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Policies to attract R&D-related FDI in Chile: Aligning incentives with local linkages and absorptive capacities

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Over the last decade we have witnessed an unprecedented growth in the number of cross-border R&D investments towards developing countries. Large emerging economies like China or India have become the first destination of R&D-related investments in the world. Latin America, however, has played a rather marginal role as recipient of R&D-related FDI – barely 3.7% of the world total between 2003 and 2013. In an effort to revert this trend, several countries in the region have launched new policy programs and incentives to enhance their attractiveness for R&D-related FDI. However, it remains uncertain whether public incentives can compensate for other locational disadvantages that characterize Latin American innovation systems. The case of Chile provides an interesting empirical setting to explore these issues, because since the early 2000s its government is actively promoting R&D-related FDI through a new policy mix. This policy mix encompasses various grants and tax incentives, targeting not only multinational corporations but also foreign start-ups, universities and public research institutes. Rather than limiting the scope of our analysis to individual policy instruments, we also consider the complementarities and synergies among them. We emphasize that for national innovation systems to benefit from R&D-related FDI it is important to ensure that appropriate linkages are established with local actors that hold absorptive capacities. Equally important for a small emerging economy like Chile is to prioritize R&D-related FDI in strategic technology areas where the country can realistically attain critical mass to compete globally.

JEL codes: O38, F21, E61

Keywords: FDI, technology, R&D, innovation policy, development, globalization

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Abstract

Over the last decade we have witnessed an unprecedented growth in the number of cross-border R&D investments towards developing countries. Large emerging economies like China or India have become the first destination of R&D-related investments in the world. Latin America, however, has played a rather marginal role as recipient of R&D-related FDI – barely 3.7% of the world total between 2003 and 2013. In an effort to revert this trend, several countries in the region have launched new policy programs and incentives to enhance their attractiveness for R&D-related FDI. However, it remains uncertain whether public incentives can compensate for other locational disadvantages that characterize Latin American innovation systems. The case of Chile provides an interesting empirical setting to explore these issues, because since the early 2000s its government is actively promoting R&D-related FDI through a new policy mix. This policy mix encompasses various grants and tax incentives, targeting not only multinational corporations but also foreign start-ups, universities and public research institutes. Rather than limiting the scope of our analysis to individual policy instruments, we also consider the complementarities and synergies among them. We emphasize that for national innovation systems to benefit from R&D-related FDI it is important to ensure that appropriate linkages are established with local actors that hold absorptive capacities. Equally important for a small emerging economy like Chile is to prioritize R&D-related FDI in strategic technology areas where the country can realistically attain critical mass to compete globally.

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1. Introduction

Innovation has long been an international phenomenon but has hardly been a global one. For long, the international business literature has argued that cross-border research and development (R&D) investments tend to be located in close proximity, often in neighboring countries or countries with similar levels of development (Narula and Zanfei, 2004; OECD, 2011; Laurens et al., 2015; Schmitz and Strambach, 2009). However, since the early 2000s we have observed an increasing propensity of multinational corporations (MNC) to locate their R&D activities in emerging countries (Gammeltoft, 2006; Manning et al., 2008; Lewin et al., 2009; Yusuf, 2012). China and India have now become the top destination of R&D-related foreign direct investments (FDI) worldwide (Castelli and Castellani, 2013).

Despite this dramatic shift in the geography of innovation to and from developing countries (UNCTAD, 2005), not all developing countries have been so successful in attracting R&D-related FDI. This is either because they lack the large markets that countries like China or India can use as a bargaining tool, or because they lack the technological infrastructure, human capital, and specialized knowledge that MNCs are looking for when deciding where to offshore their R&D (OECD, 2011). Indeed, although the new geography of innovation is more multi-polar, it is by no means fully 'global'.

In Latin America, with the shift from an import substitution to an export-oriented industrialization strategy, inward FDI increased substantially since the 1980s and MNCs became key agents in the region's industrial restructuring (Bielschowsky and Stumpo, 1995). Influenced by the prescriptions of the Washington Consensus, FDI was embraced primarily as a means of gaining access to international markets and as a stable source of foreign capital to address current account deficits. Thus, public policies initially focused on attracting as much FDI as possible through deregulation, liberalization of capital flows and privatization of state-owned enterprises. Under this framework, Latin America was not successful at using FDI as a lever for learning and technology transfer (Katz, 2001; Mortimore, 1993). Since the mid-1990s a shift from 'quantity' to 'quality' started to emerge in the region's FDI policies (Enderwick, 2005; Nelson 2005). It became apparent that the objective guiding FDI policies should not be limited to maximizing FDI inflows, but also to attracting the kind of FDI that contributes to diversifying the economy, gaining access to foreign knowledge and technology, providing better jobs, and building deeper linkages with global value chains. Against this background, attracting R&D-related FDI has become a more explicit policy priority for several Latin American countries as a means of accelerating international technology transfer and catching-up (Lederman et al., 2014; Monge-González and Tacsir, 2014).

As acknowledged in the Latin American Economic Outlook 2015, "*there is still a huge gulf that must be closed for FDI to provide more technology and more skills in Latin America. There are opportunities to be explored in the design of new strategies to attract FDI with a stronger R&D component and stronger knock-on effects on production and technology in the recipient economy*" (OECD et al., 2014: p. 146). Along these same lines, a recent report by the United Nation's Economic Commission for Latin America and the Caribbean shows that the region attracts a very small share of global flows of FDI in R&D (ECLAC, 2014). Between 2003 and 2013, Latin America

hosted just 3.7% of global greenfield FDI projects with a focus on R&D, while the Asia-Pacific region attracted 51.6% of the world total[1].

Therefore, a question remains on how can Latin America increasingly attract R&D-related FDI and on the role of public policies in this process. The present paper contributes to exploring these issues by focusing on the case of Chile, one of the most developed countries in the region and among the most successful in attracting FDI. Chile constitutes an interesting empirical setting given that during the last decade its government has adopted a more proactive approach to promote R&D-related FDI, encompassing a comprehensive policy mix to improve the country's attractiveness. This policy mix comprises generous grants and tax incentives to foreign investors in R&D, in addition to broader measures to enhance the national innovation system and the business climate. The country has used some pioneering policy instruments in international context, such as a program to attract foreign public research institutes or a program to attract foreign start-ups. Thus, the recent experience of Chile is highly relevant to inform policy learning in other countries from Latin America and beyond.

This research relied on 16 personal interviews with key informants and on a variety of secondary sources. Section 2 contextualizes further the paper within the literature dealing with the policy implications of the internationalization of R&D. Section 3 describes the empirical context and methodology of our research. Sections 4 and 5 analyze the new policy mix used by the government of Chile to promote R&D-related FDI during 2000-2015. Finally, Section 6 rounds up the paper with some concluding remarks emphasizing the broader policy implications.

2. R&D-related FDI: the role of public policies

The literature on R&D internationalization has provided significant insights into the drivers of R&D-related investments, that is, why firms decide to locate R&D offshore (Dachs, 2014). Among the reasons of doing so, there are traditional drivers such as market size, income level and costs, as well as knowledge related considerations like the qualification of the workforce or the possibility to access specialized knowledge (Lewin et al., 2009). While traditional drivers like lower costs or access to market tend to be associated to 'asset exploiting' strategies and R&D related to the adaptation of new products to different markets, the access to specialized skills and knowledge responds to a strategy of 'asset seeking' (Castellani and Zanfei, 2006; Edler, 2008) and the need to develop new knowledge by tapping into globally dispersed knowledge reservoirs (Kafouros et al., 2012). A critical question here is which of these drivers can be influenced by policy-makers aiming to attract R&D-related investments to their country.

R&D-related FDI may have very positive effects on the host economy, thus the interest of policy-makers in attracting this type of FDI. It can facilitate the absorption of foreign knowledge, strengthen national technological capabilities, and improve the position of a country in global innovation networks (Cantwell and Piscitello, 2000; Mytelka and Barclay, 2006). The opportunities for upgrading and the benefits for the host country are magnified when MNC subsidiaries become embedded in the domestic milieu by collaborating with local firms, universities or business associations (Heidenreich, 2012; Meyer et al., 2011). But the benefits associated with R&D-related FDI do not accrue automatically. In order to tap into the potential spillovers, countries

[1] Authors' calculations based on fDi Markets (Financial Times Group). For further detail on this database see: http://www.fdimarkets.com

need to develop a threshold level of 'absorptive capacity', which can be defined as the ability to acquire, assimilate, and exploit knowledge developed elsewhere (Cohen and Levinthal, 1990; Criscoulo and Narula, 2008; Ferragina and Mazzotta, 2014). This implies that public policies to support the endogenous development of domestic skills and innovation capabilities are essential not only to attract R&D-related FDI but also to benefit from the externalities associated with such investments.

The rationale for policy intervention is based on the positive impact of R&D-related FDI on the host country's national innovation system, including both direct effects and indirect effects or spillovers (Görg and Strobl 2001; Narula and Dunning, 2010). Direct effects are associated with a net increase in domestic R&D activity and with the transfer of foreign knowledge into the country through intra-firm linkages (i.e. from the MNC to the subsidiary). R&D-related FDI leads directly to incremental R&D expenditure and to the quick creation of job opportunities for highly skilled labor locally, which could slow down or revert brain drain. These direct benefits will be larger when the subsequent R&D activities of MNC subsidiaries complement (rather than replace) the R&D activity of local companies. Still, some extent of 'crowding-out' of the technological activity of local firms can be expected through intensified competition for limited specialized assets, including human capital and available public funding for business R&D (García et al., 2013).

In addition to its direct impact, R&D-related FDI can bring along indirect effects or spillovers, which refer to productivity improvements resulting from knowledge diffusion – both in the form of unintentional transmission or intentional transfer – from multinational affiliates to domestic firms (Görg and Strobl, 2001; Farole and Winkler, 2012). Among other indirect effects, R&D-related FDI can enable locally produced components to be incorporated at the design stage of new products, opening up new markets for local suppliers and new opportunities to collaborate with MNCs. Besides collaborative agreements with local firms and research centers, knowledge spillovers also unfold through indirect employment effects, whereby the host country benefits from training provided by MNC subsidiaries to their employees, who subsequently become available to local firms through the job market or may establish new ventures themselves (Fosfuri et al., 2001). Other sources of indirect benefits include demonstration and competition effects, because the presence of innovative MNC subsidiaries spurs domestic firms to engage in R&D. From a systemic perspective, the arrival of FDI in R&D can contribute to addressing existing inefficiencies of the national innovation system, for example by fostering university-industry collaboration or by accelerating the development of critical mass in certain strategic technologies.

The impact of R&D-related FDI can be especially relevant for developing countries, given its potential contribution to closing technology gaps and accelerating catching-up (Fu et al., 2011; Santangelo, 2005). In many occasions, FDI in large-scale manufacturing activities naturally evolves over time to also include some extent of knowledge-intensive and R&D activities, like in the case of the automotive industry in Brazil or the electronics industry in China. Thus, from a policy perspective, it is important to understand the attraction of R&D-related FDI as an evolutionary and sequential process following the development of local capabilities. These upgrading efforts require "system coordination initiatives" to improve the education system, infrastructures, and institutions in line with the needs of MNCs, as illustrated with the case of the electronics industry in Malaysia (Rasiah, 2002). But a key issue worth further discussion is whether - and how - developing countries can benefit from the internationalization of R&D (Archibugi and Pietrobelli, 2003). In general terms,

developing countries tend to face more difficulties in attracting R&D-related FDI than developed countries and see a higher need of government intervention to counterbalance for other locational disadvantages. Targeting R&D-related FDI requires a more proactive kind of policy intervention, unlike generic FDI policies which can rely largely on investment liberalization and macroeconomic stability, along with marketing and promotion.

Government intervention to attract R&D-related FDI can be further justified by the presence of market failures and systemic imperfections. On the R&D side a well-known market failure is that, if left to the market, firms would underinvest in R&D due to the difficulty of appropriating the results, because of the nature of knowledge as a quasi-public good. These market failures arguably apply to a larger extent to the specific case of MNC subsidiaries, which operate in more unknown markets where the risk of knowledge leakages may be perceived as higher. With regard to FDI, an example of market failure is that those who decide the allocation of R&D centers within global innovation networks lack perfect information about all potential countries and regions, implying that their location decisions may be biased. Beyond market failures, the rationale for policy intervention can be justified on the grounds of 'systemic failures'. Under this approach, policy-makers are expected to intervene when the system of knowledge generation and diffusion does not achieve its objectives of contributing to innovation and technological progress in an efficient manner, because of the lack of well-developed networks between the different actors of the system or because of other institutional weaknesses (Chaminade and Edquist, 2010).

There are many different policy instruments that can be used to attract R&D-related FDI, involving a close coordination of innovation policy and FDI policies (Guimón, 2009). On the one hand, the role of innovation policy is to improve the investment climate for R&D by identifying and acting upon the strengths and weaknesses of the national innovation system. The objective would be to provide the necessary infrastructures, public R&D, human capital, and regulatory regimes, in addition to fiscal and financial incentives to private firms undertaking R&D. On the other hand, the role of FDI promotion policies is to improve the image of the country as an R&D location and to provide targeted services to both potential and existing foreign investors in R&D.

As discussed earlier, the positive impact associated with inward FDI in R&D is not automatic but rather highly dependent on the extent of domestic absorptive capacity. Besides attracting new flows of R&D-related FDI, a related policy objective is to reap the benefits associated with the existing R&D activity of MNC subsidiaries by stimulating their embeddedness into the national innovation system (e.g. linkages with local firms and universities) and by augmenting the absorptive capacity of domestic agents (e.g. human capital, research infrastructure, public R&D). Otherwise, the R&D centers of foreign capital may end up acting as enclaves, with insufficient linkages with local actors and very limited knowledge spillovers. Another risk is that MNCs may concentrate their R&D activity on problems that are of little relevance to the local economy, diverting scarce technological resources from more useful purposes. The extent to which initial limitations in absorptive capacity can be overcome by active policies will be discussed next for the case of Chile.

3. Empirical context and method

As discussed in Section 2, there are various policy instruments available to attract R&D-related FDI. To be effective, these policy instruments should be combined

within a comprehensive policy mix (Guimón, 2011) and should be aligned with identified problems in the national innovation system (Chaminade and Padilla, forthcoming). The experience of Chile during the period 2000-2015 provides an interesting case study to explore the policy mix that governments of small emerging countries may use to attract R&D-related FDI. Our research relied on a review of official documents and a set of 16 personal interviews with key informants. The interviews were conducted on November 2014 in Santiago de Chile and lasted 1h on average. The interviewees included the main stakeholders involved in the attraction of R&D-related FDI into Chile, including policy-makers and foreign investors in R&D, as well as other experts (Table 1). A first draft of the paper was later reviewed in detail by two managers of CORFO, who made some corrections and provided useful feedback.

INSERT TABLE 1 HERE

Table 2 presents some comparative statistics to contextualize the position of Chile in comparison with the main Latin American countries. With a population of 17.6 million, Chile constitutes a small market compared to neighboring countries such as Brazil or Argentina, although it is the country with the highest income per capita in the region. Despite its relatively high income level, Chile's gross national expenditure in R&D stood at just 0.39% of GDP in 2013; a low figure not only with respect to the OECD average (2.4%) but also compared to other Latin American countries like Brazil, Argentina or Costa Rica.

INSERT TABLE 2 HERE

Chile was one of the first countries in Latin America to actively promote FDI as part of its development strategy since the mid-1970s which, combined with its rich natural resource endowments, made it one of the major recipients of FDI in the region (Alatorre and Razo, 2010; Poniachik, 2002). In relative terms Chile stands out as the country with the largest stock of inward FDI as a share of GDP in Latin America (Table 2) whereas in absolute terms it ranks third only behind the two largest economies in the region, Brazil and Mexico.

To provide an overview of R&D-related FDI in Chile within the Latin American context, we rely on the fDi Markets database, which collects information on greenfield FDI project announcements (excluding mergers and acquisitions). Despite its limitations[2], this database is one of the few sources available to measure R&D-related FDI, because it provides information not only of the sector but also of the business activity associated with each investment announcement. In particular, the database classifies each FDI project into 18 business activities, including sales and marketing (the largest category); manufacturing; business services; retail; distribution and transportation; customer contact centers; logistics; headquarters; research and development (R&D); design, development and testing (DDT), and others. DDT is similar to R&D although it is more oriented towards the last stages of the innovation process. Both categories, R&D and DDT, can be jointly used as a proxy to measure R&D-related FDI.

[2] The use of this data implies underestimating the R&D that occurs through FDI, because projects that are classified in a different business activity such as manufacturing may also bring along some associated R&D expenditure even if it is not the main focus of the project. In addition, the database used here only allows us to measure the inflows of greenfield investment projects from 2003 to 2013, without taking into consideration the R&D activity of the preexisting stock of foreign companies located in the country.

Table 3 presents the total number of R&D and DDT projects recorded in Latin America between 2003 and 2013. More than 40% of the projects is concentrated in Brazil, while the rest of Latin America attracted a very small number of R&D-related FDI projects. The capacity of Brazil to attract FDI in R&D relates to its large market size and to a substantial increase of national investments in innovation. Indeed, Brazil's population and R&D intensity are by far the highest in the region (Table 2). In addition, the government has introduced new measures to stimulate the R&D activity of foreign firms in the country, such as the Inovar Auto Program launched in 2013 whereby auto manufacturers are offered tax incentives on the condition that they engage in R&D locally in cooperation with their Brazilian suppliers.

INSERT TABLE 3 HERE

In contrast with Brazil, Chile's capacity to attract R&D-related FDI is constrained by its small market size and its poor performance in science and technology indicators. Indeed, between 2003 and 2013 Chile received just 12 foreign investment projects in R&D and 22 in DDT (Table 2). Chile ranks third in the region in the R&D category after Brazil and Mexico, hosting 11.8% of the total, while it ranks fifth in DDT, after Argentina and Colombia too. The foreign companies that opened new R&D centers in Chile during this period included some internationally renowned firms such as Pfizer, Yahoo!, DuPont, 3M, or Nestle. On average, each of these R&D projects involved a capital investment of 22.5 million US$ and the creation of 69 new jobs in Chile.

The case study results presented in the following sections focus on assessing the main policy instruments that Chile has used to attract R&D-related FDI. These policy instruments are analyzed independently and also as part of a broader policy mix. This analysis enabled us to draw some broader policy implications that may be of special interest to other middle-income countries. We will first start by describing the broader context and rationale that led to the emergence of Chile's policy mix to attract R&D-related FDI.

4. Chile's policy mix to attract R&D-related FDI (2000-2015)

During the last decade, promoting R&D and innovation has become a cornerstone of the Chilean government's strategies to increase competitiveness and economic growth. In particular, the National Innovation Strategy for Competitiveness 2010-2014 comprised the following action lines: i) creating a culture of innovation and entrepreneurship; ii) increasing critical mass in scientific and entrepreneurial capacity; iii) removing bottlenecks to business creation and competitiveness; iv) encouraging global connections; v) improving technology absorption and transfer; and vi) generating, attracting and retaining top talent to become the innovation hub of South America. Priorities iv, v and vi demonstrate a strong emphasis on increasing the internationalization of Chile's national innovation system, including through the attraction of R&D-related FDI. This strategic plan was followed by the Growth, Innovation and Productive Agenda launched in 2014 with a strong focus on fostering economic diversification building on R&D and innovation in a set of strategic sectors.

In parallel, the scope of FDI policies shifted substantially since the year 2000, through a new focus on targeting more knowledge intensive sectors and fostering technology transfer and upgrading (Alatorre and Razo, 2010; Poniachik, 2002). This led to a growing convergence between innovation policy and FDI promotion policies. FDI

was conceived as a way of compensating for low levels of R&D investment by domestic firms, building national scientific capabilities, and accelerating technology transfer. The rationale for public intervention was further supported by the need to compensate for the country's peripheral condition within global innovation networks, as argued in Section 3.

In recent years, the Chilean government has launched a comprehensive mix of policy instruments to attract R&D-related FDI (Table 4). Most of these policy programs and incentives were implemented by Chile's national innovation agency (CORFO), while the role of the FDI promotion agency (CIE) was only marginal, focusing on image-building and international missions and trade shows. This policy mix was initiated in the year 2000 and was substantially expanded since 2008, demonstrating the growing awareness of the government on the importance of attracting R&D-related FDI into the country.

INSERT TABLE 4 HERE

A key event driving the emergence of this new policy mix was the failure to attract a major investment from Intel in the late 1990s. Chile was one of the shortlisted locations for Intel's project to establish a large micro-chip manufacturing plant in Latin America, but the company finally chose Costa Rica because Chile was not able to match Costa Rica's generous tax incentives and export-processing-zone scheme. This generated a heated debate as to whether Chile should have offered tax incentives, and it was concluded that Chile should not enter into competition with other Latin American countries based on costs and low taxes, but rather should adopt a more proactive and tailored approach while expanding the financial incentives package offered to more technology-intensive projects (Nelson, 2005; Poniachik, 2002). We now turn to analyze further the emerging characteristics of Chile's policy mix to attract R&D-related FDI, which includes incentives to attract corporate R&D, to attract the R&D of universities and public research institutes, and to attract innovative entrepreneurs.

4.1. InvestChile

The first significant milestone in the government's new strategy occurred in 2000 with the establishment of InvestChile as a branch of CORFO aimed at attracting high-technology FDI into the country, including a new package of incentives. The program offered grants to cover pre-investment studies, acquisition of fixed assets, staff training, and R&D activities (Poniachik, 2002). In particular, a grant for the acquisition of fixed assets was offered to foreign firms with high technology investment projects in Chile of at least US$ 500,000. The grant covered 40% of the investment in fixed assets with a maximum of US$ 2 million per firm. With regard to pre-investment studies, the grant covered up to 60% of the study's cost with a maximum of US$ 30,000, while for human resources training the grant could reach up to 30% of the cost with a limit of US$ 25,000. The application for grants was open permanently throughout the year.

The program had an initial focus on ICT but with time it broadened substantially to include other industries such as biotechnology, agribusiness, renewable energy, mining, and salmon farming. In addition to this industrial focus, the program progressively adopted a more functional approach, targeting high value added business functions such as R&D and shared service centers (Alatorre and Razo, 2010; Nelson, 2005).

An evaluation of the program conducted by CORFO reveals that a total of 62 FDI projects participated in the program from 2011 and 2012, out of which 51% were in global services, 24% in mining, 15% in biotechnology, and 10% in food industry. These projects generated a total of 3,826 new jobs in the country. The average investment per project was US$ 2 million in 2011 and US$ 3.4 million in 2012.

Although the incentives were relatively low, they served to attract the attention of prospective investors, who otherwise might have overlooked the country's advantages. Other significant benefits of the program stemmed from the development of a transnational strategic network of companies, universities, and individuals that could facilitate the promotion of R&D-related FDI (Nelson, 2005). In addition, following the creation of the InnovaChile committee by CORFO in 2005, new incentives to support business innovation were created and became available to foreign investors in R&D, such as a grant for business innovative projects covering up to 50% of the investment with a maximum of US$ 800,000 per project. Through a close coordination between InnovaChile and InvestChile, CORFO was able to offer a more integrated support to R&D-related FDI.

Up to 2012 InvestChile was managed by CORFO, and the national FDI agency (CIE) only played a more marginal role focusing on providing information to prospective foreign investors and organizing some joint seminars with multinational companies in the targeted sectors. However, in 2013 the government decided to transfer the program away from CORFO and shifting over to CIE's hands, as part of a broader strategy to reform CIE and make it a world-class investment promotion agency. As a result, according to one of our interviewees, "*the program lost momentum and remained quite inactive up to 2015, pending the implementation of CIE's new operating model*".

More recently, the InvestChile program has been transformed into the so-called Support Program for Technology Investments. This new program is co-managed by CIE and CORFO, illustrating the need for a close coordination between innovation promotion agencies and foreign investment promotion agencies in order to efficiently target R&D-related FDI. CIE focusses on international promotion and initial dialogue and negotiation with foreign investors while CORFO is responsible for following-up and for the management, implementation and monitoring of the grants. The program started in 2015 so it is still in a very early stage. In essence, it provides similar lines of support as InvestChile although offering larger incentives and a more streamlined application process. In particular, it offers two lines of subsidies for investment projects larger than US$ 2 million. First, a grant for pre-investment studies of up to 70% of the cost with a maximum of US$ 300,000. Second, an integrated grant of incentives for the investment and post-investment phase of up to 30% of the total investment with a limit of US$ 5 million. Eligible expenses include investment in fixed assets, human capital training and supplier development programs.

4.2. R&D tax incentive

In 2008 a tax incentive was enacted to encourage private investment in R&D, consisting in a tax credit of 35% for expenditures on R&D contracts with pre-certified third party R&D centers and universities. However, up to 2012 this incentive was used only sparingly due to its many restrictions. The fact that only R&D activities contracted to local actors were eligible represented a major drawback for foreign investors in R&D.

To improve its impact, in 2012 CORFO decided to simplify the eligibility criteria and application procedures. The eligibility requirements for collaboration with external research centers and the requirement to invest at least 15% of the company's gross annual revenue were abolished. Therefore, firms were allowed to claim the tax incentive for in-house R&D projects in addition to those developed by external partners. Moreover, the maximum amount of tax credit available to each company was tripled to US$ 1.2 million per year. Additionally, the incentive was broadened to include a wider variety of eligible expenditures, including the purchase of equipment, real estate, and intellectual property protection.

The removal of the requirement to subcontract R&D activities with local agents points to the difficulty of enforcing domestic linkages. While such linkages are an important condition to ensure spillover effects on the national innovation system, it is not easy to impose them as foreign investors may end up losing interest on the incentive. In fact, according to the managers of CORFO that we interviewed, since the change in the tax incentive was enacted the number of foreign investors that applied for it has increased substantially (from 40 in 2011 to 102 in 2014), but their collaboration in R&D with local agents has declined.

This tax incentive for R&D is available on an equal basis for foreign and domestic companies, but an explicit objective is to attract foreign companies interested in executing R&D projects. According to OECD (2014) there is evidence suggesting that this kind of incentives can have an impact in diverting FDI from one country to another within a geographic region, and countries like Canada or France have recently enhanced their R&D tax incentives with the aim of attracting more R&D-related FDI at the expense of their neighbors. By offering one of the most generous tax regimes for R&D in Latin America (OECD, 2014), Chile aims to become the preferred location in the region for the R&D activity of multinational corporations.

4.3. International Centers of Excellence

The International Centers of Excellence program was launched by CORFO in 2008 to co-finance the establishment in the country of R&D centers from world-class universities and public research organizations (Guimón et al., 2016). The first call for proposals was launched in 2009 and resulted in the selection of 4 centers, which were established in Chile between 2011 and 2012. In 2011, a second call for proposals was launched and the program was extended to target also the R&D centers of multinational companies, leading to the creation of ten new centers between 2014 and 2015. Thus a total of thirteen centers have been established so far in Chile through this program, comprising eight leading research institutes and five multinational companies coming from seven different countries (Table 5).

INSERT TABLE 5 HERE

The program is currently the most costly among CORFO's programs to promote innovation in Chile, with an annual budget of around US$ 30 million. In the first call, each of the four selected centers was offered a non-refundable matching grant of up to US$19.5 million for a 10-year period. The grant recipients should commit to contribute to the centers' funding with at least the equivalent to 59.5% of the grant received. In the second call, the maximum grant was reduced to US$12.8 million per center for an 8-year period, while the minimum co-financing increased to 87.5% of the grant. Funding for the new business track introduced in the second call was further limited to

US$8million over 4 years, with the foreign corporation contributing with at least twice the amount of the grant. The centers are required to hire Chilean scientists and to establish collaboration agreements with local universities and research centers.

The size of these R&D centers varies from over 120 researchers in Fraunhofer IME to around 25 in Wageningen UR. All centers are clearly oriented towards the specific needs of Chilean industry, but some focus on specific sectors (such as mining, nutrition or renewable energy), while others embrace platform technologies with applications across several industries (such as IT, biotechnology or nanotechnology). The nine centers selected in the second call have only very recently been established in the country or are in the process of doing so, whereas those from the first call are still in their early years of operation but have already attained visible results.

The program's ultimate objective is to contribute to strengthening national technological capabilities and industrial competitiveness through the establishment in Chile of R&D centers from leading international research institutions that will carry out R&D, technology transfer and commercialization activities. In addition to developing new solutions for Chilean industry, the Centers are expected to foster a systemic change in the national innovation system.

Another indirect impact of the attraction of these R&D centers relates to their capacity to engage existing foreign investors in the country in enhanced R&D activities and to attract new FDI flows, acting as an attraction factor. For example, Mentor Graphics, a leading firm in microcircuit design from the United States, and Komatsu, a mining corporation from Japan, which arrived years ago to the country and were supported by the InvestChile program, have recently expanded their R&D activity in the country through new cooperation agreements with the Centers of Excellence (INRIA and Fraunhofer Gesellschaft, respectively). Moreover, in the words of the director of one of the Centers of Excellence that we interviewed:

> "*During the last year we have been contacted by several companies from our country of origin that were exploring the possibility of investing in Chile and engaging in new R&D activities in the country. Some companies were interested in partnering with us in this process and saw us as an interesting intermediary or broker within Chile's national innovation system. At the same time, the Chilean government has also asked us to participate in some commercial visits of multinational companies from our country.*"

Rather than distributing available public funding among a large number of projects, the program was designed to select a limited number of centers of excellence and offer them substantial funding, so they could reach critical mass relatively fast. Centers of excellence schemes to concentrate public R&D funding on a competitive basis have been adopted in a large number of countries (Langfeldt et al., 2015), but the distinctive feature of the ICE program is its focus on attracting foreign institutions. Thus, the program combines elements of centers of excellence with elements of global R&D attraction. This represents a useful learning model for other countries since it was one of the few policy programs in the world explicitly aimed at attracting the R&D centers of foreign universities and public research organizations, and the first of its kind in Latin America.

4.4. Start-up Chile

The Start-up Chile program was launched in 2010 to attract innovative entrepreneurs from abroad by offering them a residence visa and a non-reimbursable grant to develop their projects (Higgins, 2015). In the pilot phase released in 2010, a total of 22 startups from 14 countries were brought to Chile, providing each of them with US$40,000 of equity-free seed capital, and a temporary one-year visa to develop their businesses for a period of at least six months. Following this pilot experience, in 2011 the first official call for proposals attracted 330 applications, from which 87 start-ups from 30 different countries were selected. In the next rounds, around 1000 entrepreneurs applied and 100 were selected in each round, rising to over 2000 in 2014. The latest call for proposals was issued in January 2015 with the goal of selecting 100 new start-ups.

The program's objective is to turn Chile into the innovation and entrepreneurship hub of Latin America by attracting the world's best and brightest entrepreneurs to enhance their start-ups in Chile. The selected entrepreneurs need to commit to live in Chile during at least 6 months and are also expected to organize and actively participate in networking events, mentoring and other activities that foster entrepreneurship locally. In addition to the grant, the selected start-ups receive mentoring, office space, and access to social and capital networks in the country. To enhance the program, CORFO has partnered with some global technology companies like Google, Amazon, Microsoft and PayPal, among others.

In order to evaluate the program's impact, in 2012 CORFO surveyed the group of start-ups that arrived to the country in 2011 calls, obtaining a total of 91 replies (30% response rate). The results reveal that 64% of these start-ups hired new employees in Chile; 76% established collaboration linkages with Chilean firms; 29.5% declared having exported to other countries from Chile; and 22% have developed new patents in Chile since obtaining the grant. In addition, 75% declared that thanks to their participation in the program they gained access to external funding.

This program complements other programs to attract R&D-related FDI, by focusing not only on attracting R&D investments by large multinational corporations and world-class public research institutes, but also by entrepreneurs and small technology-intensive firms. As argued by one of our interviewees:

> "*Although the program is not explicitly aimed at attracting FDI in R&D, it is expected to contribute to meeting this target, since some of the start-ups funded might ultimately set up a company in Chile and engage in R&D and innovation. Moreover, the arrival of foreign entrepreneurs creates a dynamic ecosystem of global actors that improves the attractiveness of the country as a destination of technology-intensive FDI*."

A major challenge is that only 20% of foreign start-ups participating remain active in Chile after the program (Higgins, 2015). To address this, in 2015 CORFO expanded the program by offering the so-called Start-up Chile Scale grant, on top of the initial grant. This grant aims at scaling-up the most successful start-ups that emerge through the program and at ensuring that they remain in Chile after the initial program. In particular, this grant is designed to provide an additional equity-free grant of around US$ 100,000 to the best 1% of the start-ups that initiate the Start-up Chile program each year. To qualify for this grant, the start-up must incorporate in Chile and commit to maintain the operations in the country. It also needs to commit to co-finance at least 30% of the project's total budget. In addition, according to our interviewees, in future calls of this program CORFO expects to target specific topics of strategic interest for

the country such as smart mining, astronomy, biotechnology or healthy foods, among others.

5. Aligning policies to the specificities of national innovation systems

As indicated in Section 3, R&D-related investments are driven by a variety of factors including income, market size, cost advantages, geographical proximity and the availability of a qualified labor force and specific knowledge pools. Chile cannot compete in attracting R&D-related FDI on the bases of the market size or generic qualified labor force with other geographically close countries like Brazil. It may compete, however, on the basis of specialized knowledge pools and of a favorable institutional framework.

We have shown how the government of Chile has put in place a comprehensive set of policy instruments aimed at attracting R&D-related FDI, to overcome the locational disadvantages related to the country's peripheral nature and to the weaknesses of its national innovation system. This policy mix comprises both fiscal and financial incentives, and adopts a broad scope to include not only large multinational corporations but also start-ups, as well as foreign universities and public research institutes. There are two inherent tensions in these type of instruments: First, the choice between generic policies or industry specific policies and, second, the choice between investing in developing the technological capabilities of indigenous companies or providing incentives to foreign companies. The rest of this section addresses these dilemmas in further detail.

Chile is a clear example of a fragmented or dual innovation system, characterized by medium levels of technological capabilities and some pockets of excellence - particularly related to traditional resource-based industries like salmon or mining but also to newer fields like biotechnology or ICT, as well as less conventional areas where Chile constitutes a unique "natural lab" such as astronomy or natural disasters. Along these lines, one could argue that R&D-related FDI could be more effective (at least initially) when targeted towards these industries or technological fields in which there is already some capabilities, thereby enabling the transfer of knowledge to domestic firms. Chile cannot compete with the size and diversity of the innovation system of countries like Brazil or Mexico, thus a "niche" strategy would be better fitted, specializing in technological fields where Chile has some competitive advantage and potential to develop critical mass. The general nature of some policy instruments such as tax incentives (targeting all kinds of sectors and not those in which Chile has a particular advantage in terms of competences) may limit the impact of the targeted investments; the lack of local capabilities or absorptive capacity may severely limit the potential transfer of knowledge to the local economy.

This paper has emphasized that in order for national innovation systems to benefit from R&D-related FDI it is important to ensure that appropriate linkages are established with local actors and strategic technological priorities at national level. With this in mind, as we have shown, the incentives provided by the Chilean government to attract foreign investors in R&D have been designed in a way that encourages (or even enforces) the establishment of deep collaboration linkages between foreign investors in R&D and local firms and universities. However, this remains a challenging task given the "inmature" nature of Chile's national innovation system (Klerkx et al., 2015).

These policy instruments to attract R&D-related FDI have often been criticized because of the generous funding provided to foreign institutions, which could be used instead to strengthen national universities, R&D institutes, and private enterprises. In the words of one of the policy-makers interviewed:

> "*we need to constantly address the concern that supporting FDI in R&D may not be desirable since it might lead to some sort of 'techno-colonialism', whereby foreign investors in R&D focus their efforts of commercializing in Chile technologies they had developed in their home countries.*"

This kind of global-local frictions makes monitoring and evaluation efforts especially important, focusing on the additionality effect of the program *vis-à-vis* the counterfactual alternative of dedicating those resources to firms and R&D centers of national ownership. Such additionality derives from the capacity of foreign investors to develop new solutions for Chilean industry and to instigate a systemic change in the national innovation system, by improving university-industry collaboration, enhancing technology commercialization, and forging closer linkages with global value chains. This would contribute to addressing existing inefficiencies in Chile's national innovation system.

5. Concluding remarks

The case of Chile is useful to illustrate the need for proactive policies in small emerging countries to attract R&D-related FDI, in order to counterbalance for other locational disadvantages. However, this kind of programs need to be carefully integrated into a broader science, technology and innovation national strategy that ensures an endogenous development of local technological capabilities in tandem. Indeed, policies to promote R&D-related FDI will only produce substantial outcomes in the presence of a dynamic national innovation system where local researchers, universities and firms can absorb the expected knowledge spillovers. It remains unclear whether public incentives to attract R&D-related FDI are an efficient approach to compensate for a country's weaknesses in other, more important, location factors, such as the quality of universities and the availability of well-trained engineers and scientists, unless those incentives are targeted to specific industries or technology areas in which there is already a threshold level of R&D capabilities.

Equally important is to consider the technological specialization of the country and in which technological fields or industries there is already a strong absorptive capacity that can facilitate the transfer of knowledge and the development of critical mass in the national innovation system. Incentives should be offered cautiously, after carefully considering the potential spillovers and linkages and how these would translate to actual benefits for the host economy.

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Table 1. Distribution of the interviews by type of respondent

Managers of national innovation agency ("Corporación de Fomento", CORFO)	5
Directors of foreign-owned R&D centers established in Chile	4
Managers of national investment promotion agency ("Comité de Inversión Extranjera", CIE)	2
Director of the Innovation Division at the Ministry of Economy, Development and Tourism	1
Director of Investment Attraction at the Economic Commission for Latin America and the Caribbean (ECLAC), United Nations	1
Other experts	3
Total	16

Table 2. Chile in Latin American context, comparative indicators

	Population	Income per capita	R&D expenditure	FDI stock
Argentina	41.5	6,290	0.65	23.2
Brazil	200.4	11,690	1.21	32.2
Chile	17.6	15,230	0.39	77.2
Colombia	48.3	7,590	0.17	33.6
Costa Rica	4.9	9,550	0.48	42.3
Cuba	11.3	5,890	0.42	-
Dominican Rep.	10.4	5,770	-	44.2
Ecuador	15.7	5,760	0.23	14.7
Mexico	122.3	9,940	0.43	30.8
Panama	3.9	10,700	0.2	77.6
Peru	30.4	6,270	0.15	34.7
Uruguay	3.4	15,180	0.43	36.0
Venezuela	30.4	12,550	-	14.5
Latin America & Caribbean	588	9,536	-	44.2

Notes: 2013 or latest year available. Population in million. Gross national income per capita in current US dollars, Atlas method. Gross annual expenditure in R&D as percentage of GDP. Accumulated inward FDI stock as percentage of GDP.

Sources: World Development Indicators, World Bank (Population and income per capita), UNESCO (R&D investment) and UNCTAD (FDI Stock). Data extracted on March 3, 2015.

Table 3. R&D-related FDI in Latin America, number of projects by country 2003-2013

	R&D		DDT		R&D + DDT	
	Number	% of total	Number	% of total	Number	% of total
Argentina	1	1	36	10	37	8.3
Brazil	49	48	131	38	180	40.4
Chile	12	11.8	22	6	34	7.6
Colombia	5	4.9	24	7	29	6.5
Costa Rica	3	2.9	10	3	13	2.9
Dominican Rep.	0	0	4	1	4	0.9
Ecuador	1	1	2	1	3	0.7
Mexico	17	16.7	99	29	116	26
Panama	5	4.9	3	1	8	1.8
Peru	3	2.9	3	1	6	1.3
Puerto Rico	5	4.9	3	1	8	1.8
Uruguay	1	1	4	1	5	1.1
Others	0	0	3	1	3	0.7
Total	102	100	344	100	446	100

Notes: R&D refers to "research and development" and DDT refers to "design, development and testing".

Source: Authors' elaboration based on fDi Markets database, Financial Times Group.

Table 4. Main policy programs to attract R&D-related FDI into Chile

Program	*Years*	*Description*
InvestChile	2000-2012	Small grants for FDI in high-technology sectors and international promotion campaign. Interrupted in 2012. Re-launched and expanded in 2015 under a different name.
R&D tax incentive	2008-present	Tax credit of 35% for R&D expenditures. Modified in 2012 to expand eligibility criteria.
International Centers of Excellence	2008-present	Large grants to co-finance the establishment in Chile of selected R&D centers from leading universities, public research organizations, and multinational companies.
Start-up Chile	2010-present	Competition offering foreign entrepreneurs a residence visa and a small grant to develop their projects in Chile. Expanded in 2015 with a scale-up grant to ensure the continuation of selected projects.

Source: Authors

Table 5. International Centers of Excellence established in Chile, 2011-2015

Center	*Call*	*Track*	*Country*	*Research field*
Fraunhofer IME	1	Institutional	Germany	Biotechnology
CSIRO	1	Institutional	Australia	Mining
INRIA	1	Institutional	France	ICT
Wageningen UR	1	Institutional	Netherlands	Nutrition
UC Davis	2	Institutional	United States	Nutrition
LEITAT	2	Institutional	Spain	Nanotechnology and renewable energy
University of Queensland	2	Institutional	Australia	Mining
Fraunhofer Gesellschaft	2	Institutional	Germany	Solar energy
DCNS	2	Institutional	France	Sea energy
Pfizer	2	Business	United States	Medical equipment and pharmaceutical
GDF Suez-Laborelec	2	Business	Belgium	Renewable energy
Emerson	2	Business	United States	Mining
Telefonica	2	Business	Spain	ICT

Notes: Call 1 was issued in 2009 and the selected centers started operating in 2011/2012. Call 2 was issued in 2011 and the start of operations was 2014/2015. The "institutional" track targets international non-for-profit universities and research institutes. The "business" track targets multinational companies.

Source: Adapted from Guimón et al. (2016).