



Neostructural innovation and directionality in Chilean salmon aquaculture

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ABSTRACT

The recent work of Mariana Mazzucato on the role of public funding in economic development seeks to rebalance debates on innovation to highlight the role of the State, as opposed to the dominant narrative of unregulated private initiative. This is particularly relevant for the case of the Chilean salmon industry where, besides the diffusion of technology and management practices by a combination of international agencies and private initiatives, its boom has been supported by considerable national public funding since the 1970s and especially after the transition to democracy in 1990. In this regard, the main argument of this paper is that the innovation system of the Chilean salmon industry should be understood within a neostructural model of economic development. However, although the State has had an essential role in financing and promoting innovation, we found that it has not served as a guiding entity (directionality) for how innovation should be undertaken. This is important to recognise since it helps to explain why the Chilean salmon industry has been able to direct innovation towards its own economic interests without attending to broader social issues related to its operations, despite this public expenditure. The main conclusion is that, due to the type of knowledge developed and how innovations are valued within the sector's innovation system, the goal is to increase volume, reduce costs, and marginally mitigate negative socio-ecological externalities.

1. Introduction

1.1. Rethinking innovation in the Chilean aquaculture sector

The Chilean salmon industry has received considerable attention regarding its impacts. Numerous studies have focused on the environmental effects of the sector [4,22,23,82], the challenges for sustainable development [11], Global Production Networks [55] and the broader political ecology and local development effects, including social conflicts [12]. This work has exposed the sector's negative impacts to counterbalance a more positive economic growth narrative. While these impacts have gained considerable attention, innovations that address these problems in the Chilean salmon industry have only been partially explored. Only a small number of researchers have analysed the evolution of this national sector and the innovation that has emerged from it [53,76], the role of collective capacities in this process [51], and managerial innovation differences between Chile and Norway [88]. An essential element within this literature is that, although the State has

been recognised as a critical actor in terms of funding, its role in guiding the directionality of innovation has been weak.

Focusing on the State's role is a particularly relevant issue for Chile, given that a neoliberal development agenda has been promoted since the mid-1970s, permeating all areas of the economy and creating a specific environment for innovation where private actors are responsible for innovation activities, at least in theoretical and political terms [13, 34,77]; Chile was for a long time recognised as an international model for the Washington Consensus of free-market economics [63]. We argue that it is important to scrutinise this statement because of its implications for how innovations have been directed within the Chilean salmon sector. There is a need to explore the invisible structures that constitute the innovation system, and the interests and logic contained within them. In other words, the rationale behind the innovation system and the elements forming this multiscalar system. Accordingly, by focusing on the innovation system of the Chilean salmon industry, this paper seeks to reveal the role of the State in funding the salmon innovation system, and the role of the State in defining the directionality of

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innovation. It explores the following question: What has been the State's role in funding and directing the innovation system of the Chilean salmon industry?

The article first elaborates on the conceptual and historical background that frames the discussion on the role of the State in the Chilean salmon industry and the innovation system that derives from it. We then explore the idea of the directionality of innovation, which is particularly relevant for analysing the path followed by technological change. This path is key to discussions on sustainable development and responsibility within innovation systems. This is followed by the concept of neostructuralism to describe the rationale behind private-public initiatives in this sectoral history. An understanding of the neostructural development path, as opposed to neoliberal market dogmatism, provides a more critical standpoint on the role of the State in driving economic development. We utilised public data on innovation expenditure intensity and the main areas of innovation during the 1990–2016 period, also the actor networks derived from R&D projects financed through public and private initiatives. Interviews with these actors unveil the directionality of innovation.

2. What is the role of the State? Directionality and neostructuralism

The question on the role of the State in funding and directing innovation in the salmon industry is a contingent one. To answer this question, we first must discuss what we understand by directionality in innovation and why it is crucial when unveiling the Chilean model. Here, the concept of directionality helps us construct the article's main argument as we move towards understanding the Chilean State innovation policy in salmon aquaculture as one made created within neoliberal boundaries but based on neostructural intervention in practice.

2.1. The directionality of innovation

The concept of innovation systems implies the formation of actors (individuals, firms, collectives, or other organisations), networks (interdependencies), and institutions (social rules, norms, standards, good practices, etc.), as well as the role of material artifacts and different types of knowledge (scientific and technology-based innovation - STI, or learning-by-doing, by-using and by-interacting - DUI) [58,70]. An essential element that is usually overlooked but has gained force in recent years is how innovations are valued in other ways besides the purely economic, thus including the ethical positions of actors that lie behind networks and institutions [33,48]. The basic characteristic of innovation systems is that all elements within them must be understood as constantly interacting [69], generating innovation in such a way they would not have been possible if they were to do so independently.

The study of the directionality of innovation systems is also recent [85]. Among the first were studies on [87] the concept of 'directionality failures' alongside other types of failures associated with innovation (e.g. demand articulation failures, policy coordination failures, and reflexivity failures). Directionality failures underline the problem that some innovations are promoted as 'good', usually related to more sustainable alternatives, but only result in substituting one problem for another. In this sense, the discussion around directionality is helpful because it allows us to analyse more critically if the innovation system of a given technology is heading in a direction desired by most actors. Furthermore, it also enables a focus on ethical and social issues that are usually addressed in narratives but are often short on concrete practices [66].

Directionality failure does not need to be necessarily the development of 'failed innovations'. Instead, it can refer to successful innovations that have enabled a particular industry to develop and expand. It means that the innovations may have created a path that limits itself to a specific type of innovation or only benefits a particular

type of production model [47]. This is relevant in terms of contemporary grand societal challenges, where health, demographic change, well-being, and sustainability issues need to be addressed [61]. Specific innovations may help industries become more productive and respond better to market demands, and even address some critical aspects of local development (such as job creation and generations of royalties), but they might also restrain the industry from coping with sustainability, such as ecological degradation in the case of salmon farming [44]. Therefore, [66], what is needed is a reflection on why an innovation system has been directed in a certain way, and by whom, and what is required to shift it towards what has become known as responsible innovation [13].

Influencing the directionality of innovation systems requires an understanding of the variety of directionalities that may exist, either between different innovation systems or even within one innovation system [89]. This is because actors and innovations struggle, compete and create several similar ideas about how innovation should be undertaken [48]. This is important to contemplate, not only because of the potential conflict of interests that may emerge, but because having different directionalities within one innovation system may imply that different world views must be considered [86], where some prevail over others. Consequently, because of internal power struggles and contextual settings, the directionality of an innovation system is dependent on how internal relations are formed. Understanding such a system logic, or rationale, allows us to understand why an innovation system is directed towards one development pathway and not another.

2.2. Neostructuralism and the role of the State

The concept of neostructuralism is key to understanding the rationale that exists in innovation systems in Chile. It is the first step in describing the system's operation and the State's role. There have been two dominant narratives for understanding the State and its role in innovation in the Chilean case. The first is the narrative of a State that has been 'hollowed out' by neoliberalism, contributing little or nothing significant to economic development ideas, investment, or promotion of industrial activities. This narrative is present in the economic and sectoral reforms made during the 1980s [42]. The second involves accrediting major productive advances as the result of the efforts of private actors, as if the initiatives were a product of unfettered marketplaces. It is this second narrative that lies at the core of this article since the capture of the dominant narrative of economic development and innovation by neoliberal advocates was particularly evident in Chile from the 1970s under dictatorship but also persisted under democracy from 1990 to the present [78,80]. The envisioned role of the State as a facilitator for economic activity is pivotal in the Chilean economic model, and has characterised its development path from the 1980s onwards [43]. The development model imposed from the mid-70s positions the market as the key agent of development with the State in a secondary role in providing the conditions for market and sectoral growth [64].

The term neostructuralism, as opposed to neoliberalism, is the most appropriate term to describe the phenomenon that counterpoises the two ideas noted above. It highlights public-private partnerships and differentiated responsibilities rather than a blanket conviction of market solutions in all economic, social, and environmental policy realms. During the 1940s, the UN Economic Commission for Latin America and the Caribbean (UN ECLAC/CEPAL) coined structuralism to define the need for State intervention to promote industrial capacity in the region and revert the worsening terms of trade. This was successful in Mexico and Brazil but weak elsewhere [49]. Nevertheless, with the deficiencies of market liberalisation evident in the 1990s, particularly in terms of social protection and environmental regulation, UN ECLAC promoted the concept of neostructuralism to define the perpetuation of heterodox economic development aligned with State support in social provision and environmental protection [64,65]. Bielschowsky [17] summarises it

as follows: “heterodox in macroeconomics, development-oriented in terms of resource allocation and State intervention, universalist in the social field and conservationist on the environment”. (p. 172).

More recently, some basic ideas of neostructuralism have emerged in work on the State’s role in innovation. Mazzucato [73–75] reassesses the role of State agency and the development of breakthrough innovations in different fields, arguing that the State is crucial in developing innovations beyond its social construction as a mere regulator. Moreover, she provides a framework for rethinking the role of public institutions in the context of global capitalism, which we refer to as neostructuralism. Using the term the ‘risk-taking State,’ [73] she highlights that the State has been criticised for ‘picking losers’, as many State-supported innovations fail. However, through the examples of nanotechnology, digital devices and green technologies, she establishes that this is due to investment in far-reaching, high-risk projects that may not bear fruit in the short-term but lead to longer-term discoveries and spin-offs: “Not only has the government funded the riskiest research whether applied or basic, but it has indeed often been the source of the most radical, path-breaking types of innovation.” ([73], p. 68).

The State’s role in supporting industrial innovation in developed economies goes beyond fixing market failures [81]. The State has been shown to be central in creating the visions and plans that empower innovation and create the context in which such innovations are performed. This is evidence of directionality, including directionality failures. It is a process in which the State defines winners by targeting new growth areas for development [73]. A classic example of this is the internet, as it resulted from a small Defence Department network project (ARPANET) financed by the United States government [26], which then went out into the market alongside the State. In terms of training and research numbers, the State still has a vital role in knowledge creation, as public universities still predominate worldwide. In Denmark, the State’s investment in basic research is up to 80 % of the budget for higher education, while in the US, Russia, and Korea, it is around 20 % ([Dataset] [38]). Investment in basic research is highly important in providing a platform for innovation and enhancing national competitiveness, including Chile.

Even though the State’s relevance in funding innovation and technology is apparent, an important discussion emerges to unveil its true role. While most debates have centred their attention on ‘more or less State’ (a relevant political discussion in Chile), it is important to focus on whether State support for innovation activities is sufficient to direct it towards more sustainable development. Furthermore, we must ask if the State’s role is primary or secondary. Authors have described the Chilean neoliberal model by the principle of subsidiarity. Indeed, this principle is in the Constitution and has permeated much of Chile’s political, social and economic life. In innovation, this principle remains central, portraying the State as a mere observer and facilitator of technological development [7,8,68].

The idea of the Chilean State as a facilitator is imprinted deep within the Chilean neoliberal model. Barandiarán [7,8] provides evidence that the creation of markets has been central to the innovation policy in the country, with limited results. She refers to it as the “umpire” State in order to describe its role as a market creator and as a “game master” that creates the rules of the game. This implies that science and innovation are relegated to the action of private agendas. However, despite the State’s inaction in directing innovation, it is important to note that the State’s financial support to private initiatives for innovation has been highly significant. Madariaga [67] noted that the Chilean neoliberal model had supported some economic sectors over others, with an emphasis on the comparative advantages identified by neoliberal economists. The Chilean salmon industry’s history of technological development and sectorial evolution falls within this category, as the State has been the leading actor since its inception in the 1960s [52,53].

It was not only under the dictatorship in Chile (1973–90) that the State was active in economic development and innovation. The case of Chilean economic development from the 1950s onwards provides a

paradoxical case to work through the issues of public sector versus private sector research and development. The reliance on nitrate exports, then copper exports following the German development of synthetic nitrates during the First World War, reveals the persistence of a highly concentrated export profile during the twentieth century. Given the restrictions generated by the Dutch disease and the resource curse [84], economic diversification was led by the State. The returns from mining led to a relatively risk-averse economic elite. Hence the need for State-driven diversification. For example, in the 1950s, the development of the forestry sector was led by the State, which encouraged private participation with subsidies and other support mechanisms for installing industrial processing capacity. This was followed in the 1960s with the agrarian reform led by the Christian Democratic government of Eduardo Frei Montalva and financed by Kennedy’s Alliance for Progress, which was paved the way for promoting fruit production and horticulture [72].

The case of salmon aquaculture, which became a key export sector following a new emphasis on non-traditional exports after the economic crisis of the early 1980s, reveals that the idea of the State having a secondary role is somewhat misleading, at least regarding industrial innovation. During its early stage of growth, companies in the Chilean salmon industry needed technological upgrading to compete with other producers, particularly Norwegian firms, and it was the State which served as a driving force for this innovation [53]. The genesis of Chilean salmon aquaculture resulted from a small collaboration between Fundación Chile (a public-private partnership) and JICA (the Japanese State development assistance agency) in the 1970s. The financial input for this project was not privately led but based on public experimentation, with the first production site established in Coyhaique in 1976. Once the experiment had established the viability of production and created a company, private investment flowed in [25]. However, the Washington Consensus model emphasised the importance of private initiative and innovation, hence the fact that industrial development supported by public research has historically been critical for national economic competitiveness yet deliberately minimised in the Chilean context via narratives based on the efficacy of private entrepreneurialism [3].

The evidence of State involvement in economic production across all sectors through financing instruments is considerable, such as with CORFO (the National Productive Development Corporation), or with subsidies for forestry plantations in the 1974 forestry law, water rights allocations in the 1981 Water Code, and public ownership of CODELCO. Further evidence of this support can be seen in the 1958 law (Ley Reservada del Cobre 13.196), which was passed under the semi-authoritarian government of Carlos Ibañez del Campo, by which 10 % of copper mining profits were channelled to the military budget. Even during the public bail-out of the financial system following the 1982–83 international economic crisis, the role of State financial support was not fully recognised [10]. Instead, the idea or narrative of Chile as a ‘free market miracle’ remained and was perpetuated. The Chilean pensions model and the privatisation of water rights in Chile might well stand out as examples of market-based instruments that have been widely promoted and discussed in the literature [19,28]. Baer [6], however, states that the privatisation of the water system in Chile can be seen as relatively successful but that this is due to the silent yet strong support of the State. The social uprising of October 2019, which led to major protests, a plebiscite on a new Constitution, and the creation of a democratically-elected Constitutional Assembly (in May 2021), was based on highly critical opposition to these market-based reforms in resource management and social provisions.

Since the 2000s, the emphasis on private initiative and market efficacy has been maintained in both centre-left and centre-right political blocs. As a result, market-based instruments have been favoured in social, environmental, and economic policymaking. This is a consequence of the influence of neoliberal promotion by different groups: commercial associations, such as the Chamber of Production and Commerce (CPC)

and the Society for the Promotion of Manufacturing (SOFOFA); media, through the two main groups of COPESA and *El Mercurio*; and strong links between political parties and business interests (see [41]). This narrative went as far as creating the 'miracle' of the Chilean 'tiger' economy, generating comparisons similarities with the South Asian 'tigers' in the 1990s [57]; this narrative was based on an upbeat view of Chilean development compared with its regional neighbours. More recently, membership of the OECD and its status as a World Bank high-income country is also used as 'evidence' of private initiative. However, this narrative is blind to the massive State presence and support since the 1970s, which demands a revision of the political economy model at its core. This State support, and the directionality behind it, is explored in the following section.

3. Exploring public funding of Chilean aquaculture innovation

Two publicly available databases were used to characterise the investment in innovation, the types of innovation, and which organisations are part of the innovation system. We complemented this information with semi-structured interviews with actors related to the salmon industry in Chile. These interviews included managers of Chilean and Norwegian firms, and academics who work on the sector; twelve interviews were conducted online during 2021 (due to COVID-19-related restrictions). The interviewees were selected based on an initial list of companies participating in Chile and performing research and development activities. We used the snowball effect to contact new interviewees as the interviews progressed.

The original goal of the interviews was to unveil connections between the Chilean and the Norwegian innovation systems and to analyse their differences and similarities concerning responsible research and innovation within the industry. Unfortunately, due to major restrictions between 2020 and 2021, many actors were impossible to contact, as many research activities were constrained during the pandemic period. Similarly, it is more challenging to perform interviews remotely, as videoconferences do not permit one to grasp specific details otherwise detected during in-person interviews (e.g. gaining access to new interviewees).

Once the interviews were finalised, the analysis included the organisation of the information and searching for codes that enabled the classification and analysis of themes. Here, we followed particular themes from the interviews (such as the role of the State, discussed in this article), and we also delved into other topics suggested by the literature.

The first database is a survey of companies that reported innovation activities for two periods between 2011 and 2016. The survey only considers companies that registered annual sales of over 100,000 USD and were active until 2016. According to the Ministry of Economy, Development, and Tourism, the survey has economic sector statistical representation, extracting a sample from the total number of firms in a particular sector. The database contains 3,772 companies, with margin errors between 4 % and 7 % at the sectoral level, and is the only instrument that measures Chilean investment and outcomes in innovation; it is also the primary source of data provided to the OECD. However, the survey only identifies companies that had developed innovations in the past, repeating the survey on those companies in the following period.

For this reason, the survey reveals a bias, overestimating innovation output (since companies that stopped R&D activities were still considered in the survey). Also, many micro-enterprises are not considered in the survey, as new companies are added to the survey in each iteration. This is particularly problematic as many new start-up companies have led Chilean innovation in recent years [46].

The second database gathers information from innovation projects financed through State-managed agencies, mostly CORFO, the Ministry of Economy, Development, and Tourism, and the Ministry of Science, Technology, and Innovation (ex-CONICYT), alongside the regional offices of various public services. In addition, some non-governmental

organisations, such as the COPEC Foundation (Chilean Petroleum Corporation), are included. The database contains expenditures on each project and participants, facilitating the creation of innovation maps using social network analysis software. Consequently, we were able to create an actor-network map that allows us to see how actors connect in the innovation system. Using this data, we can also identify which technological domains are developed to determine the predominance of specific technologies. Here, we use the 'betweenness centrality indicator' to highlight the relevance of actors in a simple manner. This indicator is frequently used to reveal the nodes that 'control' the flow of information across the whole network [45].

We used these databases to provide an empirical response to our initial question, and to complement the conceptual and historical discussion presented in the previous sections. First, the database that contains firm data allows us to discern how relevant R&D activities are in the salmon industry compared with other sectors, revealing the importance of innovation across different sectors and in the Chilean economy. The second database enabled us to identify which actors are relevant and understand the roles of public and non-firm research organisations in the sectoral innovation system. Here, the database already contained some indications regarding the field (e.g. process, marketing, and biotechnology). However, by reading the descriptions of each project, it is possible to discern the purpose of such innovations. For instance, innovations oriented toward vaccine development and genetics, which make up most of the type of innovations, were catalogued as 'biotechnology'. These are different from 'animal health', which comprises non-biotechnological solutions to animal health management, including research on animal diseases. Finally, defining the type of technology enabled us to determine the types of knowledge and valuations present in the system (see [18]).

4. The Chilean salmon innovation system

4.1. Evidence of low levels of investment in innovation and the role of the State

Chilean R&D expenditure has remained low in recent decades, whether by firms or the State [2,15,35]. The following graph (Fig. 1) illustrates this low investment in comparative terms. In 2017, Chilean expenditure on R&D was 0.39 % of GDP, similar to other countries in the region but very low in the context of the OECD. Despite recent reforms to the State innovation system (e.g., the creation of the Ministry of Science, Technology, Knowledge and Innovation, which will be explained later), this has not been translated into a significant increase in the budget for R&D or innovation. In 2006, the National Council for Innovation and Competitiveness stated that only 0.7 % of GDP is invested in R&D activities, and less than a third comes from the private sector [29].

These low investments in innovation at a national level can also be seen in aquaculture. Fig. 2 reveals that the fisheries and aquaculture sector is low when compared to other national sectors. On average, companies invest USD 35 per USD 1,000 in sales, far lower than other key sectors. Historically, the major export industries (fisheries, forestry, and mining) have been portrayed as 'success stories' of Chilean economic development [77]. However, despite this apparent success, they have maintained low levels of R&D due to the focus on commodity exports and a lack of processing within their value chains. Most of the innovation policy in Chile has focused on reinforcing comparative advantages for the global economy, rather than diversification [29]. While there is interest in the potential of private companies to develop significant innovations, particularly from intermediaries in the value chain [62], private investment R&D activities are meagre.

Chile's National Innovation System (NIS) has focused on sectors with competitive advantages, such as mining, forestry, and fisheries [16,83]. Among these industries, salmon farming is presented as a sector with particular economic potential, receiving considerable support from diverse public organisations [50]. Here, the National Development

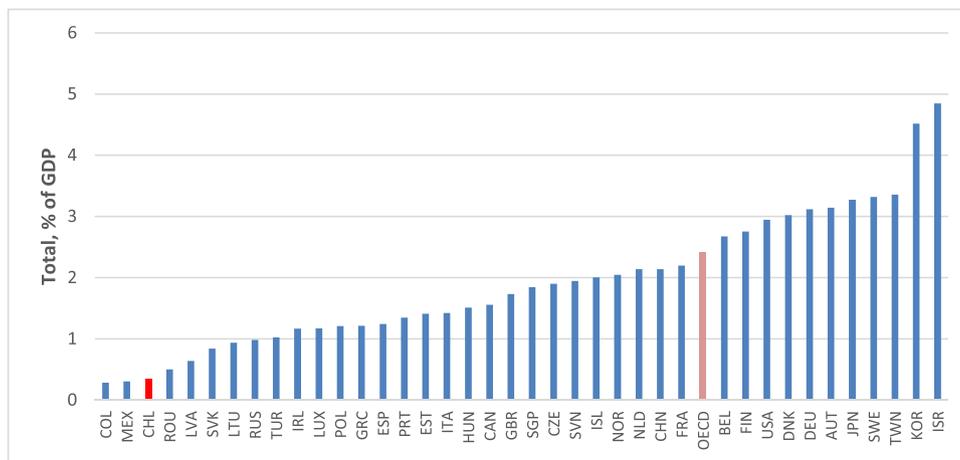


Fig. 1. Gross domestic spending on R&D as a percentage of GDP, OECD and selected countries, 2018. [39].

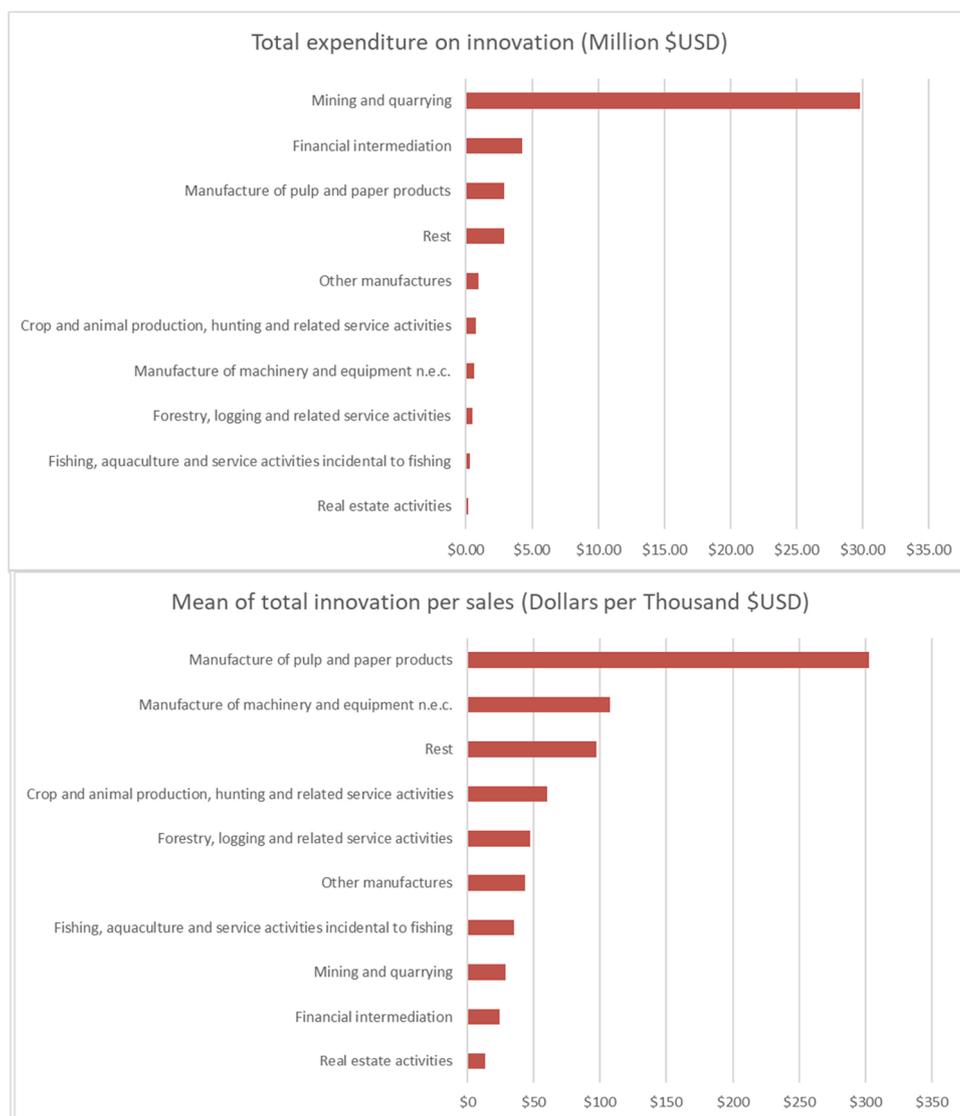


Fig. 2. Expenditure on innovation among key Chilean economic sectors. Authors' calculations based on national innovation surveys, 2011–2016 ([Dataset] Ministry of Economy, Development and Tourism [37]).

Corporation (CORFO), established in 1939 to trigger economic development and promote industrialisation via public investment and other support mechanisms, and the National Commission for Scientific Research and Technology CONICYT, which is now the Ministry of Science, Technology, Knowledge, and Innovation (MSTI), are the main actors. Both CORFO and MSTI are crucial in coordinating and providing funding for research and development activities across different productive sectors [1,13,35].

Despite the shifts in political economy, from the agricultural development programmes of Frei Montalva to Allende's Road to Socialism, Pinochet's neoliberalism, and the 'growth with equity' models of the democratic administrations from the 1990s, CORFO has persisted in its role, providing considerable inputs into economic development, particularly in R&D. It is fair to say that it has been the most stable institution in Chilean innovation over many decades, yet its role has been underplayed in dominant economic narratives.

CORFO is closely associated with the development state of the mid-twentieth century. Although the Import-Substitution Industrialisation (ISI) model started to fail in the 1950s, there were other interesting development initiatives, in particular the agrarian reform of the 1960s with support from the Alliance for Progress (with its associated anti-Communist objective - similar to the sub-title of W.W. Rostow's modernisation theory book title). The Allende Road to Socialism marked a reinforcement of this State-led model, and this was avowedly dismantled by the Chicago Boy model from the mid-1970s, alongside strict authoritarianism. However, the paradox is that CORFO remained alive and well throughout dictatorship, as did CODELCO and other State-owned enterprises. This hybrid or heterodox model in practice belied the narrative of neoliberalism and free markets. Under dictatorship, those social scientists and economists who might have commented on this paradox were effectively silenced, leading to a dominant, hegemonic view of the Chilean socio-economic model in this period that was perpetuated by the democratic administrations of the 1990s, who were still restricted in many ways by the persistence of Pinochet as Head of the Armed Forces (to 1998).

Apart from CORFO, the role of the MSTI (mainly through its former guise, as CONICYT) has also been vital in financing business-oriented research and innovation. This can be seen in Fig. 3, which illustrates the network of actors in the salmon industry's innovation system. The network illustrates the knowledge and resource flows between universities (public and private), public agencies and private companies. For example, the role of the Salmon Technology Institute (INTESAL) can be identified, which brings together 70 % of all national companies and is the most crucial techno-scientific organisation among salmon sector firms. Previous research on the Chilean innovation system (see [16]), with only a few exceptions (e.g. [71]), focuses on describing the relevance of public agencies in financing innovation across different sectors (which can also be seen in this network), underplaying the role of universities in coordinating financial sources from different institutions in the pursuit of R&D objectives. Universities and other research institutions have been essential articulators in the NIS [83]. For example, Fundación Ciencia & Vida (Science and Life Foundation), a private institution, has played a pivotal role in developing vaccines and animal health-related innovations in the salmon industry. The pivotal nodes of the Ministry of Economy (CORFO - with strong firm participation), the Ministry of Science (stronger university coordination), and the Ministry of Agriculture (links to other sectors) stand out, articulating particular clusters of organisations.

CORFO also acts as a bridge between different clusters within this network, connecting private companies and organisations that receive financial support through other sources, such as the MSTI and the Ministry of Agriculture. The resources that flow through CORFO's network are considerable and reveal the relevance of this agency in promoting innovation and technology in the sector during this period. Overall, the State spent approximately USD 75 million on different innovation projects related to salmon aquaculture during the period

under review. In most of these projects, recipients of those funds were expected to partially co-finance activities. For instance, many CORFO programmes (e.g., INNOVA Chile) require that recipients finance 50 % of the project's total cost, which accounted for approximately USD 66 million in 1991–2016 in relation to salmon innovation projects. It is also important to note that one of the aims of CORFO's programmes is to reduce the risks in developing tangible products and knowledge that are new to the market. Reducing risk is one of the State's most relevant roles in supporting innovation activities in Chile and elsewhere and could be considered a dimension of directionality. Considering that most innovations fail, the State has played a crucial role in supporting businesses in their risk-taking activities and assuming the costs associated with these higher risks [73]. In Chile, these programmes cover a significant percentage of the costs associated with developing innovation. CORFO data reveals that, for every Chilean peso that the State invests through these initiatives, private companies invest only 0.43 pesos. This reveals where the weight of risk-taking in innovation lies.¹

The creation of the MSTI in 2018 sought to resolve the deficiencies in national innovation, by bringing science and innovation closer together, and by merging State capacities that had been diluted via ANID (ex-CONICYT) and CORFO financing instruments that supported R&D but which were disconnected. These weaknesses had been identified sometime earlier and were apparent when the Mining Royalty was approved in 2005. This royalty on sales was directed at economic diversification through an Innovation Fund for Competitiveness and a National Council, established to finance R&D, reduce dependency on the mining sector, and anticipate the Hotelling effect. A Commission of Science for the Development of Chile, created by President Bachelet, provided a diagnosis of the situation of R&D in the country and the need for more articulation of public policy and increased private commitment. In 2014, the National Council changed its name to the National Council of Innovation for Development. This Council published a strategy document titled *A New Pact for Inclusive and Sustainable Development* in 2017 [31,32], which in turn created the momentum for the creation of MSTI. However, an internal report in 2018 made the relevant observation that although R&D investment had risen as a percentage of GDP, from 0.22 % in 2005 to 0.39 % in 2017, the total amount of spending on science, technology, knowledge, and innovation was only half that of one US university, Johns Hopkins in Baltimore [13].

The sector has been particularly focused on biotechnology innovations (see Fig. 4). Most of these innovations are for vaccine development. Among the 49 patents awarded during the period, 36 are for vaccine components and other pharmaceutical products to prevent fish health problems. Biotech. patents made up 11 % of the total registered patents between 2010 and 2019, focused mainly on animal health [27]; this can be seen in the type and number of projects promoted by INTESAL (see also [14]). It can be argued that the reason innovation in Chilean aquaculture has been directed towards biotech. vaccines is due to the urgent needs presented by Infectious Salmon Anaemia virus (ISAv) outbreaks in 2007 and 2009 [90]. Prior to these outbreaks, and given research development in other sectors concerning phytosanitary issues and exports [5], Chile launched a national strategy for biotechnology development in 2003, and there was clear evidence for State support for these initiatives (see Fig. 4). Although not specific to the aquaculture sector, this focus on phytosanitary biotechnological development could be seen as evidence of directionality, although it was principally reactive (to disease and health risks) rather than proactive in nature.

4.2. Directionality failures in the Chilean salmon innovation system?

Chilean innovation policy efforts have focused on reinforcing market-oriented policies while identifying innovation as a means to

¹ Data presented by CORFO in their website www.datainnovacion.cl.

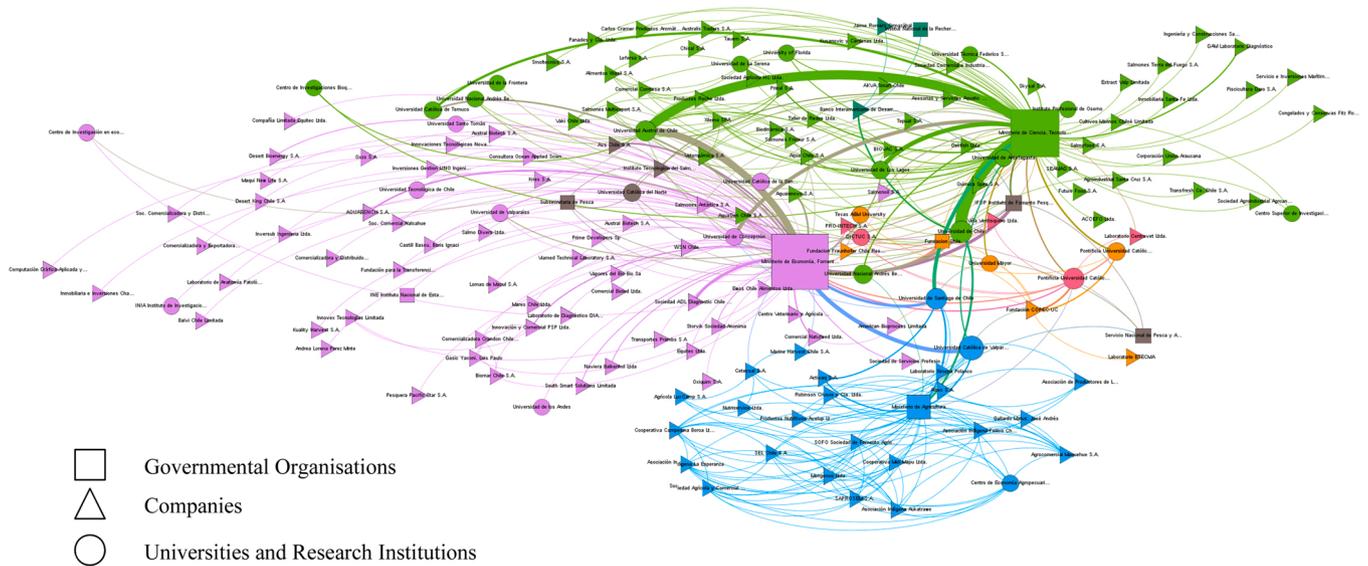


Fig. 3. Innovation network of public-funded projects in the Chilean salmon industry 1990–2016. Authors’ based on FIA ([Dataset] Ministry of Agriculture [36]). Node’s size reveals higher ‘betweenness centrality’.

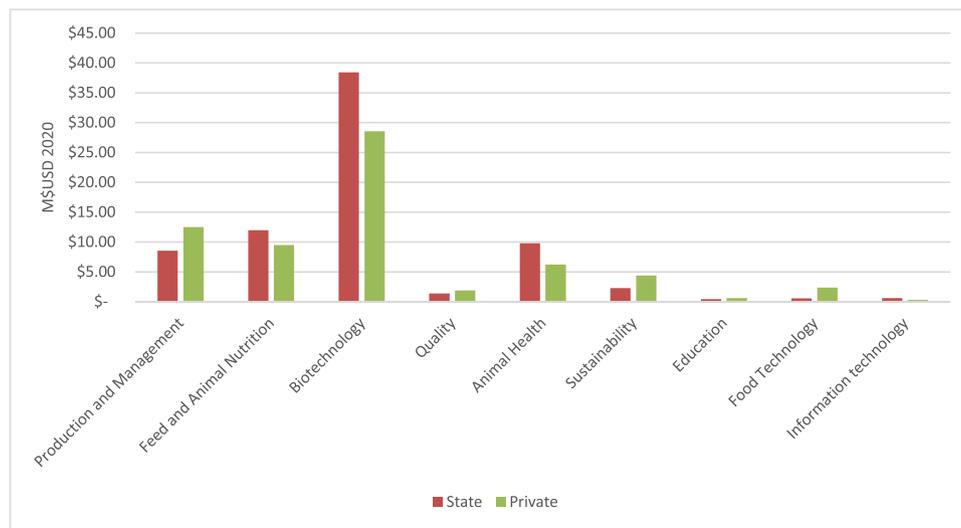


Fig. 4. Expenditure on public funded projects by type of project and actor in the salmon industry, 1990–2016 (2020 USD million). Authors’ based on the FIA Database ([Dataset] Ministry of Agriculture [36]).

strengthen the comparative advantages of the Chilean commodity-oriented economy [29,32]. This emphasis on productivity belies the significant challenges the sector has faced over recent decades [9,22,55]. Most innovations have failed to address the main socio-ecological problems since their focus is not directed towards tackling the effects of climate change, working conditions, or local community impacts, but on maximising profits by reducing mortality rates and increasing productivity [15,20,24,40]. There is no clear directionality in terms of lowering environmental impacts or improving animal welfare beyond regulatory obligations. This is interesting since biotechnology is often presented as having this purpose within other sectors, e.g. for bioremediation in mining or for reducing chemical use in agriculture in Chile [27].

Much of this can be seen in how the economic resources of CORFO have been allocated. An interviewee commented on this issue, stating that:

“... the environmental office of the State has been progressing on these issues [water consumption and efficiency], but slowly. But, they

could have been leading the changes, establishing biophysical and biochemical water parameters, for example. Now that has been resolved, but not previously [...] I believe that the environmental part should be more dynamic. They should be leading, instead of following behind.” (C-01).

Environmental issues have not been prioritised by State agencies in this field. The Ministry of Environment was only created in 2010, while its predecessor – CONAMA – was a weaker political and technical entity, with little influence over investments in innovation. The fact that CORFO sits within the institutional framework of the Ministry of Economy rather than the National Agency for Research and Development (ANID) points directly to the role of the State in promoting and financing R&D in support of business objectives around productivity. However, most innovation remains guided by ‘learning-by-doing’ (DUI), rather a coordinated strategy at the firm level or across particular sectors [1,2].

In another example, an interviewee noted that even when environmentally-friendly technological solutions were developed and

were ready to be implemented, the State was not proactive enough to enable companies to implement new initiatives legally.

"The first time I went to a seminar to know what we can do with the sludge, after production. If you don't treat the sludge it has 0.5 % of dry content. It is brown water. We tried to treat that water to transform it into pellets, but in Chile, we can't do anything with the sludge. We still don't have authorization or a legal way to use that material that is rich in phosphorus and nitrogen". (C-06).

Preparing the normative scenario for implementing new innovations goes beyond resource allocation. While resources have always been available for innovation, with important contributions from the State, the utility of these innovations and resource allocation can be questioned. This is one of the major problems that can be identified, since innovation-related issues have focused on financing activities rather than directing innovation towards more sustainable paths. It should be remembered that it was only recently that a formal national innovation policy was introduced. Another interviewee noted this problem:

"CORFO was good at assigning money [the interviewee notes how Fundación Chile received CORFO's resources from the 1990s] but was terrible in directing the money and controlling the quality of the innovation that was performed." (C-04).

The quote unpacks a critical issue. It is particularly evident that alongside the low-budget and resources allocated to innovation and technology, the Chilean State has also poorly managed the development of this innovation and the problems expected to be solved by these technologies. Here, the State acted as a market facilitator to improve competitive advantages (reducing production costs), but without taking major risks in directing a mission-oriented type of innovations [75]. Bustos-Gallardo (2015) describes this as 'business as usual' in terms of environmental governance, and in our analysis this appears to apply to innovation also. However, envisioning the State as a high-risk taker to tackle major societal and environmental problems, as Mazzucato proposes, implies (in the Chilean case) transforming its inherent role as a mere market facilitator beyond the neoliberal model. This is a transformation that has yet to be seen, and which involves a discussion about the political and economic model that failed to be nationally recognised in the proposed new Constitution of 2022, but it is still under discussion in the upcoming constitutional process [8].

It is also important to recognise that, in recent years, the long-term Chilean policy on innovation has proposed substantial changes, focusing on sustainable and inclusive development as a key concept to guide the innovation agenda towards 2030 [30]. This implies recognition of Chile's science, technology and innovation as tools for tackling 'grand societal challenges', orienting funding towards these issues, however, without clear funding instruments for this purpose, beyond the older FONDAP programme (Priority Areas Fund) [32]. This policy is important to support mission-oriented, strategic objectives, which represents clear directionality [75]. This objectives of social justice and sustainability, as persisting, prevalent missions in which the State must have a crucial role and where the State is highly relevant in ongoing debates about types of innovation, should be encouraged. This follows the example of the European Union where guideline initiatives such as Responsible Research and Innovation (RRI) and a mission-oriented approach policy have been developing in this direction over the last decade, as businesses are encouraged to link their activities to these challenges [33].

5. The importance of directionality in State-supported innovation

The Chilean model of R&D since the 1970s and the onset of dictatorship is best described as one defined by neostructuralism. By revealing who the key actors are, the type of networks that are formed, and the institutions involved in aquaculture research and innovation, the dominant narrative of Chilean aquaculture development must also be shifted slightly. Risk-taking in the Chilean salmon innovation system

has been exercised as a State prerogative, while failure has also required intensive public intervention [54]. The focus on biotechnology for phytosanitary management is evidence of a more reactive rather than proactive strategy, lacking clear directionality. CORFO was a vital funding source for reducing mortality rates and ensuring product quality for export markets. However, these technological solutions, focused on productivity and high production volumes have not been balanced with R&D in relation to urgent socio-ecological concerns and local development impacts.

This technological focus is a consequence of not correctly recognising the State's role in supporting these innovations and its broader obligations to the 'common good' and development issues. By funding innovation without a clear strategy or directionality, these resources focused on business needs and their accumulation strategies rather than the sector's externalities. There was also relatively little acknowledgement of the role of the State in innovation more generally (perhaps because it was seen merely as a funder and not a strategic actor). There is a dominant narrative in Chile that has persisted since the dictatorship of the role of the private sector in dynamising the economy and promoting growth: the logic of neoliberalism. However, there is evidence of considerable State involvement in innovation and private-public partnerships in the NIS, in networks of Ministries, universities and research centres, and firms. This is important to highlight, especially in the context in which the innovation system is financed with the support of public funds. In this sense, it is more similar to other countries in the OECD, although with considerably less public and private funding [21, 56]. Rather than underplaying the role of the State, the focus of directionality should be on encouraging public-private partnerships for Responsible Research and Innovation (RRI) in pursuit of regional and sectoral social and environmental sustainability, transcending or at least complementing the current productivity maximisation orientation.

The determination of the directionality of innovation does not need to come solely from institutions within the State apparatus, but may also emerge from other actors with solid connections within the network. Based on our network maps, public and private research institutions are important potential articulators in this process of the definition of directionality. Their direct involvement with the development of research and technologies, and the fact that their interests are broader than those of firms and may be longer-term, suggests that the nature of neostructuralism and the configuration of the NIS should also consider these actors more explicitly. Consequently, policy recommendations should focus on the role of research centres and the strengthening of their ability to engage with strategy and directionality issues, beyond their immediate technological skills and desire to access new funding opportunities.

In terms of Chilean political economy, the focus on neostructuralism shifts the gaze from neoliberalism, which has been the dominant leitmotif for several decades. The problem with the neoliberal fixation, however, is that it stresses firms and markets to the point of leaving to one side, or minimising the role of the State, and State companies such as CODELCO (National Copper Company), ENAP (the National Petroleum Company), ENAMI (National Mining Company), and EFE (National Railway Company). The work of Bob Jessop [59,60] on state theory, Mariana Mazzucato [73,74] on the role of the state in innovation, and Peck and Theodore's [79] concept of 'variegated capitalism' all point towards ways in which State involvement in capitalist development should be reconsidered. In Chile in particular, the narrative of market-led, export-oriented development has underplayed the role of the State (paradoxically, given the overwhelming role of CODELCO in the national economy, public spending and military financing since the early 1970s). In the example of research and innovation policy, this key role of state agencies is abundantly clear, hence requiring a shift in thinking about Chilean political economy more generally, where the term neostructuralism provides a more appropriate term for analysing the relationship between private and public institutions and organisations, including their synergies and tensions.

Our analysis shows how critical it is to understand the rationale behind an innovation system, and to make this explicit. By identifying how the NIS is built, who are the key actors, how the networks are formed, and which institutions are the most relevant, we can better define the system's framing, which in this case is neostructural. This in turn allows us to determine why the system has been directed in a particular way and how it could be improved. Accordingly, we argue that the State's *active role* in financing the innovation system, but the *passive role* in directing it explains why innovations within the system and this sector in particular, do not attend to societal or common goods goals as much as the goals defined by the private firms themselves. Instead, the State should be more proactive in motivating innovations that address sustainability through direct requirements or incentives when using public funds, following RRI guidelines. This should be seen as in the long-term interests of all actors in the NIS, as the aim is to create a more socially-robust and environmentally-responsible salmon industry.

CRedit authorship contribution statement

Jonathan R. Barton: Conceptualization, Formal analysis, Funding

Appendix A: List of interviewees

Code	Type	Sex
C-01	Company	Male
C-02	Company	Male
C-03	Company	Male
C-04	Company	Male
C-05	Company	Male
S-01	Services	Female
C-06	Company	Female
C-07	Company	Male
A-01	Academy	Male
A-02	Academy	Female
C-08	Company	Male
S-02	Services	Male

References

- [1] R. Alvarez, J.M. Benavente, R. Campusano, C. Cuevas, *Employment Generation, Firm Size, and Innovation in Chile*, IDB, 2011.
- [2] R. Alvarez, C. Bravo-Ortega, L. Navarro, *Innovation, R&D Investment and Productivity in Chile*, 2011, pp. 1–61.
- [3] A. Arora, S. Belenzon, A. Pataconi, J. Suh, The changing structure of American Innovation: some cautionary remarks for economic growth, *Innov. Policy Econ.* 20 (2020) 39–93, <https://doi.org/10.1086/705638>.
- [4] F. Asche, H. Hansen, R. Tveterås, S. Tveterås, The Salmon disease crisis in Chile, *Mar. Resour. Econ.* 24 (4) (2009) 405–411, <https://doi.org/10.1086/mre.24.4.42629664>.
- [5] P. Bachmann-Vargas, C.S.A. (Kris) van Koppen, M. Lamers, Re-framing salmon aquaculture in the aftermath of the ISAV crisis in Chile, *Mar. Policy* 124 (2021), 104358, <https://doi.org/10.1016/j.marpol.2020.104358>.
- [6] M. Baer, Private water, public good: water privatization and state capacity in Chile, *Stud. Comp. Int. Dev.* 49 (2) (2014) 141–167, <https://doi.org/10.1007/s12116-014-9154-2>.
- [7] J. Barandiarán, *Science and Environment in Chile: The Politics of Expert Advice in a Neoliberal Democracy*, MIT Press, 2018.
- [8] J. Barandiarán, Assessing 30 years of neoliberal environmental management in Chile: effective, democratic or neither? in: J. Sowers, S.D. VanDeveer, E. Weintal (Eds.), *The Oxford Handbook of Comparative Environmental Politics* Oxford University Press, 2021 <https://doi.org/10.1093/oxfordhb/9780197515037.013.21>.
- [9] J. Barton, A. Fløysand, The political ecology of Chilean salmon aquaculture, 1982–2010: a trajectory from economic development to global sustainability, *Glob. Environ. Change* 20 (4) (2010) 739–752, <https://doi.org/10.1016/j.gloenvcha.2010.04.001>.
- [10] J.R. Barton, L. Tedesco. *The State of Democracy in Latin America*, 1st ed., Routledge, 2004 <https://doi.org/10.4324/9780203339039>.
- [11] J. Barton, Á. Román, Sustainable development? Salmon aquaculture and late modernity in the archipelago of Chiloé, Chile *Isl. Stud. J. ; Charlottet.* 11 (2) (2016) 651–672.
- [12] J. Barton, Á. Román, A. Fløysand, Resource extraction and local justice in Chile: conflicts over the commodification of spaces and the sustainable development of places, in: H. Haarstad (Ed.), *New Political Spaces in Latin American Natural Resource Governance*, Palgrave Macmillan, US, 2012, pp. 107–128, https://doi.org/10.1057/9781137073723_6.
- [13] J. Barton, Á. Román, J. Rehner, Responsible research and innovation (RRI) in Chile: from a neostructural productivist imperative to sustainable regional development, *Eur. Plan. Stud.* 27 (12) (2019) 2510–2532, <https://doi.org/10.1080/09654313.2019.1658719>.
- [14] T. Bas, A. Ernesto, K. Martin, Innovation, entrepreneurship and clusters in Latin America natural resource – implication and future challenges, *J. Technol. Manag. Innov.* 3 (4) (2008), <https://doi.org/10.4067/S0718-27242008000200005>. Article 4.
- [15] J. Benavente, The role of research and innovation in promoting productivity in Chile, *Econ. Innov. New Technol.* 15 (4–5) (2006) 301–315, <https://doi.org/10.1080/10438590500512794>.
- [16] J.M. Benavente, J.J. Price, Evolution of the Public Institutions of Science, Technology, and Innovation in Chile: 1990–2012, in: G. Crespi, G. Dutrénit (Eds.), *Science, Technology and Innovation Policies for Development*, Springer International Publishing, 2014, pp. 45–62, https://doi.org/10.1007/978-3-319-04108-7_3.
- [17] R. Bielschowsky, *Sesenta años de la CEPAL: Estructuralismo y neoestructuralismo*, *Rev. CEPAL* 97 (2009) 173–194.
- [18] C. Binz, B. Truffer, Global innovation systems—a conceptual framework for innovation dynamics in transnational contexts, *Res. Policy* 46 (7) (2017) 1284–1298, <https://doi.org/10.1016/j.respol.2017.05.012>.
- [19] G.A. Bitrán, E.P. Valenzuela, *Water Services in Chile: Comparing Private and Public Performance*, World Bank, 2003. (<https://openknowledge.worldbank.org/handle/10986/11303>).

- [20] S. Bravo, P.J. Midtlyng, The use of fish vaccines in the Chilean salmon industry 1999-2003, *Aquaculture* 270 (1) (2007) 36–42, <https://doi.org/10.1016/j.aquaculture.2007.06.017>.
- [21] M. Burget, E. Bardone, M. Pedaste, Definitions and conceptual dimensions of responsible research and innovation: a literature review, *Sci. Eng. Ethics* 23 (1) (2017) 1–19, <https://doi.org/10.1007/s11948-016-9782-1>.
- [22] B. Bustos, Moving on? Neoliberal continuities through crisis: the case of the Chilean salmon industry and the ISA virus, *Environ. Plan. C: Gov. Policy* 33 (6) (2015) 1361–1375, <https://doi.org/10.1068/e1316>.
- [23] B. Bustos, The post 2008 Chilean Salmon industry: An example of an enclave economy, *Geogr. J.* 183 (2) (2017) 152–163, <https://doi.org/10.1111/geoj.12204>.
- [24] F.C. Cabello, Antibiotics and aquaculture in Chile: Implications for human and animal health, *Rev. Med. De Chile* 132 (8) (2004) 1001–1006, <https://doi.org/10.4067/s0034-98872004000800014>.
- [25] P. Camus, F. Jaksic, Piscicultura en Chile: Entre la productividad y el deterioro ambiental, 1856-2008, Pontificia Universidad Católica de Chile, Facultad de Historia, Geografía y Ciencia Política, Instituto de Geografía, 2009.
- [26] M. Castells, La galaxia internet, Plaza & Janés Barcelona, 2001. (https://irla.cat/wp-content/uploads/2017/06/La_Galaxia_Internet.pdf).
- [27] CDTI, El Sector de la Biotecnología en Chile. Capacidades tecnológicas en el sector de la biotecnología, Desarrollo Tecnológico Industrial. Ministerio de Ciencia, Innovación y Universidades, 2020. (https://www.cdti.es/recursos/doc/Programas/Cooperacion_internacional/Eureka/Chile/34031_10111012020195759.pdf).
- [28] R.A. Cerda, The Chilean pension reform: a model to follow? *J. Policy Model.* 30 (3) (2008) 541–558, <https://doi.org/10.1016/j.jpolmod.2006.12.008>.
- [29] CNIC, Informe Final. Consejo Nacional de Innovación para la Competitividad., Consejo de la presidencia, 2006.
- [30] CNID, Ciencias, tecnologías e innovación para un nuevo pacto de desarrollo sostenible inclusivo (p. 218), 2017.
- [31] CNID, Ministerio de Ciencia, Tecnología, Conocimiento e Innovación, CNID, 2018. (https://cdn.digital.gob.cl/filer_public/27/98/2798ac23-2590-4855-a42d-0e0a4965a16c/24_minciencias-f.pdf).
- [32] CNID, Base para la estrategia nacional CTCI 2021 (Policy Report No. 1; p. 65), 2021. (https://www.cnid.cl/wp-content/uploads/2021/04/Digital_Reporte_CTCI_2021.04.21.pdf).
- [33] L. Coenen, K. Morgan, Evolving geographies of innovation: Existing paradigms, critiques and possible alternatives, *Nor. Geogr. Tidsskr. - Nor. J. Geogr.* 74 (1) (2020) 13–24, <https://doi.org/10.1080/00291951.2019.1692065>.
- [34] A. Cortés, La Reprimarización del Modelo de Desarrollo Chileno, OIKOS (Rio De Jan.) 11 (1) (2012). (<http://www.revistaoikos.org/seer/index.php/oikos/article/view/275>).
- [35] A. Cruz, La Ruta de la Innovación en Chile, *J. Technol. Manag. Innov.* 3 (1) (2008) 1–9.
- [36] [Dataset] Ministry of Agriculture, Innovation Projects National Database [Dataset], 2021. (<http://aplicaciones.fia.cl:8080/sigesfia/bdn/bdn.aspx>).
- [37] [Dataset] Ministry of Economy, Development and Tourism, Encuesta nacional de innovación en empresas [Dataset], 2021. (<https://www.economia.gob.cl/category/estudios-encuestas/encuestas-y-bases-de-datos/encuesta-nacional-de-innovacion-en-empresas>).
- [38] [Dataset] OECD, Main Science and Technology Indicators Database [Dataset], 2014. (www.oecd.org/sti/msti.html).
- [39] [Dataset] OECD, Gross domestic spending on R&D [Dataset], 2021. (<https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm>).
- [40] M. Engelstad, Vaccination and consumer perception of seafood quality, *Dev. Biol.* 121 (2005) 245–254.
- [41] H. Fazio, Los mecanismos fraudulentos de hacer fortuna: Mapa de la extrema riqueza 2015, LOM Ediciones, 2016.
- [42] R. Frensch-Davis, Economic Reforms in Chile. From Dictatorship to Democracy, 1st ed., Springer, 2010. (<https://link.springer.com/book/10.1057/9780230289659>).
- [43] R. Frensch-Davis, Is Chile a Model for Economic Development? Univ. de Chile, Department of Economics, 2014. (<https://econ.uchile.cl/uploads/publicacion/71e8693f7c36b774c875772d8cb9933f59988ad0.pdf>).
- [44] A. Fløysand, E.T. Lindfors, S.-E. Jakobsen, L. Coenen, Place-based directionality of innovation: Tasmanian salmon farming and responsible innovation, *Sustainability* 13 (1) (2021), <https://doi.org/10.3390/su13010062>. Article 1.
- [45] N. Ghali, M. Panda, A.E. Hassanien, A. Abraham, V. Snasel, Social networks analysis: tools, measures and visualization, in: A. Abraham (Ed.), *Computational Social Networks*, Springer, London, 2012, pp. 3–23, https://doi.org/10.1007/978-1-4471-4054-2_1.
- [46] J. Gonzalez-Urbe, M. Leatherbee, The effects of business accelerators on venture performance: evidence from start-up Chile, *Rev. Financ. Stud.* 31 (4) (2018) 1566–1603, <https://doi.org/10.1093/rfs/hhx103>.
- [47] M. Grillitsch, T. Hansen, L. Coenen, J. Mörner, J. Moodysson, Innovation policy for system-wide transformation: The case of strategic innovation programmes (SIPs) in Sweden, *Res. Policy* 48 (4) (2019) 1048–1061, <https://doi.org/10.1016/j.respol.2018.10.004>.
- [48] J. Heiberg, B. Truffer, The emergence of a global innovation system – a case study from the water sector, in: GEIST - Geography of Innovation and Sustainability Transitions, (2021(09)); GEIST - Geography of Innovation and Sustainability Transitions), GEIST Working Paper Series,, 2021. (<https://ideas.repec.org/p/aoc/wpaper/2109.html>).
- [49] R. Hernández, Transformation of the State and development paradigms in Latin America, in: *Neoliberalism and Heterodox Thinking in Latin America and the Caribbean in the Early Twenty-first Century*, 1st ed., ECLAC, 2016, pp. 299–336. (<https://repositorio.cepal.org/handle/11362/43346>).
- [50] A. Hosono, M. Iizuka, J. Katz (Eds.), *Chile's Salmon Industry*, Springer, Japan, 2016, <https://doi.org/10.1007/978-4-431-55766-1>.
- [51] M. Iizuka, Standards as a platform for innovation and learning in the global economy: a case study of the Chilean salmon farming industry, *Int. J. Technol. Learn., Innov. Dev.* 2 (4) (2009) 274, <https://doi.org/10.1504/IJTLID.2009.026818>.
- [52] M. Iizuka, J. Katz, Globalisation, sustainability and the role of institutions: the case of the Chilean Salmon Industry, *Tijdschr. Voor Econ. En. Soc. Geogr.* 106 (2) (2015) 140–153, <https://doi.org/10.1111/tesg.12132>.
- [53] M. Iizuka, P. Roje, V. Vera, The development of salmon aquaculture in Chile into an internationally competitive industry: 1985–2007, in: A. Hosono, M. Iizuka, J. Katz (Eds.), *Chile's Salmon Industry*, Springer, Japan, 2016, pp. 75–107, https://doi.org/10.1007/978-4-431-55766-1_4.
- [54] F. Irrazábal, B. Bustos, ¿Peces Gordos y Peces pequeños?: Los empresarios salmoneros, cambio institucional y conflicto sectorial en Chile, *Polis (Santiago)* 19 (56) (2020) 158–184.
- [55] F. Irrazábal, B. Bustos-Gallardo, Global Salmon Networks: unpacking ecological contradictions at the production stage, *Econ. Geogr.* 95 (2) (2019) 159–178, <https://doi.org/10.1080/00130095.2018.1506700>.
- [56] S.-E. Jakobsen, A. Fløysand, J. Overton, Expanding the field of Responsible Research and Innovation (RRI) – from responsible research to responsible innovation, *Eur. Plan. Stud.* 27 (12) (2019) 2329–2343, <https://doi.org/10.1080/09654313.2019.1667617>.
- [57] R. Jenkins, Learning from the Gang: are there lessons for Latin America from East Asia? *Bull. Lat. Am. Res.* 10 (1) (1991) 37–54, <https://doi.org/10.2307/3338563>.
- [58] M.B. Jensen, B. Johnson, E. Lorenz, B.Å. Lundvall, Forms of knowledge and modes of innovation, *Res. Policy* 36 (5) (2007) 680–693, <https://doi.org/10.1016/j.respol.2007.01.006>.
- [59] B. Jessop, *State Theory: Putting the Capitalist State in Its Place*, 1st ed., Polity Press, 1990.
- [60] B. Jessop, *State Power: A Strategic-Relational Approach*, 1st ed., Polity, 2007.
- [61] E. Kallerud, E. Amanatidou, P. Upham, M. Nieminen, A. Klitkou, D. Olsen, M. Lima Toivanen, J. Oksanen, L. Scordato, Dimensions of Research and Innovation Policies to Address Grand and Global Challenges, 2013.
- [62] L. Klerkx, R. Álvarez, R. Campusano, The emergence and functioning of innovation intermediaries in maturing innovation systems: the case of Chile, *Innov. Dev.* 5 (1) (2015) 73–91, <https://doi.org/10.1080/2157930X.2014.921268>.
- [63] P.-P. Kuczynski, J. Williamson, *After the Washington Consensus: Restarting Growth and Reform in Latin America*, Columbia University Press, 2003.
- [64] F. Leiva, *Latin American Neoliberalism: The Contradictions of Post-neoliberal Development*, University of Minnesota Press, 2008.
- [65] F. Leiva, Toward a Critique of Latin American Neoliberalism, *Lat. Am. Polit. Soc.* 50 (4) (2008) 1–25, <https://doi.org/10.1111/j.1548-2456.2008.00028.x>.
- [66] R. Lindner, S. Daimer, B. Beckert, N. Heyen, J. Koehler, B. Teufel, P. Warnke, S. Wydra, *Addressing Directionality: Orientation Failure and the Systems of Innovation Heuristic. Towards Reflexive Governance*, Fraunhofer ISI Discussion Papers - Innovation Systems and Policy Analysis, 2016. (<https://www.econstor.eu/handle/10419/145315>).
- [67] A. Madariaga, *Neoliberal Resilience: Lessons in Democracy and Development from Latin America and Eastern Europe*, in: *Neoliberal Resilience*, Princeton University Press, 2020, <https://doi.org/10.1515/9780691201603>.
- [68] C. Mardones, A. Zapata, Determinants of public funding for innovation in Chilean firms, *Contad. Y. Adm.* 64 (1) (2018) 89, <https://doi.org/10.22201/fca.24488410e.2018.1602>.
- [69] J. Markard, Transformation of infrastructures: sector characteristics and implications for fundamental change, *J. Infrastruct. Syst.* 17 (3) (2011) 107–117, [https://doi.org/10.1061/\(ASCE\)IS.1943-555X.0000056](https://doi.org/10.1061/(ASCE)IS.1943-555X.0000056).
- [70] J. Markard, R. Raven, B. Truffer, Sustainability transitions: an emerging field of research and its prospects, *Res. Policy* 41 (6) (2012) 955–967, <https://doi.org/10.1016/j.respol.2012.02.013>.
- [71] D. Marotta, M. Mark, A. Blom, K. Thorn, Human Capital and University-Industry Linkages' Role in Fostering Firm Innovation: An Empirical Study of Chile and Colombia, *Policy Res. Work. Pap.* (2007). (<https://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-4443>).
- [72] J. Martínez, A.H. Díaz, Chile, the Great Transformation, *Brookings Institution; United Nations Research Institute for Social Development*, 1996.
- [73] M. Mazzucato, *The Entrepreneurial State: Debunking Public vs. Private Sector Myths* (Revised edition), Anthem Press, 2014.
- [74] M. Mazzucato, *The Value of Everything: Making and Taking in the Global Economy*, Hachette, UK, 2018.
- [75] M. Mazzucato, *Mission Economy: A Moonshot Guide to Changing Capitalism*, Penguin, UK, 2021.
- [76] C. Montero, Formación y desarrollo de un cluster globalizado: El caso de la industria del salmón en Chile, *Cepal*, 2004. (<http://hdl.handle.net/11362/4538>).
- [77] J.T. Nem Singh, Reconstituting the Neoliberalist State: the political economy of continuity and change in Chilean mining policy, *Third World Q.* 31 (8) (2010) 1413–1433, <https://doi.org/10.1080/01436597.2010.538240>.
- [78] L. Oppenheim, *Politics in Chile: Democracy, Authoritarianism, and the Search for Development*, 2nd ed., Westview Press, 1999.
- [79] J. Peck, N. Theodore, Variegated capitalism, *Prog. Hum. Geogr.* 31 (6) (2007) 731–772, <https://doi.org/10.1177/0309132507083505>.
- [80] J. Petras, F.I. Leiva, H. Veltmeyer, *Democracy and Poverty in Chile: The Limits to Electoral Politics*, Routledge, 2019, <https://doi.org/10.4324/9780429046049>.
- [81] E. Pohulak-Zołędowska, A. Żabiński, The state's role in creating innovation-driven economic growth, *Stud. Ekon.* 214 (2015) 201–215.

- [82] R.A. Quiñones, M. Fuentes, R.M. Montes, D. Soto, J. León-Muñoz, Environmental issues in Chilean salmon farming: a review, *Rev. Aquac.* 11 (2) (2019) 375–402, <https://doi.org/10.1111/raq.12337>.
- [83] J. Rehner, S. Baeza, *Innovación e investigación científica en Chile*, in: A. Borsdof, C. Marchant, A. Rovira, R. Sanchez (Eds.), *Chile cambiando. Revisitando la Geografía regional de Wolfgang Weischet*, 1st ed., GEOLibros/Universidad Austral de Chile, 2020.
- [84] J. Rehner, S. Baeza, J. Barton, Chile's resource-based export boom and its outcomes: regional specialization, export stability and economic growth, *Geoforum* 56 (2014) 35–45, <https://doi.org/10.1016/j.geoforum.2014.06.007>.
- [85] J. Schippel, B. Truffer, Directionality of transitions in space: diverging trajectories of electric mobility and autonomous driving in urban and rural settlement structures, *Environ. Innov. Soc. Transit.* 37 (2020) 345–360, <https://doi.org/10.1016/j.eist.2020.10.007>.
- [86] A. Stirling, *Direction, Distribution and Diversity! Pluralising Progress in Innovation, Sustainability and Development*, STEPS Centre, 2009. (<https://steps-centre.org/publication/direction-distribution-and-diversity-pluralising-progress-in-innovation-sustainability-and-development/>).
- [87] K.M. Weber, H. Rohracher, Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive 'failures' framework, *Res. Policy* 41 (6) (2012) 1037–1047, <https://doi.org/10.1016/j.respol.2011.10.015>.
- [88] K.I. Westeren, *Innovation processes in aquaculture: Comparing companies in Norway and Chile*. Entrepreneurship, 2022.
- [89] X.-S. Yap, B. Truffer, *Shaping selection environments for industrial catch-up and sustainability transitions: a systemic perspective on endogenizing windows of opportunity*, *Res. Policy* 48 (4) (2019) 1030–1047.
- [90] J.P. Zanlungo, J. Katz, C. Araya, *Servicios intensivos en conocimiento en la industria salmonera chilena* | Publications, 2015. (<https://publications.iadb.org/publications/spanish/document/Servicios-intensivos-en-conocimiento-en-la-industria-salmonera-chilena.pdf>).