies are distinguished, and many become workers on their land.

Once the harvest is completed according to the buyer's required characteristics, such as degree of ripeness, consistency, color, and size, "shelf life" begins as the period during which a food product maintains the properties expected by the consumer. The end of this period is identified with the expiration or loss of the product's useful life. This time spans from harvest to final sale. For this, it goes through different post-harvest phases, such as 1) selection and sorting of the crop (automated processes); 2) packaging and storage; 3) management of traceability; and 4) formation of the cold chain until its presentation on the final shelf (Fernandez-Stark et al., 2011).

The "traceability" process aims to develop a tracking record of each product, from production, cutting, packaging, and final destination, through a numbering system and barcode encoding, known as the European Article Numbering-Uniform Code Council (EAN.UCC) system, which allows identifying the trajectory of the crop from when it is planted in the field, to its final point of sale, responding promptly to health contingencies due to its use or consumption. Information on the lot, section, land, place of production, and the day and time of harvest and transfer is available (Secretary of Agriculture, Livestock, Rural Development, Fisheries and Food [SAGARPA for its acronym in Spanish], 2016).

The cold chain is positioned as a central element for "shelf life," as its implementation ensures the quality and safety of perishable products by managing a cold system at optimal temperatures that keep them in quality conditions from their packaging to their final sale (SADER, 2023).

This stage demands low to medium-skilled labor specialized in packing, packaging, storage, quality control, technical handling, and administrative management. After navigating the packaging and storage phase, the following link in the chain is the distribution of the fresh product. Its packaging for land transportation begins by utilizing trailers equipped with refrigeration units (thermos) to maintain the cold chain. It involves logistics processes and information management necessary for customs procedures for the product's exit and entry into the destination country.

The last link in the chain is the marketing process for sale to the consumer, where large retail companies such as Walmart, Target, and Kroger in the United States participate. These companies' marketing of horticultural products adheres to the required quality standards, influencing the industry's organization mode in response to changes in global regulations.

Governance arrangements in the horticultural GVC: formation of technological, commercial and financial rents

Under this dynamic, the technical-productive structure of the chain is shaped by the governance relationships exercised by the leading companies established in the supply (backward) and accumulation and marketing (forward) links. Governance is the control and coordination by leading companies whose capital and property rights are concentrated, allowing them to obtain extraordinary profits (Sandoval, 2019). Entry barriers are established that define leadership and market competitiveness, limiting the process of advancement in the value chain through ownership structures that restrict the exchange and application of knowledge, generating rents from intellectual property (productive consumption of seeds and specific uses of agrochemicals and machinery) that define asymmetrical relationships with the producing segment.

In the specific case of the horticultural GVC, a form of governance consistent with the oligopolistic/monopsonistic structure is highlighted, establishing high barriers to entry and asymmetrical competition patterns in the central segments. Backward oligopolies in seeds and agrochemicals (technological rents), and forwards, the retail network oligopoly like Walmart (commercial rents by market power). The formation of rents or extraordinary benefits is explained by the network's organization, which adheres to the profit maximization by the leading companies under top-down coordination mechanisms executed through safety and health requirements, environmental care, and social responsibility. A property right grants its holder the power (including coercive power) to periodically appropriate a portion of the created value or existing wealth (Serfati, 2013).

Following the governance classification (Gereffi et al., 2005), the horticultural GVC is configured under the following processes. See Scheme 2:

1. "Modular" governance exercised by seed, agrochemical, design, and technology provider companies at the initial nodes of the chain as a condition of the technical-productive organization, in compliance with the requirements of retail companies. A "technological rent" is realized through the acquisition of property rights to strategic assets (patents), which are exercised on inputs (seeds, agrochemicals, machinery, etc.), which are realized in the producer segment through the acquisition of the necessary "technological package".

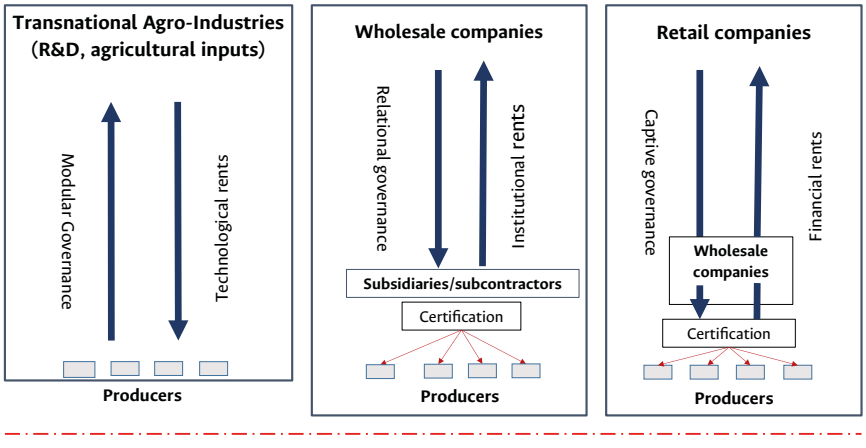
2. "Relational" governance exercised by wholesale companies over the central node is characterized by promoting information and knowledge schemes with high degrees of complexity, codification, and high barriers to entry to connect supply and demand in compliance with the requirements and final consumer satisfaction. The acquisition of the technological package as a condition of the product design is verified through public and private standards and certifications, leading to the achievement of a "commercial" or "institutional" rent.

3. "Captive" governance exercised by retail companies over the production and distribution nodes, characterized by a high complexity of transactions in their integration for the final sale, which ultimately falls on the limitation of learning curves in the producer node and the capacity to codify information in each transaction. "Financial rents" are obtained, appropriated from the increase in stock market valuation (e.g., Walmart), consequent with the strategic control of assets such as a) information management, b) logistical capacity, c) customer loyalty, d) brand power; e) exclusivity in marketing channels; f) speed and reliability of delivery; and g) product customization through processing and packaging, as well as guarantees on product safety.

Monopolistic control is assumed over "intangible assets" (also called immaterial, incorporeal, intellectual), expanding their speculative dynamics on the financial markets and increasing their stock market value. These types of assets, whose valuation by the financial community is totally uncertain and to which Veblen had already paid central attention for more than a century, fall into the category of fictitious capital highlighted by Marx.

In this context, competitiveness equates to meeting requirements, which has led medium-sized producers to organize collective efforts for integration and certification through the CAADES, which is currently responding to the needs of leading companies. The architecture of the producing segment implies the acquisition of a specific technological package that, in turn, determines the technical-productive structure and the mode of organization across different links in the chain.

Figure 2. Mexican agri-food sector: Governance dynamics in the horticultural GVC



Source: Own elaboration

The analysis of activities producing and circulating vegetables in the commercial context between Mexico and the United States reveals a significant technical-productive base. According to Elings et al. (2017), as well as Ibarra et al. (2018), this base positively impacts productivity and efficiency in resource use, contributing to the development of agricultural activity. However, Maya-Ambía (2011) identifies limitations in the agro-industrial organization that restrict more significant development, a situation exacerbated by the inefficiency of policies, as pointed out by Borbón-Morales et al., 2021.

Sandoval (2013, 2015, 2019) delves into the requirements of the technological package, highlighting its evolution in inputs, machinery, and equipment. This evolution influences labor demand. The author argues that horticultural production for export in Sinaloa has shown sustained development in terms of productivity and efficiency. However, this growth has led to a process of business concentration driven by increasing requirements for access to financing and technology. Additionally, she highlights how trust relationships forged through repeated transactions have evolved from captive governance to a more semi-relational one among Sinaloan producers, nourishing the concentration process.

A vertical integration network, with significant intermediation power from the leading companies located at the initial and final nodes, deepens dependence and subordination in the productive segments subject to increasingly stringent quality standards, limiting their advancement along the chain. This has led to a greater investment in inputs, technological components, and training mechanisms to meet these standards, generating two trends in the current configuration of the technical-productive structure of the enclave. On the one hand, wholesalers and the food industry, seeking to harmonize their quality schemes, are linked with a decreasing number of suppliers who meet the established standards, leading

to a concentration and centralization of horticultural supply with high entry barriers (J.R. Elizalde, personal communication, March 28, 2023).

On the other hand, degrees of structural heterogeneity are exacerbated, as only a specific segment of producers (large and medium-sized) has better adapted to these technical and productive requirements, defining their mode of insertion and participation within the GVCs.

This means that the integration strategy and the specialization pattern that supports it, as well as the institutional aspects that underpin it, hinder productive development through innovation and technological change (Borja & Sandoval, 2024). Few endogenous benefits emerge, capable of linking local and/or regional productive sectors, with influence on strengthening the domestic market and regional integration.

Discussion

The Horticultural GVC: Industrial Organization and Market Structures

In line with the so-called "Neoliberal Globalization" established in the 1980s, a new "global agri-food order" emerged, established as the set of international structures, unwritten economic, political, and territorial norms and rules that define the relations of production, distribution, and consumption of food in accordance with the International Division of Labor (Bonanno, 2014; Cortés, 2024; Otero, 2012). While the centers assume the role of producers and marketers of staple crops for human diets, such as wheat and corn, the peripheries specialize in the agro-export of a group of non-traditional crops (e.g., fruits and vegetables) to meet the needs of certain population segments located in the centers, driven by changes in diets and consumption patterns. This global agri-food configuration is framed by the presence of transnational agribusinesses, which assume the dominant role by controlling everything from the provision of inputs to the marketing channels for food (Cairó & Cortés, 2022; Espinosa, 2022; Fuglie, et al., 2024).

In this context, the horticultural industry operates as a value chain driven by the retail segment, headquartered in the export markets. These buyers integrate towards greater cost competitiveness, differentiation of their products, shorter supply chains, and long-term relationships with various suppliers (Humprey, 2006; Reardon et al., 2009; Lee et al.,2012). This generates a "monopsony"[3] type positioning within the chain, thereby defining the technical-productive organization of the chain, as well as the packaging, processing, and distribution links.

3 If we analyze the dynamics in the production segment moving forward along the links of the horticultural chain, it stands out that the quality requirements are driven by retail buyers. This represents—following Gereffi's classification (2001)—that the chain is led by the retail segment, whose profits are realized both through the pivot role assumed by input supplier companies via the "technology package" provided, and through the role of wholesale-export companies, which ensure certification and compliance with standards related to health and safety, social responsibility, and environmental care. For more details on the character of these chains see the following authors: Lee et al., (2012), Reardon et al. (2009), and Burch & Lawrence (2005).

> This control has been achieved by introducing private standards and codes of conduct that govern product characteristics, including quality, size, pesticide use, and the social and environmental conditions of cultivation and post-harvest handling (Fernandez-Stark; et al., 2011, p. 9).

In the case of the Mexican agri-food sector and its integration with the North American market, this control is defined by the standards established for the importation of fruits and vegetables, particularly for the US market through the "Fruits and Vegetables Import Requirements" (FAVIR), regulated both by the Animal and Plant Health Inspection Service (APHIS) and the Food and Drug Administration (FDA, n.d.), indicating that all imports of fruits and vegetables must be subject to a series of procedures, as well as the issuance of phytosanitary, safety, social responsibility, and environmental management certifications in the countries of origin.

These mandatory requirements and procedures are linked to the so-called "Global Food Safety Initiative" (GFSI, n.d.), implemented in the early 2000s by the "Action Coalition" member of the Consumer Goods Forum, which brings together 45 large wholesalers and manufacturers of consumer goods globally (Walmart, Cargill, Tyson Foods, Unilever, Nestlé, The Coca-Cola Company, PepsiCo, Danone, Dole Food Company, among others); to harmonize, standardize, and overseeing "food safety" standards for companies and consumers worldwide. In line with international standards such as the ISO and *Codex Alimentarius*[4], the GFSI has implemented a certification requirements program regarding food health and safety, making implementing GAP, GMP, traceability, and social and environmental responsibility mandatory. It grants powers to national and international private certifying companies to be in charge of issuing certifications globally[5]. Wholesale companies play a strategic role in disseminating this information, providing the necessary acknowledgments to private sector certifying companies to be in charge of their issuance. For tomatoes, it is estimated that there are around 120 large companies that produce and export the majority of Sinaloa's tomatoes. These companies develop various "business models" ranging from providing technological packages to producers, offering financing sources under contract schemes, and leasing land to cover the entire production process (Elizalde, cited by Sánchez, 2015).

With the implementation of NAFTA, a series of public norms and protocols guaranteeing the dissemination of regulation criteria in production and food marketing were established. "In the 1990s, the required standards focused primarily on quality standards, implying that vegetables met the appropriate characteristics to satisfy consumer needs" (J. Kondo, personal communication, June 15, 2007). Later, "phytosanitary" processes related to meeting "health and safety

4 ISO (International Organization for Standardization) standards are a tool to ensure that products and services meet quality requirements. The *Codex Alimentarius* is a set of food standards and international practices that contribute to food safety, quality, and fairness in international food trade.

5 The main companies recognized according to the 2020 version of the Global Food Safety Initiative (GFSI) benchmarking are: CanadaGAP (Canada), Global Seafood Alliance (GSA [United States]), GLOBALG.A.P. (United States), Food Safety Management Association (JFSM [Japan]), PrimusGFS Standard (United States), and SQF Institute (United States) (FAO, n.d.).

standards" were added, implying adherence to GAP and GMP. In recent decades, due to various policies of retail (marketing) companies, requirements have focused on "social responsibility" by implementing labor measures to ensure that production processes are developed under conditions respecting workers' rights, dignified working conditions, no child exploitation, elimination of forms of forced or compulsory labor, among others; as well as the application of measures for "protection and care of the environment," implying the adoption of more sustainable processes in the use of natural resources; protection of biological diversity, soil conservation, and water non-pollution (J.R. Elizalde, personal communication, April 7, 2011, and March 28, 2023).

With the entry into force of the United States-Mexico-Canada Agreement (USMCA) in July 2020, the requirements were formalized under a new legal framework, expanding their execution and interference regarding agricultural innovation, biotechnology (Section B: Agricultural Biotechnology, Chapter 3: Agriculture), phytosanitary measures (Section B: Agricultural Biotechnology, Chapter 3: Agriculture), intellectual property rights (Section F: Patents and Undisclosed Test or Other Data, Subsection A: General Patents, Chapter 20: Intellectual Property), labor rights (Article 23.3: Labor Rights, Chapter 23), and environmental protection (Chapter 24).

Implementing these requirements defines producers' participation in the chain, conditioned by increasingly rigorous evaluation methodologies, leading to more significant investment in inputs, technological components, and protection and training mechanisms, with high barriers to entry in a context of high competitiveness (J.R. Elizalde, personal communication, April 7, 2011, and March 28, 2023). Compliance with public regulations, part of the obligations of the government of Mexico acquired in the International Plant Protection Convention of the Food and Agriculture Organization of the United Nations (FAO) in 1951, aligns with the export requirements established by the National Plant Protection Organization (NPPO) of the destination country. The National Service of Health, Safety, and Agri-Food Quality (SENASICA for its acronym in Spanish) is the governmental institution issuing the "International Phytosanitary Certificate" that guarantees that plant-origin products meet the necessary phytosanitary conditions for export.

The need to increase traceability, providing a constant and reliable supply that meets the requirements, norms (private and public), and strict certification processes, has led to significant downstream consolidation of the supply chain. (Reardon et al., 2009). This reflects an exacerbation of "structural heterogeneity" among producers, with increasingly exclusive processes that condition income stagnation for those unable to integrate (regardless of the intensity of capital accumulation and increases in the social productivity of labor) and high-income concentration in integrated segments.

Competitive advantage implies closer coordination by leading companies, consolidating the strengthening of a small group of generally large-scale suppliers capable of meeting their strict and costly requirements, while expanding the exclusion of small and medium-sized producers

with low levels of competitiveness (Carton de Grammont & Lara, 2010; Lee et al., 2012; Rello & Saavedra, 2007). This agro-export specialization pattern has led to an emerging dualism between large-scale industrialized production and production based on medium and small producers coexisting at the same time (Maya-Ambía & López, 2009; Avendaño et al., 2006).

In addition to this, the participation of producers is largely established through contracts (contract farming) with wholesalers, where the former commits to delivering the crop at an agreed date and price, while complying with the established quality and regulatory standards. This is an unequal framework of negotiation, which acts as a barrier to entry, where the producer accepts that the company audits and supervises the use of the agreed technology package (seeds, fertilizers, irrigation systems, protection systems, etc.), reserving the right to reject the product whenever deemed necessary (Associated producers, personal communication, July 24, 2011).

The comparative and competitive advantages of the technical-productive space are evident. The former arises from proximity to the U.S. market and ideal natural conditions for production (soil quality, climate, water, etc.), while the latter can be seen as a kind of "perverse advantage" due to the establishment of low wages in low-skilled labor structures (though increasingly complex, especially in the packing process), combined with a large supply of agricultural workers, mostly from highly marginalized and impoverished indigenous regions. Although wages have shown an upward trend in recent years, they remain low compared to those in the United States (Flores, 2021). This suggests a competitive advantage, but with little articulation in the economic and social conditions of agricultural workers and horticultural agro-exporting regions (Borja & Sandoval, 2024).

It expresses a condition that is not exclusive to this enclave, but responds to a modality of capital accumulation at a global level[6].

> The processes of productive internationalization allow capital to develop economies of specialization on a global scale. However, they are highly selective, limiting their expansion to certain countries and activities within their value chains. Multinational corporations' strategies of outsourcing manufacturing activities and retaining R&D activities in their headquarters lead to a continuity in the technological dependency of peripheral countries on industrial centers. (Mancini & Lavarello, 2013, p.33).

6 Within the Mexican agri-food sector, the governance and organizational dynamics of the horticultural GVC show similar processes to the development of other agro-export enclaves integrated into global circuits. This is the case with so-called berries and avocados, which by 2023 ranked as the third and fourth most exported agri-food products. For a comprehensive analysis of the organizational modalities of the berry supply chain and the "contract farming schemes" in place, see the analyses of Cortés (2021); González et al. (2020) and Crespo (2016). For the case of avocados, see Reyes et al. (2023), Valenzo et al. (2015) and Echánove (2008).

Analysis of the criteria and conditions of competitiveness in the producer segment

Dentro de la CGV hortícola, los criterios de competitividad quedan articulados a tres procesos fundamentales: 1) high barriers to entry, 2) increasing production costs, and 3) stagnation in average export prices.

The barriers to entry are defined under the compliance with requirements and certification standards imposed by leading companies. In the case of horticultural producers, Sandoval and Borja (2023, p.160) position it as follows:

> [...] the Mexican horticultural specialization led by Sinaloa shows us that only a small group of large producers have remained competitive as suppliers in the network, and an even smaller group with long trajectories, international certifications, and their brand has developed relational links. Relational links are characteristic of value chains where interactions between buyers and sellers create mutual dependencies and high levels of goods specification.

Furthermore, Mexican producers have faced U.S. trade barriers, such as the "Fresh Tomato Suspension Agreement" of 1996, established following dumping accusations by Florida producers. This agreement was terminated in 2019, reactivating an anti-dumping investigation and applying a 17.5% tariff on Mexican tomatoes. A new deal in August 2019 eliminated the tariff. Still, it imposed border inspections and price increases for specialty and organic tomatoes, suggesting unfair competition favoring U.S. commercial interests (Secretariat of Economy, [SE for its acronym in Spanish] 2019).

In this scenario, access to financing sources and producers' technological and organizational capacity emerge as entry barriers for new suppliers, generating a growing trend of concentration and centralization of production, as previously noted. Wholesale companies seek to maintain a select number of suppliers for the entire agricultural cycle, which can "modularize" the supply network, obtaining greater certainty given the business capacities.

Identifying agricultural financing sources in the central vegetable-producing states nationwide (Sinaloa, Sonora, San Luis Potosí, and Chihuahua), it's evident that commercial banks serve as the primary financing source, followed by Multiple Purpose Financial Societies (SOFOMES for its acronym in Spanish), development banks, and finally, warehousing, cooperative societies, and credit unions[7].

7 SOFOMES are anonymous societies regulated by Mexican legislation, whose main purpose is to carry out one or more activities related to granting credit, financial leasing, or factoring.
On the other hand, development banks are entities of the Federal Public Administration with their legal personality and assets. They are established as national credit institutions. Their fundamental purpose is to facilitate access to savings and financing for individuals and legal entities and to provide them with technical assistance and training.

However, agricultural production units need more access to credit lines. Only 35% of agricultural production units in Sinaloa accessed credits during 2022. Also, of the total credits granted by SOFOMES for national agricultural development during 2018, only 3.2% was channeled towards tomato cultivation, highlighting its low funding compared to other productive chains, such as corn with 12% and sugarcane with 7% (Duran et al., 2019; INEGI, 2023).

There is a high dependence on external financing and a low participation of internal sources, particularly those granted by public institutions. According to Marte Vega Roman, president of CAADES, the difficulties in accessing financing have increased as commercial banks impose high requirements that are often unattainable:

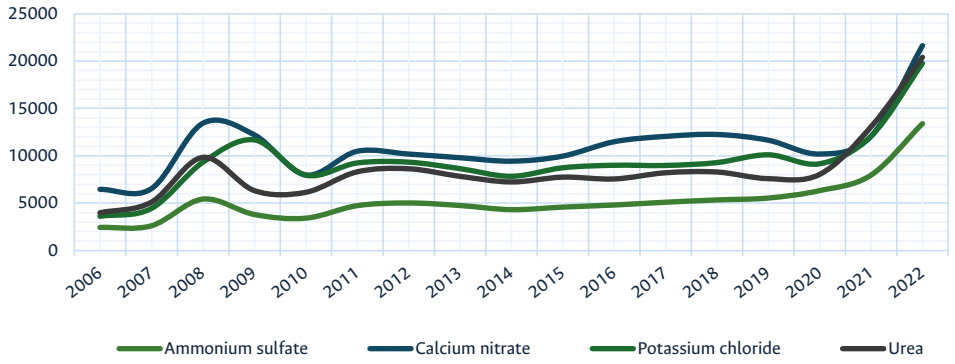
> The field can't stop, and despite the difficulties, producers have made significant efforts to meet financial requirements. However, commercial banking, now the first floor, imposes strict requirements, including agricultural insurance and water guarantee.
>
> [...] The situation is complicated. Although credit flows, the bank is cautious, and honestly, the issue of agricultural credit is one of the main challenges we face. The lack of an official entity supporting the agricultural sector further complicates matters. (Vega, quoted by Meza, 2024, p.1).

Credit limitation has led most producers to opt for direct credit from suppliers or organizations like farmers' associations even though these loans are usually more expensive (Meza, 2024).

These asymmetries observed in access to financing sources combine with high production costs. An example of this behavior is found in the prices of the main inputs and agricultural machinery; recalling that—as mentioned in the first section—there's a high dependence on imports of such inputs.

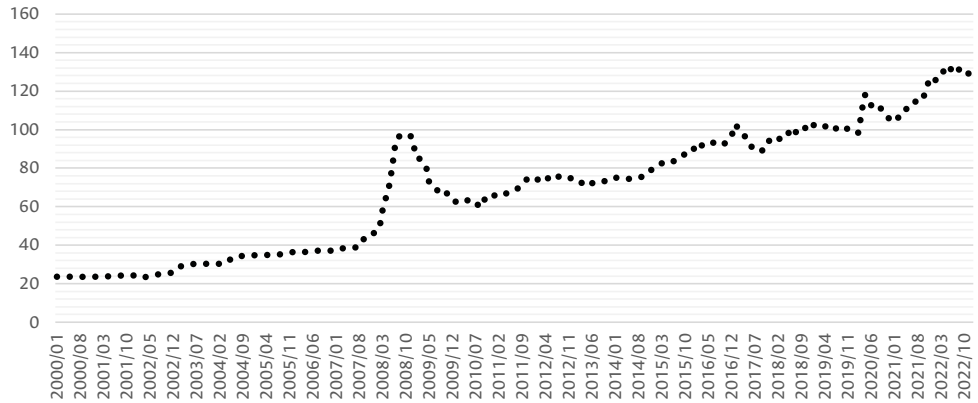
In recent years, the prices of chemical fertilizers have increased significantly by more than 400%. From 2006 to 2022, the price of ammonium sulfate went from 3,582 (Mexican pesos [MXN for its acronym in Spanish] per ton) to 13,385 (MXN per ton); urea from 4,000 to 20,423 (MXN per ton); calcium nitrate from 6,466 to 21,651 (MXN per ton); and finally, potassium chloride from 3,582 to 19,755 (MXN per ton). Moreover, the annual inflation rate for these fertilizers went from 4.6% in 2018 to 14.3% in 2022. (See Figures 3 and 4).

Figure 3. Mexico. Fertilizers. Average Annual Price (Pesos/Ton) 2006-2022 at Current Prices



Source: Own elaboration based on data SNIIM (n.d.).

Figure 4. México. Fertilizers. Price index of generic products (July 2019=100) 2000-2022



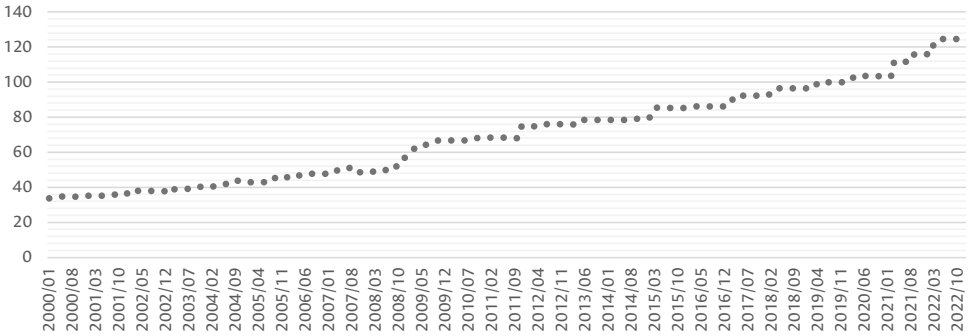
Source: Own elaboration based on data from INEGI (n.d.).

In addition, the price of tractors also recorded an exponential increase, with the annual inflation rate going from 4.8% in 2018 to 10.1%. (See Figure 5).

Aligned with the high barriers to entry, the increase in production, and the competitiveness criteria required by wholesale companies, the average export prices paid in the United States

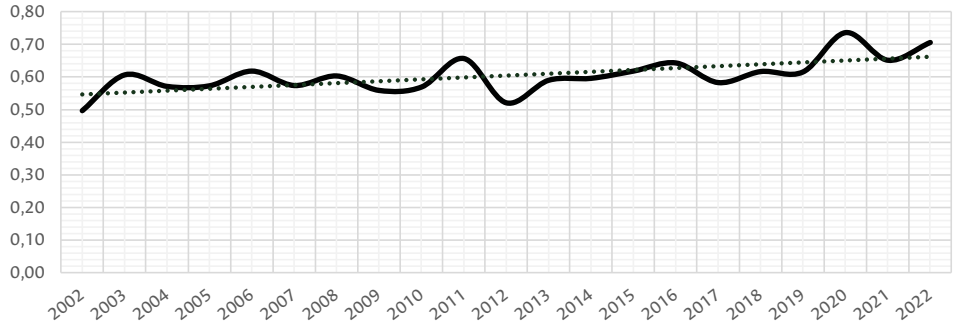
market do not show a constant growth trend against increased productivity and export volume. During the period from 2000 to 2022, the export prices in the United States market (dollars per pound) for fresh tomatoes (including cherry, roma, round, and greenhouse varieties) registered an average annual growth rate of 1.7%, indicating that prices have tended to stagnate over the last decades. While the average price paid by consumers in the retail market in 2022 was $2.4 (dollars per pound), the average export price was $0.79 (dollars per pound), which is 300% lower. (See Figure 6).

Figure 5. Mexico. Tractors. Price index of generic products (July 2019=100) 2000-2022



Source: Own elaboration based on data from INEGI (n.d.).

Figure 6. Fresh Tomatoes. Average Annual Export Price Paid in the U.S. Market at Current Prices (Dollars/Ton) 2002-2022



Source: Own elaboration based on USDA (2023).

Conclusions

The Global Value Chain (GVC) for horticulture in Sinaloa is driven by the large buyers within the retail segment, who, as noted, determine the "rules of the game" for all actors in the chain, conditioning their integration throughout it. At the first link (design), the use of specific seeds, types of agrochemicals, machinery, etc., shapes the acquisition and application of a technological package as a condition of the production process, ensuring the profitability of input suppliers in that chain link.

Thus, the central node is assumed to be a "maquiladora" segment, where work is alienated from unproductive capacities, financial management, and organizational process efficiency. The transfer of value towards the initial nodes occurs under the realization of a "technological" rent, expressed by the degree of ownership over strategic assets and the acquisition of patents.

The application of the technological package is not defined per se, as it undergoes institutional validation through certifications, ensuring compliance with public and private requirements and norms regarding health and safety, social responsibility, and environmental care. High barriers to entry arise, resulting in "commercial" or "institutional" rents appropriated by wholesale companies while expanding structural heterogeneity in the producer segment.

The technological package and various certifications emerge as fundamental elements expressing the governance dynamics by large buyers (e.g., Walmart), who demand product safety guarantees and their requirements through quality standards, using their monopsony power. This maximizes the effectiveness of their investment level in terms of customer loyalty, brand power, and speed and reliability of delivery. The "financial" rent is appropriated under the strategic control of their assets, increasing their stock market value.

In this process, producers remain captive, facing increasing competitiveness standards, production costs, and stagnation in export prices, limiting their scaling both "backward" and "forward" in the chain. The high requirements for small and medium-sized producers increasingly hinder their participation, pushing them towards strategies involving historical organizational forms.

Dependence, "structural heterogeneity," and extroversion exacerbate historical features of underdevelopment. This condition is not exclusive to this enclave but expresses a mode of capital accumulation globally.

This situation inevitably leads us to question the benefits of the Mexican agri-food sector's integration into global circuits over the last decades. This downgrading process has hindered forming a local productive system capable of ensuring its extended reproduction of capital with broad endogenous links. This entails the urgent need to build a rural development strategy that looks beyond the agro-export logic.

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Appendix

Table A1. Sinaloa. Active Certified Companies. Eleven Rivers Growers

Company Name	Location	Products	Website
Agroexportadora del Noroeste S.A. de C.V.	Villa General Angel Flores, Navolato, Sinaloa	Tomato, Roma tomato, round tomato, slicer cucumber.	https://agroex.mx/
Del Campo y Asociados S.A de C.V.	Aguaruto, Sinaloa	Tomato, organic eggplant, sweet pepper, cucumber.	Not available
De la Costa, S.A. de C.V.	Chapultepec, Culiacan, Sinaloa	Green beans.	Not available
Daniel Cárdenas Cevallos	Intersection of irrigation canal No.10	Saladette tomato, slicer cucumber, European cucumber, bell pepper, baby peppers.	https://tricar.com.mx/
Vitanova Fresh Produce S.P.R. de R.L. de C.V.	Ruiz Cortines 1, Guasave, Sinaloa	Grape tomato, cherry tomato.	https://sunripecertified.com/
Agricola Belher	Villa Angel Flores, Navolato, Sinaloa	Tomato, Roma tomato, round tomato.	https://agbelher.com/
Agroindustrias Tombell, S.A. de C.V.	La Cruz de Elota, Sinaloa	Round tomato, Saladette tomato, grape tomato, bell pepper.	Not available
Agricola Chaparral S.P.R. de R.L. de C.V.	Field Diez, Culiacan, Sinaloa	Round tomato and bell pepper	https://agricolachaparral.com
Campaña Agricultores, S.P.R. de RL de C.V	Villa Juarez, Navolato, Sinaloa	Bell peppers, European cucumber, eggplant, green beans, mini peppers, habanero and Fresno chilies.	Not available
Agricultores de San Isidro Navolato, S.A. de C.V.	Villa Juárez, Navolato, Sinaloa	Eggplant, bell pepper, green beans.	https://asic.com.mx/
Promotora Agroindustrial y Comercial de Tamazula de S.P.R. de R.L. de C.V.	Villa Benito Juarez, Navolato, Sinaloa	Eggplant, slicer and pickle cucumbers.	Not available
Agricola Maor	Ahome, Sinaloa	Bell pepper.	Not available
S.P.R. de R.L. de C.V. Agricola	A. Ruiz Cortinez	Green beans and bell pepper.	Not available

Source: Eleven Rivers Certification Scheme; Eleven Rivers Growers. Reviewed on May 6, 2024.

Table A2. Semi-structured Interviews Conducted with Actors from the Horticultural Agro-export Enclave of Sinaloa, Mexico

Actors	Description	Methodological sheet
Heads of production units. Associated producers and day laborers.	Interviews conducted with the heads of four of the six horticultural export companies certified as "socially responsible."	Interview location: Navolato, Sinaloa. Interview dates: June 2007 and April 2011. In compliance with the terms established in a confidentiality agreement, it was agreed: "We commit to not using your name or the name of your company. Additionally, it is understood that the information is solely for academic purposes and will not be provided to the media or individuals outside of this research project."
Associated producers	Agroexportadora del Noroeste S.A. de C.V.	Interview location: Navolato, Sinaloa. Interview date: July 2011
Ing. Magdalena Leyson. General management.	Agrícola San Isidro S.P.R. de R.L.	Interview location: Culiacán, Sinaloa. Interview date: November 2007
Ing. Jorge A. Madrid. Head of production unit. Ing. Luis Amezquita Tarriba. Field technician.	Farmer´s Best International.	
Ing. Alfredo Ontiveros Chavarrín. Head of production unit.	Agrícola Chaparral S.P.R. de R.L.	
Jorge Kondo López	Secretary of Agriculture, Livestock, and Fisheries in the state of Sinaloa (2005-2015).	Interview location: Culiacán, Sinaloa. Interview dates: June 2007 and March 2021
Ing. Alfredo Araujo	Heads of irrigation districts 010 and 0174. National Water Commission.	
Lic. José Raymundo Elizalde Gastelo	General Director. Company: "Eleven Rivers Growers." Confederation of Agricultural Associations of the State of Sinaloa (CAADES, by its acronym in Spanish, n.d.).	Interview location: Los Mochis, Sinaloa. Interview dates: March 28, 2011, and March 28, 2023

Source: Own elaboration.