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# Globalisation and innovation dynamics in Latin American economies

Gabriela Carmen Pilay Jamarillo

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par

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**Globalisation and innovation dynamics in  
Latin American economies**

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¡Una vida juntos!

## Abstract

Latin American countries are remaining poor compared to other emerging countries. This region is losing ground in the US and European markets. Literature suggest one of the main challenges from this region has been productivity stagnation. How can Latin American countries change their structural productive system? We focus on how to enjoy the advantages of trade liberalization and innovation to help the region to move from agricultural and natural resources production to high technological products.

**keywords:** *trade liberalization, deindustrialization, innovation.*

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## Part 1

# Introduction

## 1.1 Introduction in English

Why Latin American countries are not catching-up developed countries? Why most of countries from this region remain poor and the productivity is not increasing? Latin American countries are remaining poor compared to other emerging countries that have been able to pull out of poverty and to diversify their structural production passing from agriculture and natural resources to more sophisticated products. Moreover, Latin American countries are losing ground in the US and European markets, while other partners as Asian countries are experiencing gains in foreign or third markets (Cole et al., 2005).

Considering the economic success of developed countries and as response to several economic crisis in the region, in the 1990s The Washington Consensus was emerged, this was a package of different neo-liberal reforms. Latin American implemented different macroeconomic policies to stabilize and to improve their economies. Policy makers focused on market oriented policies to create a more flexible and stable economic environment. Moreover, instrumental policies and reforms focused in growth-enhancing structural industrialization. Public policies such as private and trade liberalization, opening to foreign direct investment, and privatization were implemented (Goldfajn et al.,2021).

But have Latin American countries been able to catch up developed countries? Are we observing the expected economic success? What empirical evidence shows us it is that while European and Asian have experienced a rapid and extensive economic growth after liberalization policies, the results in Latin American countries have been disappointing. The basket of exporting-products is still mainly based on natural resources. Even countries that are members of the OECD such as Mexico and Chile are producing and exporting mainly primary goods. Moreover, most of their exports have lost relevance in main third markets as USA, while competitors countries such as China have increased their exports share to USA (Utar & Ruiz, 2013; OECD, 2007).

Literature suggest one of the main challenges from this region has been productivity stagnation. The main reason of Latin American failure is the difference in total factor productivity compared to other developed countries. This difference in productivity is mainly due to gap in labor productivity (Cole et al., 2005). According to this, in order to maintain a sustainable growth and to be able to catch-up leading economies, it becomes crucial to understand the different reasons behind productivity stagnation in Latin American economies.

Globalization and trade liberalization have helped in the transfer of technology and knowledge, promoting structural change to high technological sectors. Moreover, convergence between rich and poor countries can be reach by taking advantages and benefits of industrialization. Lagging countries can benefit from innovation and experience of developed countries (Acemoglu et al., 2006) and productivity-enhancing effects obtained through technological developments is a key factor for economic success (Rodrik, 2016).

However, what empirical evidence show us it is that while in developed countries, labor and other resources are moving from less productive to more productive activities, in Latin American countries the opposite pattern is observed: resources are moving to less productivity sectors or even informality. This make us to ask the following question. How can Latin American countries change their structural productive

system? In the present thesis, we focus on how to enjoy the advantages of this trade liberalization and how innovation can help the region to move from agricultural and natural resources production to high technological products (Rodrik, 2016).

As point out by Rodrik (2016) trade liberalization can represent an advantage only if accompanied by higher productivity in exporting sector relative to international competitors. If this double dynamics is not occurring, the risk is to import deindustrialization: the higher productivity of international competitors makes local manufacturing goods not competitive and finally to reducing both employment and output in that sector. The manufacturing sector is not working anymore as engine of growth and stagnation is the more likely outcome. In this sense, since the beginning of the century, Chinese competition has been one of the main challenges for LAC. Is this Chinese trade penetration detrimental for economic performance in Latin America? In the first chapter, we attempt to address this question analyzing the effect of Chinese competition in manufacturing employment and output for Latin American countries. We observe if Chinese product competition is having a double effect: direct effect with the penetration in local market, and an indirect effect because Chinese product are substituting one LAC product on third market, namely USA. This implies a structural change in LA economies. A structural change that makes the region to go into the services economy sooner and faster than what has been observed historically for developed countries. A process known such as premature deindustrialization (Rodrik, 2016). To do that, we perform a macroeconomic empirical analysis at a country and sectoral level, in which we focus on nine countries: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru and Uruguay.

We found a negative impact of Chinese competition in local markets of Latin American countries, suggesting a substitution of domestic by Chinese products. There is impact of Chinese product competition in third markets, only for those sectors where countries are specialized and more interestingly is observed only in the case of employment but not the level of production is not affected. Findings give strong support about the need of industrial policies that give protection to infant-industries.

Productivity stagnation in Latin American countries also puts on the table the relevant role of innovation as a key tool to have a sustain growth path (OECD, 2007). Policy makers are aware of the need of firms' innovation and the fact policy instruments can help to push strategic innovation decisions. Therefore in the second chapter. We developed a microeconomic empirical analysis at a firm level for the case of Chilean economy. A country with a problem of productivity stagnation and in which main exports are still based on natural resources such as cooper. We attempt to answer if Chilean innovation strategies such as import technologies from abroad (external R&D innovation strategies) or developing their own technology (internal R&D innovation strategies) (Acemoglu et al., 2006) are affecting the probability of innovation both in terms of product and process. In addition, we evaluate if these R&D innovation strategies are affecting productivity of Chilean manufacturing firms. Results suggest innovation strategies have a positive impact on the likelihood of innovation. External R&D innovation strategies are more related to process innovation while internal R&D innovation strategies seems more related to product or radical innovations. Moreover, R&D strategies are complement rather than substitutes in innovation performance. Each R&D innovation strategy reinforce the effect of the other one. We do not observe R&D strategies are affecting firms productivity of Chilean manufacturing firms. Findings support to introduce R&D investment as key part of the Chilean Government development agenda, and to stress not only internal or external strategies but the promotion of both R&D strategies due to its complementary on the development of firms innovation.

Finally, once considering the importance of innovation in sustained economic performance. In the last chapter, we link R&D cooperation and innovation at a firm level. We observe if it is better to have R&D investment alone or in cooperation with other partner's such as competitors, customers, suppliers, universities and institutions. Is R&D cooperation increasing or decreasing the likelihood of firm innovation? Is R&D cooperation positive for firms productivity? Again, we focus only in the Chilean economy. We developed a microeconomic analysis for Chilean manufacturing firms. We found R&D cooperation brings out positive

effects on innovation even if not in firms' productivity. Innovation is a process in which it is crucial not to be alone but rather to share the benefits and cost of innovation with R&D partners. This R&D cooperation complements internal firms resources. Once considering heterogeneity in R&D cooperation partners there is not impact on firms' innovation. Findings shed light on the promotion of network relationships among firms as key for their success.

## Outline of the thesis

The present thesis is composed of three chapters. They aim to explore Globalisation and innovation dynamics in Latin American economies. Chapter 1: *Chinese opening-up and Premature Deindustrialization in Latin American Countries: empirical evidence 1995-2016* gives a view of the trade dynamism after the Chinese opening-up in 2001 at a country and sectoral level in the Latin American region. This chapter is developed with Lorenzo Cassi. Then in Chapter 2: *Innovation strategies, Innovation and Firm Productivity: Chilean empirical evidence 2009-2016*. We focus on innovation dynamism for Chilean manufacturing firms, specifically we discuss innovation strategies behaviour at a firm level. Finally, in Chapter 3: *R&D cooperation, Innovation and Firm Performance: Evidence from Chile 2009-2016*. We focus again on innovation dynamism for Chilean manufacturing firms, but here specifically in R&D cooperation strategies. Three chapters can be read independently from one another.

## Chapter 1: Chinese opening up and Premature Deindustrialization in Latin American Countries: empirical evidence 1995-2016

During the last third of the 20th century, a shift towards a service economy era has been observed in both developed and developing countries. Economies are moving from manufacturing to services activities, a process known as “deindustrialization”. This manufacturing falling can be measure through a reduction in manufacturing employment or manufacturing output (Rodrik, 2016).

Manufacturing grows, reach a peak or maximum level and start to decrease. However, Latin American countries (LAC) are having a reduction of their manufacturing's share of employment at lower income per capita level than early industrializers. For instance, European countries such as: Britain, Sweden, and Italy, and Asian countries: Japan and South Korea have reached the turning point of manufacturing share of employment at income levels of around USD 10,000-15,000, while Latin American countries: Argentina, Brazil, Chile and Mexico at an income level between US 5,000-7,000. Deindustrialization is an expected process in the growth cycles but Latin American countries are going too early without profiting all potential benefits of a good manufactiurazing process. (Rodrik, 2016; Castillo and Martins Neto, 2016).

Economic literature suggest both internal and external factors as potential drivers of deindustrialization. The first group is related to domestic features such as preferences, labor productivity heterogeneity between sectors and intermediate goods. While external factors is related to international trade and globalization (Kollmeyer, 2009; Van Neuss, 2018). External factors may be the main reason behind deindustrialization in developing economies while internal factors the reason of deindustrialization for developed countries.(Rodrik, 2016).

In these sense, in the last few decades Latin American countries have promoted trade openness. How-

ever, the success of this trade liberalization has been criticized, most of countries are not having comparative advantages that allow them to get more benefits from trade. We do not observe the same success of trade liberalization in Asian countries such as the giant China. Latin American exports are mainly focused on intensive -resources goods. The level of technological sophistication in exports is the same observed in previous years. This behaviour suggest policy makers should restore industrialization policies to enjoy the advantages of trade liberalization (Rodrik, 2016).

Latin American countries are facing Chinese competition in both local and external markets, especially after the opening of China in 2001, there is a rapid growth of trade flow between Latin American countries and China. Latin American exports to China has increased. However, the region is experiencing an overwhelming trade manufacturing deficit with China. On the other hand, more than 50% of exports to China are mainly focused on raw materials and intermediate goods. Moreover, China is affecting not only domestic production but also displacing exports of Latin American in third main markets destination as USA. Latin American share of total USA imports has decreased from about 5.9% to 4.9% between 2001 and 2016 respectively. This behaviour raises the following question. Is Latin American ready to face key challenges of China's role at global markers?

Therefore, in the first chapter, we attempt to evaluate the effect of Chinese trade penetration in Latin American premature deindustrialization. Is it Chinese product competition generating a reduction in manufacturing employment in the region? We specifically focus on the effect of Chinese trade penetration in both local and third markets. Where local markets makes references to internal or domestic demand and third markets makes references to product competition in main export destinations. Are Chinese products replacing domestic products? Are Chinese exports replacing our exports abroad?

This is one of the first empirical studies that explore a panel data at a country and sectoral level. Moreover, we examine at the same time the direct(internal) and indirect effect (external) of Chinese trade penetration in Latin American deindustrialization. Having a panel data allows controlling for potential endogeneity and unobserved country and sector specific effects. We are trying to avoid biased estimators.

This chapter works with different database such as the INDSTAT 2 2020, ISIC Revision 3 data developed by the United Nations Industrial Development Organization (UNIDO), CHELEM - International Trade Database elaborated by the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII), World Bank database and Bruegel Datasets, we build up a panel data at a sector- country level between 1995 and 2016. Our sample is made up of 9 countries. Specifically: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru and Uruguay as Latin American countries (LAC). Sample is focused on main manufacturing sectors. At the end we finish with a sample of about 3,600 observations.

In this chapter, we used as methodology random and fixed panel estimation. Moreover, since our dependent variable is manufacturing share (employment or value added), the direct effect risks to be endogenous because manufacturing can affects trade exposure and vice-versa. To dealt with potential endogeneity issues, we also incorporate an IV approach. An instrument defined as the Chinese penetration in three similar countries in terms of population and per capita gdp for each of the nine Latin American Countries included in the sample.

Results show there is a negative effect of Chinese trade penetration in local manufacturing employment. Chinese competition is generating the downward shift in manufacturing employment shares over time for Latin American economies. Chinese products are replacing local products. This effect is similar once considering another measure of deindustrialization such as manufacturing real value added share. We observe a negative impact of Chinese competition in manufacturing real value added share for Latin American coun-

tries. Results are robust once considering potential endogeneity through the used of our IV.

On the other hand, amplifying China's potential impact on foreign or third markets (indirect effect). We observe there is not impact of Chinese trade competition in third markets, Chinese exports are not replacing exports of Latin American countries in foreign markets but there is a negative indirect effect working only for those sectors where countries are specialized and more interestingly is observed only in the case of employment: the level of production is not affected. In other words, the number of workers decrease but not the value of the production as trade partners are more and more exposed to Chinese import. Productivity gains of exporting firms can help us to understand this behavior. LAC firms, exporting to countries where China has been able to penetrate, are increasing their productivity and in this way they resist to the increasing pressure of Chinese commodities but reducing the number of workers: the overall effect is they are not decreasing the value of their production but sacrificing employment. Unfortunately, this interpretation cannot be empirical tested within our empirically framework, there is the need of a firm-level data that allow us to identify firms who are exporting and not.

Finally, even tough the success of trade liberalization in Asian countries, the Latin American countries experience is totally different. The region is importing high technological products but still exporting raw materials. Most countries are not having comparative advantages, they are not getting all benefits from trade liberalization. These findings shed light about industrialization policies. Policy markers should restore industrialization policies, there is the need of an incremental but not radical trade liberalization in the region. It becomes crucial to identify and to distinguish between sectors in need of protection and sectors with the abilities and structure to face the challenges of foreign competition.

## **Chapter 2: Innovation strategies, Innovation and Firm Productivity: Chilean empirical evidence 2009-2016.**

Second chapter focus on Chilean economy. Chile has experienced a high and stable growth (i.e. 4.7% average growth between 1991- 2019). However, Chilean factor productivity has remained more or less stagnant over this period. Chilean growth path can be manly explained by exports based on natural resources such as cooper but Chilean exports level of sophistication are very behind compared to other OECD countries. Chile should increase its productivity to maintain its sustained growth (OECD, 2007).

Economic literature suggests, Chile can adopt two different innovation strategies to improve its productivity: either import technologies from abroad (external R&D innovation strategies) or developing their own technology (internal R&D innovation strategies) (Acemoglu et al., 2006). Importing is a strategy mainly used by firms far from de technological frontier and investing in their own technology by firms close to this frontier. According to this, countries that are far to the technological frontier tend to imitate and countries close to this frontier tend to make real innovation.

Therefore, in the second chapter. We aim to investigate the effect of different R&D innovation strategies, specifically we consider three innovation strategies. They are: internal R&D, external R&D , and a mixed strategy that it is considered for firms who are applying both internal and external R&D innovation strategies at the same time. We evaluate the effect of these innovation strategies on innovation outcomes such as new or significantly improved product and process. Moreover, we also look for the effect of this R&D innovation strategies on Chilean firm productivity, considering some firms'characteristics. We test the following four

hypothesis. They are :

- *First*, we should expect that internal sources or strategies have a significant and potentially positive effect on both product and process innovation outcomes, stronger for the case of product innovation due to its needs of higher levels of research, design, patenting and market exploration.
- *Second*, we should expect that external sources or strategies have a significant and potentially positive effect both product and process innovation outcomes, stronger for the case of process innovation due to its needs of cost reductions, price competitiveness, labor savings, and exploitation of resources.
- *Third*, we should expect a positive and significant coefficient in a mixed strategy (combining both internal and external strategies) on innovation outcomes. We expect complementarity impact between strategies, that makes that the use of one strategies reinforce the use of the another. In other words, the fact of using two strategies together not decrease the productivity of each strategy by itself .
- *Fourth*, we should expect a positive effect of innovation strategies on firm performance. Here, firm performance is measure by a proxy of productivity defined as the ratio of sales over the number of employees.

The empirical evidence for Chilean economy about R&D innovation strategies is limited. Therefore, this chapter contributes to the empirical microeconomic literature by examining the impact of R&D innovation strategies on Chilean firm innovation and productivity. This is one of the first empirical studies that explore a panel data set which help us to control for unobserved firm specific factors.

As methodology, in this chapter we perform a conditional fixed effects logit model over the period 2009-2016, combing four different surveys of Encuesta de Innovacion en Empresa (ENI) elaborated by the Instituto Nacional de Estadísticas (INE). Data is available online for every year of the survey but there is not possibility to observe firms across time. However, thanks to the Ministerio de Economía, Fomento y Turismo collaboration, we are able to merge the four surveys and build a panel data. The sample is restricted to Chilean manufacturing firms and we finish with a final sample of 1,852 Chilean firms between 2009 and 2016. We focus on manufacturing firms due to its relevance in the Chilean economy. Moreover, we also make a cross section and pooled analysis as robustness check.

We found results in favor of our three first hypothesis tested. Internal strategies are increasing the likelihood of innovation, specially in the case of product. External strategies are increasing the likelihood of innovation, specially in the case of process. There is complementarity in a mixed strategy for both innovation outcomes. Specifically, we observe *Make&Buy* strategy has the biggest positive impact on the probability of firm product innovation, followed by *MakeOnly* and then *BuyOnly*. Firm'who have incorporated a dual R&D or *Make&Buy* have 0.52 more probability to have product innovation compared to those firms who don't introduce any innovation strategies. In the case of firms that have introduced *MakeOnly* and *BuyOnly* the increase in the likelihood of product innovation is about 0.37 and 0.25 respectively.

On the other hand, considering process innovation outcome we also observe *Make&Buy* strategy has the biggest positive impact on the probability of firm process innovation, followed by *BuyOnly* and then *MakeOnly*. Firm'who have introduced *Make&Buy* have 0.45 more probability to have process innovation than those who didn't introduce any innovation strategies, in the case of firms that have introduced *BuyOnly* and *MakeOnly* the increase in the likelihood of process innovation is about 0.38 and 0.28 respectively.

To sum up importing or buying technologies seems to have an important impact on the likelihood of process innovation, while developing their own technologies seems to be more related with product innovation. Moreover, If firms implement internal and external R&D innovation strategies together, they may be seen as complement rather than substitutes. Firms able to combine the two strategies have the biggest positive impact on innovation probability in both product and process. The productivity of each strategy is increasing when they are applying simultaneously.

On the other hand, our hypothesis number four is rejected. There is not a positive impact of innovation strategies on firm productivity. External R&D activities or mixed R&D strategies have no statistically significant impact on firms productivity. Developing internal R&D activities is having a negative impact on Chilean firm productivity, however, this negative impact changes once considering another measure of firm performance such as sales growth, if we consider sales growth, we even observe there is not statistically significant impact of internal R&D activities on sales growth of Chilean firms. This suggest a better proxy of firm productivity such as labor productivity or value added should be used. Moreover, even if we are able to observe firms across time, our period of analysis is too short, and probably a longer period of analysis is required to observe changes in firms productivity.

As we mentioned before, the econometric panel data conditional fixed effects logit estimation allows to take into account unobserved firm specific effects that may bias the results. However, one of the limitations of this chapter is the absence of some firm features such as: credit facilities and manager experiences. Moreover, even if we observe firms across time, most of our firms are only observed in two periods of the survey. A longer period of analysis is needed to obtain a better perspective of innovation dynamics in the Chilean economy.

The findings in this second chapter of the thesis provide strong support to introduce R&D investment as key factor of the Chilean government development agenda. Internal and external R&D strategies should be promoted but also policy makers should stress the role and advantages of a mixed R&D strategy, because the intensity and choice of R&D investment strategy is going to define firms future. So, a better exploration and exploitation of firms sources is crucial to profit from the innovation virtuous circle.

### **Chapter 3: R&D cooperation, Innovation and Firm Performance: Evidence from Chile 2009-2016**

Third chapter, it is again focus on Chilean Economy. Here, we are interesting in R&D cooperation or alliances. Firm R&D cooperation or alliances has increased steadily in the 90s, especially in fast developing technologies. Moreover, this increase of alliances is observed in both developed and developing countries. Firms are applying R&D cooperation to complement their in-house technology. Firms can not innovate alone anymore but they should establish R&D cooperation for a better management and controlling of resources. (Belderbos et al., 2004; Becker et al. 2004)

Chilean policy makers aware of the importance of R&D collaboration for firm innovation development are also pushing on R&D collaboration through some public programs such as the the Science and Technology Development Fund(FONDEF). R&D collaboration with research institutions is increasing Chilean firm performance. Moreover, firms who are close in terms of geography and technology are experiences spillover effects. We observe that R&D collaboration promises a better innovation future for firms who apply the

R&D alliance but also for their neighbours (Crespi et al., 2020).

Firms establishing R&D collaboration are increasing their capacity of exploiting and organizing internal sources. Costly and risky projects, skills, opportunities to access to higher technological resources, higher R&D global networks, and the spillover benefits of R&D cooperation are also some of the reasons why firms are choosing more and more R&D cooperation rather than going alone (Belderbos et al., 2004; Becker et al. 2004).

But R&D cooperation also needs firms to be ready, firms need structure and expertise to profit of this R&D cooperation. R&D cooperation by itself generates adaption cost such as: coordinating, managing and controlling. Nowadays, firms are facing the strategic question of whether or not to establish R&D cooperation and which R&D cooperation partner to choose? if benefits of these alliances are greater than cost, they opt for alliance in innovation (Becker & Dietz, 2004; Aschhoff & Schmidt, 2008).

Therefore in the third chapter, our main point of interest is to investigate the effect of R&D cooperation on Chilean firms performance both in terms of innovation and and productivity. Moreover, once considering R&D cooperation heterogeneity we also look for the effect of different types of R&D cooperation on Chilean firms innovation. We consider five types of R&D cooperation for the analysis (i.e. Competitors, Customers, Suppliers, Institutions and Universities). After this, we go one step further and consider other two classifications of R&D cooperation partners: 1)by knowledge position in the industry chain and 2)knowledge distance between firms and partners. To sum up, we test the following three hypothesis. They are :

- *First*, R&D cooperation has a positive and significant impact on the probability of innovation.
- *Second*, the impact of R&D cooperation on innovation varies across R&D cooperation partners.
- *Third*, there is a positive impact of R&D cooperation on firms productivity.

This chapter contributes to the empirical microeconomic literature by examining the role of R&D cooperation and different types of R&D cooperation on Chilean firm performance in terms of both innovation and productivity. We explore a panel data that help us to control for potential endogeneity and unobserved firm specific effects, firms characteristic such as size and manufacturing sector are also considered in the analysis.

The methodology used for this chapter it is a linear probability model with firm fixed effects over the period 2009-2016. We use as data a combination of different surveys of Encuesta de Innovacion en Empresa (ENI) elaborated by the Instituto Nacional de Estadísticas (INE). It is the same data used in Chapter 2 of the present thesis. But here we have to redefine our sample since firms who are replying to the question of innovation are only those who are replying to the questions of innovation alliance. Moreover, the sample is restricted to Chilean manufacturing firms and we finish with a final sample of 746 Chilean firms between 2009 and 2016. The manufacturing sector was chosen because of it is relevance in the GDP (third part of Chilean GDP) .

After the empirical analysis, in this chapter we found evidence in favor of our first hypothesis. R&D cooperation is increasing the likelihood of product and process innovation. The positive effect of R&D cooperation seems stronger in product innovation, an innovation outcomes that often needs research and patenting due to its high level of novelty. Firms who have R&D cooperation have more likelihood of product



and process (0.158 and 0.146 respectively) than firms without innovation alliances. On the other hand, once considering our second hypothesis, about different types of R&D cooperation for the analysis (i.e. Competitors, Customers, Suppliers, Institutions and Universities). We observe there is not significant impact on innovation performance. If we consider R&D with partners advance in knowledge such as Universities, Institutions and Suppliers, we observe this R&D partnership is having a positive impact on process innovation while R&D cooperation with partners behind in knowledge such as Customers and Competitors can decrease the likelihood of product innovation due to some private interests that can limit the transfer of knowledge. Finally, our hypothesis number three is rejected. R&D cooperation is not affecting firms productivity.

The empirical evidence about R&D cooperation is limited specially for developing countries. In this chapter we offer a first perspective about R&D cooperation for Chilean manufacturing firms. Even though we are able to observe firms across time, our period of analysis is still too short. Moreover, one of the main limitations of this chapter, it is the sample size (our sample is restricted to less than 1000 firms). Only firms who are having innovation are those who have information about their level of R&D cooperation, which may generate potential problems of sample biased. According to this, it is recommended to establish a longer panel database in further research.

Findings in this paper give strong support for the promotion of networking and relationships among firms and partners as a key factor for firms success. Policy makers should focus on the development of instruments that allows firms to take advantages of knowledge, geographical and cultural features of innovation partners.

## 1.2 Résumé en français

Pourquoi les pays d'Amérique latine ne parviennent-ils pas à rattraper les pays développés ? Pourquoi la majorité des pays de cette région restent-ils pauvres et pourquoi la productivité n'augmente-t-elle pas ? Les pays d'Amérique latine restent en retard par rapport à d'autres pays émergents qui ont réussi à sortir de la pauvreté et à diversifier leur production structurelle, qui s'appuyait auparavant sur l'agriculture et les ressources naturelles et repose désormais sur des produits plus sophistiqués. Les pays d'Amérique latine perdent par ailleurs du terrain sur les marchés américain et européen, alors que d'autres partenaires, comme les pays asiatiques, enregistrent des gains sur les marchés étrangers ou les marchés tiers (Cole et al., 2005).

Face au succès économique des pays développés et en réponse aux multiples crises économiques dans la région avait émergé, dans les années 1990, le Consensus de Washington, un ensemble de diverses réformes néo-libérales. Les pays latino-américains avaient mis en place différentes politiques macro-économiques pour stabiliser et améliorer leurs économies. Les responsables politiques s'étaient concentrés sur des politiques axées sur le marché afin de créer un environnement économique plus flexible et plus stable. En outre, les principales politiques et réformes s'étaient focalisées sur une industrialisation structurelle favorable à la croissance. Des politiques publiques, telles que la libéralisation des échanges, l'ouverture aux investissements directs à l'étranger ainsi que la privatisation, avaient ainsi été mises en œuvre (Goldfajn et al., 2021).

Mais les pays d'Amérique latine ont-ils réussi à rattraper les pays développés ? Le succès économique attendu est-il au rendez-vous ? La preuve empirique nous montre que si les pays européens et asiatiques ont connu une croissance économique majeure et rapide après la mise en place de politiques de libéralisation, les résultats ont été décevants dans les pays latino-américains. Le panier des produits d'exportation repose encore majoritairement sur les ressources naturelles. Même des pays membres de l'OCDE comme le Mexique et le Chili produisent et exportent essentiellement des produits primaires. En outre, la majorité de leurs exportations ont perdu du terrain sur les principaux marchés tiers, tels que les États-Unis, tandis que d'autres pays concurrents, comme la Chine, ont augmenté la part de leurs exportations vers les États-Unis (Utar Torres Ruiz, 2013; OECD, 2007).

La littérature spécialisée montre que la stagnation de la productivité a constitué l'un des principaux défis dans cette région. La différence de productivité de l'ensemble des facteurs, par rapport aux autres pays développés, constitue la principale explication aux échecs en Amérique latine. Cette divergence de productivité s'explique principalement par les écarts de productivité du facteur travail (Cole et al., 2005). En effet, pour maintenir une croissance durable et être en mesure de rattraper les principales économies, il est essentiel de comprendre les différentes raisons expliquant la stagnation de la productivité dans les économies latino-américaines.

La mondialisation et la libéralisation des échanges ont contribué au transfert de technologies et de connaissances, encourageant une évolution structurelle vers des secteurs de haute technologie. En tirant profit des avantages et bénéfices de l'industrialisation, une convergence entre les pays riches et pauvres est par ailleurs possible. Les pays en retard de développement peuvent profiter de l'innovation et de l'expérience des pays développés (Acemoglu et al., 2006) tandis que les améliorations de productivité engendrées par les évolutions technologiques constituent un facteur clé de la réussite économique (Rodrik, 2016).

Cependant, la preuve empirique nous montre que, alors que dans les pays développés, le travail et les autres ressources évoluent d'activités moins productives vers des activités plus productives, les pays d'Amérique latine connaissent une évolution inverse: les ressources se déplacent vers des secteurs à moindre productivité, voire vers des secteurs informels. Ce qui nous invite à nous poser la question suivante: comment les pays d'Amérique latine peuvent-ils modifier leur système productif structurel ? Dans cette thèse, nous nous con-

centrons sur la manière de tirer profit des avantages de la libéralisation des échanges ainsi que sur la manière dont l’innovation peut aider cette région à passer de la production de ressources agricoles ou naturelles à celle de produits de haute technologie (Rodrik, 2016).

Comme le souligne Rodrik (2016), la libéralisation des échanges ne peut être bénéfique que si elle est accompagnée d’une augmentation de la productivité dans les secteurs d’exportations soumis à la concurrence internationale. En l’absence de cette double dynamique, le risque est d’importer de la désindustrialisation: la productivité plus forte des concurrents internationaux rend les biens manufacturés locaux non compétitifs, ce qui aboutit à une baisse à la fois de l’emploi et de la production dans ce secteur. Le secteur manufacturier ne fonctionne plus comme moteur de la croissance et la stagnation devient la conséquence la plus probable. Depuis le début du siècle, le concurrent chinois constitue de ce fait l’un des principaux défis pour les pays d’Amérique latine. La pénétration commerciale de la Chine est-elle néfaste aux performances économiques en Amérique latine ? Dans le premier chapitre, nous tentons de répondre à cette question en analysant les effets de la concurrence chinoise sur l’emploi et sur la production du secteur manufacturier dans les pays d’Amérique latine. Nous cherchons à analyser si la concurrence chinoise au niveau des produits a un double effet: un effet direct avec la pénétration sur le marché local, et un effet indirect car les produits chinois remplacent les produits latino-américains sur les marchés tiers, et notamment les États-Unis. Cela implique une évolution structurelle dans les économies latino-américaines, qui permettrait à la région de devenir une économie de services plus tôt et plus rapidement que lors de la transition historiquement observée dans les pays développés. Ce processus est appelé “désindustrialisation prématurée” (Rodrik, 2016). Pour cela, nous réalisons une analyse empirique macro-économique aux niveaux nationaux et sectoriels de neuf pays: Argentine, Bolivie, Brésil, Chili, Colombie, Équateur, Mexique, Pérou et Uruguay.

Nous avons constaté que la concurrence chinoise avait un impact négatif sur les marchés locaux latino-américains, laissant entendre que les produits nationaux étaient remplacés par des produits chinois. La concurrence des produits chinois a un impact négatif sur les marchés tiers, uniquement dans les secteurs de spécialisation des pays; il est intéressant de noter qu’elle n’est observée que dans les cas où l’emploi est concerné, et non le niveau de production. Ces résultats insistent fortement sur la nécessité de mettre en place des politiques industrielles qui protègent les industries émergentes.

La stagnation de la productivité dans les pays d’Amérique latine souligne également le rôle majeur de l’innovation comme outil-clé pour un chemin de croissance durable (OECD, 2007). Les responsables politiques sont conscients du besoin d’innovation des entreprises et du fait que les instruments politiques peuvent aider à prendre des décisions stratégiques en matière d’innovation. Dans le deuxième chapitre, nous avons donc réalisé une analyse empirique micro-économique, au niveau des entreprises de l’économie chilienne. Ce pays est confronté à un problème de stagnation de la productivité tandis que la majorité de ses exportations repose encore sur les ressources naturelles, comme le cuivre. Nous cherchons à savoir si les stratégies chiliennes d’innovation, telles que l’importation de technologies de l’étranger (stratégies externes d’innovation en R&D) ou le développement de leurs propres technologies (stratégies internes d’innovation en R&D) (Acemoglu et al., 2006) ont une incidence sur la probabilité d’innovation, à la fois pour les produits et les procédés. Nous analysons par ailleurs l’impact éventuel de ces stratégies d’innovation en R&D sur la productivité des entreprises manufacturières chiliennes. Les résultats montrent que les stratégies d’innovation ont un impact positif sur la probabilité d’innovation. Les stratégies externes d’innovation en R&D touchent davantage l’innovation de procédés, alors que les stratégies internes d’innovation en R&D semblent davantage associées aux innovations de produits ou aux innovations radicales. En outre, en termes de performance d’innovation, ces stratégies sont plus complémentaires que substitutives. Chaque stratégie d’innovation en R&D renforce les effets des autres stratégies. Les stratégies de R&D ne semblent pas affecter la productivité des entreprises manufacturières chiliennes. Les résultats encouragent les investissements dans la R&D, en tant qu’élément essentiel de l’agenda du développement du gouvernement chilien, et soulignent la nécessité de se concentrer non seulement sur les stratégies internes ou externes, mais aussi de promouvoir les deux types de stratégies de R&D en raison de leur complémentarité pour le développement de l’innovation des entreprises.

Enfin, après avoir étudié l'importance de l'innovation pour des performances économiques soutenues, dans le dernier chapitre, nous associons coopération en matière de R&D et innovation au niveau de l'entreprise. Nous constatons qu'il est préférable d'avoir des investissements en R&D seuls ou en coopération avec d'autres partenaires, qu'il s'agisse de concurrents, de consommateurs, de fournisseurs, d'universités et d'institutions. La coopération en matière de R&D augmente-t-elle ou diminue-t-elle la probabilité d'innovation des entreprises ? La coopération en matière de R&D est-elle favorable à la productivité des entreprises ? Nous nous sommes à nouveau concentrés sur le cas de l'économie chilienne et avons réalisé une analyse micro-économique des entreprises manufacturières chiliennes. Nous avons constaté que la coopération en matière de R&D est bénéfique à l'innovation, même si ce n'est pas le cas en termes de productivité de l'entreprise. L'innovation est un processus dans lequel il est indispensable de ne pas être seul ; il est préférable de partager les bénéfices et les coûts de l'innovation avec des partenaires de R&D. Cette coopération en matière de R&D complète les ressources internes des entreprises. L'hétérogénéité des partenaires de coopération en matière de R&D n'a pas d'impact sur l'innovation des entreprises. Les résultats soulignent que la promotion des réseaux relationnels inter-entreprises constitue un élément clé de leur succès.

## Aperçu de la thèse

Cette thèse comporte trois chapitres visant à analyser la mondialisation et les dynamiques d'innovation dans les économies d'Amérique latine. Le chapitre 1 *L'ouverture chinoise et la désindustrialisation prématurée dans les pays d'Amérique latine: preuve empirique 1995-2006* donne un aperçu du dynamisme des échanges après l'ouverture chinoise en 2001, aux niveaux nationaux et sectoriels dans la région latino-américaine. Ce chapitre est écrit avec Lorenzo Cassi. Puis, le chapitre 2 s'intitule *Stratégies d'innovation, innovation et productivité des entreprises: le cas du Chili en 2009-2016*. Nous nous concentrons sur le dynamisme de l'innovation pour les entreprises manufacturières chiliennes et nous étudions plus spécifiquement le comportement des stratégies d'innovation au niveau des entreprises. Enfin, le chapitre 3 s'intitule *Coopération en matière de R&D, innovation et performance des entreprises: le cas du Chili en 2009-2016*. Nous nous intéressons à nouveau au dynamisme de l'innovation des entreprises manufacturières chiliennes, et plus particulièrement aux stratégies de coopération en matière de R&D. Les trois chapitres peuvent être lus indépendamment les uns des autres.

## Chapitre 1:

### **L'ouverture chinoise et la désindustrialisation prématurée dans les pays d'Amérique latine: preuve empirique 1995-2006**

Au cours du dernier tiers du XX<sup>ème</sup> siècle, les pays développés mais aussi ceux en développement ont évolué vers une ère d'économie de services. Les économies voient leurs activités manufacturières se transformer en activités de services, processus communément appelé " désindustrialisation". Cette baisse de l'activité manufacturière peut être mesurée par une réduction de l'emploi ou de la production du secteur manufacturier (Rodrik, 2016).

La production manufacturière augmente, atteint un pic ou un niveau maximum puis commence à décliner. Les pays d'Amérique latine connaissent cependant une baisse de la proportion manufacturière de l'emploi

alors que leur niveau de revenu par habitant est inférieur à celui observé dans les premiers pays industrialisés lors de leur tournant. De la sorte, des pays européens comme la Grande-Bretagne, la Suède et l'Italie ainsi que des pays asiatiques comme le Japon et la Corée du Sud ont atteint le tournant de leur part manufacturière de l'emploi à des niveaux de revenus d'environ 10000 – 15000 USD, tandis que dans les pays d'Amérique latine, tels que l'Argentine, le Brésil, le Chili et le Mexique, ce niveau de revenus est compris entre 5000 et 7000 USD. La désindustrialisation est un processus normal dans les cycles de croissance mais il se produit trop tôt dans les pays d'Amérique latine, ce qui ne leur permet pas de profiter de tous les avantages potentiels d'un bon processus de fabrication (Rodrik, 2016 ; Castillo and Martins Neto, 2016).

La littérature économique indique que des facteurs internes mais aussi externes peuvent être de potentiels moteurs de la désindustrialisation. Les premiers concernent des aspects nationaux, tels que les préférences, l'hétérogénéité de la productivité du travail entre les secteurs ainsi que les biens intermédiaires. Quant aux seconds, ils concernent les échanges internationaux et la mondialisation (Kollmeyer, 2009; Van Neuss, 2018). Les facteurs externes peuvent constituer la principale explication de la désindustrialisation des économies en développement, tandis que les facteurs internes peuvent l'être pour celle des pays développés (Rodrik, 2016).

Au cours des dernières décennies, les pays d'Amérique latine ont favorisé l'ouverture commerciale. Cependant, le succès de cette libéralisation des échanges a fait l'objet de critiques, la majorité des pays ne disposant pas d'avantages comparatifs qui leur permettraient de profiter davantage du commerce. Nous n'observons pas le même succès que lors de la libéralisation des échanges dans les pays asiatiques, et notamment chez le géant chinois. Les exportations latino-américaines reposent principalement sur des biens nécessitant d'importantes ressources. Le niveau de sophistication technologique des exportations reste identique à celui observé au cours des années précédentes. Cela devrait inciter les responsables politiques à restaurer des politiques d'industrialisation pour profiter des avantages de la libéralisation des échanges (Rodrik, 2016).

Les pays d'Amérique latine sont confrontés à la concurrence chinoise, à la fois sur leurs marchés locaux mais aussi sur les marchés extérieurs, notamment après l'ouverture de la Chine en 2001, qui a entraîné une hausse rapide des flux commerciaux entre les pays d'Amérique latine et la Chine. Les exportations latino-américaines vers la Chine ont augmenté. Cependant, l'Amérique latine connaît un déficit commercial majeur du secteur manufacturier avec la Chine. Plus de 50% des exportations vers la Chine concernent principalement des matières premières et des biens intermédiaires. En outre, la Chine a non seulement une incidence sur la production nationale mais elle modifie aussi les exportations latino-américaines sur des marchés tiers, tels que les États-Unis. La part latino-américaine dans l'ensemble des importations américaines a baissé, passant d'environ 5,9% à 4,9% entre 2001 et 2016. Ce qui soulève la question suivante: l'Amérique latine est-elle prête à relever les défis majeurs que pose la Chine sur les marchés mondiaux ?

Dans ce premier chapitre, nous essayons d'analyser les conséquences de la pénétration commerciale chinoise sur la désindustrialisation prématurée en Amérique latine. La concurrence des produits chinois entraîne-t-elle une réduction de l'emploi manufacturier dans cette région? Nous nous intéressons tout particulièrement aux conséquences de la pénétration commerciale chinoise sur les marchés locaux et sur les marchés tiers. Si l'on considère que les marchés locaux sont liés à la demande interne et les marchés tiers à la concurrence des produits sur les principaux marchés d'exportation, on peut s'interroger: les produits chinois remplacent-ils les produits nationaux? Les exportations chinoises remplacent-elles nos exportations à l'étranger?

Il s'agit là d'une des premières études empiriques analysant des données de panel au niveau d'un pays et d'un secteur. En outre, nous examinons parallèlement les effets directs (internes) et indirects (externes) de la pénétration commerciale chinoise sur la désindustrialisation latino-américaine. Ces données permettent de vérifier une éventuelle endogénéité et des effets spécifiques à un pays ou un secteur non étudié jusqu'à présent. Nous essayons d'éviter les estimateurs biaisés.

Ce chapitre utilise plusieurs bases de données telles que les données INDSTAT 2 2020, ISIC Revision 3 élaborées par l'Organisation des Nations Unies pour le développement industriel (ONU/DI), la base de données CHELEM - International Trade Database élaborée par le Centre d'Études Prospectives et d'Informations Internationales (CEPII), les bases de données de la Banque mondiale ainsi que les données de Bruegel.

Dans ce chapitre, nous utilisons comme méthodologie les estimations à effets fixes et aléatoires des données de panels. Notre variable dépendante étant la part manufacturière (emploi ou valeur ajoutée), l'effet direct risque d'être endogène car le secteur manufacturier peut affecter l'exposition commerciale, et vice-versa. Pour analyser les questions d'endogénéité potentielle, nous introduisons également l'approche des variables instrumentales. Cet instrument permet de définir la pénétration chinoise dans trois pays similaires en termes de population et de PIB par habitant, pour chacun des neuf pays d'Amérique latine étudiés dans l'échantillon.

Les résultats montrent un effet négatif de la pénétration commerciale chinoise sur l'emploi manufacturier local. La concurrence chinoise génère une baisse progressive de l'emploi manufacturier dans les économies latino-américaines. Les produits chinois remplacent les produits locaux. On observe le même effet pour d'autres aspects de la désindustrialisation, tels que la part de la valeur ajoutée réelle du secteur manufacturier. Nous constatons un impact négatif de la concurrence chinoise dans la part de la valeur ajoutée réelle du secteur manufacturier des pays d'Amérique latine. Les résultats sont solides du fait de la prise en compte de l'endogénéité potentielle par le biais de l'utilisation de nos variables instrumentales. En observant par ailleurs l'impact potentiel de la Chine sur les marchés étrangers et tiers (effet indirect), nous constatons l'absence d'impact de la concurrence commerciale chinoise sur les marchés tiers: les exportations chinoises ne remplacent pas les exportations des pays latino-américains sur les marchés étrangers, mais nous constatons un effet indirect négatif uniquement pour les secteurs de spécialisation des pays, et uniquement dans le cas de l'emploi, ce qui mérite d'être souligné, le niveau de production n'étant pas concerné. En d'autres termes, le nombre de travailleurs décroît, contrairement à la valeur de la production, lors de la plus forte exposition des partenaires commerciaux aux importations chinoises. Les gains de productivité des entreprises exportatrices peuvent nous aider à comprendre ce phénomène. Les entreprises latino-américaines, qui exportent vers des pays dans lesquels la Chine a réussi à pénétrer, augmentent leur productivité, ce qui leur permet de résister à la pression croissante des produits chinois, mais elles réduisent leur main d'œuvre: finalement, elles ne baissent pas la valeur de leur production mais sacrifient l'emploi. Malheureusement, cette interprétation ne peut être vérifiée empiriquement dans le cadre de notre analyse; nous avons besoin de données au niveau de l'entreprise nous permettant d'identifier les entreprises exportatrices ou non.

Enfin, malgré le succès de la libéralisation des échanges dans les pays asiatiques, la réalité est complètement différente en Amérique latine. La région importe des produits de haute technologie mais continue à exporter des matières premières. La majorité des pays ne dispose pas d'avantages comparatifs et ne bénéficie donc pas de tous les avantages de la libéralisation des échanges. Ces résultats mettent l'accent sur les différentes politiques d'industrialisation envisageables. Les responsables politiques devraient restaurer des politiques d'industrialisation: la région a besoin d'une libéralisation commerciale progressive, et non radicale. Il devient essentiel d'identifier et de distinguer les secteurs ayant besoin d'être protégés et ceux ayant les capacités et la structure requises pour relever les défis de la concurrence étrangère.

## Chapitre 2:

# Stratégies d'innovation, innovation et productivité des entreprises: le cas du Chili en 2009-2016

Le second chapitre porte sur l'économie chilienne. Le Chili a connu une croissance élevée et stable (croissance moyenne de 4,7% entre 1991 et 2019). Néanmoins, le facteur de productivité chilien est resté plus ou moins stable au cours de cette période. Le chemin de croissance chilien repose principalement sur les exportations, basées sur les ressources naturelles comme le cuivre, mais le niveau de sophistication des exportations chiliennes est très en retard par rapport aux autres pays de l'OCDE. Le Chili devrait accroître sa productivité pour maintenir une croissance soutenue (OCDE, 2007).

La littérature économique estime que le Chili peut adopter deux stratégies d'innovation différentes pour accroître sa productivité: il peut soit importer des technologies de l'étranger (stratégies externes d'innovation en R&D), soit développer sa propre technologie (stratégies internes d'innovation en R&D) (Acemoglu et al., 2006). L'importation est la stratégie privilégiée par les entreprises éloignées de la frontière technologique, tandis que les entreprises proches de cette frontière investissent dans leur propre technologie. Ainsi, les pays éloignés de la frontière technologique ont tendance à imiter, tandis que les pays proches de cette frontière sont plus enclins à développer une innovation réelle.

Dans ce deuxième chapitre, nous cherchons donc à analyser les conséquences des différentes stratégies d'innovation en R&D, notamment en étudiant trois stratégies d'innovation: l'innovation interne ou créant de la R&D, l'innovation externe ou achetant de la R&D, ou une stratégie mixte qui concerne les entreprises appliquant simultanément des stratégies d'innovation achetant et créant de la R&D. Nous étudions les effets de ces stratégies d'innovation en termes de résultats d'innovation: s'agit-il de produits ou procédés nouveaux ou sont-ils considérablement améliorés? De plus, nous observons aussi les conséquences de ces stratégies d'innovation en R&D sur la productivité des entreprises chiliennes, en tenant compte de certaines caractéristiques de ces entreprises. Nous testons les quatre hypothèses suivantes:

- Premièrement, il faut s'attendre à ce que les sources ou stratégies internes aient des conséquences importantes et potentiellement positives en termes d'innovation, tant au niveau des produits que des procédés, et d'autant plus encore dans le cas d'innovation de produits en raison de la nécessité d'améliorer les niveaux de recherche, de conception, de brevetage et de prospection de marché.
- Deuxièmement, il faut s'attendre à ce que les sources ou stratégies externes aient des conséquences importantes et potentiellement positives en termes d'innovation, tant au niveau des produits que des procédés, et d'autant plus encore dans le cas des stratégies d'innovation de procédés, en raison de la nécessité de réduction des coûts, de compétitivité des prix, d'économies sur le facteur travail et d'exploitation des ressources.
- Troisièmement, il faut s'attendre un effet positive et significatif dans l'interaction entre les stratégies internes et externes d'innovation. Une complémentarité entre les stratégies est attendue, le recours à une stratégie devant renforcer le recours à l'autre. En d'autres termes, le fait d'utiliser deux stratégies simultanément ne diminue pas la productivité de chacune des stratégies prises individuellement.
- Quatrièmement, il faut s'attendre à une influence positive des stratégies d'innovation sur les performances des entreprises. Celles-ci sont mesurées ici par le biais de la productivité, définie ici comme la

proportion des ventes par rapport au nombre d'employés.

Il existe peu de preuves empiriques relatives à l'économie chilienne en termes de stratégies d'innovation en R&D. Ce chapitre contribue donc à la littérature empirique micro-économique en analysant les conséquences des stratégies d'innovation en R&D sur l'innovation et la productivité des entreprises chiliennes. Il s'agit d'une des premières études empiriques analysant des données de panel nous aidant à vérifier des facteurs spécifiques à certaines entreprises non étudiés.

Notre méthodologie dans ce chapitre consiste à utiliser un modèle logit conditionnel à effets fixes sur la période 2009-2016, en combinant quatre études différentes intitulées Encuesta de Innovacion en Empresa (ENI) [Enquêtes sur l'innovation des entreprises] et élaborées par l'Instituto Nacional de Estadística (INE) [Institut national de la statistique]. Les données sont accessibles en ligne pour chaque année couverte par l'enquête mais il n'est pas possible d'analyser les entreprises sur la durée. Cependant, grâce à la collaboration du Ministerio de Economía, Fomento y Turismo [Ministère de l'économie, du développement et du tourisme], nous sommes en mesure de fusionner les quatre études et d'élaborer des données de panel. Cet échantillon est limité aux entreprises manufacturières chiliennes et nous aboutissons à un échantillon final de 1852 entreprises chiliennes entre 2009 et 2016. Nous nous intéressons aux entreprises manufacturières en fonction de leur pertinence pour l'économie chilienne. Nous réalisons par ailleurs une analyse transversale et combinée en guise de vérification de la robustesse.

Les résultats obtenus confirment nos trois premières hypothèses testées. Les stratégies internes augmentent la probabilité d'innovation, notamment dans le cas des produits. Les stratégies externes augmentent la probabilité d'innovation, notamment dans le cas des procédés. Dans une stratégie mixte, il existe une complémentarité des deux résultats en termes d'innovation. Plus précisément, nous constatons qu'une stratégie "Créer&Acheter" enregistre l'impact positif le plus fort sur la probabilité d'innovation de produits d'une entreprise, suivie ensuite par la stratégie "Uniquement créer" puis "Uniquement acheter". Les entreprises ayant introduit une stratégie duale de R&D ou une stratégie "Créer&Acheter" ont une probabilité 0,52 supérieure de parvenir à une innovation de produit par rapport à celles n'ayant pas introduit de stratégies d'innovation. Dans le cas des entreprises ayant introduit les stratégies "Uniquement créer" et "Uniquement acheter", l'augmentation de la probabilité d'une innovation de produits est respectivement d'environ 0,37 et 0,25.

D'autre part, si nous tenons compte des résultats en termes d'innovation de procédés, nous observons également que la stratégie "Créer&Acheter" enregistre l'impact positif le plus fort sur la probabilité d'innovation de procédés d'une entreprise, suivie par la stratégie "Uniquement acheter" puis "Uniquement créer". Les entreprises ayant introduit une stratégie d'innovation "Créer&Acheter" ont une probabilité 0,45 supérieure de parvenir à une innovation de procédés par rapport à celles n'ayant pas introduit de stratégies d'innovation; dans le cas des entreprises ayant introduit des stratégies "Uniquement acheter" et "Uniquement créer", l'augmentation de la probabilité d'une innovation de procédés est respectivement d'environ 0,38 et 0,28.

Pour résumer, l'importation ou l'achat de technologies semble avoir un impact important sur la probabilité d'innovation de procédés, alors que le développement de ses propres technologies semble être davantage associé à l'innovation de produits. En outre, si les entreprises mettent parallèlement en œuvre des stratégies internes et externes d'innovation en R&D, celles-ci peuvent être davantage considérées comme complémentaires que comme substitutives. Les entreprises en mesure de combiner les deux stratégies enregistrent l'impact positif le plus important en termes de probabilité d'innovation de produit mais aussi de procédés. La productivité de chaque stratégie augmente en cas de mise en œuvre simultanée.



Inversement, notre quatrième hypothèse est rejetée. Les stratégies d'innovation n'ont pas d'influence positive sur la productivité des entreprises. Sur le plan statistique, les activités externes de R&D ou les stratégies mixtes de R&D n'ont pas d'impact important sur la productivité des entreprises. Le développement d'activités internes de R&D a un impact négatif sur la productivité des entreprises chiliennes. Cependant, cet impact négatif évolue si l'on examine un autre facteur de mesure des performances des entreprises, comme la croissance des ventes. Dans ce cas, nous observons même qu'il n'existe pas d'impact important, sur le plan statistique, des activités internes de R&D sur la croissance des ventes des entreprises chiliennes. Cela suggère qu'il serait préférable d'utiliser un meilleur indicateur de la productivité des entreprises, tel que la productivité du travail ou la valeur ajoutée. En outre, même si nous sommes en mesure d'observer les entreprises sur une certaine durée, notre période d'analyse est trop courte; il serait sans doute nécessaire de l'allonger pour observer une évolution de la productivité des entreprises.

Comme mentionné précédemment, l'estimation logit conditionnelle des effets fixes de données de panels économétriques permet de tenir compte d'effets spécifiques à certaines entreprises non étudiés jusqu'à présent mais susceptibles de biaiser les résultats. Cependant, l'une des limites de ce chapitre est l'absence de prise en compte de certaines caractéristiques des entreprises, telles que les mécanismes de crédit et les expériences managériales. En outre, même si nous étudions les entreprises sur plusieurs années, la majorité de nos entreprises ne sont analysées que sur deux périodes de l'enquête. Une plus longue période d'analyse est nécessaire pour obtenir une meilleure perspective des dynamiques d'innovation dans l'économie chilienne.

Les conclusions du deuxième chapitre de cette thèse plaident en faveur d'un soutien massif aux investissements en R&D comme facteur clé de l'agenda du développement du gouvernement chilien. Les stratégies internes et externes de R&D devraient être encouragées, mais les responsables politiques devraient aussi souligner le rôle et les avantages d'une stratégie mixte de R&D, car l'intensité et le choix de la stratégie d'investissement en R&D peuvent être déterminants pour l'avenir des entreprises. Il est donc crucial d'améliorer l'analyse et l'exploitation des sources des entreprises pour profiter du cercle vertueux de l'innovation.

### **Chapitre 3:**

## **Coopération en matière de R&D, innovation et performance des entreprises: le cas du Chili en 2009-2016**

Le troisième chapitre porte à nouveau sur l'économie chilienne, mais nous nous intéressons ici aux coopérations ou alliances en matière de R&D. Ces coopérations ou alliances inter-entreprises en matière de R&D ont fortement augmenté dans les années 1990, notamment pour les technologies en plein essor. Par ailleurs, cette augmentation du nombre d'alliances s'observe non seulement dans les pays développés mais aussi dans ceux en développement. Les entreprises utilisent la coopération en matière de R&D pour compléter leur technologie interne. Les entreprises ne peuvent plus innover seules mais elles devraient instaurer des coopérations en matière de R&D pour améliorer la gestion et le contrôle des ressources (Belderbos et al., 2004 ; Becker et al. 2004).

Les responsables politiques chiliens, conscients de l'importance de la collaboration en matière de R&D pour le développement de l'innovation des entreprises, encouragent aussi cette collaboration par le biais de certains programmes publics comme le Fonds pour la promotion du développement scientifique et technologique (FONDEF). La collaboration en matière de R&D avec des institutions de recherche augmente les performances des entreprises chiliennes. En outre, certaines entreprises proches en termes géographiques et technologiques bénéficient d'effets d'entraînement. Nous observons que la collaboration en termes de R&D

promet un avenir meilleur en termes d'innovation aux entreprises mettant en œuvre des alliances en matière de R&D, mais aussi à leurs voisins (Crespi et al., 2020).

Les entreprises collaborant en matière de R&D augmentent leurs capacités d'exploitation et d'organisation des sources internes. Un certain nombre de raisons, telles que le coût et le risque de certains projets, certaines compétences, des opportunités d'accès à des ressources de plus hautes technologies, une amélioration des réseaux mondiaux en termes de R&D ainsi que les avantages des effets indirects de la coopération en matière de R&D, peuvent aussi expliquer pourquoi certaines entreprises choisissent de plus en plus de coopérer en matière de R&D plutôt que d'avancer seules (Crespi et al., 2020).

Mais la coopération en matière de R&D implique aussi que les entreprises soient prêtes: elles ont besoin d'une certaine structure et d'une certaine expertise pour tirer profit de cette coopération en matière de R&D, qui génère elle-même des coûts d'adaptation pour la coordination, la gestion et le contrôle par exemple. Aujourd'hui, les entreprises sont confrontées à la question stratégique suivante: faut-il ou non s'engager dans une coopération en matière de R&D et quel partenaire choisir ? Si les avantages de ces alliances sont plus importants que les coûts, alors les entreprises optent pour l'alliance en matière d'innovation (Becker & Dietz, 2004 ; Aschhoff & Schmidt, 2008).

De ce fait, dans ce troisième chapitre, nous cherchons principalement à étudier les conséquences de la coopération en matière de R&D sur la performance des entreprises chiliennes, à la fois en termes d'innovation et de productivité. Par ailleurs, en tenant compte de l'hétérogénéité de la coopération en matière de R&D, nous recherchons aussi les conséquences des différents types de coopération en matière de R&D sur l'innovation des entreprises chiliennes. Dans cette analyse, nous envisageons cinq types de coopération en matière de R&D (les concurrents, les consommateurs, les fournisseurs, les institutions et les universités). Ensuite, nous passons à l'étape ultérieure et envisageons deux autres classifications des partenaires de coopération en matière de R&D: 1) la position de la connaissance dans la chaîne industrielle et 2) la distance de la connaissance entre les entreprises et les partenaires. Pour résumer, nous étudions les trois hypothèses suivantes:

- Premièrement, la coopération en matière de R&D a une incidence positive et significative sur la probabilité d'innovation.
- Deuxièmement, l'impact de la coopération en matière de R&D sur l'innovation varie en fonction des partenaires de coopération en termes de R&D.
- Troisièmement, il existe un impact positif de la coopération en matière de R&D sur la productivité des entreprises.

Ce chapitre contribue à la littérature microéconomique empirique en examinant le rôle et l'impact des différents types de coopération en matière de R&D sur les performances des entreprises chiliennes, à la fois en termes d'innovation et de productivité. Nous analysons des données de panel qui nous aident à contrôler l'endogénéité potentielle et les effets spécifiques à certaines entreprises non étudiés jusqu'à présent, mais certaines caractéristiques des entreprises, telles que la taille et le secteur manufacturier, sont également prises en compte dans l'analyse.

La méthodologie utilisée pour ce chapitre est un modèle de probabilité linéaire avec des effets fixes sur la période 2009-2016. Les données utilisées proviennent d'une combinaison de différentes enquêtes intitulées Encuesta de Innovacion en Empresa (ENI) [Enquêtes sur l'innovation des entreprises] et élaborées par

l'Instituto Nacional de Estadística (INE) [Institut national de la statistique]. Il s'agit des mêmes données que celles utilisées au chapitre 2 de la présente thèse. Mais nous devons redéfinir ici notre échantillon dans la mesure où les entreprises répondant à la question de l'innovation sont uniquement celles répondant aux questions relatives aux alliances en matière d'innovation. L'échantillon est en outre limité aux entreprises manufacturières chiliennes; nous aboutissons à un échantillon final de 736 entreprises chiliennes entre 2009 et 2016. Le choix du secteur manufacturier s'explique par son poids dans le PIB (un tiers du PIB chilien).

Après l'analyse empirique, nous avons trouvé dans ce chapitre des éléments de preuve confirmant notre première hypothèse. La coopération en matière de R&D augmente la probabilité d'une innovation de produits ou de procédés. L'effet positif de la coopération en matière de R&D semble plus fort en termes d'innovation de produits, dont l'aboutissement nécessite souvent recherche et processus de brevetage en raison de son degré élevé de nouveauté. Les entreprises coopérant en matière de R&D sont davantage susceptibles d'innovation de produits ou de procédés (respectivement 0.158 et 0.146) que les entreprises sans alliance en termes d'innovation. Si l'on examine notre deuxième hypothèse, relative aux différents types de coopération en matière de R&D étudiés dans cette analyse (concurrents, consommateurs, fournisseurs, institutions et universités), nous observons qu'il n'y a pas d'impact majeur sur les performances d'innovation. Si nous étudions la coopération en matière de R&D avec des partenaires ayant des connaissances avancées, tels que les universités et les fournisseurs, nous constatons que ce partenariat en matière de R&D a un impact positif sur le processus d'innovation alors que la coopération en matière de R&D avec des partenaires ayant des connaissances moindres, tels que les consommateurs et les concurrents, peut réduire la probabilité d'innovation de produits, certains intérêts privés étant susceptibles de limiter le transfert de connaissance. Enfin, notre troisième hypothèse est rejetée. La coopération en matière de R&D n'affecte pas la productivité.

Il existe peu de preuves empiriques relatives à la coopération en matière de R&D, notamment pour les pays en développement. Dans ce chapitre, nous offrons une première perspective sur la coopération en matière de R&D pour les entreprises manufacturières chiliennes. Même si nous sommes en mesure d'observer les entreprises au fil du temps, notre période d'analyse reste trop courte. En outre, l'une des principales limites de ce chapitre est la taille de l'échantillon (restreint à moins de 1 000 entreprises). Seules les entreprises innovantes disposent d'informations relatives à leur degré de coopération en matière de R&D, ce qui peut générer de potentiels problèmes de biais dans l'échantillon. De ce fait, lors de travaux de recherche ultérieurs, il est recommandé d'établir une base de données sur une période plus longue.

Les résultats de cette thèse plaident fortement en faveur de la promotion du réseau et des relations entre les entreprises et les partenaires, qui constituent le principal facteur du succès d'une entreprise. Les responsables politiques devraient se concentrer sur le développement d'instruments permettant aux entreprises de tirer profit des avantages des caractéristiques des partenaires d'innovation en termes de connaissance, de géographie et de culture.

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## Part 2

# Chapter I: Chinese opening-up and Premature Deindustrialization in Latin American Countries: empirical evidence 1995-2016<sup>1</sup>

## 2.3 Introduction

During the last third of the 20th century, a shift towards a post-industrial era has been observed in developed countries. Economies have been moving from manufacturing to service activities, generating a falling in shares of both manufacturing employment and output, a process known as deindustrialization. More recently, a similar pattern of structural change has been occurring for developing countries as well.

According to Kuznets (1973), deindustrialization is one element characterizing any process of modern growth: manufacturing sector grows, absorbing workforce from a shrinking primary sector, reaches a peak and starts to decrease in favor of the service sector. The main explanation would be the increasing productivity of manufacturing sector that combine with some features of the demand, can explain such a path observed in developed countries.

However, Latin American countries (LAC) and other emerging economies have observed reduction of their manufacturing share starting early (i.e. lower income per capita level), and at a lower level of manufacturing share peak compared to what historically observed for developed countries. For instance, European (e.g. Great Britain, Sweden, and Italy) and some Asian countries (e.g. Japan and South Korea) have reached the turning point of manufacturing share of employment in correspondence of a GDP per capita around USD 10,000-15,000, while Latin American countries such as Argentina, Brazil, Chile and Mexico have reached the turning-point in correspondence of a GDP per capita between USD 5,000 and USD 7,000 (Rodrik, 2016; Castillo and Martins Neto, 2016).

This phenomenon characterizing developing economies has been labelled as premature deindustrialization. The determinants of premature deindustrialization are considered peculiar as well (Rodrik, 2016). Structural change literature has been traditionally focusing on developed countries and privileged a closed-economic approach: the main determinants are identified in local supply (i.e. productivity differential between sectors, e.g. Baumol, 1967) and/or local demand (i.e. Engels curve, e.g. Ngai and Pissarides, 2007). While, for premature deindustrialization, the main determinant of the structural change would be the dynamic of local productivity compared with that of international competitors. Therefore, trade is identified as a key determinant for the structural change of developing economies.

However, since the literature has focused mainly on developed economies, the role of external factors, such as trade, have been neglected or barely explored, especially theoretically till recently. A first exception for theoretical approach is the model proposed by Matsuyama (2009), while for empirical analysis the first seminal contribution is an article by Rowthorn and Ramaswamy (1999). Other works adopting an open-economy perspective have followed these two, but still the majority of the them has been focusing on developed economies.

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<sup>1</sup>This chapter is developed with Lorenzo Cassi

More recently, Rodrik (2016) has proposed a simple open-economy model in order to analyze the effect of trade and technology on deindustrialization. According to his analysis, developing economies, specialized in price-taker market (e.g. textile), could suffer of deindustrialization if they are not able to improve productivity at the same rate of international competitors: the decrease of international price can imply deindustrialization if a country is not able to keep the path of others. Countries risk importing deindustrialization, both in terms of employment and output.

If Rodrik model has provided a theoretical explanation of the different role that trade could have for developing countries and for developed ones, complementary empirical evidence is still missing. Till now, the empirical analysis (e.g. Kruse et al., 2021) has more focused on how much and for which countries the premature deindustrializing hypothesis is verified than analyzing the determinants of this type of deindustrialization for those where is verified. Some interesting exceptions exist (e.g. Jenkins, 2015), but they lack of systematic empirical evidence.

The aim of this chapter is to empirically analyze the effect of international competition on the deindustrialization path of Latin American countries. In particular, we are interested in analyzing how the increase of competitors, such as China, has affected manufacturing share. We intend to distinguish two possible effects of Chinese increasing competition: (i) the effect of Chinese trade on meeting local needs, and (ii) the effect of Chinese trade competition on main foreign trade partners of Latin American countries. The former effect is a direct one, the latter is an indirect one because it depends on how much the LA trade partners are affected by Chinese penetration.

To our knowledge, our paper is one of the first empirical studies that explores a panel dataset to examine jointly direct and indirect effects of Chinese trade on Latin American deindustrialization. To do that, we have used country-sector panel data allows controlling for potential endogeneity and unobserved country and sector specific effects. Moreover, the sector-country unity of analysis helps us to deal with great heterogeneity across LAC.

The dataset developed combines four sources of data: the INDSTAT 2020, UNIDO dataset for manufacturing sector, CHELEM-CEPII dataset for trade data, World Bank database for country information, and finally Bruegel Datasets for exchange rate data. The obtained dataset consists of an unbalanced panel data at a sector-country level: it covers 22 manufacturing sectors of the main economies of LA, over the period 1995-2016. We performed a random and fixed panel estimation, and dealt with endogeneity issues with an IV approach.

Results show there is a negative effect of Chinese trade penetration in local manufacturing employment and output. Chinese opening-up, i.e. a proxy of globalization, is one of the reasons behind the downward shift in manufacturing shares over time for LAC. This effect is by replacing local product by Chinese imports. Moreover, the indirect effect is at work only for those sectors where countries are specialized and more interestingly is observed only in the case of employment: the level of output is not affected. The interpretation of this result is key in order to design policy implications and deserve further inquiries.

The rest of the chapter is organized as follows: Section 2 reviews the relevant literature and presents our interpretive framework and the following hypothesis. Section 3 discusses the data and methods, with particular focus on how to measure the effect of globalization. Section 4 presents the results and Section 5 concludes.

## 2.4 Premature deindustrialization in perspective

Premature deindustrialization is a phenomenon characterizing many developing countries. Even if a vivid debate concerns which group of countries are suffering of this, empirical literature (Kreuse et al, 2021) seems to agree that LAC are “perfect” example of this: many of them have started to deindustrialize sooner and at a lower level than modern growth (Kuznets, 1973) should require. The aim of this section is to contextualize our research question. In order to do that, we start defining more precisely the concept of premature deindustrialization and to grasp both positive and normative dimensions, then we present the main determinants with a specific focus on the role of trade and on LAC. In the final part of the section, we present our framework and the hypothesis we intend to test.

### 2.4.1 Premature deindustrialization: history of concept

Nowadays, a shift towards a post-industrial era has been observed in both developed and developing countries, in which economic growth is based on services rather than the production of goods and manufactures: a process known as deindustrialization. Deindustrialization is defined as the process of falling continuously of shares of manufacturing employment in total employment (Rowthorn & Ramaswamy, 1999), or when manufacturing loses relevance within the production and employment creation of the country’s economy (Tregenna, 2011).

Manufacturing share in terms of both employment and output normally follows an inverted U-shaped path over the course of economic development. Countries starts to develop a manufacturing industry until it reaches a peak point, then it starts to decrease to move into services activities. For some developing countries, deindustrialization process has been occurring at a lower income peak level than early-industrialized countries. For instance, western European countries, such as Great Britain, Sweden, and Italy, and some Asian countries, such as Japan and South Korea, have reached the turning point of manufacturing share at a level of GDP per capita income around USD10,000-15,000. Latin American countries, for instance: Argentina, Brazil, Chile and Mexico, have reached their manufacturing peak in correspondence of a much lower GDP per capita, around USD 5,000-7,000 (Rodrik, 2016; Castillo & Martins Neto, 2016).

Developing countries are undergoing a process of premature deindustrialization. Those countries are going toward service economies without having experienced the total process of manufacturing that developed countries had. Premature deindustrialization may be detrimental to the economic growth for developing countries because they are losing the different benefits of a proper manufacturing process, i.e. a modern growth à la Kuznets.

Manufacturing is a dynamic sector that offers opportunities for technological spillovers effects and therefore catch-up. Moreover, manufacturing offers a strong unconditional labor productivity convergence, industries that start at lower levels of labor productivity experience more rapid growth. In addition, this industry can absorb unskilled workers who are not absorbed in typically highly skill-intensive sectors such as service. The fact of moving workers to manufacturing activities and taking them away from agriculture -basic activities- improves the economic growth. Finally, manufacturing is a tradable sector, products can sell to foreign markets which allow producers to overcome home market restrictions (e.g. size of internal demand), in other words, when the economy is stagnant the manufacturing sector can absorb workers through selling goods to foreign markets. All of this explain why the term premature should interpreted not only in positive terms but also in normative one: manufacturing can be considered as the engine of growth.

If some countries are suffering of premature deindustrialization, it is debated that all the developing countries are affected. A recent analysis (Kruse et al., 2021) based a new dataset (GGDC/UNU-WIDER Economic Transformation Database for 12 sectors in 51 countries between 1990 to 2018) has raise some issues about Rodrik’s empirical conclusions (2016). The new evidence has confirmed that the great majority of developing countries have been showing a deindustrialization trend until the early 2000s as argued, but Kruse and co-authors evidence has shown as well that more recently this trend has been reversed in the case of some Asian and sub-Saharan African countries due to the rise of small unregistered manufacturing firms. This makes the authors talking about manufacturing renaissance for those countries. However, this new evidence has confirmed the of premature deindustrialization process characterizing the LAC and that makes our analysis even more meaningful.

#### 2.4.2 Premature deindustrialization: the determinants

Deindustrialization is part of the development process, characterizing modern growth (Kuznets, 1973). As potential drivers of deindustrialization, economic literature considers both internal and external factors. Internal factors such as sectoral differences in labor productivity have been identified as main reason of deindustrialization in advanced economies. When output growth is about the same in both sectors manufacturing and services, lower productivity in service sectors makes this sector to absorb work-force. Less productive sectors develop a greater demand for workers which makes salaries more attractive-increasing the production costs and the relative prices. Consequently, a substitution of labor by capital known as labor-saving is observed in the more dynamic sector (Baumol, 1967; Rowthorn & Ramaswany, 1999).

Another internal factor is related to domestic issue also known as non-homothetic preferences where an income effect is observed. The patterns of demand changes as a function of income levels: as income increases, consumption of service increasing making, on share consumption of service more and more important and symmetrically manufacturing goods consumption share become less and less important. As countries develop, there is a shift of demand from manufacturing toward services (Van Neuss, 2018). Moreover, another internal factor is intermediate goods. Many manufacturing have increased outsourcing to specialized services such as cleaning, design, among others or to low-wage regions looking for becoming more flexible and more cost-efficient. generates a reallocation of activities in favor of services (Berlingieri, 2014). The downward shift in manufacturing shares due to this outsourcing is positively related to ratio of intermediates to gross output in manufacturing (Kollmeyer, 2009).

Concerning the external factors: trade and globalization. Exporters with a greater comparative advantage get more benefits from globalization, reflecting the role of relative prices. Developed countries have experienced a big loss of employment, especially from low-skill workers. However, they have good levels of manufacturing output shares at constant prices, due to globalization and labor-saving technological progress in manufacturing which is not the case for developing countries (Rowthorn & Ramaswany, 1999; Rodrik, 2016). As developing countries are opened up to trade, they face the restriction of being price takers from the world market, become net importers of manufacturing, reversing the process of import-substitution. Developing countries import cheap labor-intensive manufacturing from the world market that displaces more local workers than their value added. According to this, internal factors above described play a key role behind the deindustrialization in developed economies, but trade and globalization may be the reason behind deindustrialization in developing economies, especially for countries with low comparative advantage (Rodrik, 2016).

Premature deindustrialization, observed in developing countries, is mainly explained by globalization and trade. A phenomenon specially observed after China’s transition to a market-oriented economy, through the country’s accession to the WTO in 2001 and several internal policy changes that generate a huge growth in productivity and investment, ranked nowadays China as the second largest economy in the world.



But why China is affecting premature deindustrialization in Latin American Countries? Chinese competition distinguishes from other low-wages countries for three reasons. First, dominant Chinese labor abundance in the world trade flows. Second, Chinese exports competition have lower prices compared to countries with similar income per capita. Finally, Chinese exports products are more sophisticated than other competitors. According to this, Chinese competition may exercise more pressure than other countries with similar income (Álvarez & Claro, 2009). Literature suggests both a direct and indirect effect of Chinese penetration in trade on premature deindustrialization in Latin America Countries. Chinese industries access to foreign technologies, capital, intermediate goods, higher productivity and lower trade barriers have impact manufacturing employment in the LAC region. Latin American countries are unable to escape from Chinese competition and to shift their production to more sophisticated and competitive goods. This is generating the exit of many firms (Álvarez & Claro, 2009).

The direct effect is related to the impact of Chinese import manufacturing goods in local- economies and this effect is mainly observed in developed economies. Exploring the US local labor markets through the use of UN Comtrade Database on US imports between 1990 and 2007, a 2SLS estimation Autor and co-authors(2016) found Chinese import competition having a negative impact on local labor markets (manufacturing employment) To deal with endogeneity issue, the authors use as instrument of USA imports from China: changes in Chinese imports by other similar high-income countries. Moreover, Chinese imports generate also a decline in wages outside of the manufacturing sector. Generating a decrease in both employment and wage levels implies a reduction of average earnings of households. The negative effect of Chinese import is stronger in sectors more exposed to foreign competition, moreover the expected employments gain in other no-tradable sectors or export oriented products is still not taking place yet, highlighting the role of the mobility cost and the fact that short-run trade gains are probably lower than long-run trade gain.

By using the US Census micro data to analyze job creation and destruction margins of local labor markets, Bloom et co-authors et al., (2019) found no evidence that Chinese import competition generated unemployment. The negative impact of Chinese imports between from 2000 to 2007, seems to disappear after 2007. Authors instrument the changes in U.S. imports from China with Chinese exports to eight other developed countries. Jobs and survival rate fell in low technological firms with high human capital areas that are more exposed to Chinese competition but high technological firms that are more protected are experiencing larger gain in service employment. Most of manufacturing job losses are in large, multinational firms, firms that are moving or expanding their activities to services. The negative effect of manufacturing job losses is offset by the gains in service employment so at the end there is no evidence of a negative impact of Chinese imports in the US employment market but it highlights the reorganization of activities across establishments, firms, industries and local economies. Moreover, working with panel data from 18 countries in the OECD between 1970 and 2003 and a FE-2GLS estimation, Kollmeyer (2009) found that liberalization of trade regulations has two main impacts on employment growth in advanced economics: direct and an induced one. The imbalance between two trade coefficients (imports and exports) use as measure of direct effect suggest a displacement of workers greater than the creation of new jobs. However, the strongest impact is observed for the induced effect due to more spending of additional consumer's incomes devoted to services. Again, this pattern is more likely to be observed in more economically advanced countries.

On the other hand, there is an indirect effect of Chinese trade due to China's penetration of foreign or third markets. In 2000, before Chinese opening-Chinese exports to USA were less than 8% from total USA imports but in 2016 Chinese share of total USA imports is about 21%. Ranking China as the main trade provider of USA. United States is also one of the most important trade destination for Latin American countries, even though considering some fluctuations the trade flows have been increasing. What is interesting to notice is that Latin American share of total USA imports has decreased from about 5, 9% to 4, 9% between 2001 and 2016.

Is Latin American ready to face key challenges of China's role at global markets? By using a Mexican export processing plants plant-level data set from 1990 to 2006 and incorporating Chinese import penetration to high-income countries as instrument of Chinese imports in the US market, Utar & Torres Ruiz, 2013 found that employment in Mexican maquiladoras has a negative relationship with Chinese competition in the US market (considering US maquila companies in Mexico). In other words, China is affecting the slowdown on employment and plant growth of Mexican maquiladora industry, this effect is stronger in unskilled labor intensive sectors, highlighting the role of reallocation across sectors. Moreover, Chinese competition has also a negative impact on plant growths, entry and survival probabilities. Furthermore, considering skill-intensity and plant productivity, authors found Chinese competition with low-wage is related to higher productivity in Mexican Maquiladoras, helping to move up in the global production chain.

By using manufacturing imports database over the period 1995 to 2005 for 40 manufacturing exports industries and 10 developing countries exporters and a gravity estimation, Robertson and Hanson (2008) found Chinese manufacturing competition has a small negative impact on developing manufacturing oriented countries. In other words, Chinese competition is producing a decrease in demand for the other developing countries' a exporting products (Robertson & Hanson, 2008). Moreover, for most specialized countries in export manufacturing even though the observed similarities in export patterns with China the negative shock is modest. Moreover, Jenkins (2015) found for Brazil there were direct and indirect negative impacts of Chinese (main trade partner of Brazil and big investor in the Brazilian oil and gas and in mining sector) trade penetration on the Brazilian deindustrialization between 1995 and 2012. Here deindustrialization is measured as the share of the manufacturing sector in gross domestic product. The main loss in manufacturing comes from a large trade deficit in manufactures with not changes in changes in demand or relative productivity growth (direct effect). Chinese competition is affecting domestic and export products. Here, the indirect effect comes from an increase in the demand of Brazilian primary products by China, increasing prices of Brazilian commodities and the real exchange rate (changing the export structure). As a consequence, Jenkins suggests to re-embrace exchange rate and industrial policies to make Brazilian industry more competitive at the global market.

### 2.4.3 Premature deindustrialization in LAC

In this subsection, we give a general view about trade pattern and deindustrialization for Latin American countries (LAC) once considering Chinese trade competition. Deindustrialization is measured by manufacturing employment and valued added. Our sample consider: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru and Uruguay between 1995 and 2016. We focus our analysis with most trade open economies such us Mexico and Chile, followed by most conservative countries such as Colombia, Brazil and Argentina.<sup>23</sup>

#### Mexican Case

Mexico is probably one of the most affected countries by China's reform and opening-up. Due to NAFTA that gives Mexico comparative advantage in the export of labor intensive goods, Mexico was the second main import's providers of USA just after Canada. However, nowadays China overtook both Canada and Mexico, and became the main trade partner of USA. By using a Monthly Industrial Survey (EIM) data on Mexican plants that covers about 85% of all Mexican industrial output (maquiladoras are excluded) between 1994 to 2004 Iacovone and co-authors (2013) found Chinese exports having a negative impact on both the domes-

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<sup>2</sup>Trade openness is defined by TheGlobalEconomy.com such as: exports plus imports as percent of GDP in Latin America: The average for 2020.

<sup>3</sup>More details about trade and manufacturing behaviour for Ecuador, Peru and Uruguay in Annex 1.

tic market and third markets (USA). However, size and firm characteristics matter. For smaller and less productive firms, it is observed firms exit, product exit and sales contraction. This is not the case for large firms: it seems that larger firms are able to overcome the adverse effects of Chinese competition, and even to obtain benefits from cheaper imported Chinese intermediate products. This result highlights the role of intermediate goods benefits (i.e. being part of global value chain) and the heterogeneous results at firm level. Results suggest selection and reallocation at both firms and product levels as a key to productivity growth. Chinese penetration is measured as the share of Chinese imports in total imports to either the domestic market or the export market (USA). Moreover, to control for endogeneity authors use the Chinese share of EU imports and the Chinese share of the imports in all the rest of world.

Figure 1 shows after the opening of China in 2001, there is a rapid growth of trade flow between Mexico and China. Between 2001 and 2016 Mexican exports to China increased on average 21%. However, Mexico is experiencing an overwhelming trade manufacturing deficit with China. Manufacturing sectors with the largest trade deficit are: communication, computing and electrical machinery and apparatus. On the other hand, more than 50% of exports to China are mainly focused on raw materials and intermediate goods. Since Mexico was the second main import's providers of USA. Results suggest that China is affecting not only domestic production but also displacing exports.

Figure 1: Mexico vs China: Manufacturing Trade Flows in Millions USD

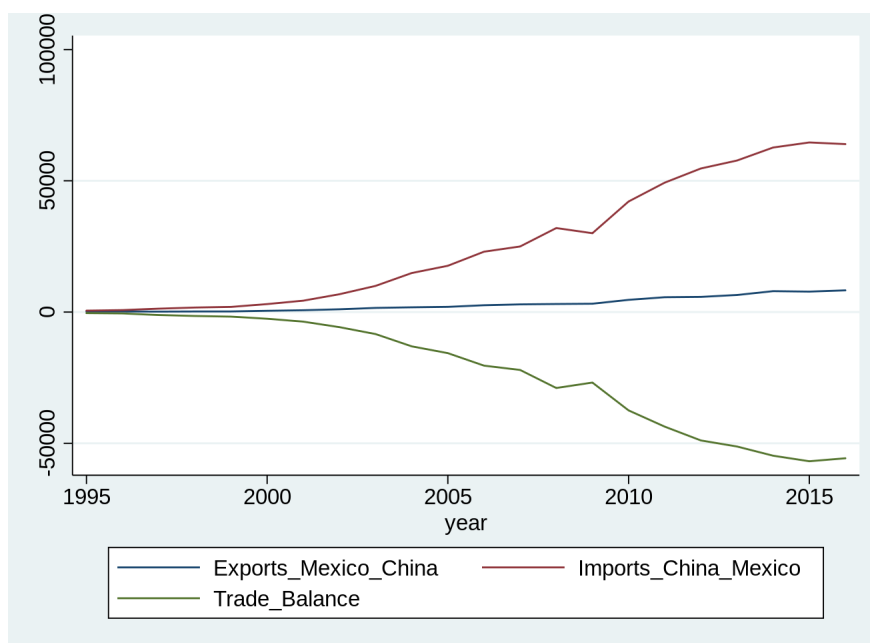


Figure 2 and 3 show the extent of Chinese import penetration in both domestic and foreign markets (direct and indirect effects indicators<sup>4</sup>) for top 3 Mexican manufacturing exporting sector to USA (motor vehicles and trailers; radio, TV and communication; electrical machinery and apparatus). We also include textiles due to the importance of Mexican Maquiladoras in USA-Mexico bilateral trade (more than 90% of maquiladora exports go to USA). We can appreciate a steadily increasing effect of both direct and indirect effect. Again, we observe this path has been accompanied by a reduction in the shares of manufacturing employment in total employment or manufacturing loses relevance within the production, except in the case of manufacturing employment and production for Motor, Vehicles and electrical machinery. However, it is important to highlight Mexican exports more auto-parts and electrical motors than vehicles. See Figure 4 and 5.

<sup>4</sup>The construction of these indicators is explained in the next section

Figure 2: Chinese import penetration in Mexican domestic market

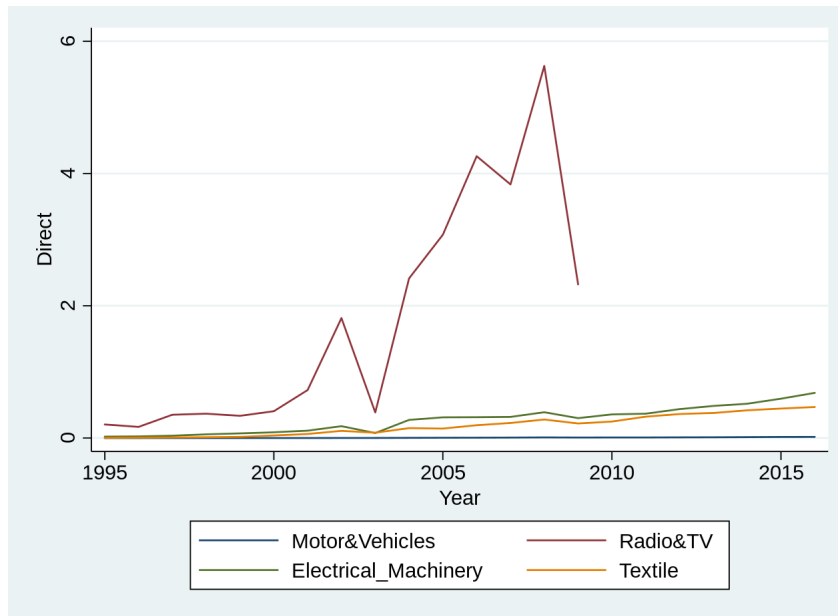


Figure 3: Chinese import penetration in Mexican exports main foreign destination markets

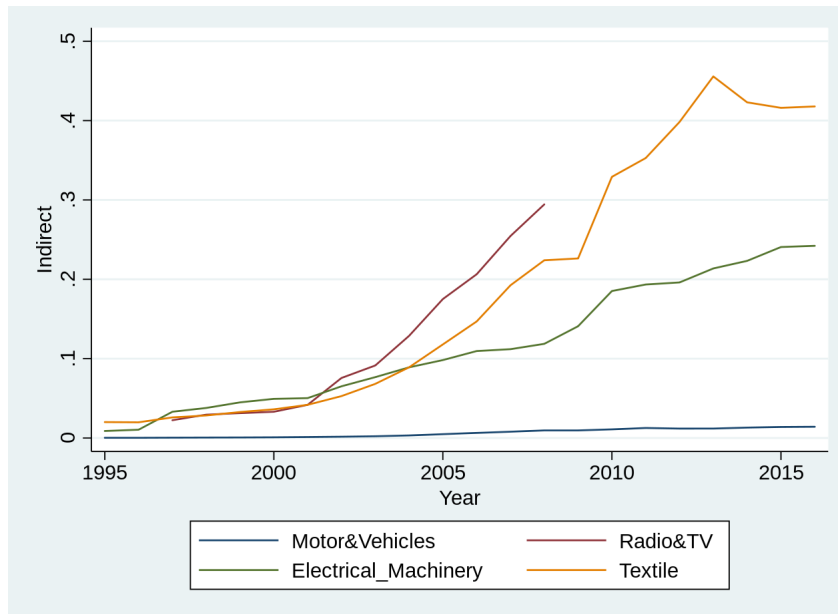


Figure 4: Mexican Manufacturing Employment

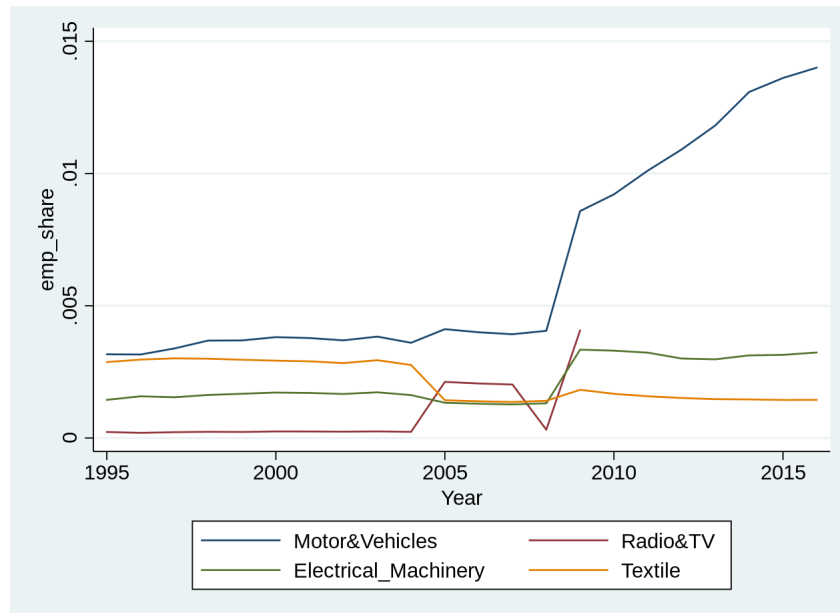
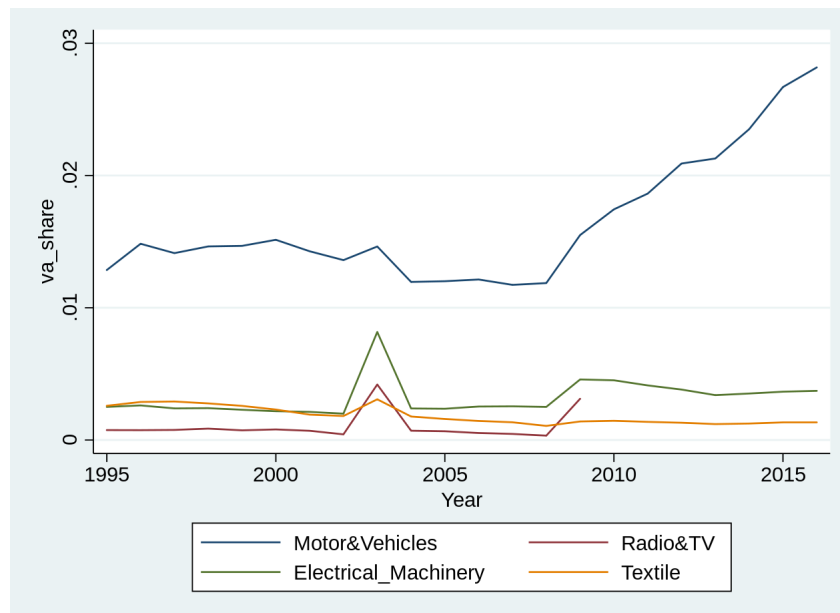


Figure 5: Mexican manufacturing relevance within the production



### Chilean case

Since 1990, Chile has established several measures to boost economic growth, such as international trade liberalization. Average GDP growth between 1995 and 2016 was about 4,2% partially explained due to Chile's main export markets. Ranking Chile among the high middle-income countries, with the highest GDP per capita in Latin America (14,777.15 USD in 2016). However, Chilean economy is mainly based on natural resources, suggesting a primarization of its export basket (López et al., 2007). By using a plant-level data from firms with 10 or more workers obtained from the Annual National Industrial Survey (ENIA)

mixed with a sector-level import data obtained from the UNIDO between the period of 1990 and 2000 Álvarez and Claro (2009) found that Chinese penetration has a negative impact on employment growth of Chilean plants. Moreover, Chinese competition increases the firms' probability of exit. Here, Chinese penetration is measured as the ratio between imports from China in a specific sector and year over the total of import plus domestic production minus Chilean exports. To control for potential endogeneity authors incorporate industry-specific productivity shocks and the interaction between minimum wage and industry plant characteristics. Authors concludes that Chilean firms are not responding to Chinese competition with upgrading changes in output, productivity or increase exports. Chinese competition is generating deindustrialization in Chile due to firm inability to produce more sophisticated goods.

Figure 6 shows that after 2001, there was a rapid growth of trade flow between Chile and China. Between 2001 and 2016, manufacturing exports from the South American country into China increased on average of 20 percent. Ranking China as the main destiny of Chilean exports (about 30% of total exports in 2016) overtaking USA as a main trade partner. This trade flow shows Chile has experienced a trade manufacturing deficit with China. Deficit that surpassed the surplus in natural-resource-based commodities such as cooper. The manufacturing sectors with the largest trade deficit are equipment related to communication, wearing apparel, and textiles. All this highlights the problem of Chilean exports competitiveness at the global market.

Figure 6: **Chile vs China: Manufacturing Trade Flows**

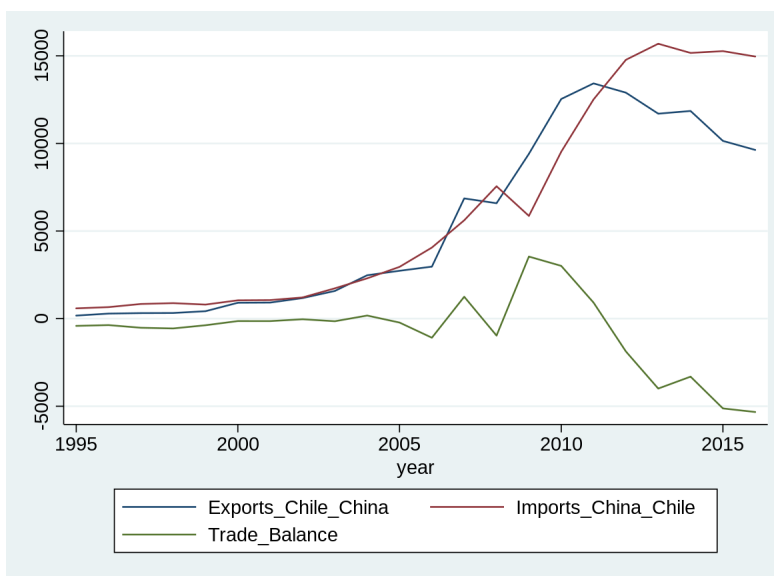


Figure 7 and 8 display the extent of Chinese import penetration in both domestic and foreign markets for top 3 Chilean manufacturing products exported to USA (basic metals, food products and beverages, wood). We can appreciate an increasing effect of Chinese trade flows. Moreover, this path has been accompanied by a reduction in the shares of manufacturing employment in total employment or manufacturing loses relevance within the production in the sectors mention, as shown by Figure 9 and 10.

Figure 7: Chinese import penetration in Chilean domestic market

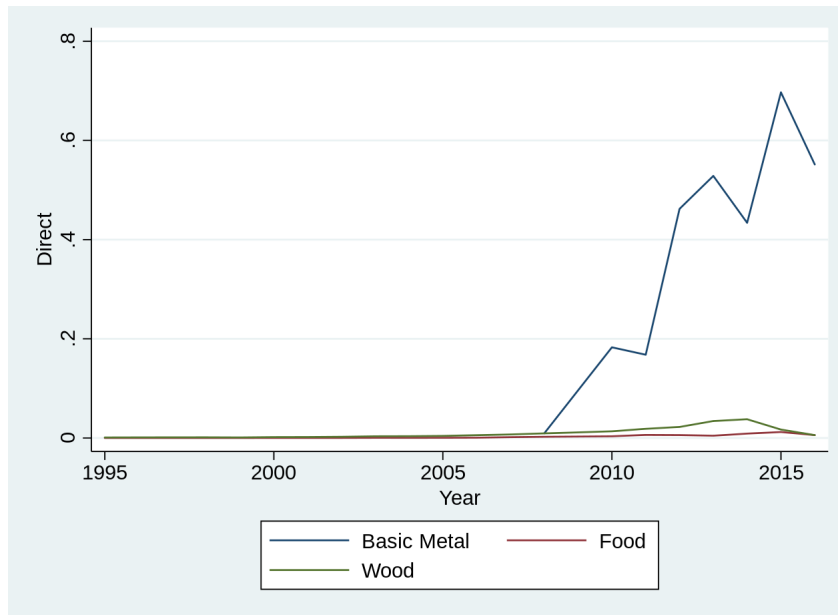


Figure 8: Chinese import penetration in Chilean exports main foreign destination markets

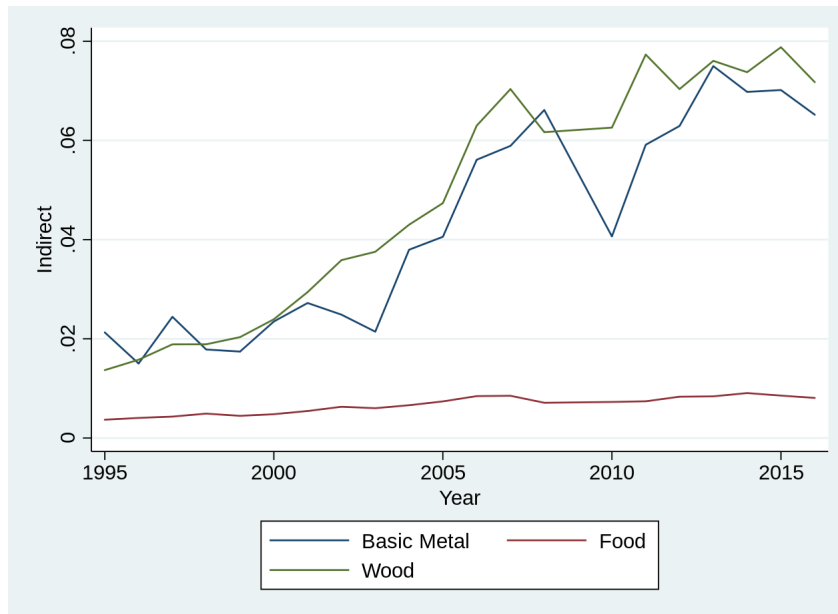


Figure 9: Chilean Manufacturing Employment

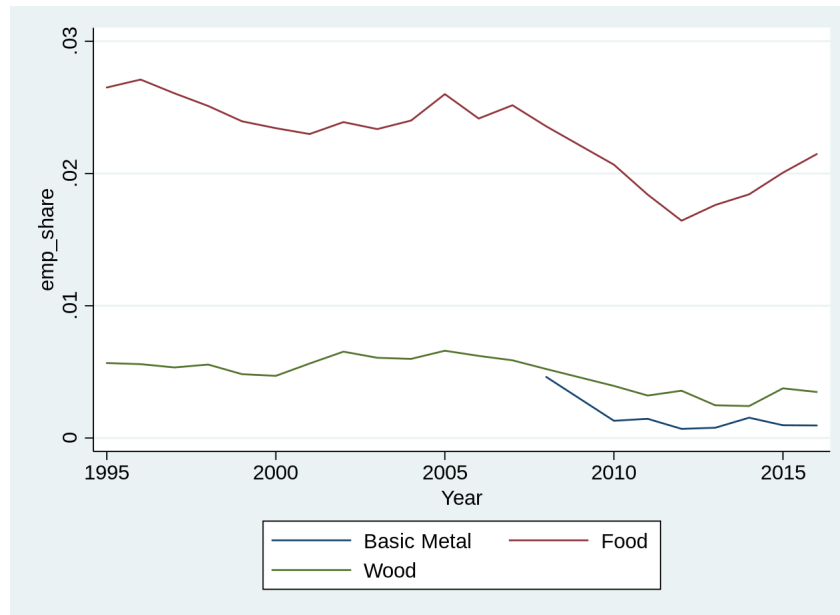
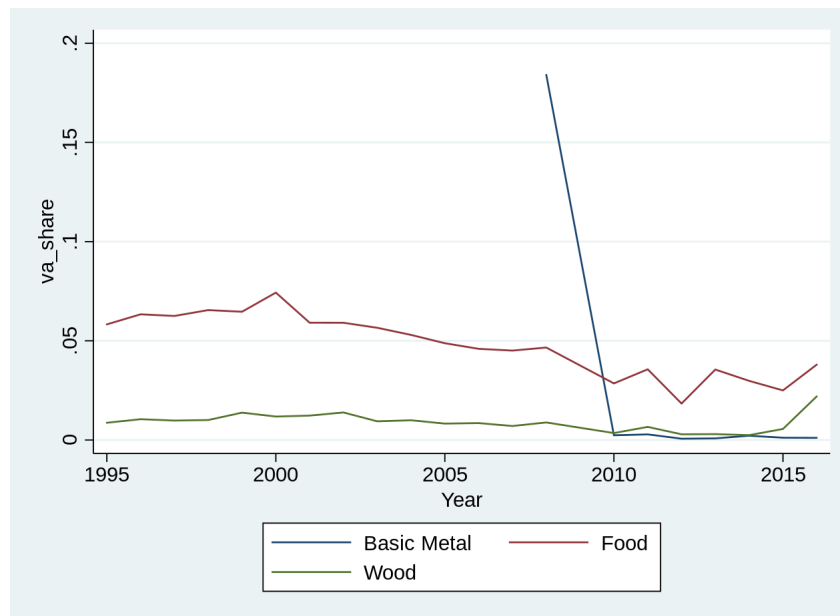


Figure 10: Chilean manufacturing relevance within the production



### Colombian Case

After 1991 Colombia has taken different measures to promote an economic liberalization, concerning foreign trade policy, exchange rate regime, capital flow controls, etc. These policies have been accompanied by an elimination of industrial promotion instruments. Nowadays, Colombia's exports are still based on natural resources, unable to produce industrial competitive manufacturer goods. Colombia has been experiencing a loss in industrial dynamism and experiencing a premature deindustrialization (Kassem, 2010). By using a sample for 14,022 firms-level data on manufacturers within 153 industries between 1996 and 2013 that



includes both formal and informal employment and a two-stage estimation approach, Molina (2020) found that Chinese penetration has a negative impact on the domestic market of Colombian firms (direct effect). Chinese penetration is measured by a sector's total value of imported goods from China over the total value of imported goods for a sector. To control for potential bias author incorporates a LAC's sector-specific import value coming from China over the total value of imported goods for a sector over LAC's sector-specific total import value. The obtained results show that future growth rates for employment, workforce composition, wages per employee, productivity, and domestic sales are going to be negatively affected by Chinese competition but there is not effect of Chinese shock on informal employment. On the other hand, in the case of indirect effect measure as Chinese share in import market penetration of the export market. Also for Colombia, USA is the most important export destination. There is negative effect of Chinese penetration on the current growth rate of exports, however this effect does not affect exports in the future.

Figure 11 shows a rapid growth of trade flow between Colombia and China. Between 2001 and 2016 Colombian exports to China have increased on average more than 30%. By 2018, China had already surpassed Panama as the Colombian's second most important destiny only behind USA. However, Colombia experiences an overwhelming trade manufacturing deficit with China. Deficit that surpassed the surplus in natural-resource-products such as metals, coke, refined petroleum products. The manufacturing sectors with the largest trade deficit are related to communication, computing, machinery and equipment.

Figure 11: **Colombia vs China: Manufacturing Trade Flows in Millions USD**

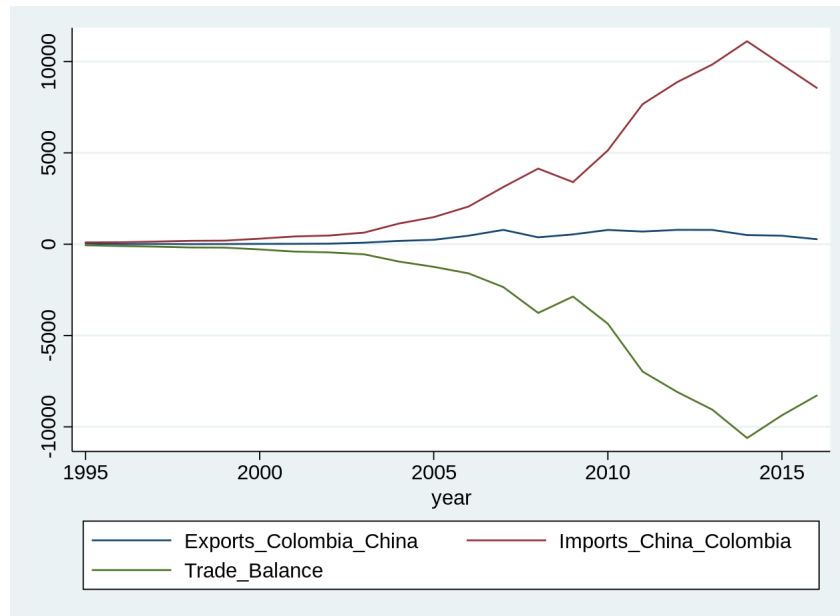


Figure 12 and 13 show the extent of Chinese import penetration in both domestic and foreign markets for top 3 Colombian manufacturing products exported to USA (Basic metals products; Coke, refined petroleum products and nuclear fuel; Food products and beverages). We can appreciate a steadily increasing effect of Chinese trade flows, a reduction in the shares of manufacturing employment in total employment or manufacturing loses relevance within the production in the sectors mention is observed (see Figure 14 and 15).

Figure 12: Chinese import penetration in Colombian domestic market

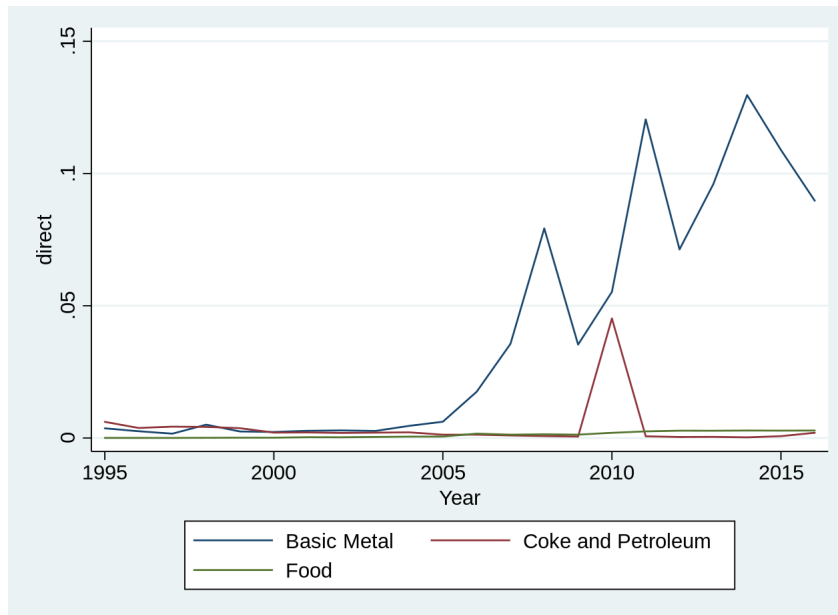


Figure 13: Chinese import penetration in Colombian exports main foreign destination markets

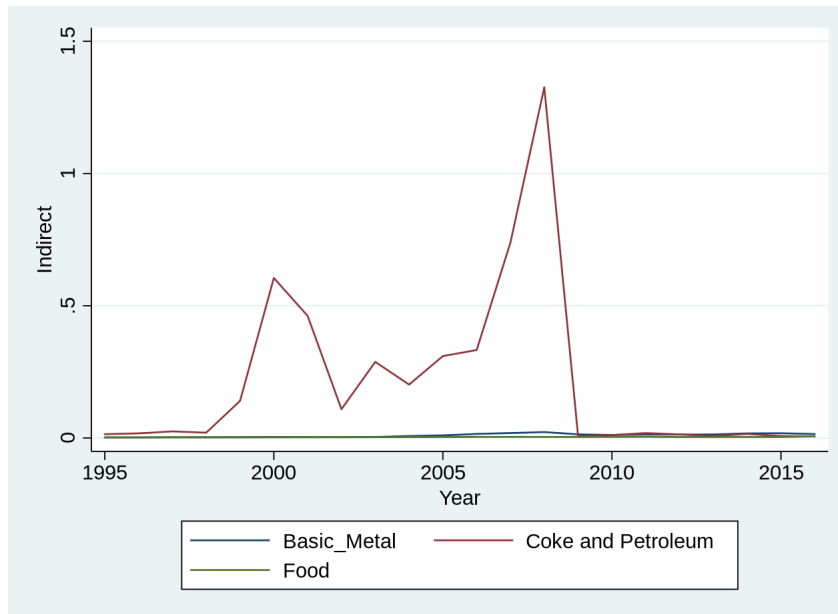


Figure 14: Colombian Manufacturing Employment

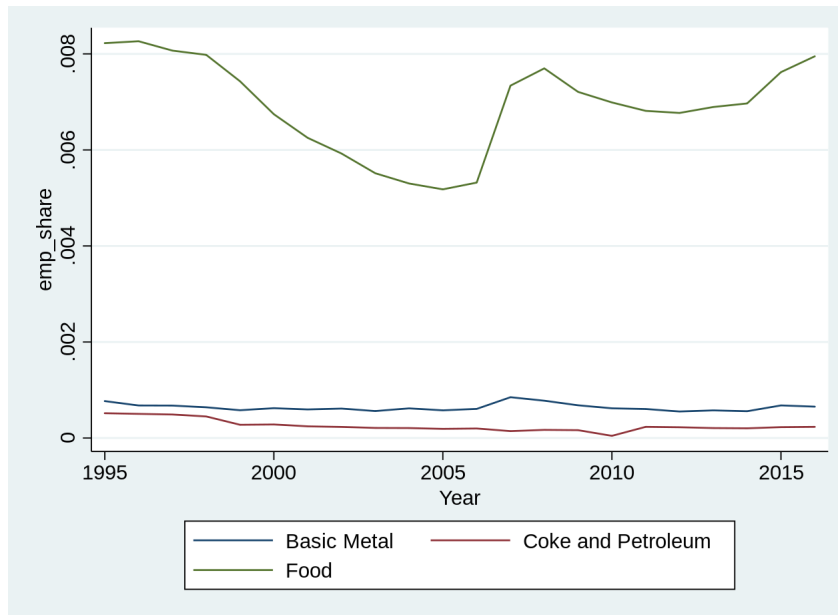
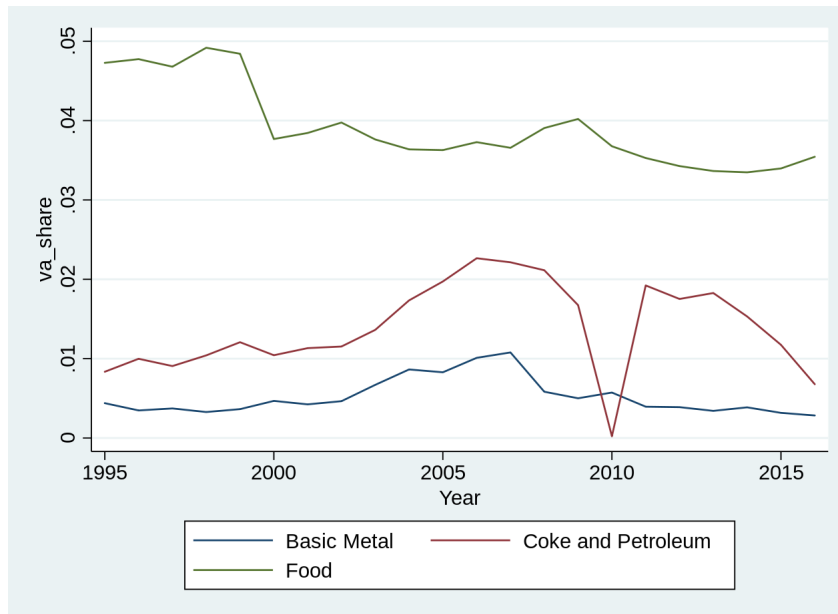


Figure 15: Colombian manufacturing relevance within the production



## Brazilian Case

Brazil is a very particular case due to its size and for being the most developed industrial economy in all Latin American Region. Since 2006, there has been a debate about Brazilian premature deindustrialization. Chinese trade penetration, demand on commodities and investment in oil and gas sector; and the overvaluation of the exchange rate have been seen as the main responsible of the Brazilian premature deindustrialization. Jenkins (2015) found for Brazil there is both a direct and indirect impact of Chinese trade penetration on the deindustrialization. Changes in productivity growth are measured of direct effect. The indirect effect comes from an increase in the demand of Brazilian primary products from China. Jenkins highlights the fact that if Brazil, one of the main representatives of the region, cannot escape from Chinese imports by upgrading their output there are few opportunities for a good manufacturing development of the rest of Latin American economies. Unfortunately, one of the limitations of this study is the lack of an empirical analysis.

Nowadays, a rapid and huge growth of trade flow between Brazil and China is observed. Between 2001 and 2016, exports from the focal country to China increased on a 24 percent average. China is ranking first as main destination of Brazilian products (about 19% of total exports in 2016) overtaking USA as main trade partner. However, this trade flow is mainly a Brazilian deficit for manufacturing goods. Deficit that overcomes the surplus in agricultural products such as soja, metals and petroleum. The sectors with the largest trade deficit are related mainly in communication, machinery and equipment, and basic chemicals. This show clearly that the main problem of Brazilian exports is the degree of diversification at the global market (see Figure 16).

Figure 16: **Brazil vs China: Manufacturing Trade Flows in Millions USD**

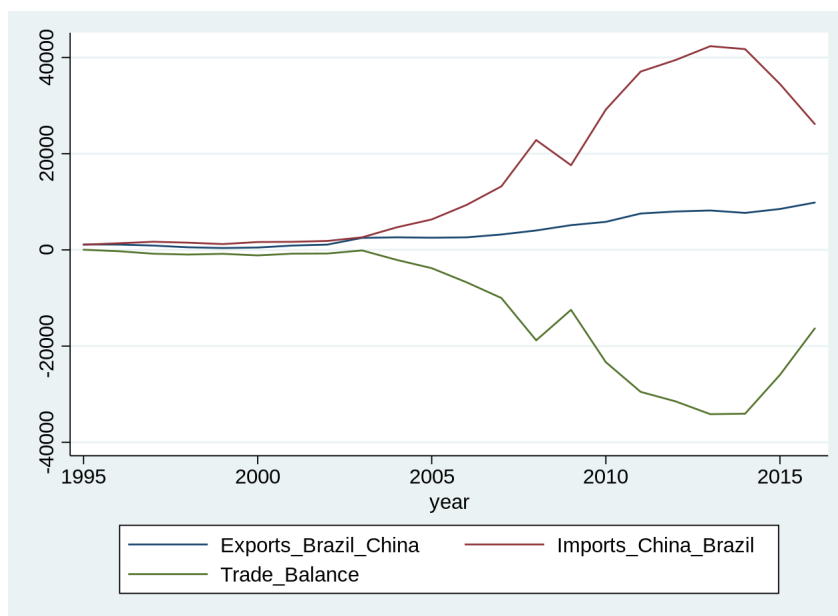


Figure 17 and 18 show the extent of Chinese import penetration in both domestic and foreign markets for top 3 Brazilian manufacturing products exported to USA (Basic metals products; Other transport equipment; Machinery and equipment). In both cases, we can appreciate a steadily increasing effect of Chinese trade flows. We can also observe a reduction in the shares of manufacturing employment and production. We notice even though there has been an increase in the machinery and equipment manufacturing employment, the production relevance of this sector has decreased (see Figure 19 and 20).

Figure 17: Chinese import penetration in Brazilian domestic market

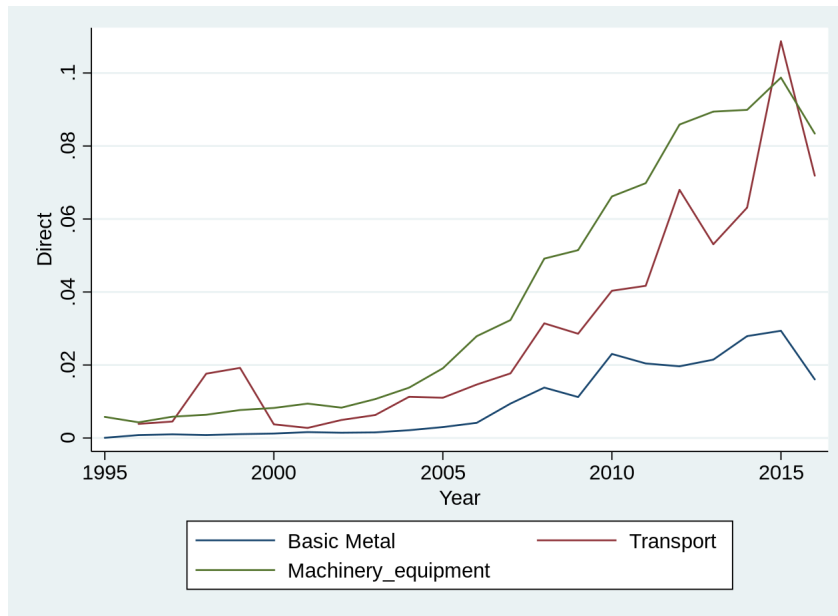


Figure 18: Chinese import penetration in Brazilian exports main foreign destination markets

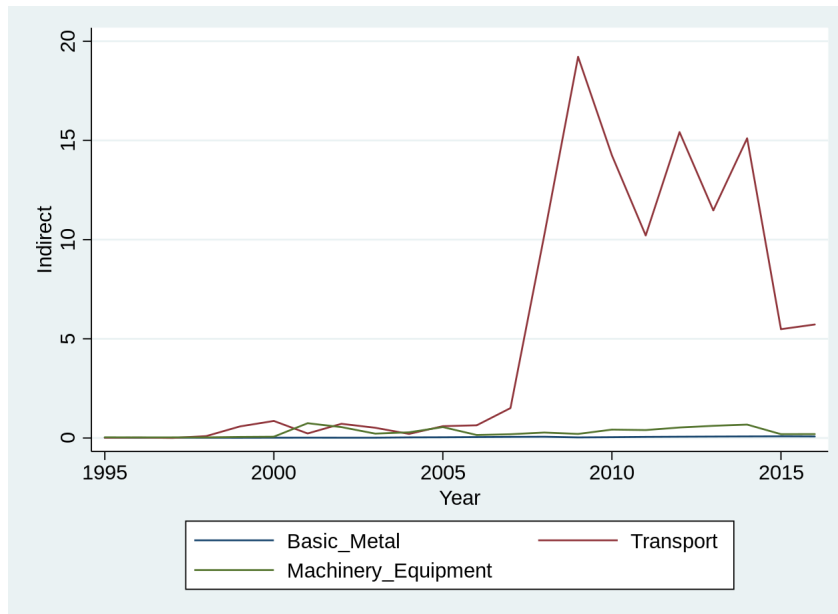


Figure 19: Brazilian Manufacturing Employment

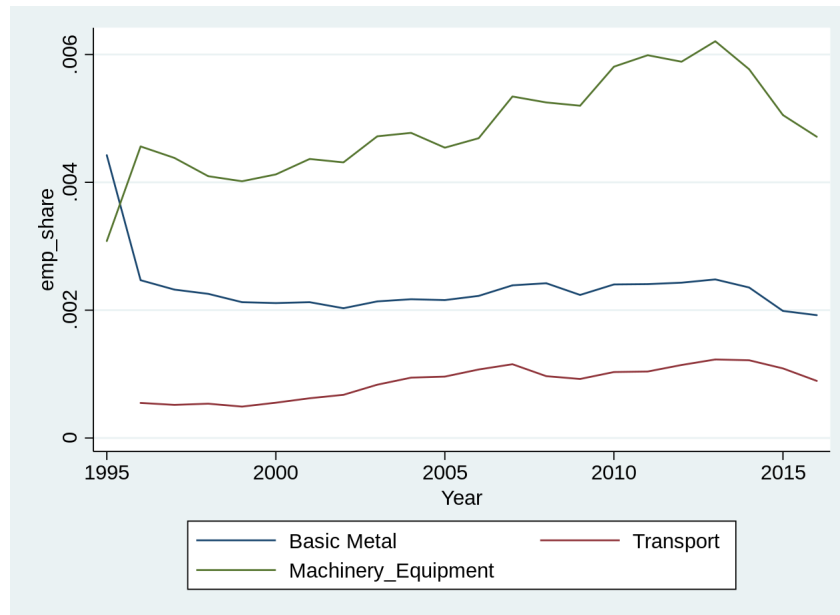
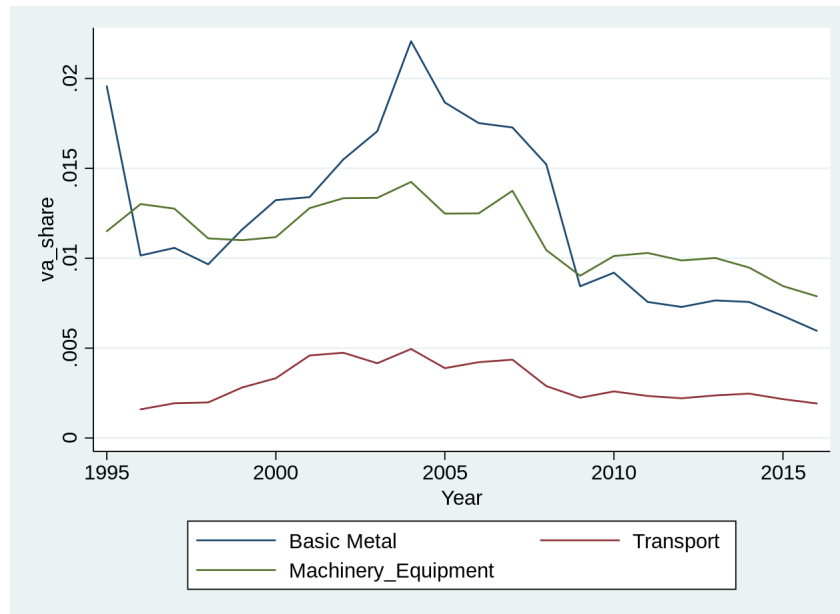


Figure 20: Brazilian manufacturing relevance within the production



### Argentinian Case

Argentina is the second largest economy in the region and is also a particular case to be analyzed. As most of Latin American countries, trade and investment with China (the main global importer of many primary commodities) has increased dramatically. Nowadays, Argentina exports are focused on natural-resource-based commodities such as petroleum oil, copper, leather, etc. Commodity exports represent about 90 percent Argentinian total exports in 2016. Moreover, the basket export is not diversified and there is a failure to include higher value-added and competitive goods in the global market. Li (2016) suggests to

target investment in human capital as priority to promote economic growth, however one of the limitations of this study is the absence of an empirical analysis.

Figure 21 shows the rapid growth of trade flow between Argentina and China. Exports to China increased about 17% between 2001 and 2016. Trade flow shows Argentina has a growing deficit in manufactured goods. Deficit that overcomes the surplus in agricultural products such as meats and grains. The manufacturing sectors with the largest trade deficit, tend to be mainly in communication, Machinery and equipment, and chemical products.

Figure 21: **Argentina vs China: Manufacturing Trade Flows in Millions USD**

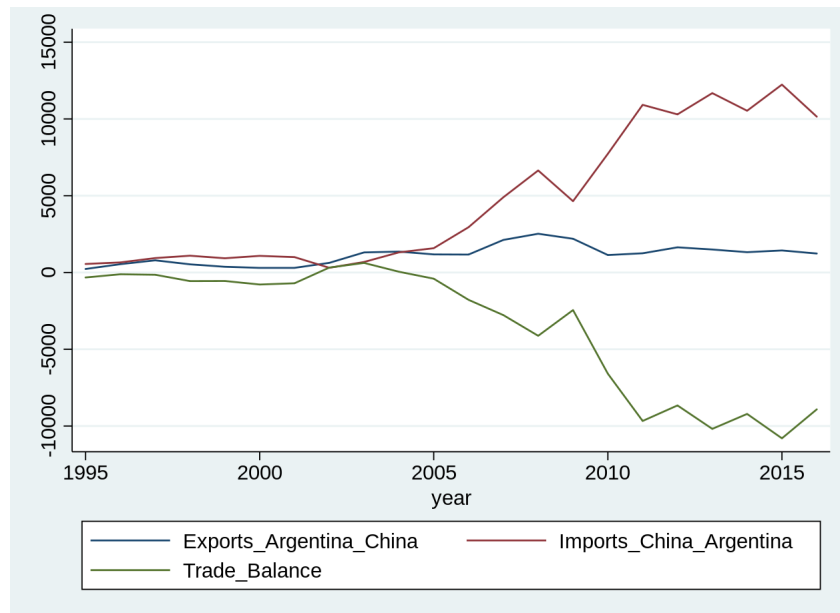


Figure 22 and 23 show the extent of Chinese import penetration in both domestic and foreign markets <sup>5</sup> for top 3 Argentinian manufacturing products exported to USA (food products and beverages, coke, refined petroleum products and nuclear fuel, leather products). In both cases, we can appreciate a steadily increasing effect of Chinese trade flows. Moreover, a reduction in the shares of manufacturing employment in total employment or manufacturing loses relevance within the production in the sectors in mention (see Figure 24 and 25).

<sup>5</sup>The graph is reduced until 2002 because of output missing values of Argentina.

Figure 22: Chinese import penetration in Argentinian domestic market

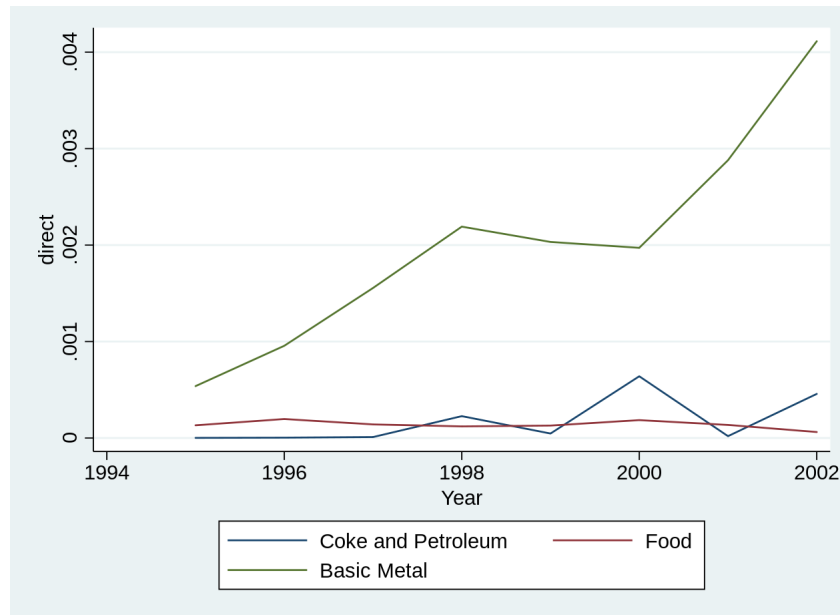


Figure 23: Chinese import penetration in Argentinian exports main foreign destination markets

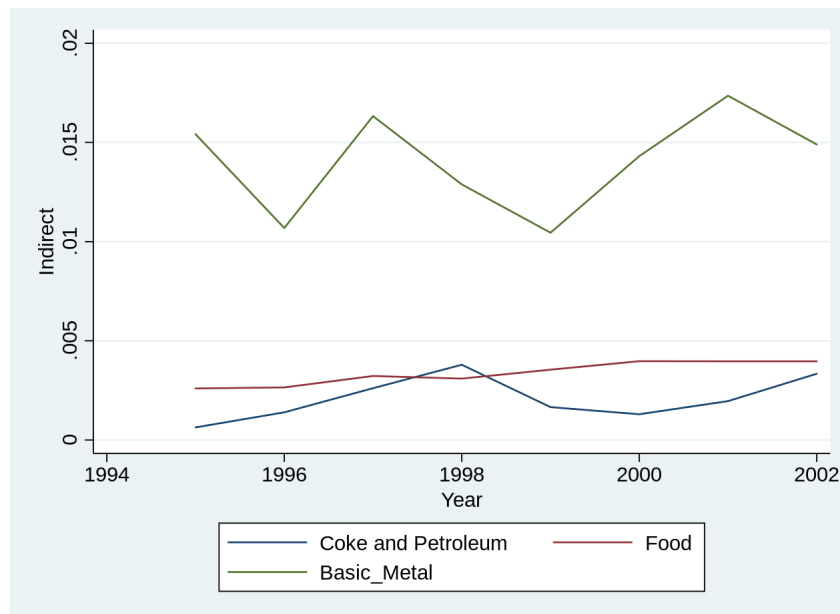




Figure 24: **Argentinian Manufacturing Employment**

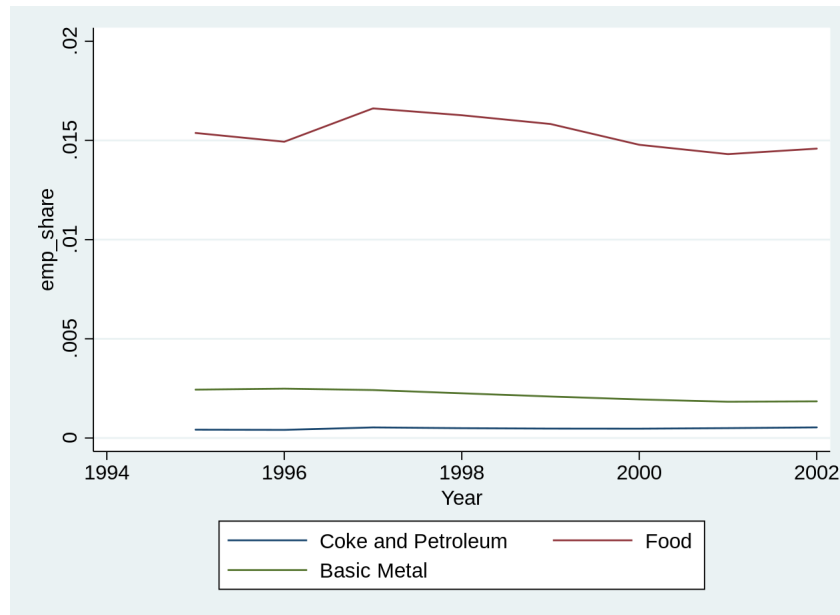
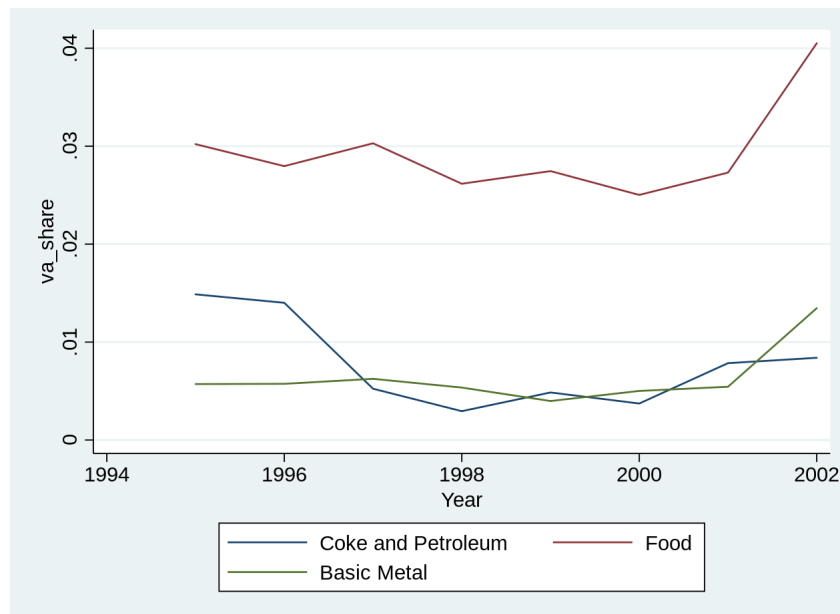


Figure 25: **Argentinian manufacturing relevance within the production**



#### 2.4.4 Direct and Indirect effect : a simple framework and some hypothesis to be tested

As argued by Rodrik (2016) LAC are importing deindustrialization because, on one hand, competition on world market is increasing and consequently commodity prices decrease especially in low and medium-low tech sectors and, on the other hand, LAC firms have not managed to have enough productivity gains, at least relative to international competitors. As seen in previous parts of the sections, trade import and export

are the main variables used in order to measure this globalisation effect on the process of industrialization, both for developed and in developing economies. However, literature focuses more on the direct effect of trade and cross- countries analysis fail to analyse the indirect effect. This section aims to introduce a simple framework to better understand the possible effects of trade on local production when external competition is increasing, looking at both the direct and the indirect effect. In order to do that, we refer to import-demand and export supply graph, as represented in Figure 26.

Figure 26: Trade relationship between countries

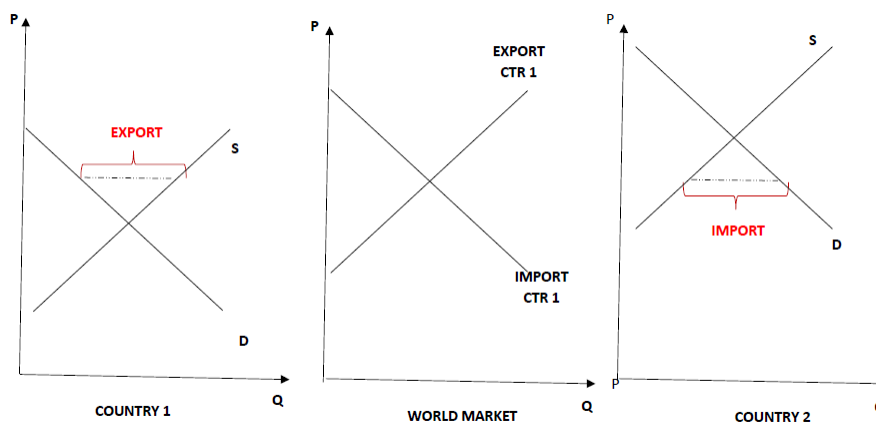


Figure 26 represents two-countries trading goods in a given sector <sup>6</sup>. Comparison of demands and supplies of two countries determines which country is going to export (country 1 in the example) and which country is going to import (country 2) if trade is allowed. A possible example can be textile and clothing sector, with Mexico as country 1 exporting to the USA (country 2) with a world market clearing price that is between the two prices that should be observed in local markets if trade is not allowed, i.e. autarky.

### What does happen if a third country enters into the market?

In 2001, China became a member of WTO and started to export its goods, among other textile goods, around the world without specific restrictions as gradually different quotas and tariffs were removed. In their analysis of the effect on USA market of removing the final set of restriction on textile and clothing products regulated by the Agreement on Textile and Clothing Arrangement (1st January 2005), Brambilla et al. (2010) observe and conclude that:

”U.S. textile and clothing imports from China jumped 40 percent in terms of quantity the year after quotas were abolished, boosting the country's share of the U.S. import market by 7 percentage points to 33 percent. [...] Though China's rapid acceleration spurred U.S. textile and clothing manufacturers to lobby, successfully, for the imposition of new safeguards, we show here that China's gains came almost entirely at the expense of other U.S. trading partners rather than domestic firms.”<sup>a</sup> [Brambilla et al. 2010, p.2]”.

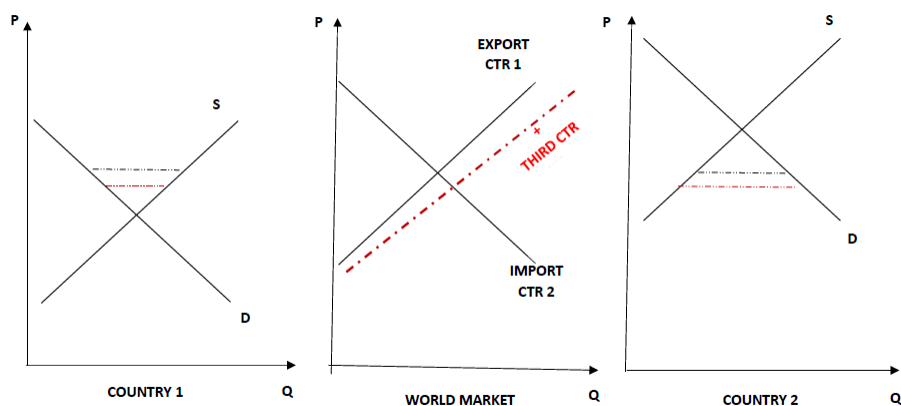
In our analysis of LAC structural change, we intend to take into account the effect of China penetration into the markets of the LAC trading partners, i.e. the indirect effect. The entering into the market of a third

<sup>6</sup>Inter-sector effects are assumed not relevant and consequently not taken into account, in this analysis. Moreover, for sake of simplicity, we are not taking into account trade tariffs, quotas or transportation costs.

country and the possible effect of that on the import and export activities of the incumbent ones can be easily captured in the above graph by a shift of export-supply curve on the world market graph, as displayed in Figure 27.

However we can have two possible cases with very different implications. The first one is that effect of Chinese export increasing is so massive that the new world market clearing price is lower than country 1 autarky price. In this case, to stick to our example, both Mexico and USA are going to import from China: USA is increasing its import, partially reducing their local production but mainly because replacing Mexican products with Chinese ones; Mexico is not exporting to USA anymore and starts to satisfy a part of the local demand with foreign, namely Chinese, goods. In this first scenario the two effects are at work for Mexico: a direct effect due to import from China to Mexico and an indirect effect because Mexico stopped exporting to USA because of more competitive Chinese prices.

Figure 27: Trade relationship between countries after an export shock



The second case is that the Chinese exporting (third country in Figure 2) makes the world price decrease but not so much to be lower than autarky price in Mexico (country 1) as represented in Figure 27. In this case, Mexico/country1 is affected only by indirect effect. The reduction of Mexican production is due to the reduction of import from Mexico to USA, because USA demand needs are partially met by Chinese exporting firms.

In order to measure the effect of globalisation on developed country, such as USA or country 2 in our figures, is enough to look at Chinese penetration in USA local market, i.e. direct effect. In order to measure the globalisation effect of developing country such as Mexico or country 1, this would not be enough. The case 2 would not be captured by Chinese penetration in Mexico, what is necessary, is to measure the Chinese penetration on trade partners of country 1: we need to proxy how much the Chinese penetration in USA has implied a reduction of Mexican export to USA.

These considerations have relevant implications for the empirical analysis we intend to carry on. Therefore, we should expect that:

- i. Countries specialised and exporting in a given sector are mainly affected by indirect effect.

- ii. Countries that are not specialised and have no or low export activities are not affected by the indirect effect.
  
- iii. The direct effect is affecting only not specialised countries. However, this hypothesis is based on two different and complementary assumptions. First, it depends on the nature of data and sector definition. This latter should be very narrow in order to not observe the direct effect for a specialised country, but since there is a huge variety of goods and their quality within the same sector, we can expect that direct effect is positive for any countries. Second, literature on trade shows that there is a huge difference between exporting firms and no-exporting firms within the same sector in a given country. The former set of firms is dealing with a different competition pressure, market and standards requirements. The goods produced by the two types of firm are not perfect substitute between each other and also the international competition they are facing could be different.

## 2.5 Methods and data

In this section, we explain the empirical strategy adopted to inquiry about the factors behind premature deindustrialization observed in Latin American countries over the last few decades. In order to do that, we intend to explain the pattern of manufacturing share both in terms of employment and value added. As argued, trade related factors are considered main determinants and the aims are (i) to distinguish within overall trade effect between direct effect and indirect effect, (ii) to determine their relative importance, even if they should not be considered mutually exclusive but rather complementary. Thus, in this section, we present a detail description of how trade variables are defined and built, the data used, and the methodology adopted.

### 2.5.1 Measuring the contribution of globalization

Following Autor et al. (2016) and others after them, we identify the exposure to China import to measure the more general effect of globalization on the structural change of LAC. The increasing export of China is usually considered as an external shock for domestic economies because more explained by Chinese reform and policies implemented since late 70s (i.e. supply) than by the dynamics of domestic economies (i.e. demand). Using this information, we are therefore able to propose a measure of direct and indirect effect, and an instrumental variable for the former because the risk of endogeneity.

**Direct effect** To capture the exposure to China import we follow the seminal work of Rowthorn and Ramaswamy (1999) where they look at the effect of the import from developing countries on developed economies manufacturing share. They consider the import normalized by GDP of the country. We adapt this definition to our context where the unit of analysis is at sectoral level. Therefore, we define the domestic exposure to China import as the ratio between imports from China in a given sector (S), for a country (C) and a given year (Y) over value of the production of that specific sector, in that country and the same year. This is what we have labelled the direct effect:

$$DirectEffect_{SCY} = ImportsFromChina_{SCY} / ValueOutput_{SCY} \quad (1)$$

An alternative measure can be to consider at the denominator local demand, but this piece of information is rarely available and it has not been possible to retrieve in a systematic way.

**Indirect effect** following the same logic and according to the import-demand and export- supply framework, we define the indirect effect as the exposure of Chinese import of trade partners of our domestic economies.

For sake of clarity, we come back to the previous section example and we consider the case of textile and clothing trade between Mexico and USA. As China prices textiles and clothing products become more and more competitive, USA consumers start to buy Chinese products rather than Mexican because they are cheaper. In order to grasp that, we have to measure how much Chinese products are penetrating foreign markets such as USA.

However, even if USA is the main destination of Mexican textile commodities (around 40% in 1995),

it is not the only one <sup>7</sup>. In order to take into account all the main destinations, we have to calculate the importance of each trade partner for a given Latin American country. In order to minimize endogeneity risks, we decide to do that in a given year, at beginning the period under analysis, namely 1995, before China increasing export occurs.

So we calculate the weights of Mexican trade partners in a given sector in 1995 as following:

$$W_{SC1995} = Exports_{forTradePartners}_{SC1995} / Total_{ofExports}_{SC1995} \quad (2)$$

The next step, it is to calculate the China penetration into all trade partners of Mexico in textile and clothing in analogy with what we have done for the direct effect calculation. Once we have these information, the indirect effect for a LAC is the weighted average of Chinese exposure of trade partners of domestic economy:

$$IndirectEffect_{SCY}^* = \sum_{C-partner} (DirectEffect_{C-partner,Y} * W_{S,C-partner,1995}) \quad (3)$$

### Direct effect and endogenous issue

Since our dependent variable is manufacturing share (employment or value added), the direct effect risks to be endogenous: the share of manufacturing could affect the country exposure and so the China penetration into domestic market. In order to avoid the reverse causality issue, following the strategy adopted by Autor and co-authors (2016), we include a potential instrumental variable (IV) defined as the Chinese penetration in three similar countries for each of Latin American Countries included in the sample. Doing so, we should be able to identify the supply- driven effect of Chinese increasing competition on domestic manufacturing share.

Three similar countries to our sample are chosen according to a composed index of GDP per capita and population in 1995. The idea is to choose countries with similar market size, defined as population multiplied average income<sup>8</sup>.

The Similarity index (normalized to 0) of a country i relative to focal country C is given by the following formula:

$$IndexSimilarity_{C,i,1995} = abs(0.7 * (GDPpercapita_{i,1995} / GDPpercapita_{C,1995}) + 0.3 * (Population_{i,1995} / Population_{C,1995}) - 1) \quad (4)$$

The three countries with the closest value to 0 in absolute terms are then selected d to define the IV<sup>9</sup>. To do that, we calculate the exposure to Chinese import in local markets of the three countries according

<sup>7</sup>In 1995, in textile and clothing sector, 40% of Mexican exports is towards USA, 10% to Brazil, 20% to Germany, and 30% to Canada

<sup>8</sup>We have assigned relative more importance to the similarity of average income (0.7) than population size (0.3). In the Annex 1, Table 2 reports the similar country selected for each of LAC of the sample under analysis.

<sup>9</sup>In the annex 1, Table 2 is reporting the selected countries for each of the LAC of our sample

to equation [1] and the IV is the result of the arithmetic average of the three similar countries direct effect.

$$IVDirectEffect_{s,c,y} = \sum_{SCtoC} (DirectEffect_{s,SC,y})/3 \quad (5)$$

## 2.5.2 Data Description and data definition

Our data is drawn from four distinct sources. First, we have retrieved all information about manufacturing employment and valued added at sectoral level (ISIC rev 3, 2 digit) from IND- STAT dataset provided by the United Nations Industrial Development Organization (UNIDO). Secondly, this data has been matched with trade data at the sectoral level using the information contained in CHELEM - International Trade Database elaborated by the Centre d'études Prospectives et d'Informations Internationales (CEPII). Finally, we complete the data with some country level information, namely GDP per capita and population from the World Bank database, and real effective exchange rates database obtained from Bruegel.

The final dataset is a panel data at sector-country level between 1995 and 2016 of 9 LAC and 22 manufacturing sectors (ISIC rev 3, 2 digit), reported in Table 1. The sample includes the bigger countries in the continent, namely the Argentina (the 3rd country for GDP in 2021), Bolivia (the 14th), Brazil (the 1st), Chile (the 5th), Colombia (the 4th), Ecuador (the 7th), Mexico (the 3rd), Peru (the 6th) and Uruguay (13th). Overall the sample corresponds around the 90% of the overall GDP of the continent.

<b>ISIC r.3, 2 code</b>	<b>Manufacturing sectors</b>
15	Food products and beverages
16	Tobacco products
17	Textiles
18	Wearing apparel; fur
19	Leather products
20	Wood & wood products excluding furniture; straw
21	Paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Manufacture of coke, refined petroleum products and nuclear fuel
24	Chemicals & chemical products
25	Rubber and plastics products
26	Other non-metallic mineral products
27	Basic metals products
28	Manufacture of fabricated metal products, except machinery and equipment
29	Machinery and equipment n.e.c.
30	Office and computing machinery
31	Electric machinery & apparatus
32	Radio, TV and communication
33	Medical & precision instruments
34	Motor vehicles and trailers
35	Other transport equipment
36	Furniture; manufacturing n.e.c

Table 1: Manufacturing Sectors

The final dataset allows us to calculate the main variables capturing the direct and direct effect and the control variables that we have taken into account following the main contributions of the literature. The Table 1 is reporting the list of variables and their definitions, and the following one, Table 2, is reporting basic descriptive statistics.

<b><i>Label</i></b>	<b><i>Description</i></b>
Emp Share <sub>SCY</sub>	Manufacturing Employment share relative to overall economy (logarithm)
VA share <sub>SCY</sub>	Manufacturing value added share relative to overall economy (logarithm)
GDP <sub>CY</sub>	GDP per capita in 2010 constant \$ (logarithm)
GDP <sup>2</sup> <sub>CY</sub>	GDP per capita in 2010 constant \$, square (logarithm)
Direct Effect <sub>SCY</sub>	Direct Effect
IV Direct <sub>SCY</sub>	Direct effect to three most similar countries of focal one
Indirect <sub>SCY</sub>	Indirect Effect
Reer	Real effective exchange rates
RCA1995	Dummy Specialization based on Balassa Index: 1, if RCA in 1995 $\geq 1$ ; 0 otherwise

Table 2: Variable description



The dataset covers 9 countries, in 22 sectors for 22 years, which means potentially 4,356 observations, however as Table 3 displays, missing data reduce observation something around 3500.

<i>Label</i>	<i>Obs</i>	<i>Average</i>	<i>Std. Dev</i>	<i>Min</i>	<i>Max</i>
Emp Share <sub>SCY</sub>	3559	-6.83	1.438	-13.88	-3.39
VA share <sub>SCY</sub>	3567	-5.98	1.549	-14.36	-1.69
GDP <sub>CY</sub>	3958	8.74	0.598	7.31	9.6
GDP <sup>2</sup> <sub>CY</sub>	3958	76.78	10.153	53.42	92.18
Direct Effect <sub>SCY</sub>	3561	1.1	10.486	0	303.3
IV Direct <sub>SCY</sub>	3790	0.59	6.868	0	357.9
Indirect <sub>SCY</sub>	3892	0.69	4.718	0	100.18
Reer <sub>CY</sub>	3960	4.68	0.219	4.15	5.4
RCA1995	3958	0.22	0.414	0	1

Table 3: Variable descriptive statistics

### 2.5.3 Methodology

Based on a country-sector panel data, we analyse the determinants of employment and output deindustrialisation in LAC countries. On the one hand, analysing a three-dimensional panel makes possible to take into account specialisation in manufacturing sectors and consequently to have the opportunity to disentangle direct and indirect effect of China up-surfing, on the other hand, allows us to control for both country and sector fixed effect and, in this way, to deal with unobservable heterogeneity, that is often the main problem with this kind of analysis.

The dependent variables are the logarithm of manufacturing employment sector overall the over- all employment either the logarithm of manufacturing sector real value added overall the real GDP.

Relative to the explanatory variables, our model focuses on the Chinese import exposure as main determinant as already mentioned above.

As control variables, we consider the GDP per capita as main demand side explanation. Following the empirical literature, the variable is taken into account also in square terms in order to capture the inverted U-shape that is a standard result.

A further control is the real effective exchange rates since the comparison across local and international price should take into account this dimension. All these three variables are defined at country level and variant over time.

Finally, we considered a dummy that is establishing if a given country is specialised in a given sector (i.e Balassa index greater than one). This variable has been calculated in 1995, at the beginning of the period under analysis in order to avoid reverse causality effects, e.g. the effect of being not more specialised because of Chinese competition pressure.

The basic model is therefore the following:

$$\begin{aligned}
DepVar_{SCY} = & \alpha + \beta_1 ChinaExpos_{SCY} + \beta_2 GDP_{CY} + \beta_3 GDP_{CY}^2 \\
& + \beta_4 RCA_{sc1995} + \mu_{trend} + \mu_Y + \mu_C + \mu_S + e_{SCY}
\end{aligned} \tag{6}$$

Where dependent variable is manufacturing employment share or manufacturing employment and China Exposure can be declined in different way according to the discussion and definitions provided in section 3.1.

In the first specification (Model 1), we just run the model only with controls without any variable capturing the Chinese Exposure.

After this, in the following specification, we start to focus on the effect of Chinese trade penetration in manufacturing employment for Latin American countries introducing the different variables one by one. We begin by incorporating the direct effect (model 2).

In Model 3 we add the effect of Chinese penetration in LAC trade partners markets, i.e. the indirect effect. Finally in Model 4, we add the relative comparative advantage in 1995 interaction of the indirect effect with the relative comparative advantage in 1995 (i.e.  $RCA_{1995Indirect}$ ), in order to observe if the effect of Chinese competition in foreign market is higher for countries that specialized, at least initially. All these models are estimated with fixed effects at the level of country, sector and year and a trend effect is taken into account, in order to capture the increasing role of China as worldwide manufacturing exporter. Errors terms are clustered around a country-sector id.

In order to check the robustness of results, we run two further specifications. The first one (i.e. Model 5) is the same main variables of model 4 but a fixed effect is considered and only within variation is analysed. Finally, in Model 6, we use an IV for direct effect because the risk of reverse causality and estimate the same specification of Model 5, i.e. fixed effect.

## 2.6 Empirical Analysis

The following the two tables reports the results of the four models for each of the two dependent variables: Table 4 reports the estimation for employment manufacturing share, and Table 5 reports the estimation for real valued added share. According to our hypothesis, we should not expect different results according to the dependent variable considered: the premature deindustrialization should affect employment and production in the same way.

Table 4: **Panel estimation: Manufacturing employment share**

Variable	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>
	<i>b/se</i>	<i>b/se</i>	<i>b/se</i>	<i>b/se</i>
GDP	7.424*** (2.616)	7.222*** (2.651)	8.001*** (2.620)	7.979*** (2.611)
GDP <sup>2</sup>	-0.405*** (0.146)	-0.393*** (0.148)	-0.437*** (0.146)	-0.436*** (0.145)
Reer	-0.100 (0.091)	-0.106 (0.090)	-0.119 (0.088)	-0.113 (0.088)
RCA1995	0.321** (0.125)	0.299** (0.123)	0.253** (0.123)	0.296** (0.126)
Trend	-0.004 (0.009)	-0.004 (0.009)	-0.005 (0.009)	-0.004 (0.009)
Direct effect		-0.011** (0.005)	-0.011** (0.005)	-0.011** (0.005)
Indirect Effect			0.004 (0.013)	0.004 (0.013)
RCA1995IndirectEffect				-0.509* (0.300)
Cons	-29.865 (18.541)	-29.122 (18.517)	-30.745* (18.447)	-32.137* (18.438)
Country FE	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Obs	3559	3532	3479	3479

Clustered standard errors (country-sector) in brackets \* p<0.10, \*\* p<0.05, \*\*\* p<0.010

The two sets of estimations, independently of the dependent variable considered, share the same results for what concerns the control variables. The GDP per income variables confirm previous results showing an inverted U-shaped relationship. The real effective exchange rates and the trend term have both the expected negative effect but they are never significant. The initial specialisation dummy has a positive significant effect on the level of manufacturing share as one can expect.

Concerning the result presented in Table 4, we limit our comments and interpretation to Model 4. The main hypothesis is verified. The indirect effect is negatively impacting the manufacturing employment share only in those sectors economy is specialised: the increasing penetration of Chinese import in trade partner is deeply affected by the number of worker in that manufacturing sector. Compared to direct effect, in specialised sector the indirect effect magnitude is 20 times higher.

However the same is not verified when the dependent variable is the output (Table 5): the indirect effect is not significant when isolated neither when interacted with specialisation dummy. This means that the number of workers decrease but not the value of the production as trade partners are more and more exposed to Chinese import. This is partially contradicting our expectation. However a recent contribution of Rodrik and co-authors (2021) about the debate of premature deindustrialization or renaissance for Sub Saharan countries can help to interpret this.

In their paper, they analyse the puzzling evidence related to the premature industrialization hypothesis concerning some Sub Saharan countries where manufacturing employment share is increasing while real value

added share is decreasing. Based on firm data survey, they analyse the case of Tanzania and Ethiopia. They can conclude that in these economies there are two groups of firms: on the one hand, small and medium firms, partially informal, able to meet the needs to local demand and, on the other one, a group of firms, of bigger size, mainly operating on international market. The former is suffering of low productivity and is able to absorb the labour force of urban area, mainly coming from countryside, while the latter highly involved in global value chain, are able to adopt sophisticated technology, to boost productivity but not to absorb labour force. The composed effects of these two firms groups in terms of productivity and employment can explain the overall puzzling evidence mentioned of increasing employment and reducing output.

Our results seem to echo this kind of argument. If we assume, as suggested by trade literature that exporting firms and no-exporting firms are systematically different, an interpretation is possible. LAC firms, exporting to countries where China has been able to penetrate, are increasing their productivity (e.g. getting benefit from global value chain and intermediary good cost reduction) and in this way to resist to the increasing pressure of Chinese commodities reducing the number of workers: the overall effect is they are not decreasing the value of their production but they are reducing their employees. Thus, The LAC value of production is not affected by trade partners China exposure means probably that a part of this production has been kept constant due to productivity gains of exporting firms. It is worth clarifying that this interpretation cannot be empirical tested within our empirically framework and it would require a deeper analysis using firm-level data, but it seems a promising complementary line of inquiry.

Table 5: Panel estimation: Manufacturing Real Value added share

Variable	Model 1	Model 2	Model 3	Model 4
	b/se	b/se	b/se	b/se
GDP	10.318*** (3.067)	10.184*** (3.066)	11.409*** (2.931)	11.393*** (2.924)
GDP <sup>2</sup>	-0.625*** (0.177)	-0.617*** (0.176)	-0.692*** (0.167)	-0.691*** (0.166)
Reer	-0.035 (0.105)	-0.049 (0.105)	-0.062 (0.103)	-0.059 (0.103)
RCA1995	0.409*** (0.155)	0.381** (0.149)	0.341** (0.151)	0.366** (0.158)
Trend	-0.005 (0.009)	-0.004 (0.009)	-0.003 (0.009)	-0.003 (0.009)
Direct effect		-0.018** (0.008)	-0.015** (0.007)	-0.015** (0.007)
Indirect Effect			-0.001 (0.008)	-0.001 (0.008)
RCA1995Indirect effect				-0.299 (0.264)
Cons	-36.001* (21.702)	-36.149* (21.430)	-43.369** (20.730)	-44.189** (20.789)
Country FE	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Obs	3,567	3,558	3,503	3,503

Clustered standard errors (country-sector) \* p<0.10, \*\* p<0.05, \*\*\* p<0.010 ,

## 2.6.1 Robustness

For each dependent variable, we adopt two further estimation methods in order to check for robustness. First we ran a fixed effect model (Model 5), secondly we intended to deal with the endogeneity issue of the direct effect considering a possible IV (Model 6)<sup>10</sup>.

Table 6: **Panel estimation: Manufacturing employment share**

Variable	<i>Model 5</i>	<i>Model 6</i>
	<i>b/se</i>	<i>IV b/se</i>
GDP	8.025*** (2.524)	8.266*** (1.103)
GDP <sup>2</sup>	-0.431*** (0.143)	-0.442*** (0.065)
Reer	-0.056 (0.096)	-0.074 (0.056)
Trend	-0.002 (0.008)	
Direct effect	-0.010** (0.005)	-0.084* (0.050)
Indirect Effect	0.015 (0.017)	0.044 (0.040)
RCA1995IndirectEffect	-0.455 (0.316)	-0.547*** (0.194)
Cons	-39.229** (17.505)	
FE	YES	YES
Obs	3479	3422

Clustered standard errors (country-sector) in brackets \* p<0.10, \*\* p<0.05, \*\*\* p<0.010

<sup>10</sup>Please note that the dummy capturing sector specialization, i.e. RCA1995, is not taken into account because time invariant and the FE estimation

Table 7: Panel estimation: Manufacturing Real Value added share

Variable	<i>Model 5</i>	<i>Model 6</i>
	<i>b/se</i>	<i>IV b/se</i>
GDP	11.342*** (2.867)	10.860*** (1.173)
GDP <sup>2</sup>	-0.677*** (0.164)	-0.656*** (0.063)
Reer	-0.036 (0.101)	-0.005 (0.096)
Trend	-0.002 (0.008)	
Direct effect	-0.015** (0.006)	-0.001 (0.114)
Indirect Effect	0.007 (0.012)	-0.001 (0.057)
RCA1995Indirect effect	-0.232 (0.264)	-0.219 (0.389)
Cons	-49.070** (19.722)	
FE	YES	YES
Obs	3,503	3445

Clustered standard errors (country-sector) \* p<0.10, \*\* p<0.05, \*\*\* p<0.010.

Table 8 is reporting the IV test for the two specifications.

Table 8: **Panel estimation: Manufacturing Real Value added share**

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Manufacturing Employment share: Model 6: endogeneity test  
 Underidentification test (Kleibergen-Paap rk LM statistic): 4.504  
 Chi-sq(1) P-val=0.0338

---

Weak identification test (Cragg-Donald Wald F statistic): 1.720  
 (Kleibergen-Paap rk Wald F statistic): 4.545  
 Stock-Yogo weak ID test critical values: 10% maximal IV size 16.38  
   15% maximal IV size 8.96  
   20% maximal IV size 6.66  
   25% maximal IV size 5.53  
 Source: Stock-Yogo (2005). Reproduced by permission.  
 NB: Critical values are for Cragg-Donald F statistic and i.i.d. errors.

---

Hansen J statistic (overidentification test of all instruments): 0.000  
 (equation exactly identified)  
 -endog- option:  
 Endogeneity test of endogenous regressors: 2.621  
   Chi-sq(1) P-val = 0.1055  
   Regressors tested: direct

---

Instrumented: direct  
 Included instruments: indirect rca1995\_indirect ln\_gdp\_pc ln\_gdp\_pc2 ln\_reer  
 Excluded instruments: directSIMILAR

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Manufacturing Real Value Added share: Model 6: endogeneity test

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Underidentification test (Kleibergen-Paap rk LM statistic): 3.327  
 Chi-sq(1) P-val = 0.0681

---

Weak identification test (Cragg-Donald Wald F statistic): 0.725  
 (Kleibergen-Paap rk Wald F statistic): 3.397  
 Stock-Yogo weak ID test critical values:  
   10% maximal IV size 16.38  
   15% maximal IV size 8.96  
   20% maximal IV size 6.66  
   25% maximal IV size 5.53  
 Source: Stock-Yogo (2005). Reproduced by permission. NB: Critical values are for  
 Cragg-Donald F statistic and i.i.d. errors.

---

Hansen J statistic (overidentification test of all instruments): 0.000  
 (equation exactly identified)  
 -endog- option:  
 Endogeneity test of endogenous regressors: 0.031  
   Chi-sq(1) P-val = 0.8608  
   Regressors tested: direct

---

Instrumented: direct  
 Included instruments: indirect rca1995\_indirect ln\_gdp\_pc ln\_gdp\_pc2 ln\_reer  
 Excluded instruments: directSIMILAR

---

Fixed effect models (Model 5) confirm the results. The only difference is the indirect effect that is not any more significant when the dependent variable is the employment share. It is weakly significant in model 4 (i.e. p-value .09) and becomes not significant if only within heterogeneity is taken into account (i.e. p-value .15).

IV model results are confirming previous results as well. But before commenting the results, let us have a look at the IV test. We start by analyzing the Kleibergen-Paap LM test, a test where the null hypothesis is that the structural equation is underidentified. Here, we observe if the minimal correlation between the endogenous variables and the instruments is statistically different from zero. In this test our  $p\text{-val}=0.0338 < 0.1$ . Therefore, we can reject the null hypothesis that our model is underidentified. Moreover; considering the Sargan-Hansen test or Sargan's J test, a test where the null hypothesis is the validity of the over identifying restrictions. A test used when more instruments than endogenous regressors are specified. We observe that our p-value is of 0.1055. Therefore, the null hypothesis is not rejected. Overidentification restrictions are valid.

We should remind that the Sargan-Hansen test or Sargan's J test is not telling us if instruments are valid or not but it is telling us there are different instruments identifying different parameters. That it is the reason why we also use the Cragg-Donald Wald F statistic to evaluate the overall strength of the instruments. Our Cragg-Donald Wald F statistic is small enough 1.720 to conclude that instruments are weak. Instruments are correlated with endogenous regressors, but very vaguely.

However, a more substantial analysis can be made by using the critical values created by Stock and Yogo test. Therefore, we also include the Stock and Yogo critical values for the Cragg-Daniels statistic. We therefore provide tables of critical values that depends on the estimator being used, there may be related to bias or size distortion (a distortion or bias greater than 10%, 15%, 20% or 25%). In this analysis, if the 95% confidence interval excludes the null value, then we can reject that the instruments are weak. A Cragg-Donald statistic of 1.720 is significantly lower than the critical value of 16.38, 8.96, 6.66, 5.53 at 10%, 15%, 20% or 25% respectively. Therefore, there is not sufficient evidence to reject the null hypothesis that the instruments are weak.

For employment share estimation, once taken into account the endogeneity of direct effect thank to IV, the estimation of the indirect effect for specialised sector becomes highly significant, reinforcing previous results. Finally, it is possible to conclude that the robustness check confirm what obtained before: the indirect effect, interacted with specialization dummy, is significant and negative only in the case of employment.



## 2.7 Conclusions

Deindustrialization is a well-known process over the path economic growth. Economies are moving from manufacturing to services activities. However, Latin American countries are moving too soon and too early to service activities. They are experiencing a premature deindustrialization. The literature has identified international competition as main determinants of this phenomenon.

Relying on a panel random and fixed estimation at a sector, country level between 1995 and 2016 for nine Latin American countries, we have analyzed the direct effect of Chinese penetration into domestic economies and at the same time an indirect effect due to the Chinese penetration into LAC trade partners. The results obtained show that the negative direct effect of Chinese trade on deindustrialization for LAC is the work and that the indirect effect only if countries are sector specialized. This latter results is only verified when employment and not when output is under analysis. This is probably explained by the strategies of exporting firms that are able to deal with new coming competitors increasing productivity in such a way to keep production constant but losing workers. If this is the case, such strategies are difficult to keep on implementing on medium or long term and raise more than a concern.

In last few decades Latin American countries have promoted trade openness- an average tariff reduction from 30% to 10% between 1980 and 1999 (The World Bank, 2003). However, the success of this trade liberalization has been criticized, most countries are not having comparative advantages that allow them to get more benefits from trade and are focusing these new exports on intensive -resources goods. This suggests government should restore industrialization policies to enjoy the advantages of trade liberalization (Rodrik, 2016).

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# Appendices

## Annex 1: Trade and manufacturing for Latin American countries. Stylized Facts

### Uruguayan Case

Uruguayan economy is more conservative. Trade openness indicator<sup>11</sup>(Exports plus imports as percent of GDP in 2020) is about 46%. Most exports are destined to Brazil, China and USA. Figure 28 shows between 2001 and 2016 Uruguayan exports to China have increased on average 19% and it is mainly focus on basic metals, food, and paper. However, as all Latin American countries, Uruguay is also experiencing a trade manufacturing deficit with China. Manufacturing sectors with the largest trade deficit are: Communication, computer, machinery and equipment.

Figure 28: Uruguay vs China: Manufacturing Trade Flows in Millions USD

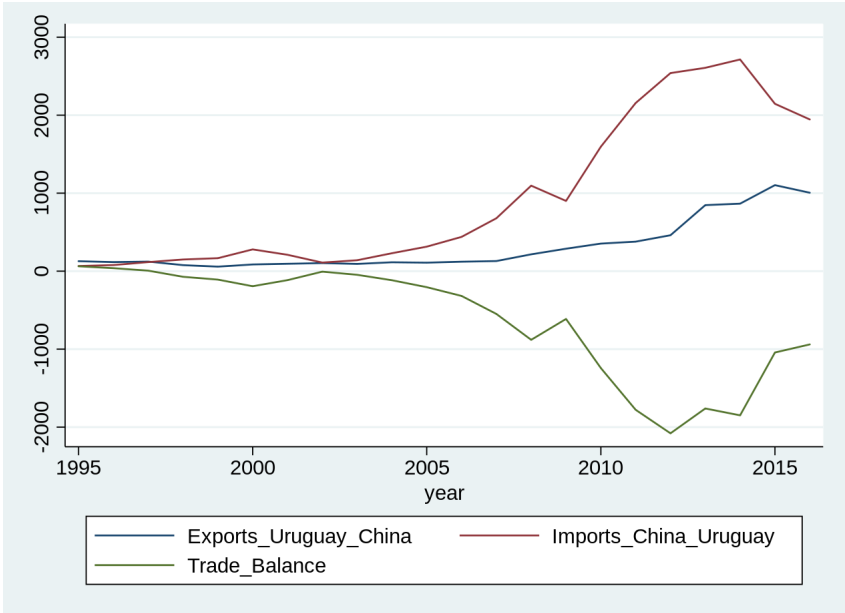


Figure 29 and 30 show the extent of Chinese import penetration in both domestic and foreign markets for top 3 Uruguayan manufacturing products exported to USA (food products and beverages, leather, coke and petroleum). We can observe an increasing effect of Chinese trade flows. Moreover, this behavior has been accompanied by a reduction in the shares of manufacturing employment in total employment or manufacturing loses relevance within the production in the sectors mentioned (except in the case of Food manufacturing employment), see Figure 31 and 32.

<sup>11</sup>Countries are presented according to the trade openness relevance defined by TheGlobalEconomy.com such as : exports plus imports as percent of GDP in Latin America: The average for 2020.

Figure 29: Chinese import penetration in Uruguayan domestic market

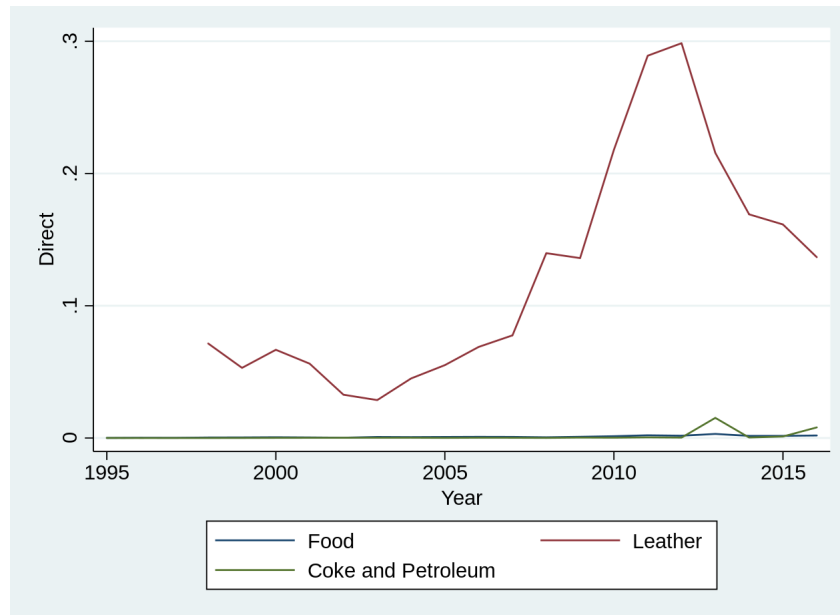


Figure 30: Chinese import penetration in Uruguayan exports main foreign destination markets

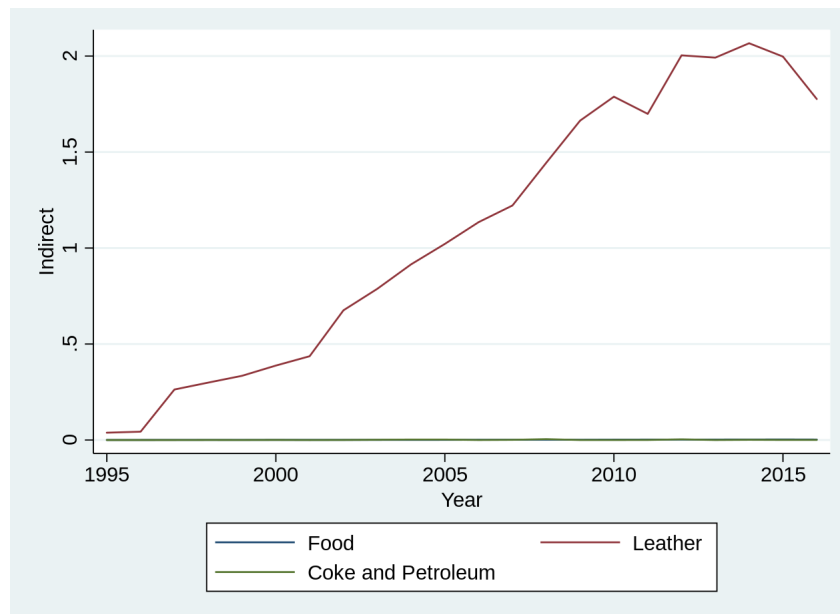


Figure 31: Uruguayan Manufacturing Employment

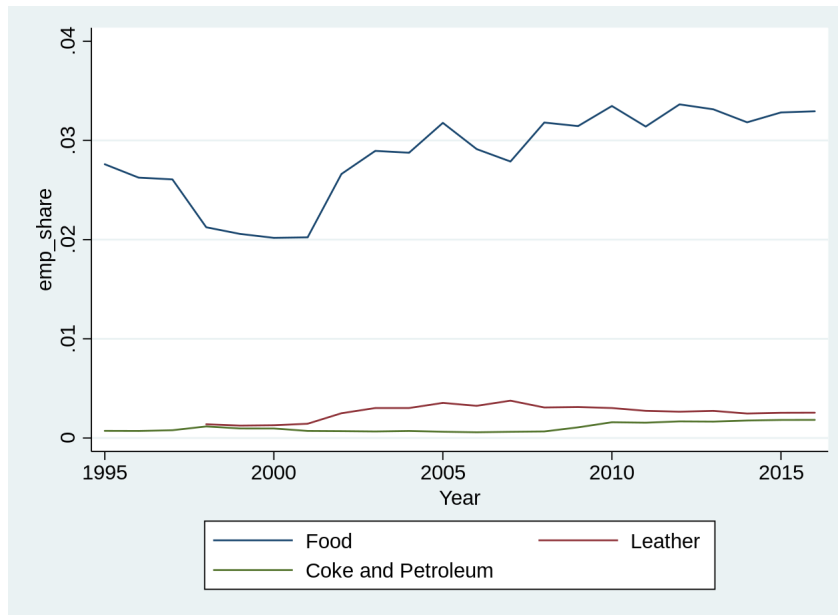
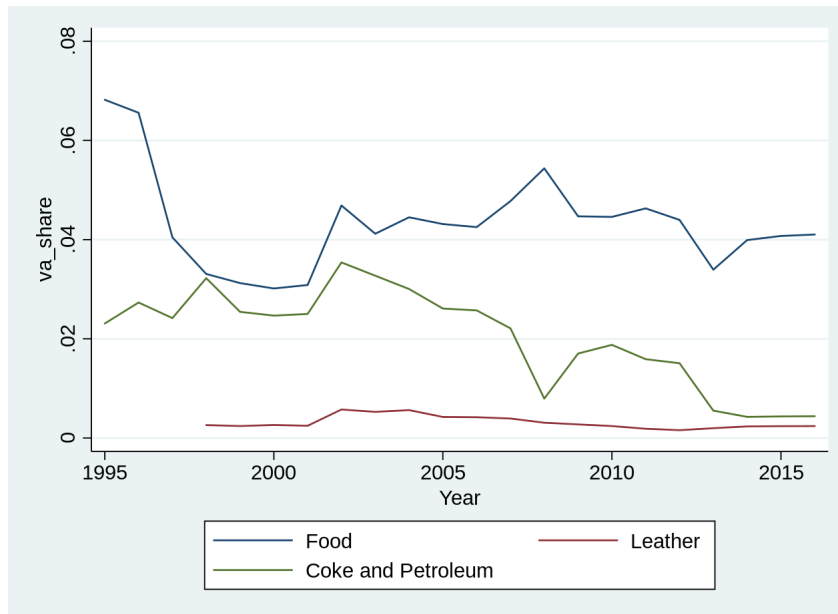


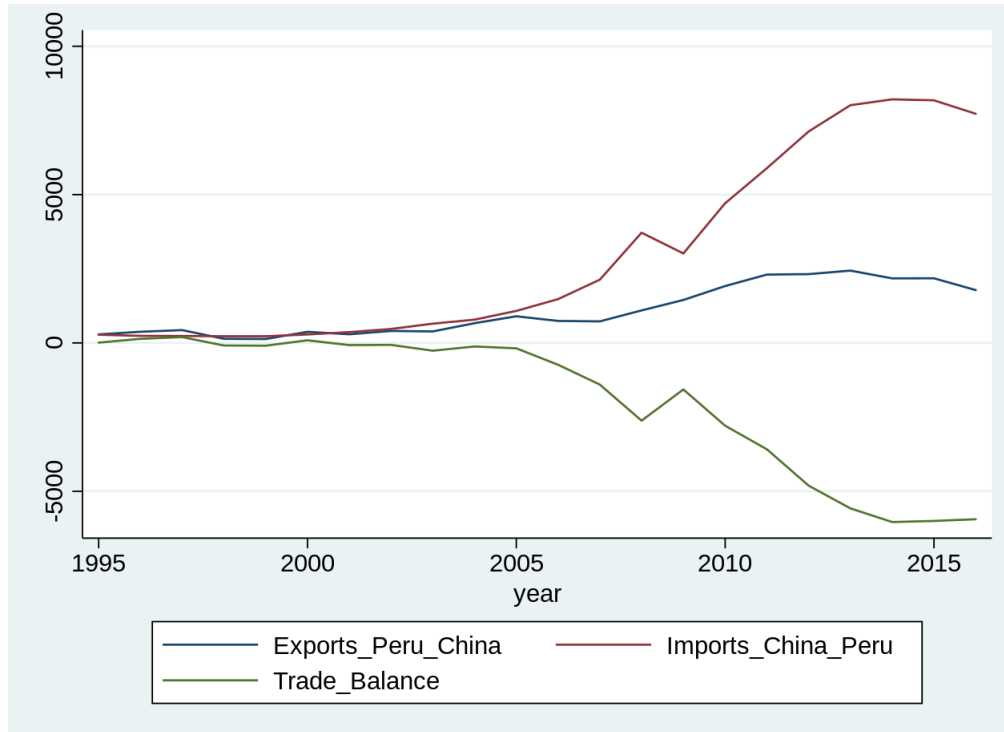
Figure 32: Uruguayan manufacturing relevance within the production



## Peruvian Case

There is a rapid growth of trade flow between Peru and China between 2001 and 2016 (Figure 33). Peru exports to China has increased on average 21%. Nowadays, China is the main destination of Peruvian exports, then USA. Exports are focused on food, basic metal and wood. However, Peru is experiencing an overwhelming trade manufacturing deficit with China. Manufacturing sectors with the largest trade deficit are: communication, computing and machinery and equipment.

Figure 33: Peru vs China: Manufacturing Trade Flows



Top 3 Peruvian manufacturing products exported to USA are Basic metal, coke and petroleum, textile, see Figure 34 and 35. We can appreciate a steadily increasing effect of Chinese trade flows. Moreover, this behavior has been accompanied by a reduction in the shares of manufacturing employment in total employment or manufacturing loses relevance within the production in the sectors in mention (see Figure 36 and 37).

Figure 34: Chinese import penetration in Peruvian domestic market

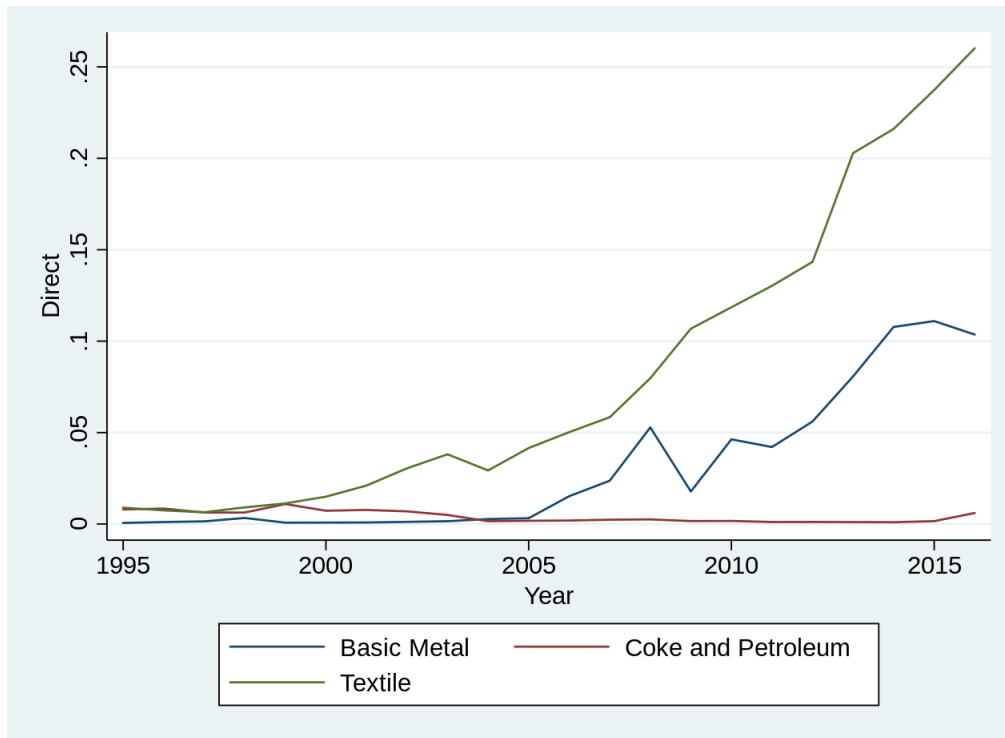


Figure 35: Chinese import penetration in Peruvian exports main foreign destination markets

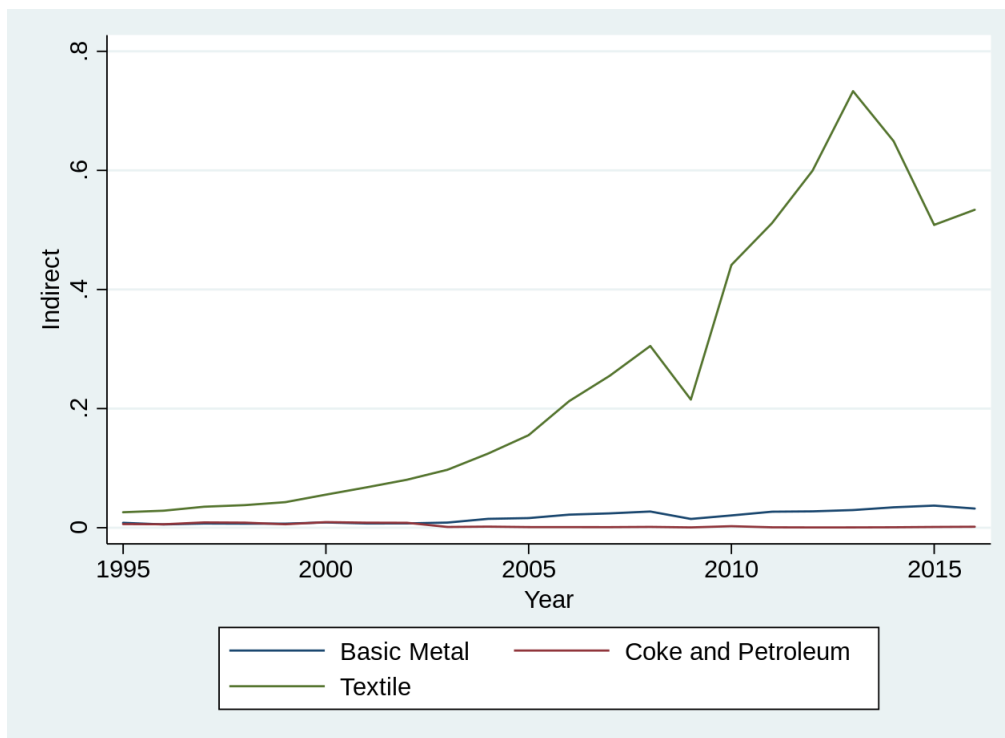




Figure 36: Peruvian Manufacturing Employment

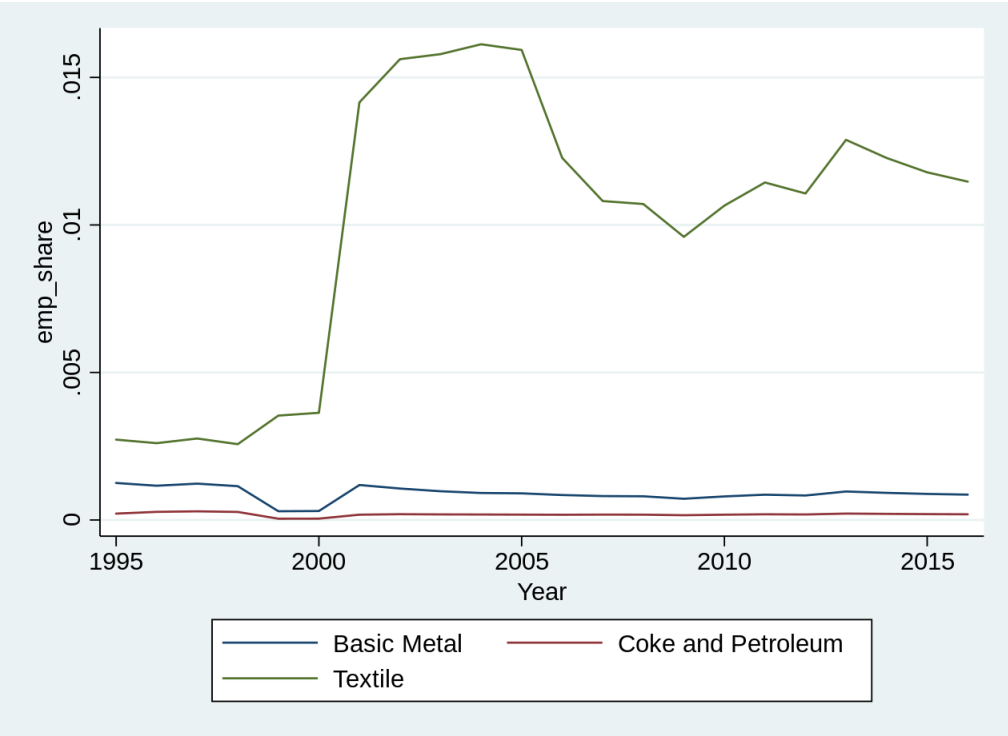
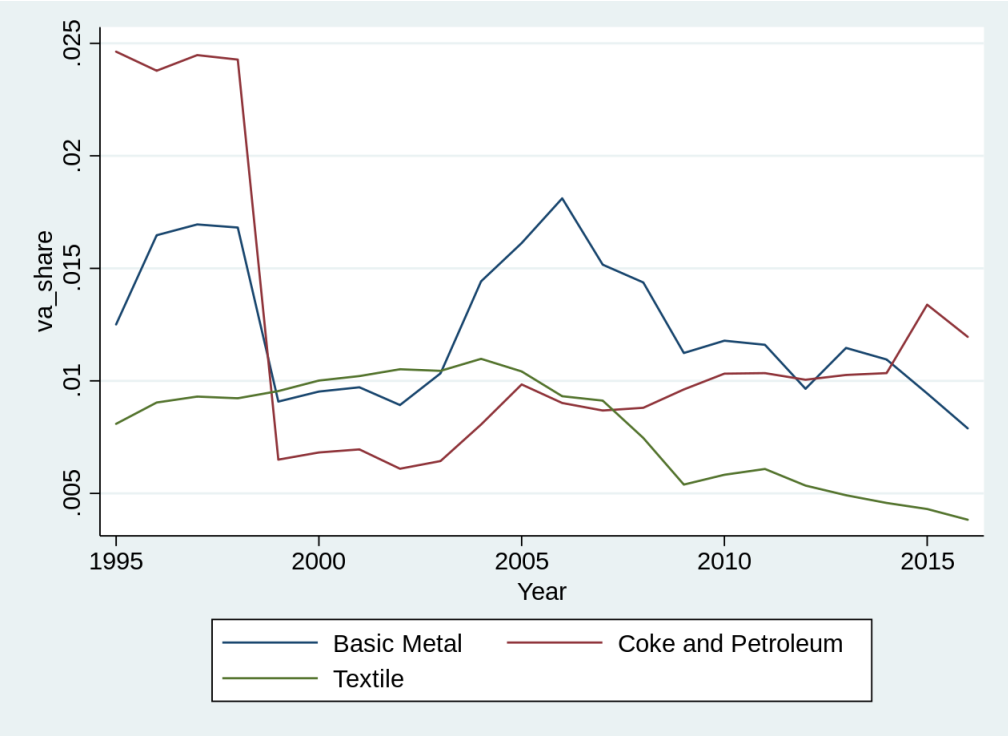


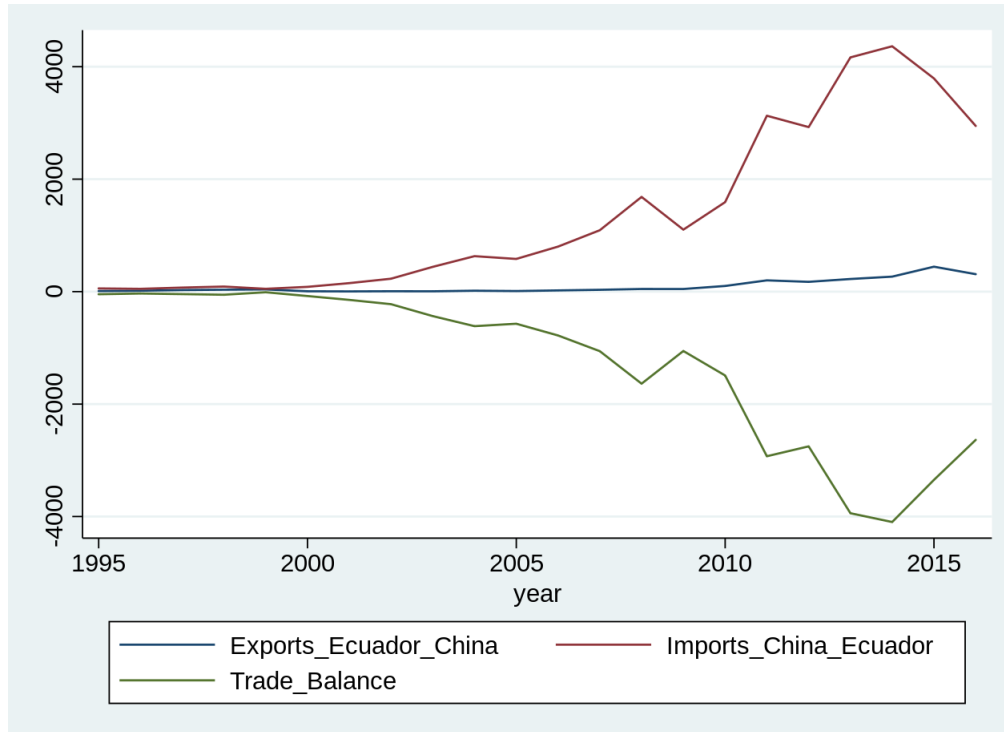
Figure 37: Peruvian manufacturing relevance within the production



## Ecuadorian Case

Ecuadorian exports to China have increased on average about 45% between 2001 and 2016, in 2020 China became the second main destination of Ecuadorian exports just after USA (about 15% of total exports). Main exports to China are focused on food, tobacco and wood. Manufacturing sectors with the largest trade deficit are: machinery and equipment, Radio, TV and communication and electrical machinery (See Figure 38).

Figure 38: Ecuador vs China: Manufacturing Trade Flows in Millions USD



Top 3 Ecuadorian manufacturing products exported to USA are food, basic metal, coke and petroleum, see Figure 39 and 40. We can appreciate a steadily increasing effect of Chinese trade flows. Moreover, this path has been accompanied by a reduction in the shares of manufacturing employment in total employment or manufacturing loses relevance within the production in the mentioned sectors (except in the case of Food manufacturing employment), see Figure 41 and 42.

Figure 39: Chinese import penetration in Ecuadorian domestic market

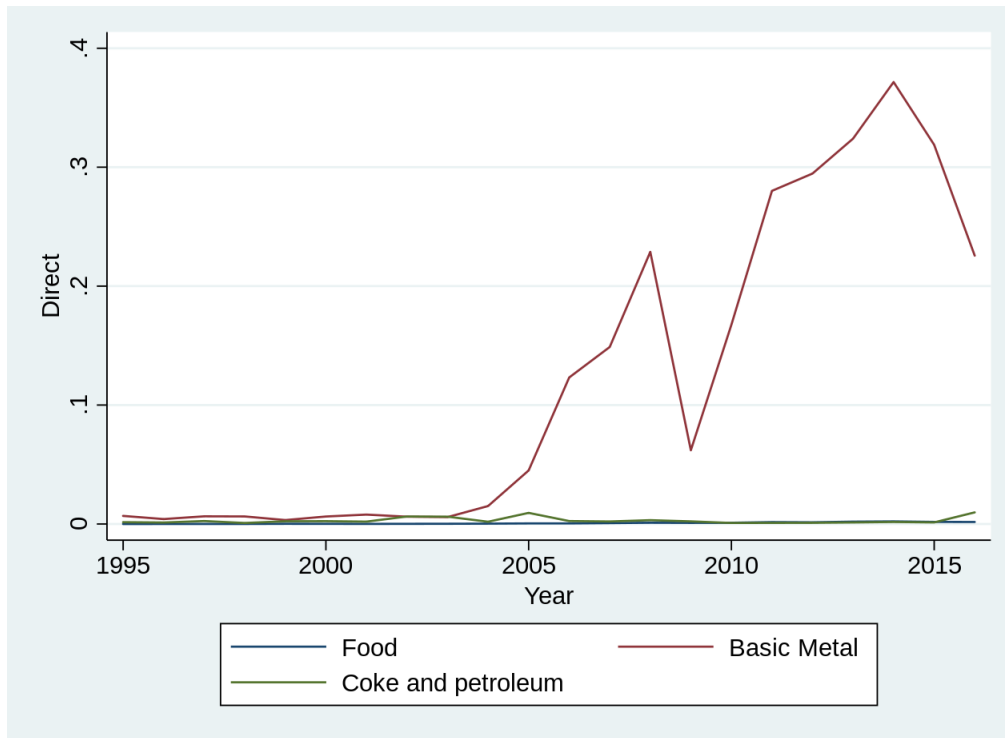


Figure 40: Chinese import penetration in Ecuadorian foreign markets

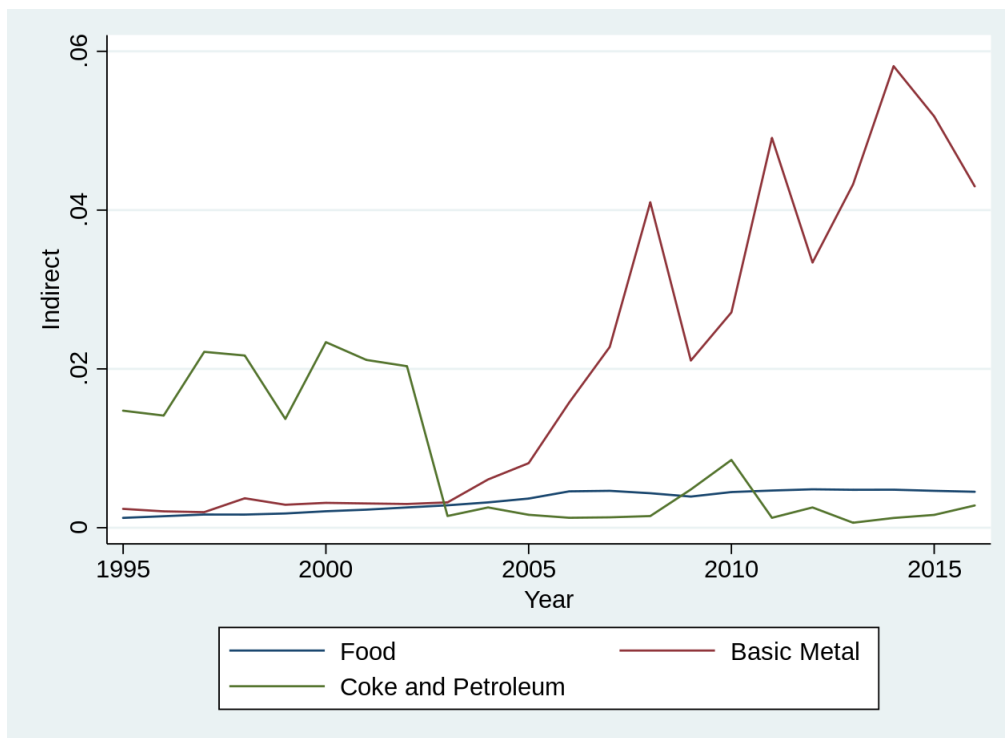


Figure 41: Ecuadorian Manufacturing Employment

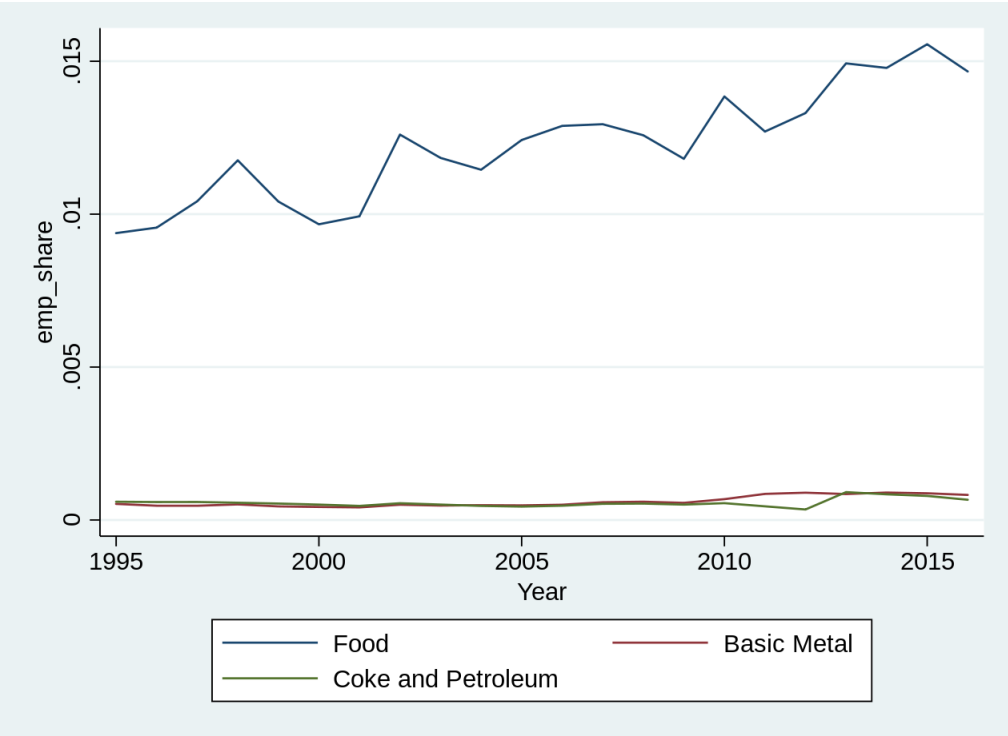
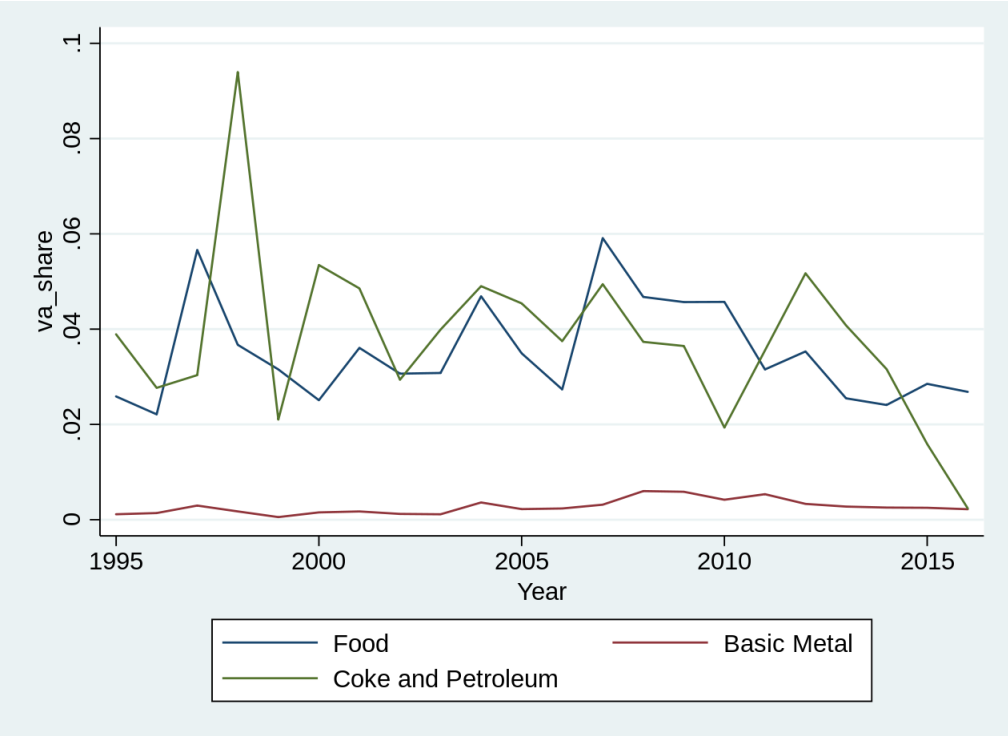


Figure 42: Ecuadorian manufacturing relevance within the production



## Annex 2: Variable Description

Variable	Description	Numerator	Denominator	Set
RME <sub>SCY</sub>	Log of Manufacturing Employment share	Employees in S / C / Y	Employee in C / Y	LAC sample
emp_share	Manufacturing Employment share	Employees in S / C / Y	Employee in C / Y	LAC sample
va_share	Manufacturing in production	Value added in S / C / Y	Current GDP in C / Y	LAC sample
GDP <sub>CY</sub>	GDP per capita constant in 2010 in C / Y			LAC sample
GDP <sup>2</sup> <sub>CY</sub>	Square of GDP per capita constant in 2010 in C / Y			LAC sample
Direct <sub>SCY</sub>	Direct Effect	Import from china in S / C / Y	Output in S / C / Y	LAC sample
Direct <sub>SSCY</sub>	Direct effect of similar countries	Import from china in SC / C / Y	Output in SC / C / Y	World sample (Similar countries) sample
Indirect <sub>SCY</sub>	Indirect Effect	Weight <sub>SC1995*</sub> (CHimportsTradePartners <sub>SCY</sub> / TradePartnerValueOutput <sub>SCY</sub> )		World sample (Main trade partners)
RCA1995	Dummy Specialization. 1 if RCA in 1995 > 1, 0 otherwise			LAC in a specific year (1995)
ExRate <sub>SCY</sub>	Real effective exchange rate			LAC sample
Weight <sub>SC1995</sub>	Weight of main trade partners	Export to Main Partners in S / C	Export in S / C	World sample (Main trade partners in 1995)
CHimportsTradePartners <sub>SCY</sub>	China imports to Trade Partners in S/C/Y			World sample (Main trade partners)
TradePartnerValueOutput <sub>SCY</sub>			Trade Partner Value-Output in S/C/Y	World sample (Main trade partners)
D.S	Dummy of Sector			LAC sample
D.C	Dummy of Country			LAC sample
D.Y	Dummy of Year			LAC sample

Table 9: Variable description

### Annex 3: Data Sources

- Source: INDSTAT 2 2020, ISIC Revision 3:
  - All countries/1963-2018/manufacturing sectors
  - Employee (numbers)
  - Value added (dollars, current)
  - Output (dollars, current)
  
- Source: CHELEM Database at the 2-digit level of ISIC Revision 3:
  - All countries/1967-2018/ manufacturing sectors.
  - Exports (USD Millions).
  - Imports (USD Millions).
  
- Source: World Bank at a country level:
  - All countries/1960-2020.
  - GDP (dollars).
  - GDP per capita (Constant USD 2010).
  
- Source: Bruegel Datasets.
  - Real effective exchange rates for 178 countries: a new database
  - All countries/1960-2022.
  - Real Effective exchange rate.

## Part 3

# Chapter II: Innovation strategies, Innovation and Firm Productivity: Chilean empirical evidence 2009-2016

## 3.1 Introduction

Over the last 30 years, Chile has known a high and stable growth (i.e. 4.7% average growth rate between 1991 and 2019), but its factor productivity has remained more or less stagnant over the same period (i.e. 1.05% average growth rate). The Chilean growth path is mainly explained by exports of natural resources, such as copper, since Chile's export basket has the same level of technological sophistication observed 40 years ago (Ministerio de Economía, Fomento y Turismo, 2016). This is not surprising: on the one hand in 2018 the Research and Development expenditures (R&D) counts for the 0.34% of GDP, less than half of LAC countries average, and, on the other hand, most of Chilean R&D is made by public sector, i.e. only about 32% of R&D expenditure is made by the private sector. Among other output measure of innovation, this is reflected in the low degree of novelty in the commercialization of Chilean products (Casanova et al., 2011). In order to make its growth path sustainable, Chile should be able to increase its productivity, which means innovating more. Not surprisingly, the last OECD evaluation of Chilean policies (2007) suggested investing more in R&D to sustain economic growth.

Lagging behind countries as Chile can adopt two different innovation strategies in order to improve productivity: they can choose between import technologies from abroad (external R&D innovation strategies) or developing their own technology (internal R&D innovation strategies) (Acemoglu et al., 2006). Importing-technology strategy is mainly implemented by firms that are far from the technological frontier where the role of imitation can be higher than innovation as a source of productivity growth. Lagging countries maximize its investment relying on existing firms and managers but sacrificing selection. However, as a country is approaching to the technological frontier, this former strategy is not going to be available anymore since the room for imitating and copying became smaller and smaller. Countries need to match quality between firms and their activities to maximize its investment.

The main aim of this empirical analysis is to investigate the effect of different R&D innovation strategies on innovation outcomes and productivity for Chilean firms. We intend to inquire if importing technologies or external sourcing are more effective than developing their own technologies or internal sourcing. Moreover, we intend to examine the relationship between the two strategies, because internal and external R&D innovation strategies can be complementary or substitute.

The most of empirical works studying the relationship between Chilean innovation and productivity have mainly focused on factors behind the probability of firms to successfully innovate and the effect of this innovation on productivity. Concerning the former, firms features are analyzed, showing how R&D activities are positively associated with firm size and market power. Big firms tend to have an advantage in costs and greater capabilities of financing while market concentration allows monopolistic rents finance R&D projects (e.g. Benavente, 2006). Relative to the latter, most of the analysis suggests a positive relationship between innovation and productivity, even if not in the short run. Moreover, some distinctions in terms of technology (e.g. basic vs sophisticated ICT, Santoleri, 2015) or type of innovation (e.g. product vs process, Santi & Santoleri, 2017), are put forward.

However, very scattered is the evidence for Chilean economy about the role that different R&D innovation strategies can play on different innovation outcomes such as product and process, on the one hand, and on firm economic performance, on the other one. Exceptions to this are Alvarez et al. (2011) and Zuniga & Crespi (2013). However, this few empirical evidence is even contradictory because they obtain opposite results. For Alvarez and coauthors, firms are more effective to boost employment growth only if they implement an internal R&D strategy but not in the case of small firms. Once considering skilled and unskilled employment, internal outsourcing increases both types of employments only in low-tech industries (Alvarez et al. (2011)). For Zuniga & Crespi (2013) doing only internal R&D does not have a significant impact on employment growth but there is a complementarity relationship between internal and external R&D strategies. Results are robust once considering different skilled and unskilled workers. Moreover, the highest positive impact on product innovation is due to the interaction between internal and external R&D strategies, followed by a significant impact of internal R&D and then external R&D strategies. While the highest positive and significant impact on process innovation is due to external R&D strategies, followed by the interaction between R&D strategies and then internal R&D strategies. To sum up, while Alvarez et al. (2011) does not found complementarity between R&D strategies for employment growth Zuniga & Crespi (2013) found a dual coexistence of R&D strategies. This divergence could be explained by the fact both analysis are restricted to the use of a cross section data analysis, failing to control for firm heterogeneity. In this sense, our paper differs from previous literature by incorporation a panel data analysis.

The present paper contributes to the empirical microeconomic literature by examining the role of internal and external R&D expenditures on Chilean firm innovation and performance. This is one of the first empirical studies that explore a panel data set to examine the effects of these strategies on innovation and performance at the firm level for the Chilean economy. Having a panel data allows controlling for unobserved firm specific factors. To do that, we perform a conditional fixed effects logit model over the period 2009-2016, combining different survey of Encuesta de Innovacion en Empresa (ENI) elaborated by the Instituto Nacional de Estadísticas (INE). We work exclusively on manufacturing firms that represent in terms of value added a third of Chilean GDP. Internal and external R&D strategies have a positive impact on innovation outcomes. Importing or buying technologies have the greatest positive impact on the likelihood of process innovation, while developing their own technologies seems to be more related with product innovation.

Moreover the two strategies may be seen as complementary rather than substitutes for both product and process innovation: firms able to combine the two strategies have a bigger positive impact on the probability to innovate, in terms of product and in process. We then repeat the same analyses considering firm size. Big firms with a better structural organization are more likely to apply innovation strategies (Basant, 1997). Comparing these last results obtained with the results without firm size, we observe robustness in the impact of innovation strategies on innovation outcomes. However, we do not observe the firm size has a significant impact on the likelihood to innovate either product or process. Finally, we were expecting that R&D innovation strategies have a positive impact on productivity. However, we found developing internal R&D activities is having a negative impact on Chilean firm productivity, which is not the case of external R&D activities or mixed R&D strategies. There may be two possible reasons for this behaviour: 1) The measure of firm productivity we are using (sales over number of employees). Another measures of firm productivity such as labor productivity or value added should be used. We try to verify this, by considering another measure of firm performance as growth of sales, and we found not significant impact of neither internal nor external R&D. 2) Our period of analysis is too short. Even though we build with a panel data, the evaluation period can be not long enough to give a clear idea about the impact of innovation strategies on firm performance.

The article proceeds as follows: Section 2 reviews the existing empirical evidence on R&D innovation strategies; Section 3 discusses the data; Section 4 econometric model; Section 5 the discussion of results; Section 6 concludes and gives suggestions for further research. Finally, references and annexes are presented.



## 3.2 Literature Review

Our analysis refers mainly to literature analyzing the role of different R&D strategies that a firm can implement in order to innovate and to better perform on the market. The literature identifies two main not exclusively strategies: (i) a strategy mainly based on internal resources in order to develop new products or implementing a new way to produce, and (ii) a strategy based on the acquiring from out of the boundaries of the firm the inputs to innovate. In the first subsection we present the main issues dealt by this literature, that concerns, on the one hand, the relationship between strategies and type of innovation implemented, and on the other hand, the complementarities or not between the two strategies. The second subsection analyses the specificities of developing economies, since the analysis has mainly focused on developed ones. The final section relates this literature on innovation strategies to the empirical literature analysing the case of Chilean firms, moreover our main hypotheses are presented.

### 3.2.1 Firm's innovation strategies and type of innovation

In order to understand the behaviour of innovation outcomes such as a new product and an innovative process we must have in mind a complex relationship between internal technology developments, and the acquisition and absorption of externally developed ones (Cohen & Levinthal, 1989 and 1990). Firms can choose either internal R&D, external R&D or combining these two strategies, i.e. a mixed R&D investment (Hagedoorn & Wang, 2002). Whether and under which conditions firms perform their own R&D investment or buying from external sources, or combining both strategies (i.e. hybrid perspective) is the research question that this paper intends to address.

R&D investment strategies can be associated with different innovation outcomes (i.e. product vs process innovation) and with the economic performance of the firm. Internal R&D investment or insourcing is associated to firms' efforts to develop its own technical knowledge. This internal strategy of technological competitiveness requires research, design, investment in patenting and the development of new products. Products that are often high-skilled intensive and require more advanced knowledge inputs and absorptive capacity (Pianta, 2001; Bogliacino & Pianta, 2010). This strategy can therefore imply an increase in the quality and variety of goods, and consequently, an increasing market shares and opening opportunities for new markets.

On the other hand, external R&D investment or outsourcing such as contracting technical and engineering services, acquisition of machinery and equipment from abroad or imported are associated to the productive system. This strategy generates a reduction of cost, higher operational efficiency or labor saving and productivity gains. By consequence, firms are able to improve the production processes and to reach potentially larger market shares. To sum up product innovation is mainly motivated by internal R&D investment followed by an interplay between these two strategies, and process innovation is driven by external R&D strategies (Pianta, 2001; Bogliacino & Pianta, 2010). Table 1 lists of publications related to R&D strategies, reporting bibliographic information, but more interestingly main results obtained with a specific focus on complementarities between internal and external R&D strategies.

Internal and external R&D strategies can coexist. Literature suggests the effectiveness of external R&D investment depends on the conditions and firms'abilities for effective technology creation and knowledge absorption. Knowledge spreading is costly and rather depends on different features such as firms'adaption conditions, skills of workers and learning ability. External knowledge may be used with replication purpose or knowledge by itself but also with compounding purpose helping to profit resources and capabilities of firms (internal R&D investment) (Serrano et al. 2018). In other words, a dual existence between internal

and external R&D investment improves the assimilation and exploitation of foreign technologies increasing firm performance. According to this, external and internal R&D investment may be seen as complements on both innovation outcomes and productivity instead of substitutes (Goedhuys & Veugelers, 2012).

A duality between external and internal R&D investment spurring innovation is also observed once considered global markets. Higher insertion in international markets and competition accelerates the increase of physical capital and new technologies imported generating a raise of demand for skills. Moving from protectionist to trade liberalism economies leads to a larger market, moving the economic to high knowledge sectors that requires educated workers, raising the demand of human capital, increasing the wage of skilled workers relative to unskilled workers (Robbins & Gindling, 1999). In other words, imported technology needs the adaption, locations and specific domestic conditions for a better exploitation of knowledge.

Therefore, a minimum level of R&D investment is essential to obtain greater advantages of purchasing new technology. The former may have two effects: 1) the creation of a new product or process; 2) motivating the integration of new external technologies to the firm productive system, increasing firm performance. The prior stock of knowledge that constitutes firm's absorptive capacity and the long-run cost of learning influence R&D spending (Cohen & Levinthal, 1989 and Cohen & Levinthal, 1990). A complementary relationship that seems stronger in the case of larger and multinational firms with greater market power that enjoys economies of scale due to the incremental and complexity behavior of technologies (Cassiman & Veugelers, 2006). Together internal and external R&D investment raise firm innovation and growth more than applying only one strategy exclusively (Goedhuys & Veugelers, 2012).

Empirical analysis has shown a positive and significant impact of a hybrid or plural sourcing strategy, a complementarity between R&D strategies that can vary under certain conditions. But why and under which constraints a firm choice one strategy rather than the other? Should firms apply a hybrid sourcing? Are these strategies always complements? Or is there a substitution relationship between internal and external R&D investment? Firms' circumstances such as firms distance to the technological frontier, size and technological regime or sector influences the strategy choice. For firms lagging behind the technological frontier the fastest and cheapest way to catch up the leaders may be by acquiring the external R&D even though increasing the dependence on external sources (Bell and Pavitt, 1993). Large firms' size are more likely to engage and spend in innovation, and at the same time these firms have greater probability of combining both strategies and doing each of them exclusively separated. For example, firm size has the most significant impact on the probability of doing only internal R&D for chemical firms and doing only technology purchase for industrial manufacturing firms (Basant & Fikkert, 1996; Basant, 1997). In high-tech industries (chemicals, television and communication etc.) where the development of new products is key to adjust to market changes, firms tend to have a higher level of internal R&D investment. These new products are related with more patents, design, marketing exploration and an increase in the expectation of sales. Having as a result sources of new jobs, increasing the demand of skilled workers. On the contrary, low-tech industries (textiles, agriculture, etc.) show a higher dependence on external R&D, promoting process innovation. This process innovation is likely to be correlated with cost and labor savings tending to displace employment, improvement in the quality (Harrison et al., 2014; Bogliacino & Pianta, 2010). The complex relationship between internal and external R&D investment seems neither perfectly complemented nor replaceable.

### **3.2.2 Developing economies: are there any specificities?**

Literature review distinguishes the impact of R&D strategies between developing and developed countries. Moreover, despite the current interest in internal and external R&D investment as a driver of firm innovation and performance, most of the empirical works have focused on developed countries. Given this context, one of the main contributions of this research is to shed some lights on the relationship between

internal and external R&D investment, firm innovation and performance for developing countries, specifically for Chilean firms.

Over the last 30 years developed countries are mainly applying internal R&D. R&D innovation strategies generate employment savings and a bias toward skilled workers. Empirical basis support complementarity between innovation strategies. A positive and significant impact of a mixed strategy is observed for these countries. Complementarity between innovation strategies was found for Belgian manufacturing firms. Internal R&D increases the returns of external R&D highlighting the importance of absorptive capabilities and a prior stock of knowledge. Firms applying only one strategy have fewer radical or incremental innovation. More appropriation regime (IPR strategy) increase the incentive to source internally but also impact the external knowledge acquisition. Moreover the degree of complementarity between internal and external R&D sourcing depends also on some firms environment factors such as firm scale and scope, size and innovation expenditure (Cassiman & Veugelers, 2006). Mixed R&D innovation strategy increases productivity for Dutch manufacturing firms. The positive impact of external R&D is only possible if there is enough internal R&D. Authors highlight role absorptive capacities such as understanding and effectively using knowledge. However, this complementarity can experience decreasing returns to scale at high levels of internal and external R&D (Loskshin et al., 2008). Finally, Park et al. (2000), compared labor productivity between internal and external firms'suppliers. In the U. S. internal and external R&D suppliers are preferable than only internal suppliers due to long-term impact of sourcing (cost, quality, delivery and cooperation). One of the main problems of having only internal suppliers it is they tend to focus on cost reduction and in the increase of sales volume but sacrificing technological improvements.

On the other hand, developing economies or countries far from the technological frontier have a distinct pattern of innovation due to weak technological capacities, insufficient human capital, limited R&D. Moreover, the presence of international spillovers may be the reasons behind why emerging economies have opted by importing foreign technologies (capital goods and/or technology licensing) from developed countries. Copying or imitation based on existence firms and managers seems the strategy mainly used for learning and catching up in firms even though increasing their dependence on external technology over time. Moreover, in these countries the presence of large firms usually based on massive and standardized production is stronger; and only few of these firms have high technological level. In Latin American countries more than 50% of R&D manufacturing investment is exclusively concentrated on buying foreign technologies such as machinery, equipment and software, the exception is Chile where 30% of R&D investment is translated in machinery, equipment and software, 10% in internal R&D strategies and 60% in both internal and external R&D strategies (Zuniga & Crespi, 2013).

However, the positive impact of external R&D is only possible if there is enough internal R&D. Firms in developing countries are trying to introduce a mixed R&D strategy combining internal and external R&D. But, empirical evidence about the positive and significant impact or the complementarity between these two strategies is not conclusive. Considering a complementarity approach we observed external R&D investment contributes more to get process innovation, while internal R&D has a greater impact on product innovation. Both product and process innovation are bigger for firms that combine both internal and external R&D. Moreover, the dual existence of investment strategies has a significant and positive impact on Brazilian firms'productivity (Goedhuysa & Veugelers, 2012). Chilean firms introducing mixed R&D strategies are having a greater positive impact in firm employment, results are independent of worker skills (Zuniga & Crespi, 2013). Here, Government State has a key role to create environments that favor technological change. In both cases, studies have been restricted to the use of cross-section data dimension bringing out potential problems of endogeneity and the ejection of firm specific effects (Goedhuys & Veugelers, 2012; Zuniga & Crespi, 2013).

On the contrary, considering a substitute relationship between internal and external R&D outsourcing approach, where the most you invest in one strategy the less you invest in the other one, we observe a sub-

stitute relationship for Indian firm's analysis, evidence suggests higher returns of technology purchase than internal R&D. Once established the interaction between technology purchase and internal R&D in most of the cases coefficient was negative, this negative sign means interaction or plural sourcing lowers the marginal productivity of the other. Moreover, authors made a distinction between foreign and local technological purchase and they found local spillovers are greater than foreign spillovers, suggesting less complementarity between internal R&D and local technology purchase: less R&D is required when buying domestic inventions than international ones due to a lower level of sophistication because technologies can be easily adapted to domestic firms conditions (Basant & Fikkert, 1996).

Mexican Pharmaceutical firms having greater export participation (outward orientation) are likely to made only internal R&D investment as a way to increase productivity and the level of sophistication of goods sold in international markets. On the contrary, firms whose main target is the local market have less incentive to innovate relying more on foreign technologies to become more price competitive. Mexican Pharmaceutical firms applying both investment strategies are facing a negative and significant impact on innovation outcomes, in other words a substitute relationship. This implies that firms tend to rely more on buying external technologies but sacrificing its investment in internal R&D. This study was restricted to use of cross-sectional data dimension (Zuniga et al., 2007). Argentine and Uruguayan companies investing in only internal R&D have greater product innovation and those investing in external R&D have greater process innovation. Firms that are investing in only internal R&D have greater growth on employment than those investing in both internal and external R&D strategies, results are still robust for small firms. Internal R&D strategies are affecting innovation but also employment growth. In the case of Chile, evidence suggests complementarity between internal and external R&D in employment growth (Zuniga & Crespi, 2013).

### **3.2.2.1 What does it happen in the case of Chile?**

Empirical evidence studying the relationship between innovation and Chilean firms behavior is limited and has mainly been focused on factors such as size, sector, worker skills, market orientation, etc. behind the likelihood of firms'innovation and the effect of this innovation on productivity. In most of cases, studies are restricted to a cross section data. In this section we briefly discuss Chilean innovation papers. We start first with cross section empirical studies, then panel empirical evidence, and finally evidence related to the role of innovation strategies on innovation and Chilean firm performance.

By using the Chilean Manufacture Survey (ENIA) for years 1997 and 1998, Benavente (2006) estimated a structural model using Asymptotic Least Squares (ALS), a generalized tobit framework. Authors found research and innovative activities are affected by firm size and market power. However, firm's productivity is not affected by innovative intensity or research expenditures at least in a short run. One of the limitations of this study is the use of R&D expenditures measure as a flow variable as dependent variable. The use of an input innovation variable instead of an output innovation variable. Moreover, the analysis is limited to the use of a cross section data. On the other hand, by using the longitudinal Chilean survey (ELE) for 2005-2006 and 2007-2008, a Crépon-Duguet-Mairesse (CDM) model that considers the firm's decision to engage in innovation investment, innovation intensity, and knowledge production; and again a generalized tobit framework, Alvarez et al. (2015) found a positive relationship between innovation input/output and productivity. Where innovation inputs are defined as R&D expenditures and innovation outputs as product or process innovations. Authors found this behaviour is similar for both services and manufacturing firms. Other variables such as firm size here measure by the log of number of employees and exposure to international markets here defined with a dummy variable that takes the value of 1 for firms that are exporting and 0 if not, are also affecting firm's innovation.

Moreover, by using a probit model and ELE data in 2009. Santoleri (2015) found the intensity and use of information and communications technology (ICT) increase the likelihood to innovate, except in the case

of basic ICT. These ICT are focused on production integrating and market-oriented ICT. Santi & Santoleri (2017) focus on innovation outcomes (product and process) and firm growth. They incorporate a Quantile treatment effects (QTE). They found a positive impact of process on firm growth for those located at the 75th and 90th percentiles from the distribution of sales. Once considering firm age: process innovation increase performance of mature firms located at top quantiles and young firms located at low-medium quantiles. However, product innovation does not affect firm performance independently of firm position in the distribution of sales. We observe that some sectors and firms are getting more benefits of innovation than others. In other words, returns of innovation will vary according to firms conditions.

Applying a logit estimation other works such as Alvarez et al. (2013) found participation in innovation public programs does not increase the probability of innovation in the Chilean Services Sector, except in the case of non- Knowledge Intensive Business Services (KIBS) where there is a positive effect of participation in innovation public programs on product innovation. Moreover, authors found large firms, a high level of intellectual property rights (here measure by patents) and, a high level innovation spending are also increasing the likely to participate in these programs (National Chilean Survey of Innovation (EIT) for years 2005-2006 and 2007-2008 covered). One of the main limitations of this study is that participation in public programs is self-reported, moreover the period of analysis is short. Indeed, we should have in mind that innovation returns are not certain.

Chilean empirical evidence using a panel analysis are: Alvarez (2016) considered two innovation inputs: ICT and R&D investment. Where most of firms are investing in ICT. Authors found investment in ICT has a positive relationship with innovation and productivity in Chilean service firms. Furthermore, ICT increases productivity directly and not only through innovation. However, R&D investment does not have a significant impact on innovation. One of the most important reasons for considering service firms it is the productivity gap of this sector compared to developed countries. Moreover, most of empirical evidence focus on manufacturing sectors rather than services. Finally, Garcia-Marin et al. (2019) found there is a complementarity effect between exports entry and R&D expenditure. Firms who have experienced technological upgrading and exports entry, have a reduction in the marginal cost, that it is translated in a mark-up increase. This increase in mark-up generates gains in productivity, specially in the case of Chilean manufacturing firms lagging behind the technological frontier (Annual National Industrial Survey (ENIA) between 1996-2007 used).

On the other hand, the role of innovation strategies (internal and external R&D investment) on innovation performance for Chilean firms has not been extensively studied. Only two studies have been made: Alvarez et al. (2011) and Zuniga & Crespi (2013). Chilean firms doing only internal R&D are positive related with employment growth, results are robust across technological sector but not across size. Interaction between internal and external R&D does not have a significant impact on employment growth. Moreover, once considering type of labor internal R&D investment favors the growth of both skill and unskilled employment only in low technological sectors but not in high technological sectors. By focusing on innovation outcomes, authors found process innovation is not related to employment growth while product innovation generates a positive impact on employment regardless size and level of technology of firms (Alvarez et al., 2011). For Zuniga & Crespi (2013) there is a positive complementarity effect between internal and external R&D strategies on employment growth for Chile, results are robust once controlling skill of workers. In addition, the probability to have product innovation is mainly affected by the interaction of R&D strategies, followed by internal and then external strategies. While the greatest impact on the likelihood of process innovation is due to external R&D strategies, followed by mixed and then internal strategies. As we observed, there is a divergence in results between both studies, Alvarez et al. (2011) does not found complementarity between R&D strategies for employment growth but Zuniga & Crespi (2013) yes, even once considering product innovation outcomes as dependent variable the complementarity persists but not in the case of process innovation outcome. These opposite results is explained by the fact both analysis are restricted to the use of a cross section data analysis. Doing so, among others, they fail to control for firm heterogeneity.

Article	Internal	External	Compliment or substitute?	Countries and period covered	Type of data	Year
Cohen & Levinthal, 1989, 1990. Bell, & Pavitt, 1993	A critical level of internal R&D investment required	Cheapest way to catch up the leaders Less internal R&D is required when buying domestic inventions produced by others. Industrial firms are likely to do only technology purchase	Complementarity in innovation	318 U.S. firms, between 1975 and 1977 Developed and Developing economies Indian firms from 1974-75 to 1981-82	Cross section Not empirical research Panel data	1989, 1990 1993
Basant & Fikkert, 1996			Substitution effects on productivity.	Indian firms from 1974-75 to 1981-82	Panel data	1996
Basant, 1997	High - tech industries are likely to do only R&D.	Industrial firms are likely to do only technology purchase	Large firm's size have greater probability of combining both strategies and doing each of them exclusively separated.	Large Indian firms: 438 manufacturing industrial machinery firms and 651 chemicals firms for 1974-84.	Panel Data	1997
Robbins and Gundling, 1999		Trade liberalization accelerates imports of physical capital generating a raise of demand for skills		Costa Rica, from 1976 to 1993 , excluding 1984 and 1986	Time-series approach	1999
Park et al., 2000			Complementarity between internal and external R&D suppliers.	1550 U.S. firms in 1995	Cross section	2000
Pianta, Bogliacino & Pianta, 2010	Product innovation	Process innovation	Contrasting effects of innovation on employment.	Europe , Asia , Africa and Latin America countries, between 2000 and 2006 (not the same for all countries)	Stratified sample	2001, 2010

Table 1: The following table sums up the main effects of internal and external R&D investment.

Article	Internal	External	Compliment or substitute?	Countries and period covered	Type of data	Year
Cassiman & Veugelers, 2006.			Complementarity in innovation. Robust across different technological levels	269 Belgian manufacturing firms in 1993	Cross section	2006
Zuniga et al., 2007.	Firms with export participation are likely to make only internal R&D .	Firms which main target is the local market rely more on foreign technologies.	Substitute relationship in productivity.	95 Mexican firms for two years, 1994 and 2000	Cross section	2007
Loskshin et al., 2008	A critical level of internal R&D investment required.		Complementary between internal and external R&D in productivity gains.	About 304 Dutch Manufacturing firms, 1996-2001	Panel analysis	2008
Goedhuys & Veugelers, 2012		The effect is stronger for both: Process Product	Complementarity in innovation and productivity.	About 1600 Brazilian manufacturing firms , period 2000-2002	Cross section	2012
Zuniga & Crespi, 2013	Product innovation	Process innovation	Substitution in employment for Argentina and Uruguay, but complementarity for Chile. Robust across workers skills.	Argentine innovation survey in 2003, Chile in 2007, and Uruguayan four surveys in 1998- 2000, 2001-2003, 2004-2006, and 2007-2009	Cross section	2013
Harrison et al., 2014	High - tech industries (source of new job)	Low tech - tech industries (displace employment moderately)		About 20,000 Manufacturing and services firms from France, Germany, Spain and the UK, 1998 - 2000	Cross section	2014
Serrano et al., 2018			Complementarity in innovation		Not empirical re-search	2018

Table 1 (Continuation): The following table sums up the main effects of internal and external R&D investment.

### 3.2.3 A simple framework and some hypothesis to be tested

In our analysis of Chilean firms R&D innovation strategies, we intend to take into account the effect of innovation investment in internal and external sources on innovation outcomes and firm performance. We distinguish from previous literature by incorporating the observation of firms across time through a panel data sources. The fact of having a longer evaluation period can help us to understand the effect of firms decision in R&D investment sourcing. Internal strategies are captured by a dummy variable that consider firm investment in the development of innovation. While external strategies are captured by a dummy variable that consider firm investment in the buying of innovation. A mixed between internal and external sources is captured by a dummy variable that considers all firms having a plural innovation sourcing.

Previous sections argues that the different strategies can affect differently the innovation outcome, according to its type. We should expect that internal strategy is more effective relative to product innovation and the meantime external strategies to process innovation. According to this, we can formulate the first two of hypothesis.

- *First*, internal sources or strategies have a significant and potentially positive effect on both product and process innovation outcomes, with the former effect more important than the latter.
- *Second*, external sources or strategies have a significant and potentially positive effect on both product and process innovation outcomes, with the latter effect more important than the former.

The presented literature and related evidence argues for complementarities between the two strategies in the majority of the case. However, under some conditions, it seems possible that there are no complementarities between the two strategies or even they are substitute. This latter case has been found in the case of both strategies replace each other in the production of knowledge. Where each innovation strategy lowers the marginal productivity of the other. The fact that Chilean level of private R&D is small (the lowest compared to other OECD countries), it is important. Since there may decreasing returns to scale at high levels of internal and external R&D (Loskshin et al. 2008). Since our case seems to not corresponding to this exceptional cases identified in the literature, it is more likely to observe a complementarities between the two strategies in the Chilean case. Consequently, we should accept.

- A positive and significant coefficient of applying internal and external strategies at the same time. We expect complementarity impact between strategies, which makes that the use of one strategy reinforces the adoption of the other.

Finally, we are interested to analyze the effect of the two strategies and their interaction on the firms'performance in terms of productivity. As argued in the previous section we should expect.

- A positive effect of innovation strategies on firm performance.



## 3.3 Data, Sample and Variables description

### 3.3.1 Data

To analyse the role of innovation strategies and firm innovation performance in Chile, we used the Encuesta de Innovación en Empresa (ENI) elaborated by the Instituto Nacional de Estadísticas (INE) which is a questionnaire made to owners and managers of firms active in different economic sectors that provide innovation information following the OECD and the Eurostat Community Innovation Survey (CIS) standards according to the OSLO innovation manual (OECD/Euro-stat, 2005).

The survey is available online for general public for years 2007-2008, 2013-2014 and 2015-2016. However, it is not possible to identify firms across time. However, thanks to the Ministerio de Economía, Fomento y Turismo collaboration. We are able to establish a panel data <sup>1</sup> between 2009 and 2016 in other words ENI 7, 8, 9 and 10 are merged.

The ENI Survey began to be collected in 1995 and since then has it been done almost uninterruptedly with some regional and sectoral representativeness changes over time. Till now, 10 surveys have been done. Each survey covers two years. For instance, survey 2017 covers 2015 and 2016. At the beginning the survey was not taken into account as a regional representativeness and only focus on some industrial sectors excluding mining. Since 2005-2006 (ENI 5) survey takes into account regional representativeness and has been done every two years continuously. Moreover, the sample survey design has tried to include more sectors. However, the survey can be considered steady in general terms for rounds ENI 7, 8, 9 and 10.

Concerning the information collected, the changes are minor. Questions have remained similar over time. The questions are getting clearer and avoiding redundant variables. For instance, in previous surveys the expenses on innovative activities were asked in % but now expenses are asked in thousands (the change was made to avoid compatibility problems). Another change was the incorporation of some social innovation questions. Table 2 sums up the main changes occurred over time especially in terms of regional and sectoral representativeness, there were not main changes for surveys version 2, 6, 8, 9 (INE 2018).

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<sup>1</sup>Survey 2011 (ENI 7), 2013(ENI 8), 2015(ENI 9), and 2017(ENI 10).

1 version (1994-1995)	3 Version (2000-2001)	4 Version (2003-004)	5 Version (2005-2006)	7 Version (2009-2010)	10 Version (2015-2016)	ENI 11 (2017-2018)
<ul style="list-style-type: none"> <li>Industrial firms with 10 or more workers.</li> <li>Sample 541</li> </ul>	<ul style="list-style-type: none"> <li>Including Mining and Electricity, gas and water</li> <li>Sample 895</li> </ul>	<ul style="list-style-type: none"> <li>New sectors</li> <li>Enterprises with a level of sale bigger than 2,400 UF (Around 59000 USD)</li> <li>ISIC Rev. 3.</li> <li>Join to a survey on Expenditure and Employment in R&amp;D.</li> <li>2,877 sample</li> </ul>	<ul style="list-style-type: none"> <li>Representativeness at regional and size level</li> <li>3,545 company</li> </ul>	<ul style="list-style-type: none"> <li>Division of Survey on Expenditure and personal in R &amp; D</li> <li>3,653 sample</li> </ul>	<ul style="list-style-type: none"> <li>CIU4.C1 2012</li> <li>5,876 sample</li> </ul>	<ul style="list-style-type: none"> <li>Ajusted to the New Oslo Manuel published in 2018.</li> </ul>

Table 2: Main Survey changes through time

Table 3 presents a general view of ENI 7, 8, 9 and 10 before establishing the panel. We observe the ENI in 2010 has the biggest sample size and number of questions (5,876 firms and 295 questions) while ENI7 that covers the period 2009 and 2010 has the smallest sample size and number of questions (3,653 firms and 232 questions).

<b>Description</b>		<b>2009-2010</b>	<b>2011-2012</b>	<b>2013-2014</b>	<b>2015-2016</b>
		<b>(ENI 7)</b>	<b>(ENI 8)</b>	<b>(ENI 9)</b>	<b>(ENI 10)</b>
No. Vari-	ables	232	275	369	295
No. Obser-	vations	3,653	4,614	5,620	5,876

Table 3: **ENI Structure by year**

### 3.3.2 Sample

The main filter to obtain the final sample to be used, it is the choice of manufacturing firms, a sector that represents in terms of value added a third of Chilean GDP. Specifically, we made use of seven manufacturing sectors. Sectors were chosen considering previous empirical works and data availability. Once the sectors have been classified by level of technology. We have: Food products, Metals Common and Furnitures as low-technological industries and Chemical substances and products, Pharmaceutical products, Electrical equipment and other machinery and equipment as high-technological manufacturing. Technological classification is defined according to OECD, 2016 standards.

After this firm sectoral selection , ENI 7, ENI 8, ENI 9 and ENI 10 finished with 613, 721 ,785, 591 firms respectively. Then, in order to observe firms across time. The four rounds of ENI. ENI 7, 8, 9 and 10 are merged. We are building a panel data. We ended with a total of 2,710 firm- year observations with 1,852 unique firms covering the period 2009 -2016. One of the limitations of this final unbalanced panel sample it is about 70% of those firms are only observed in one of the four surveys. This behaviour is homogeneous across firm size and independent of the variable used to determine the size of the firm <sup>2</sup>. For instance, there are 762 big firms in our sample from these firms 62% are in only one period, 38% in two survey periods, 19% on three survey periods, and 4% in four survey periods. On the other hand, there are 1,090 small & medium firms in our sample from these firms 73% are in only one period, 27% in two survey periods, 8% on three survey periods, and 1% in four survey periods. See Table 4.

<sup>2</sup>D.Size variable is the dummy used to define this category. Big(I) are firms who have more than Unidad de Foment (UF) 100000.01 of income in t and S&M (I) are small & medium firms who are under the reference threshold. 1 if enterprise=big 0 if enterprise=small & medium. Dsizeemployment variable is the dummy used to define this category. Big (E) are firms who have more than or 200 employees in t and S&M (E) are small & medium firms who are under the reference threshold. This variable was created by authors following the Chilean Ministerio de Economía y Turismo (2014) standards as an alternative measure of firm size. 1 if enterprise=big 0 if enterprise=small & medium.

Firm Size	Firm Pattern	No. of firms in only one survey	At least 2 surveys	At least 3 surveys	In 4 surveys
Total	1852	68%	32%	12%	3%
<b>Firm size by income (I)</b>					
Big(I)	762	62%	38%	19%	4%
S&M (I)	1090	73%	27%	8%	1%
<b>Firm size by No. of employees(E)</b>					
Big (E)	346	53%	47%	23%	7%
S&M (E)	1506	72%	28%	10%	2%

Table 4: **Pattern of firms: Unbalanced Panel using the fourth round of innovation surveys between 2009-2016**

Considering firm size more than 50% of firms analyzed are small & medium size either according to income or to number of employees. Firms size behaviour is stable across time less than 3% of firms have experienced a change in size class. Finally, the final sample is mainly composed by firms that belong to low & medium-low technological sectors (about 60% of firms), specifically to the food industry (about 40% of firms). High technological sectors represent the 40% of Chilean firms, where machinery and equipment firms are about 20% of final sample. Table 5 shows the number of firms classified by sector and size. For instance, we can observe there are 494 big and 562 small & medium firms that belong to the low & medium-low technological sector while there are 268 big and 528 small & medium firms hat belong to the high technological sector. If we considered sample size by number of employees, we see there are 216 big and 840 small & medium firms that belong to the low & medium-low technological sector while there are 130 big and 666 small & medium firms hat belong to the high technological sector.

Techno. level	Sector	Big(I)	S&M (I)	Big(E)	S&M (E)	Total (E)
Low & Medium-Low	Food	342	366	152	556	708
	Metals	116	92	49	159	208
	Furniture	36	104	15	125	140
	<b>Total</b>	<b>494</b>	<b>562</b>	<b>216</b>	<b>840</b>	<b>1056</b>
High & Medium-High	Chemical	66	150	28	188	216
	Pharmaceutical	46	67	32	81	113
	Electrical equipment	47	49	19	77	96
	others Machinery and equipment	109	262	51	320	371
	<b>Total</b>	<b>268</b>	<b>528</b>	<b>130</b>	<b>666</b>	<b>796</b>

Table 5: **Firm sample by size and manufacturing sector**

### 3.3.3 Variable Description and Stylized Facts

In this section, by using the Encuesta de Innovacion en Empresa (ENI) that provides data on product and process innovation defined according to the OSLO Manual (OECD/Eurostat, 2005) and the final unbalanced sample of 1,852 firms observed in four rounds of innovation surveys between 2009 and 2016. We intend to give some descriptive statistics of firms's innovation activities and behaviour. We start by providing definition and data of indicators related to 1) Innovation activities 2)Economic performance 3) Innovation strategies. After this, in Table 14 we present a detail description of variables used to investigate the effect of different innovation strategies on innovation and productivity for Chilean manufacturing firms.

#### 3.3.3.1 Innovation activities

As it was mentioned above, each survey covers two years of firm information. Specifically, most questions related to innovation consider directly two years. For instance, each survey asks firms if they have implemented innovation in  $t$  and/ or  $t+1$ . In other words, we are not able to identify if the innovation was made in  $t$  or  $t+1$  or in both periods. Considering this, we start the analysis by employing different dichotomous variables indicating whether the firm has innovated or not.

- *Innovation*<sup>3</sup>variable is 1 for firms that have implemented product and/or process innovation in  $t$  and/ or  $t+1$ , and 0 if they have not.
- *Product* variable considers firms who have experienced the successful introduction of new or significantly improved products or services in  $t$  and/ or  $t+1$  (equals to 1 if yes, 0 otherwise).
- *Process* variable considers firms who have experienced the successful introduction of new or significantly improved process for support of goods or services in  $t$  and/ or  $t+1$  (equals to 1 if yes, 0 otherwise).
- *ProductOnly* variable covers firms who have experienced only successful introduction of new or significantly improved products or services in  $t$  and/ or  $t+1$  (equals to 1 if yes, 0 otherwise).
- *ProcessOnly* variable covers firms who have experienced only successful introduction of new or significantly improved process for support of goods or services in  $t$  and/ or  $t+1$  (equals to 1 if yes, 0 otherwise).

We found almost 30% of firms from the final sample had experienced innovation between 2009- 2016. Firms are doing mainly process innovation (about 23%), followed by product innovation (19%). Firms who introduced either only product or only process innovation are 6% and 10% respectively. Considering this, in order to better capture innovation in firms from now on to the rest of this research we are going to consider *Innovation*, *Product*, *Process* variables as measure of innovation outcome. See table 6.

No. Firms	Experience	% No	% Yes
1852	<i>Innovation</i>	71%	29%
	<i>Product</i>	81%	19%
	<i>Process</i>	77%	23%
	<i>ProductOnly</i>	94%	6%
	<i>ProcessOnly</i>	90%	10%

Table 6: **Firms sample by innovation experience**

<sup>3</sup>Even though organizational, marketing and social innovation are variables included in the ENI survey they were excluded from the analysis due to some data limitations.

Once considering firm size, we observe an homogeneous behaviour across innovation outcome but not always across measures of firm size. According to the level of income in most cases firms who have experienced any type of innovation are big (about 70%). However, if we consider firm size according to the number of employees, innovation is mainly done by small & medium (60%). This divergence is expected due to the change in the variable used to define firm size. In order to overcome this, and since ENI surveys consider the level of sales to determine the firm's size in the stratification of the sampling, from now on to the end of this research. We only consider the level of income as a measure of firm size. See table 7.

Firms who experienced innovation	%Size by income (I)		%Size by No. of employees	
	Big(I)	S&M(I)	Big(E)	S&M (E)
<i>Innovation</i>	68%	32%	40%	60%
<i>Product</i>	73%	27%	44%	56%
<i>Process</i>	68%	32%	40%	60%

Table 7: Innovative firms by size

Moreover, if we consider firms that have experienced innovation according to manufacturing sector. We observe most of the firms who innovate are those who belong to low & medium low technological sectors, results are robust across innovation outcomes. Firms that are in Food, metals, others machinery and equipment, and chemicals are those who are innovating the most (40%, 15%, 15% and 10% respectively), these results should be taken with caution since those sectors have the biggest representation in the final sampling. See table 8.

Techno. level	Sector	Innovation%	Product Innovation %	Process Innovation%
Low& Medium-Low	Food	40%	40%	41%
	Metals	15%	17%	14%
	Furniture	6%	7%	7%
	<b>Total</b>	<b>61%</b>	<b>64%</b>	<b>61%</b>
High& Medium-High	Chemical	11%	11%	10%
	Electrical equipment	5%	5%	5%
	others Machinery and equipment	15%	12%	15%
	<b>Total</b>	<b>39%</b>	<b>36%</b>	<b>39%</b>

Table 8: Innovative firms by manufacturing sector

### 3.3.3.2 Economic performance

In this section, we intend to take into account firms' economic performance. In order to do that, we define two measures of firm performance. They are: *Salesgrowth* and *Productivitygrowth*.

We start by establishing the relationship between innovation performance or innovation outcomes and firm sales growth. We use information on sales that are reported every year (i.e. two observations per survey) to calculate growth sales as the difference of natural log of annual sales for each year. We can express *Salesgrowth* with the following formula:

$$\text{Salesgrowth} = \log(\text{Salesgrowth}_{t+1}) - \log(\text{Salesgrowth}_t)$$

As it was expected *Salesgrowth* rates are not normally distributed due to some firms features such as size and even the type of manufacturing good they produce (Bottazzi & Secchi 2006). See Figure 1. Most firms are having an average growth of sales of about 2% but firms who experienced *Innovation* exhibit about 3.75 percentage points more growth rate sale than non-innovative firms. Results are homogeneous considering others innovation outcomes, firms who have introduced *Product* innovation have 4.2 more percentage points of growth rate sale than non-product innovate firms. Firms who have introduced *Process* innovation have an average of 3.8 more percentage points of growth rate sale than non-process innovation firms. However, the differences are not statistically significant. See Figure 2. Results are robust across size and technological manufacturing levels. See Annex 1 and 2.

Figure 1: Firm sales growth density by *Innovation* execution

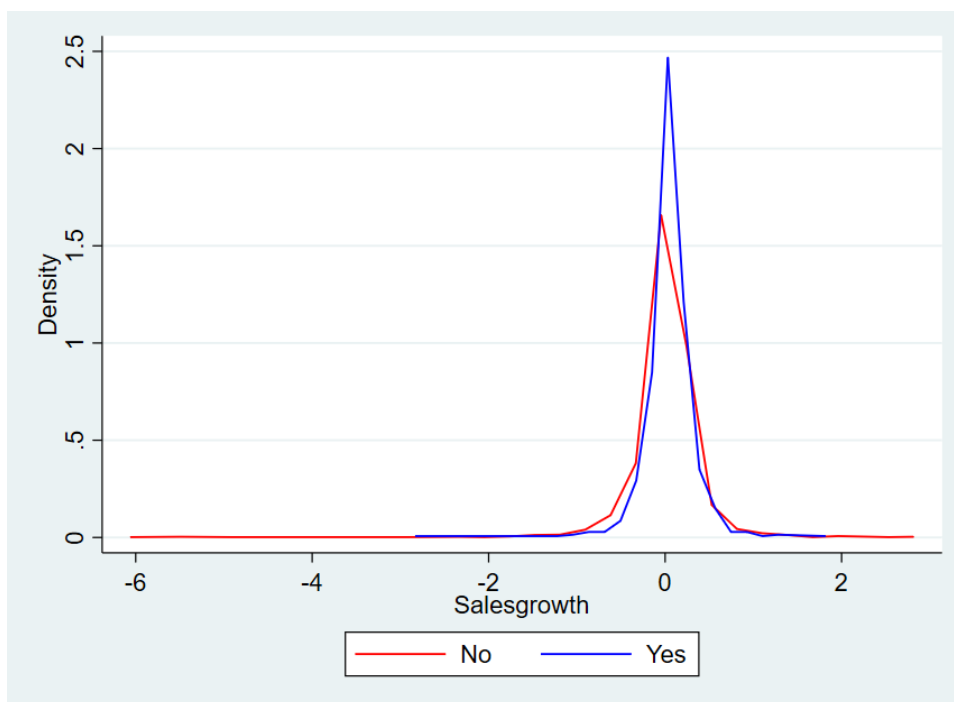
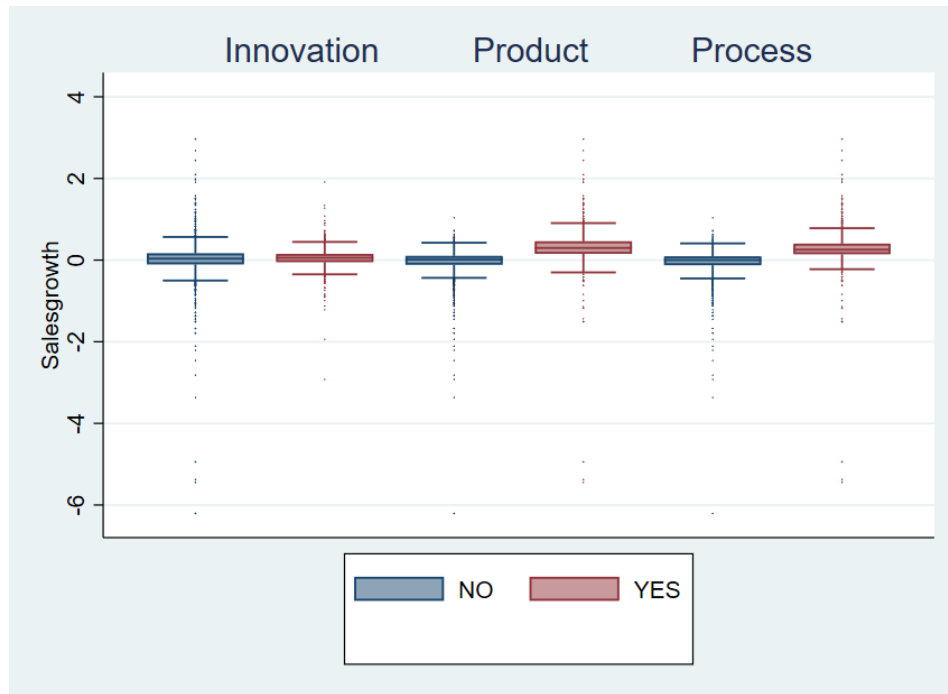


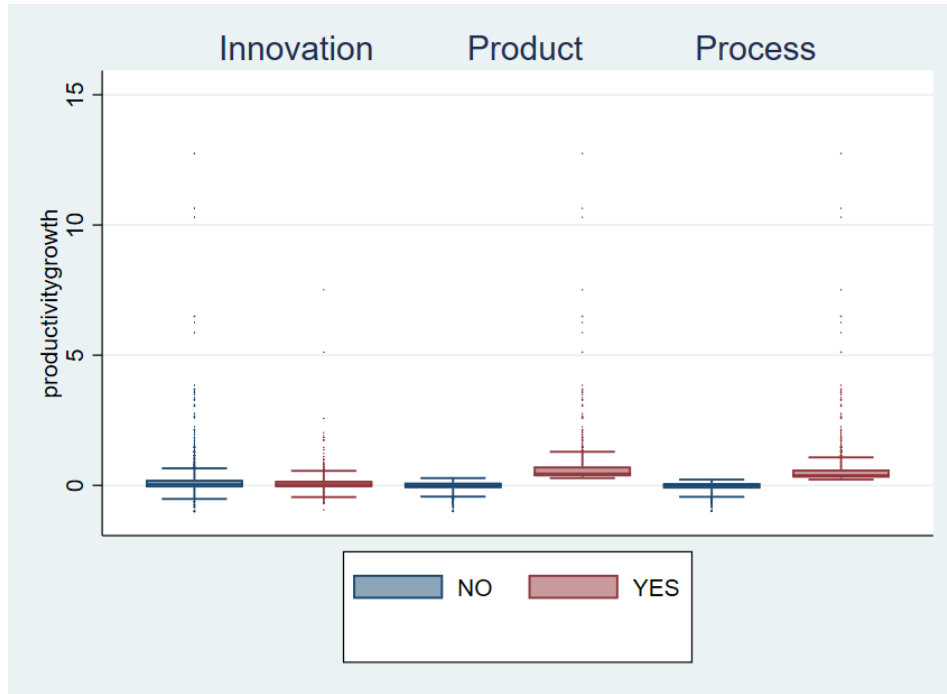
Figure 2: Firm sales growth by *Innovation* execution



A second measure of firm performance is productivity growth. Given data limitations, we should use a proxy variable called *Productivitygrowth* that considers difference between the ratio sales over number of employees in  $t+1$  minus the same ratio in  $t$ , this difference over the ratio sales over number of employees in  $t$  (Coad, et al. 2016). Results change compared to firm growth indicator. Firms who have implemented any kind of innovation have about 9% on average productivity growth, 5 percentage points less productivity growth than the observed in firms who did not implement any innovation. Results are homogeneous across innovation outcomes, firms who have introduced *Product* or *Process* innovation have an average lower productivity growth than firms who do not. A similar behaviour is observed considering firm characteristics such as size and technological manufacturing levels. See Annex 3 and 4. One of the reasons of this behaviour is the absence of labor productivity or added value to measure firm productivity. Moreover, if we notice Figure 3 none of average productivity overlaps the standard deviation limits, meaning difference in the average productivity are not significant.



Figure 3: Firm productivity by *Innovation* execution



### 3.3.3.3 Innovation strategies

As we mentioned above firms can choose external (acquisition of new equipment) or internal (development of its own innovation), or an interplay between external and internal R&D investment. According to Veugelers & Cassiman (1999), Cassiman & Veugelers (2006), Goedhuys & Veugelers (2012), it is possible to define variables based on firms decision of R&D investment. In order to measure innovation strategies we use the information about if a firm has made some external R&D expenditure together with the information about if a firm has made some internal R&D expenditure. This two dichotomies variables allow us to define three exclusive possibilities corresponding to three different strategies, as reported in Table 9.

Internal R&D expenditure	External R&D expenditure	<i>MakeOnly</i>	<i>BuyOnly</i>	<i>Make&amp;Buy</i>
1	1	0	0	1
1	0	1	0	0
0	1	0	1	0
0	0	0	0	0

Table 9: Innovation strategies variables

Given these three cases, a benchmark case is implicitly defined: if, a firm that has not adopted any of the three above strategies, i.e. the three dummies are all of them equal to zero.

Consequently, we can define the three innovation strategies as follows:

- *MakeOnly* variable considers innovation activities only inside the enterprises: Research & Development expenditure to create only its own know-how. 1 if yes 0 otherwise in t and/ or t+1. *MakeOnly* is an exclusive variable, firms who are having *MakeOnly* equal to 1 can not have *BuyOnly* equal to 1, because these firms are applying only internal innovation strategies. The coefficient of this variable will tell us, how the probability of innovation increase or decrease for firms who apply only internal strategies compared to those who do not.
- *BuyOnly* considers innovation activities only outside the enterprises: Research & Development expenditure (acquisition of machinery, equipment, software and buildings, external knowledge). 1 if yes 0 otherwise in t and/ or t+1. *BuyOnly* is an exclusive variable, firms who are having *BuyOnly* equal to 1 can not have *MakeOnly* equal to 1, because these firms are applying only external innovation strategies. The coefficient of this variable will tell us, how the probability of innovation increase or decrease for firms who apply only external strategies compared to those who do not.
- *Make&Buy* is 1 for firms that have introduced both inside & outside innovation activities and 0 otherwise in t and/ or t+1. The coefficient of this variable will tell us, how the probability of innovation increase or decrease for firms who apply both strategies at the same time compared to those who do not.

As reported by Table 10, the strategy mostly used by Chilean firms is *BuyOnly* followed by *Make&Buy* and then *MakeOnly*. The following two tables, Table 11 and 12, report information about size and sector, and the adopted strategies, showing interesting features. *MakeOnly* is mainly used by big firms (87%), and *BuyOnly* is the strategy predominant for small & medium ones (49%). Moreover, *MakeOnly* is the strategy mostly used by high technological firms (42%) and *Make&Buy* followed by *BuyOnly* are mainly used by low technological firms (65% and 59% respectively), supporting Acemoglu et al (2006) perspective that said for firms far from technological frontier the fastest and cheapest way to innovate is through imitation.

No. Firms	Experience	% No	% Yes
	<i>MakeOnly</i>	95%	5%
	<i>BuyOnly</i>	86%	14%
1852	<i>Make&amp;Buy</i>	88%	12%

Table 10: **Firms sample by innovation strategies**

Firms who implemented innovation strategies	%Size by income (I)	
	Big(I)	S&M(I)
<i>MakeOnly</i>	87%	13%
<i>BuyOnly</i>	51%	49%
<i>Make&amp;Buy</i>	82%	18%

Table 11: **Innovative strategies by size**

Techno. level	Sector	<i>MakeOnly</i> %	<i>BuyOnly</i> %	<i>Make&amp;Buy</i> %
Low&Medium-Low	Food	33%	42%	40%
	Metals	23%	10%	20%
	Furniture	2%	7%	5%
	<b>Total</b>	<b>58%</b>	<b>59%</b>	<b>65%</b>
High&Medium-High	Chemical	11%	12%	9%
	Pharmaceutical	16%	7%	9%
	Electrical equipment	5%	6%	6%
	others Machinery and equipment	10%	16%	11%
	<b>Total</b>	<b>42%</b>	<b>41%</b>	<b>35%</b>

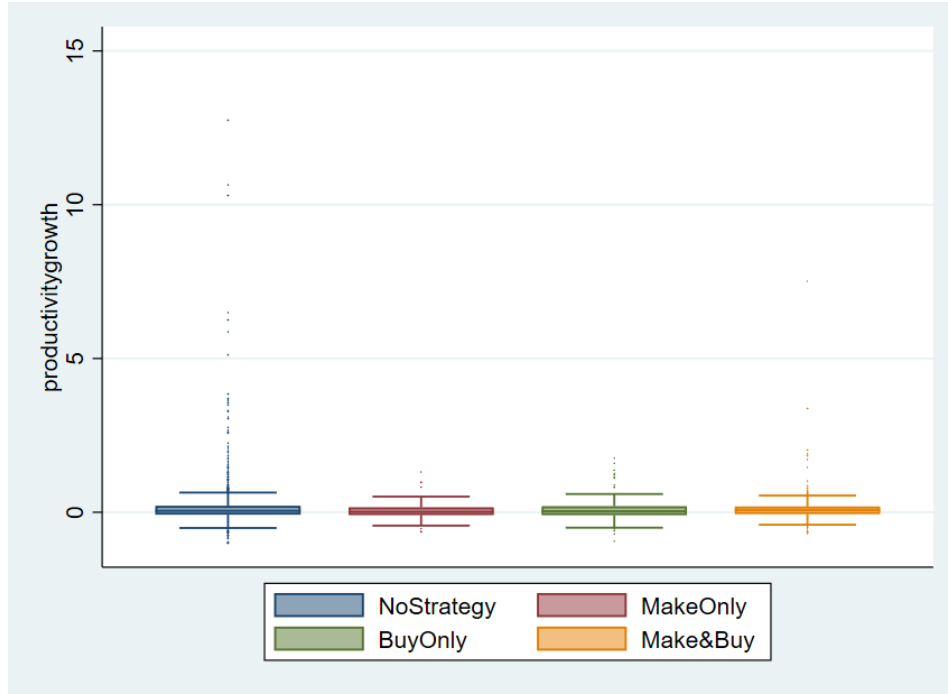
Table 12: Innovative strategies by manufacturing sector

Considering the relation between these innovation strategies and firm growth, we observe Chilean firms that have implemented *Make&Buy* exhibit highest growth rates sales on average than those firms who opted for only one strategy (5 percentage points more than those who *MakeOnly* and 3% than those who *BuyOnly*). These descriptive results support the notion of complementary between internal and external R&D strategies. On the other hand, considering the relationship between innovation strategies and firm productivity the situation totally changes, firms who have not implemented any innovation strategies have the highest firm productivity on average followed by *Make&Buy*, *BuyOnly*, *MakeOnly* (14%, 12%, 6% and 4% respectively). Again, this behaviour may be due to the type of firm productivity measure we are using and that our evaluation period is too short. Moreover, if we see Figure 4 and 5, the average sales and productivity growth differences are not statistically significant since none overlaps the standard deviation limits.

Figure 4: Firm sales growth by innovation strategy execution



Figure 5: Firm productivity growth by innovation strategy execution



Finally, in the Table 13 we observe how positive innovation outcomes is distributed relative R&D strategies. *Innovation*, *Product* or *Process* are mainly done by firms who opted for any kind of innovation strategy. Less than 20% of the firms having experience innovation did not implement any innovation strategy. Innovation outcomes are mainly driven by *Make&Buy*, followed by *BuyOnly* then *MakeOnly*. Moreover, firms that have introduced *MakeOnly* and *Make&Buy* strategies are having a highest rate of Product innovation (13% and 45% respectively). Firms that have applied *BuyOnly* are having mostly Process innovation (about 40%). Descriptive results are following the same line of (Pianta,2001; Bogliacino & Pianta, 2010) where product innovation is driven by internal R&D investment while process innovation by external R&D. These last results seems to be robust across firm size. As displayed by Table 14, we can also observe that firms that are successfully implementing product innovation and implementing *MakeOnly* and *Make&Buy* strategies are mainly big one (15% and 52% respectively). Complementarity to this, firms implementing process innovation and applying *BuyOnly* strategies are mainly small and medium one (56%). These descriptive information found echo in previous results of where large firms are more likely to engage and spend in innovation and have also greater probability of combining two strategies (Basant & Fikkert, 1996; Basant,1997).

Firms Innovation Strategy	<i>Innovation</i>	<i>Product</i>	<i>Process</i>
<i>MakeOnly</i>	9%	13%	8%
<i>BuyOnly</i>	38%	27%	40%
<i>Make&amp;Buy</i>	37%	45%	37%
<i>NoMakeBuy</i>	16%	15%	15%

Table 13: Innovative strategies and Innovation when innovation outcomes are equal to 1

<b>Innovation Strategy</b>	<i>Innovation</i>		<i>Product</i>		<i>Process</i>	
	Big(I)	S&M(I)	Big(I)	S&M(I)	Big(I)	S&M(I)
<i>MakeOnly</i>	12%	4%	15%	6%	10%	2%
<i>BuyOnly</i>	31%	53%	21%	42%	33%	56%
<i>Make&amp;Buy</i>	44%	21%	52%	28%	45%	21%
<i>NoMakeBuy</i>	13%	22%	12%	24%	12%	21%

Table 14: **Innovative strategies and Innovation when innovation outcomes are equal to 1, by size**

Table 15 sums up a detail description of the variables and their variations used to investigate the effect of different innovation strategies on innovation and performance for Chilean manufacturing firms between 2009 and 2016. Moreover, we detail all manufacturing sectors used in the sample.

Variable	Description
Productivity	Measure of firm productivity: difference between the ratio sales over number of employees in t+1 minus the same ratio in t, this difference over the ratio sales over number of employees in t.
Salesgrowth	Measure of firm performance: Difference in natural log of sales between t+1 and t.
Innovation	Successful introduction of product and/or process innovation. 1 if yes 0 otherwise in t and/ or t+1.
Product	Successful introduction of new products or services ( new or significantly improved) .1 if yes 0 otherwise in t and/ or t+1.
Process	Successful introduction of new process for support of goods or services (new or significantly improved). 1 if yes 0 otherwise in t and/ or t+1.
ProductOnly	Only successful introduction of new products or services (new or significantly improved). 1 if yes 0 otherwise in t and/ or t+1.
ProcessOnly	Only successful introduction of new process for support of goods or services (new or significantly improved). 1 if yes 0 otherwise in t and/ or t+1.
MakeOnly	Innovation activities <b>only inside</b> the enterprises: Research & Development expenditure to create only its own know-how. 1 if yes 0 otherwise in t and/ or t+1.
BuyOnly	Innovation activities <b>only outside</b> the enterprises: Research & Development expenditure (acquisition of machinery, equipment, software and buildings , external knowledge). 1 if yes 0 otherwise in t and/ or t+1.
Make&Buy	Firms that have introduces both <b>inside&amp;outside</b> Innovation activities: 1 if yes 0 otherwise in t and/ or t+1.
SkillsWork	The addition of percentage of educated workers: Technician, Bachelor, Master, PhD. Skilled workers over total of workers (included informal workers) in t and t+1 over 2.
ExportIntensity	The addition of share of exports over total of sales in t and t+1 over 2.
D.Size	1 if enterprise=big 0 if enterprise=small & medium according to the level of income Big firms are those who have more than Unidad de Foment (UF) 100000.01 of income in t.
SizeSales	Log of sales uses as a way to capture variability in the size of firms in t and t+1. Log of Sales in t + Sales in t+1 over 2
Dsizeemployment	1 if enterprise=big 0 if enterprise=small & medium according to the level of employees. Big firms are those who have more than or 200 employees in t.
SizeSalMakeOnly	MakeOnly multiplied by SizeSales
SizeSalBuyOnly	BuyOnly multiplied by SizeSales
SizeSalMake&Buy	Make&Buy multiplied by SizeSales
D.Sector	1 if enterprise belong to High & medium high technological manufacturing sectors and 0 if enterprise belong to Low & medium low technological manufacturing sectors.
	Manufacturing sectors: 15* Food products, 20 *Chemical substances and products, 21* Pharmaceutical products, 24* Metals Common, 27* Electrical equipment, 28* Machinery and equipment nec, 31* Furniture

Table 15: Variable description

## 3.4 Econometric Model

In this section, we present the specification of the main model and extensions used. We also explain methodology and its limitations, independent and dependent variables considered for each model specification.

### 3.4.1 Main Model

In the first part of the analysis we link innovation strategies with a firm's innovation performance. To model this, we defined innovation outcomes as our dependent variables. Innovation outcomes are two dichotomous variables: *Product* or *Process* already above described<sup>4</sup>. Firms who are experiencing either product or process innovation are compared with non-innovative firms as baseline.

Then we consider innovation strategies as our main independent variables : *MakeOnly*, *BuyOnly* and *Make&Buy*. Dichotomous variables above explained. Other variables such as worker skills (*SkillsWork*), intensity in exports (*ExportIntensity*), firm size(*D.Size*) and technological manufacturing level(*D.Sector*) are also included in the model as independent variables. We include these variables to control for firms conditions such as a firm's ability to recognize the value of new information and assimilate it. Based on previous empirical works such as Alvarez et al. (2015) we expect worker skills, exposure to international markets and size of firms increasing the probability to innovate. See Table 15 for a detail variable description.

Since the dependent variables *Product* or *Process* are binary. There is the need of an estimation method that allow us to work with qualitative or categorical response. A logistic regression allows us to handle with dichotomous dependent variables. The dependent variable takes the value of 1 if the occurrence of the event and 0 if not. This method allows us to calculate the probability of the outcome. We are looking for the probability to have *Product* or *Process* innovation. When independent variables take on lower values, the probability approaches zero. Conversely, if independent variables increase, the probability approaches 1. In the logit estimation, error terms follows a logistic form, a distribution with slightly fatter tails. One of the main advantages of logit model compared to a linear probability model is predicted probabilities are between 0 and 1. Finally, in logit estimation is common to report the marginal effects instead of odds ratios to make models comparable. Marginal effects can be problematic, when the dependent variable is continuous, it makes sense to have marginal effects at the means of each value of your predictors but here since our dependent variable are categorical, probabilities are evaluated the marginal average logits (the "typical" individual) (Fernandes et al., 2021).

We start with a baseline econometric model that considers the final unbalanced sample of 1,852 firms observed in four rounds of innovation surveys between 2009 and 2016. Here we run the logit estimation but considering the sample as a **pooled**, excluding the timing perspective increasing the sample size to 2,710. One of the disadvantages of this basic first approach is that it does not discriminate between units in other words, it ignores or mishandle the variability of firms, causing a potential problem of biased estimators. Our baseline model is going to be defined by the following two specifications, one for the case of product and the other one for process innovation:

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<sup>4</sup>As it was mentioned in previous section. *Innovation* variable is the interaction between *Product* and *Process*, so in order to better capture the effect and channels that may affect innovation in this section we exclude this variable from the analysis

$$\begin{aligned}
Product_i &= \beta_1 MakeOnly_i + \beta_2 BuyOnly_i + \beta_3 Make\&Buy_i \\
&+ \beta_4 SkillsWork_i + \beta_5 ExportIntensity_i + \beta_6 D.Size_i + \beta_7 D.Sector_i + e_{1i}
\end{aligned}$$

$$\begin{aligned}
Process_i &= \beta_1 MakeOnly_i + \beta_2 BuyOnly_i + \beta_3 Make\&Buy_i \\
&+ \beta_4 SkillsWork_i + \beta_5 ExportIntensity_i + \beta_6 D.Size_i + \beta_7 D.Sector_i + e_{2i}
\end{aligned}$$

Our second model of reference considers the data as **cross section**. Here, we run the same specification for every year of survey (2011 (ENI 7), 2013(ENI 8), 2015(ENI 9), and 2017(ENI 10)), excluding again the firm observation, we do this to observe if estimation is affected for the survey year sample. We are running four specifications for both innovation outcomes. One of the disadvantages of this estimation it is that the timing of analysis does not guarantee to have representative results, moreover it cannot be used to analyze firm behavior over a period of time, which generates again biased estimators. Our second model of reference is going to be defined by the following specifications:

$$\begin{aligned}
Product_i &= \beta_1 MakeOnly_i + \beta_2 BuyOnly_i + \beta_3 Make\&Buy_i \\
&+ \beta_4 SkillsWork_i + \beta_5 ExportIntensity_i + \beta_6 D.Size_i + \beta_7 D.Sector_i + e_{1i}
\end{aligned}$$

$$\begin{aligned}
Process_i &= \beta_1 MakeOnly_i + \beta_2 BuyOnly_i + \beta_3 Make\&Buy_i \\
&+ \beta_4 SkillsWork_i + \beta_5 ExportIntensity_i + \beta_6 D.Size_i + \beta_7 D.Sector_i + e_{2i}
\end{aligned}$$

Our last specification considers firm's observation across time, a **panel analysis**. Here we run the logit but considering the final unbalance sample of 1,852 firms observed in four rounds of innovation surveys between 2009 and 2016. We specifically estimate equation 1 and 2 but using a **conditional fixed -effects logistic regression**. The key advantages of this estimation is to control for all time invariant omitted variables. We are able to control for variables impossible to observe that are constant in time. This allows us managing for potential endogeneity and including the firm specific features, helping us to overcome the bias problem. For this reason, our last specification excludes two time invariant dummies such firm size (D.Size) and technological manufacturing level(D.Sector). According to this, to test the first three hypothesis of our analysis. Briefly summarized: 1) A positive and significant impact of internal sourcing in the probability to innovate, stronger in the case of product innovation 2) A positive and significant impact of external sourcing in the probability to innovate, stronger in the case of process innovation 3) A positive and significant impact of a mixed sourcing in the probability to innovate (complementarity in innovation strategies). The final specification chosen to explain the link between innovation strategies with firm's innovation performance or innovation outcomes is going to be defined by the following equations:

$$\begin{aligned}
Product_{iy} &= \beta_1 MakeOnly_{iy} + \beta_2 BuyOnly_{iy} + \beta_3 Make\&Buy_{iy} \\
&+ \beta_4 SkillsWork_{iy} + \beta_5 ExportIntensity_{iy} + e_{1iy}
\end{aligned} \tag{4}$$

$$\begin{aligned}
Process_{iy} &= \beta_1 MakeOnly_{iy} + \beta_2 BuyOnly_{iy} + \beta_3 Make\&Buy_{iy} \\
&+ \beta_4 SkillsWork_{iy} + \beta_5 ExportIntensity_{iy} + e_{2iy}
\end{aligned} \tag{5}$$



Where  $y \in 2011, 2013, 2015, 2017$  because of four rounds of ENI surveys.

### 3.4.2 Extensions and other specifications

After this, in another specification considering the previous panel framework (equation 5 and 6) we incorporate another measure of firm size (Size) that changes over the time to observe if the effect of firm strategies on innovation outcomes is affected by firm size. Here firms' size is defined such as log of sales in  $t$  plus sales in  $t+1$  over 2. Then we incorporate the interaction between each innovation strategy with firm size: *SizeSalMakeOnly*, *SizSalBuyOnly*, *SizeSalepMake&Buy* variables are included. The new specifications are defined by the following equations:

$$\begin{aligned}
 Product_{iy} &= \beta_1 MakeOnly_{iy} + \beta_2 BuyOnly_{iy} + \beta_3 Make\&Buy_{iy} \\
 &+ \beta_4 SkillsWork_{iy} + \beta_5 ExportIntensity_{iy} + \beta_6 SizeSales_{iy} \\
 &+ \beta_7 SizeSalMakeOnly_{iy} + \beta_8 SizSalBuyOnly_{iy} + \beta_9 SizeSalepMake\&Buy_{iy} + e_{1iy} \quad (7)
 \end{aligned}$$

$$\begin{aligned}
 Process_{iy} &= \beta_1 MakeOnly_{iy} + \beta_2 BuyOnly_{iy} + \beta_3 Make\&Buy_{iy} \\
 &+ \beta_4 SkillsWork_{iy} + \beta_5 ExportIntensity_{iy} + \beta_6 SizeSales_{it} \\
 &+ \beta_7 SizeSalMakeOnly_{iy} + \beta_8 SizSalBuyOnly_{iy} + \beta_9 SizeSalepMake\&Buy_{iy} + e_{2iy} \quad (8)
 \end{aligned}$$

Where  $y \in 2011, 2013, 2015, 2017$  because of four rounds of ENI surveys.

On the other hand, once established the specification to measure the role of innovation strategies on innovation, in a second part of the analysis we test our hypothesis number four, we should expect a positive effect of innovation strategies on firm performance. We evaluate the effect of innovation outcomes on firm productivity growth. Here our dependent variable is *Productivitygrowth* above already defined. Then we consider the predicted probabilities of *Product* or *Process* obtained from equation 7 and 8 as our main independent variables. Other time variant variables such as worker skills (*SkillsWork*), intensity in exports (*ExportIntensity*) are included in the model. See Table 15 for a detail variable description. Since our dependent variable is not binary anymore we consider a **panel fixed estimation** to capture the relationship between innovation outcomes and firm productivity growth. This relationship is described by the following equation:

$$\begin{aligned}
 Productivitygrowth_{iy} &= \beta_0 + \beta_1 pProduct_{iy} + \beta_2 pProcess_{iy} + \beta_3 SkillsWork_{iy} \\
 &+ \beta_4 ExportIntensity_{iy} + e_{1iy} \quad (9)
 \end{aligned}$$

Finally, in order to observe if innovation strategies are having a direct effect on firm productivity growth and not necessarily only through innovation outcomes (predicted probabilities). we run a last specification where our dependent variable is *Productivitygrowth* above already defined. Then we use innovation strategies again *MakeOnly*, *BuyOnly* and *Make&Buy* as our main independent variables. Other variables such as worker skills (*SkillsWork*), intensity in exports (*ExportIntensity*), firm size (*SizeSales*) and the interactions with each innovation strategies are also included in the model. Considering a **panel fixed estimation** the relationship between innovation strategies and firm productivity growth is described by the following equation. We also do the same analysis with sales growth of firms as dependent variable to observe if results

are robust once considering another measure of firm performance. See Annex 5.

:

$$\begin{aligned} \text{Productivitygrowth}_{iy} = & \beta_0 + \beta_1 \text{MakeOnly}_{iy} + \beta_2 \text{BuyOnly}_{iy} + \beta_3 \text{Make\&Buy}_{iy} \\ & + \beta_4 \text{SkillsWork}_{iy} + \beta_5 \text{ExportIntensity}_{iy} + \beta_6 \text{SizeSales}_{iy} + \beta_7 \text{SizeSalMakeOnly}_{iy} \\ & + \beta_8 \text{SizSalBuyOnly}_{iy} + \beta_9 \text{SizeSalepMake\&Buy}_{iy} + e_{1iy} \end{aligned} \quad (10)$$

Where  $y \in 2011, 2013, 2015, 2017$  because of four rounds of ENI surveys.

### 3.5 Results and discussion

In this section, we present the empirical analysis about the effect of innovation strategies on innovation and firm productivity growth based on the final unbalanced panel dataset which counts of 1,852 firms between 2009 and 2006.

We start analysing the results of our baseline model (specification 1 and 2). We observe *Make&Buy* strategy has the highest positive impact on the probability of firm product innovation, followed by *MakeOnly* and then *BuyOnly*. Firms with a dual R&D or *Make&Buy* strategy have 0.36 more probability to have product innovation compared to those firms who do not introduce any innovation strategies. There is a dual complementarity relationship between Make and Buy strategies. *MakeOnly* and *BuyOnly* increase the likelihood of product innovation in about 0.28 and 0.23 respectively. See Table 16.

In specification 2 we observe *Make&Buy* strategy has the highest positive impact on the probability of firm process innovation, followed by *BuyOnly* and then *MakeOnly*. This bigger, positive and significant impact suggest complementarity of innovation strategies is again supported. Firms, having implemented *Make&Buy* strategy, have 0.36 more probability to have process innovation than those who don't introduce any innovation strategies, in the case of firms that have introduced *BuyOnly* and *MakeOnly* the increase in the likelihood of process innovation is about 0.35 and 0.22 respectively. See Table 16.

Table 16: **Logit estimation: Pooled Data**

Variable	<i>Product(Model 1)</i>	<i>Process(Model 2)</i>
MakeOnly	0.279*** [0.0192]	0.221*** [0.0213]
BuyOnly	0.234*** [0.0140]	0.353*** [0.00873]
Make&Buy	0.364*** [0.0100]	0.363*** [0.0105]
SkillsWork	0.0319 [0.0252]	0.0116 [0.0287]
ExportIntensity	-0.00273 [0.00423]	-0.000251 [0.000533]
D.Size	0.0469*** [0.0133]	0.0552*** [0.0132]
D.Sector	-0.0204 [0.0125]	-0.00781 [0.0126]
Number of obs	2710	2710

Robust standard errors in brackets \* p<0.05, \*\* p<0.01, \*\*\* p<0.001

Once considering the cross section analysis (specification 3 and 4). In most of the cases we observe a similar behavior. Results are not changing across year survey sample. *Make&Buy* strategy has the highest positive impact on the probability of product innovation, followed by *MakeOnly* and then *BuyOnly* (except in the case of ENI 7 where *BuyOnly* has a stronger effect than *MakeOnly* in the probability of product innovation). On the other hand, *Make&Buy* strategy has the highest positive impact on the probability of firm process innovation, followed by *BuyOnly* and then *MakeOnly*. See Tables 17, 18, 19 and 20.

Table 17: **Logit estimation: Cross section Data - ENI 7 (2011)**

<b>Variable</b>	<b><i>Product(Model 3)</i></b>	<b><i>Process(Model 4)</i></b>
MakeOnly	0.281*** [0.0476]	0.245*** [0.0492]
BuyOnly	0.324*** [0.0329]	0.332*** [0.0281]
Make&Buy	0.414*** [0.0242]	0.412*** [0.0213]
SkillsWork	0.0485 [0.0579]	0.0653 [0.0735]
ExportIntensity	-0.0777 [0.0428]	-0.0446 [0.0510]
D.Size	0.0544 [0.0297]	0.0378 [0.0312]
D.Sector	-0.0404 [0.0257]	-0.00634 [0.0282]
Number of obs	613	613

Robust standard errors in brackets \* p<0.05, \*\* p<0.01, \*\*\* p<0.001 ,

Table 18: **Logit estimation: Cross section Data - ENI 8 (2013)**

<b>Variable</b>	<b><i>Product(Model 3)</i></b>	<b><i>Process(Model 4)</i></b>
MakeOnly	0.328*** [0.0361]	0.237*** [0.0372]
BuyOnly	0.273*** [0.0255]	0.361*** [0.0160]
Make&Buy	0.431*** [0.0201]	0.422*** [0.0207]
SkillsWork	-0.0339 [0.0474]	-0.0626 [0.0514]
ExportIntensity	-0.00170* [0.000792]	-0.000295 [0.000557]
D.Size	0.0360 [0.0272]	0.0617* [0.0258]
D.Sector	0.00104 [0.0254]	0.00662 [0.0248]
Number of obs	721	721

Robust standard errors in brackets \* p<0.05, \*\* p<0.01, \*\*\* p<0.001 ,

Table 19: **Logit estimation: Cross section Data - ENI 9 (2015)**

<b>Variable</b>	<b><i>Product(Model 3)</i></b>	<b><i>Process(Model 4)</i></b>
MakeOnly	0.236*** [0.0492]	0.189*** [0.0515]
BuyOnly	0.118*** [0.0282]	0.348*** [0.0174]
Make&Buy	0.258*** [0.0226]	0.316*** [0.0231]
SkillsWork	0.0827 [0.0454]	0.0468 [0.0552]
ExportIntensity	-0.106* [0.0424]	-0.0592 [0.0448]
D.Size	0.0874*** [0.0249]	0.100*** [0.0244]
D.Sector	-0.0518* [0.0233]	-0.00392 [0.0236]
Number of obs	785	785

Robust standard errors in brackets \* p<0.05, \*\* p<0.01, \*\*\* p<0.001 ,

Table 20: **Logit estimation: Cross section Data - ENI 10 (2017)**

<b>Variable</b>	<b><i>Product(Model 3)</i></b>	<b><i>Process(Model 4)</i></b>
MakeOnly	0.284*** [0.0303]	0.263*** [0.0373]
BuyOnly	0.208*** [0.0241]	0.356*** [0.0123]
Make&Buy	0.375*** [0.0210]	0.329*** [0.0238]
SkillsWork	-0.0370 [0.0585]	0.0322 [0.0558]
ExportIntensity	-0.107** [0.0359]	-0.0149 [0.0416]
D.Size	0.0538* [0.0233]	0.0140 [0.0271]
D.Sector	-0.0173 [0.0258]	-0.0510* [0.0257]
Number of obs	591	591

Robust standard errors in brackets \* p<0.05, \*\* p<0.01, \*\*\* p<0.001 ,

Once considering our panel data conditional fixed effect logit specification (specification 5 and 6). We can observe specification 5, *Make&Buy* strategy has the biggest positive impact on the probability of firm product innovation, followed by *MakeOnly* and then *BuyOnly*. Firm'who have incorporated a dual R&D or *Make&Buy* have 0.52 more probability to have product innovation compared to those firms who do not introduce any innovation strategies. According to this, the relationship between make and buy (internal and external R&D investment) strategies seems to be clearly complemented for product innovation. In the case of firms that have introduced *MakeOnly* and *BuyOnly* the increase in the likelihood of product innovation is about 0.37 and 0.25 respectively. See Table 21. .

Moreover, if we see specification 6 we also observe *Make&Buy* strategy has the biggest positive impact on the probability of firm process innovation, followed by *BuyOnly* and then *MakeOnly*. These results suggest complementarity of innovation strategies for the successful introduction of new process for support of goods or services. Firms, having implemented a *Make&Buy* strategy, result to have 0.45 more probability to have process innovation than those who didn't introduce innovation strategies at all, in the case of firms that have introduced *BuyOnly* and *MakeOnly* the increase in the likelihood of process innovation is about 0.38 and 0.28 respectively. See Table 21.

Results suggest complementarity of internal and external R&D. Moreover, complementarity is greater for product innovation than for process. An innovation outcome that requires a high degree of novelty. Internal R&D strategies are generating two effects. First, by increasing directly innovation and second by knowledge transference. For product innovation *MakeOnly* is more required due to the need of investment in patenting, research, design, etc. while for the case of process innovation where *BuyOnly* has a accentuated impact in its likelihood, it may be because this type of innovation is based on reduction cost or price competitiveness that needs from external sources to upgrade the productive system. These results are also in line with Zuniga & Crespi (2013) supporting the complementarity between internal and external R&D investment. To sum up empirical evidence suggests a mixed R&D strategy is highly recommended for both product and process innovation. Firms get more benefits from the virtuous circle of innovation by combining both internal and external R&D strategies.

Table 21: Panel Data conditional fixed effects Logit Model <sup>a b</sup>

Variable	<i>Product(Model 5)</i>	<i>Process(Model 6)</i>
MakeOnly	0.370*** [0.0770]	0.277* [0.123]
BuyOnly	0.253*** [0.0444]	0.384** [0.121]
Make&Buy	0.519*** [0.0830]	0.447** [0.150]
SkillsWork	0.0230 [0.120]	0.119 [0.0950]
ExportIntensity	0.0463 [0.217]	-0.0000713 [0.179]
Number of obs	418	542

<sup>a</sup>The reduction in the sample it is because according to logit methodology firms who are observed in different years always "innovating" or "non innovation" cannot be used to identify our parameters"

<sup>b</sup>Robust standard errors in brackets \* p<0.05, \*\* p<0.01, \*\*\* p<0.001

Other variables included to capture firm structural and environment conditions such as skills of employees, export intensity did not have a significant impact on the probability to have both product and process innovation. Moreover, considering extensions and other specifications (specification 7 and 8). We observe the impact of innovation strategies on innovation is robust to the interaction of firm size by innovation strategies. *Make&Buy* strategy has the highest positive impact on the probability of firm product innovation, followed by *MakeOnly* and then *BuyOnly*. Firms applying a mixed strategy have 0.53 more likelihood to have new products than those who do not implement innovation strategies at all. Firms applying *MakeOnly* and *BuyOnly* increase likelihood of product innovation in about 0.37 and 0.27 respectively. While the likelihood of process innovation is highly impacted by *Make&Buy* strategy, followed by *BuyOnly* and then *MakeOnly*. Firms applying *BuyOnly* and *MakeOnly* increase likelihood of product innovation in about 0.29 and 0.22 respectively. However, if we observe the interaction of innovation strategies with firm size (here measure as log of sales in t plus sales in t+1 over 2), variables are not statistically significant; meaning innovation strategies are not affected by firm size. See Table 22.

Table 22: Panel Data conditional fixed effects Logit Model<sup>a b</sup>

Variable	<i>Product</i> (Model 7)	<i>Process</i> (Model 8)
MakeOnly	0.366*** [0.0956]	0.221* [0.0956]
BuyOnly	0.266*** [0.0639]	0.287** [0.105]
Make&Buy	0.526*** [0.121]	0.376** [0.137]
SkillsWork	0.0152 [0.112]	0.127 [0.0834]
ExportIntensity	0.0330 [0.181]	0.0000407 [0.112]
SizeSales	0.000287 [0.00822]	0.00432 [0.00319]
SizeSalMakeOnly	0.00945 [0.330]	0.0233 [0.0840]
SizSalBuyOnly	-0.0468 [0.0981]	0.147 [0.431]
SizeSalMake&Buy	-0.0185 [0.101]	-0.0371 [0.0466]
Number of obs	418	542

<sup>a</sup>The reduction in the sample it is because according to logit methodology firms who are observed in different years always "innovating" or "non innovation" cannot be used to identify our parameters"

<sup>b</sup>Robust standard errors in brackets \* p<0.05, \*\* p<0.01, \*\*\* p<0.001

As we mentioned before in a second stage, our hypothesis number four is tested, here we are interested in measuring the effect of innovation outcomes on productivity firm growth (specification no. 9 and 10), we run a panel fixed estimation and we observe the predicted probability of *pProduct* innovation (obtained in Model 7 and 8) is not significantly affecting the productivity of firms. But *pProcess* innovation has a negative impact in productivity of firms. Moreover, if we establish the relationship between innovation strategies and firm productivity growth, we found not statistically impact of *BuyOnly*, and *Make&Buy* on productivity. Except in the case of *MakeOnly*. Firms who are applying this strategy are decreasing their productivity. These results may be taken with caution since they can change by incorporating another measure of firm productivity such as labor productivity or value added however due to data limitation we keep our definition of firm productivity growth. For instance, we run the same specifications 9 and 10 but with sales growth as dependent variable that even though it is not a measure of firm productivity, it can be used as measure of firm performance. We found a not significant impact of *pProcess* and *MakeOnly* on firm sales growth<sup>5</sup>. Moreover, the effects of internal R&D strategies and predicted process innovation may need more time to be reflected in firm productivity growth. See Table 23.

<sup>5</sup>See Annex 5

Table 23: Panel Fixed effects Estimation<sup>a b</sup>

Variable	Productivitygrowth (Model 9)	Productivitygrowth (Model 10)
pProduct	0.061 (0.033)	
pProcess	-0.069* (0.031)	
MakeOnly		-0.207* (0.091)
BuyOnly		-0.163 (0.096)
Make&Buy		-0.006 (0.061)
SizeSales		-0.015 (0.010)
SizeSalMakeOnly		0.123 (0.110)
SizeSalBuyOnly		0.057 (0.125)
SizeSalMake&Buy		-0.004 (0.078)
SkillsWork	0.037 0.037	-0.022 -0.022
ExportIntensity	-0.017* (0.008)	-0.003*** (0.000)
Const	0.189*** (0.033)	0.337*** (0.097)
Number of obs	2,684	2,684

<sup>a</sup>The reduction in the sample it is due to some missing values in the dependent variable”

<sup>b</sup>Robust standard errors in brackets \* p<0.05, \*\* p<0.01, \*\*\* p<0.001



## 3.6 Conclusions

Even though there is a large theoretical and empirical research about determinants behind R&D investment, studies analysing the role of internal and external R&D investment on firm innovation performance and firm productivity are relatively few. By using an unbalanced panel data of 1,852 firms between 2009 and 2016 obtained from the Chilean Encuesta de Innovación en Empresa (ENI), this econometric analysis tries to evaluate the impact of innovation strategies on innovation and productivity for Chilean firms. Chilean economy is a particular case of Latin American countries, even it is considered a middle income country and it is a member of the OECD, its level of R&D investment is under the OECD standards and it is experiencing a productivity stagnation for about 40 years. Moreover, most of its R&D investment is made by the public sector.

For this purpose, first we use a probability framework, we specifically work with a panel data conditional fixed effects logit model. We use innovation strategies: *MakeOnly*, *BuyOnly*, *Make&Buy* as explanatory variables. *Product* and *Process* as our dependent variables or innovation outcomes. Firms applying R&D innovation strategies are increasing the likelihood to innovate. *MakeOnly*, *BuyOnly* are increasing the probability of both product and process innovation. Moreover, firms who are applying both strategies at the same time are increasing their probability of innovation the most. Results are in favor of complementary between internal and external R&D strategies for both product and process innovation, this complementarity effect is even stronger in the case of product innovation.

Firms who have implemented both *Make&Buy* strategies have higher probability of innovation than firms who have not established innovation strategies at all. *Make&Buy* strategies also generate the highest probability to innovate for both product or process. For product innovation, *MakeOnly* seems to be also a key factor. The creation of new products requires of a higher degree of knowledge inputs and absorptive capacity. For process innovation *BuyOnly* is more relevant. External R&D investment such as contracting technical and engineering services, acquisition of machinery and equipment often sourced from abroad or imported are associated to the productive system. A strategy of cost or price competitiveness based in production flexibility and efforts to improve the production processes. To sum up product innovation is mainly motivated by *Make&Buy* followed by internal R&D investment, and process innovation is driven by *Make&Buy* followed by external R&D strategies supporting results of authors such as Pianta, 2001; Bogliacino & Pianta, 2010.

Main results are in line of Zuniga & Crespi (2013). The notion of a dual existence between internal and external R&D investment is supported for both types of innovation. Stimulating mixed innovation strategies seems to exert a positive influence on innovation for the case of Chilean firms. To understand these results the fact that Chilean R&D investment levels are low, it is relevant, if there are low levels of both internal and external R&D investment, internal strategies serve as prior stock or basic knowledge for buying external technologies, while external strategies push the need of acquiring advance skills that can manage the foreign techniques. Each innovation strategy is increasing innovation by itself but also helping to obtain more benefits from the other. Moreover, developing their own technologies is more effective for the development of product innovation while importing technologies is more effective for process innovation. However, firms' characteristics such as learning, international exposure and absorptive capacities, here measure by firm size, skill of workers and export intensity are not affecting innovation probability.

On the other hand, we found no evidence in favor of our hypothesis number four, innovation strategies are not impacting firm performance. Neither innovation outcomes nor *BuyOnly* and *Make&Buy* innovation strategies are affecting firm productivity. *MakeOnly* has a negative impact on productivity. However, this result may be taken with caution since it changes by incorporating another measure of firm performance such as sales growth, we also expect results may change by using a better proxy of firm productivity such as labor productivity or value added, measures that were not considered due to data limitations. Moreover,

it seems crucial the need of a longer period of analysis to observe the effect of innovation strategies on firm performance.

The econometric panel data conditional fixed effects logit estimation allows to take into account unobserved firm specific effects that may bias the results. However, the analysis is not without limitations due to the absence of other firm characteristic that may affect innovation such as manager experience, credit facilities, etc. Nevertheless, given the lack of empirical work on this topic for the Chilean case, these results give a first perspective of Chilean innovation strategies firm behaviour that can be used for further theoretical work where a plural innovation sourcing is a key factor to be included in innovation models.

Finally, these findings shed light on the ways in which innovation investment can be redirected. Public innovation support programs aimed at generating innovation should combine strategic management decisions, cost and market integration. There is the need of strong policy support to introduce R&D investment as key part of the Chilean Government development agenda. The current emphasis by Chilean authorities on innovation have to stress not only internal or external strategies but the promotion of both internal and external R&D investment due to its complementary on the development of innovation. After all, this R&D investment decision is going to define firms future. Public policies should promote not only the intensity of these strategies but also how organize and redirect efforts of each strategy in order to profit from the innovation virtuous circle, not only easier but also faster.

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# Appendices

## Annex 1: Sales growth by firm size

Figure 1: Firm sales growth by *Innovation/Product/Process* execution for Big firms

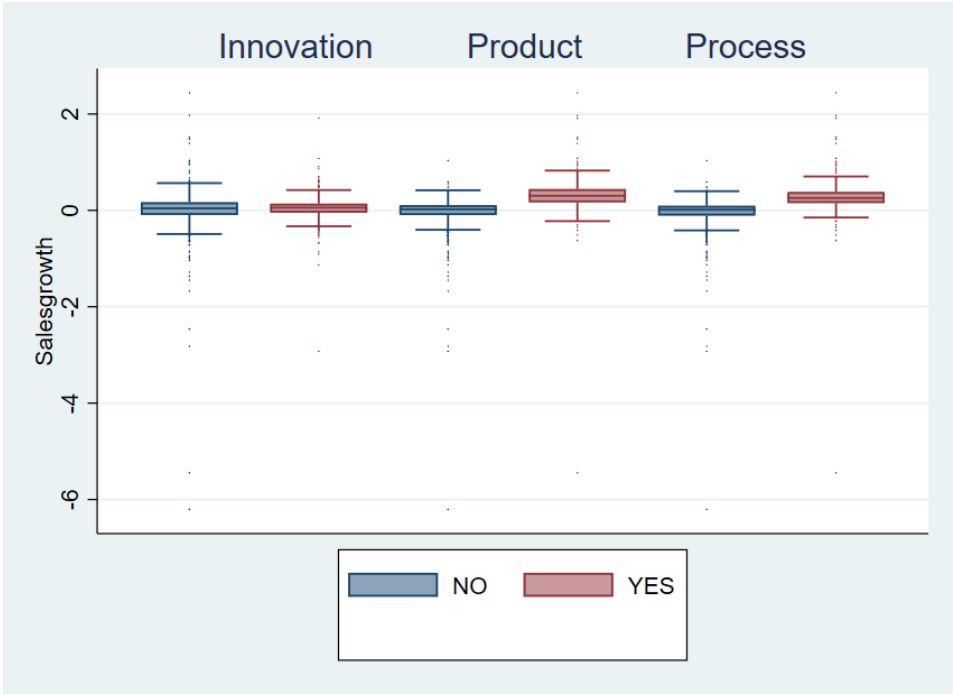
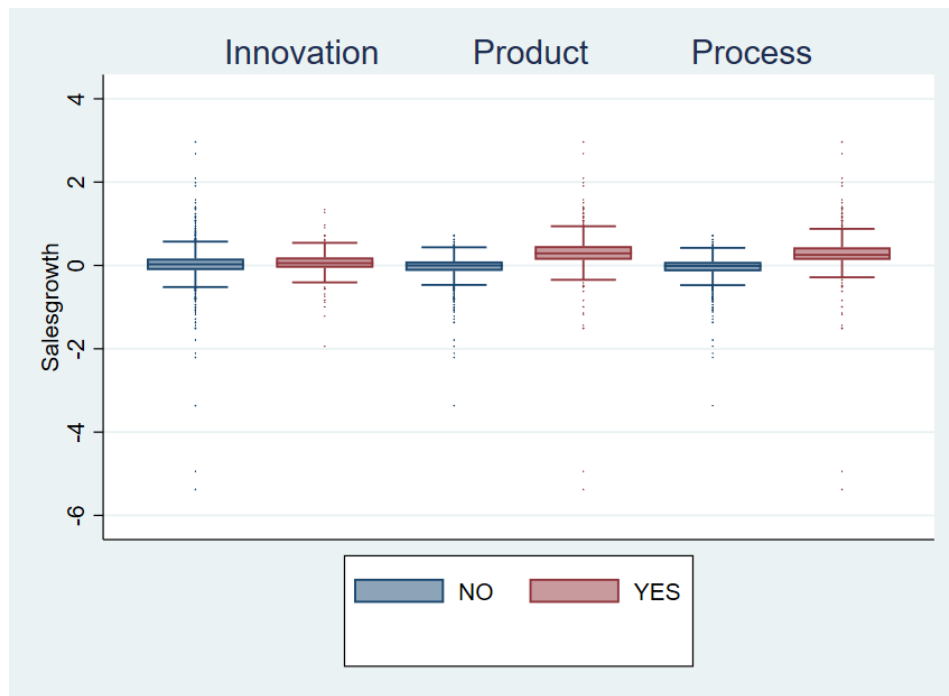


Figure 2: Firm sales growth by *Innovation/Product/Process* execution for S&M firms



## Annex 2: Sales growth by technological level

Figure 3: Firm sales growth by *Innovation/Product/Process* execution for Low& Medium low technological manufacturing firms

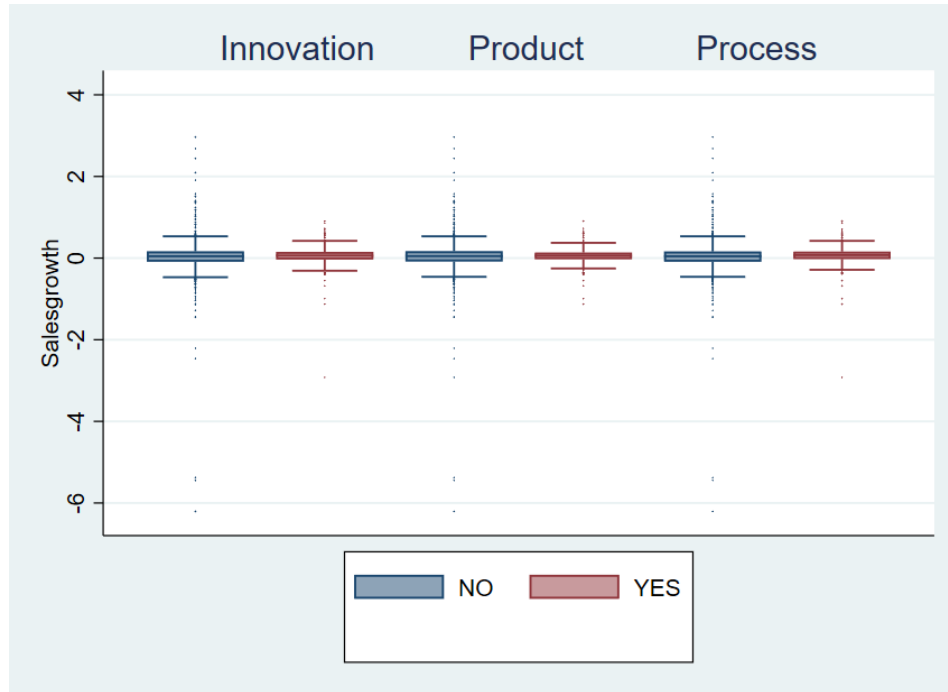
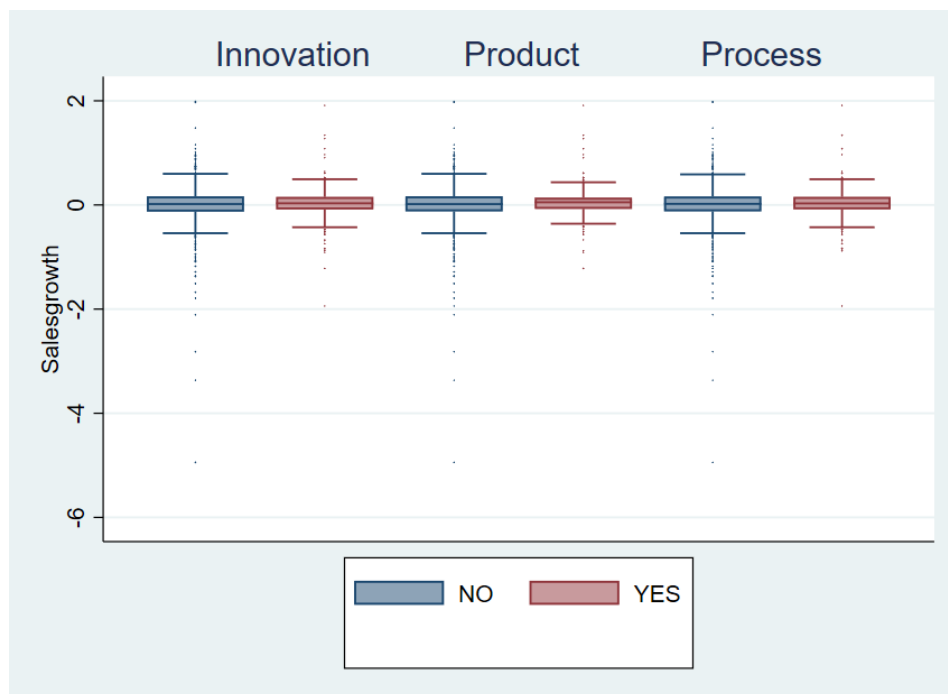


Figure 4: Firm sales growth by *Innovation/Product/Process* for High& Medium high technological manufacturing firms





### Annex 3: Productivity growth by firm size

Figure 5: Firm productivity by innovation execution for Big firms

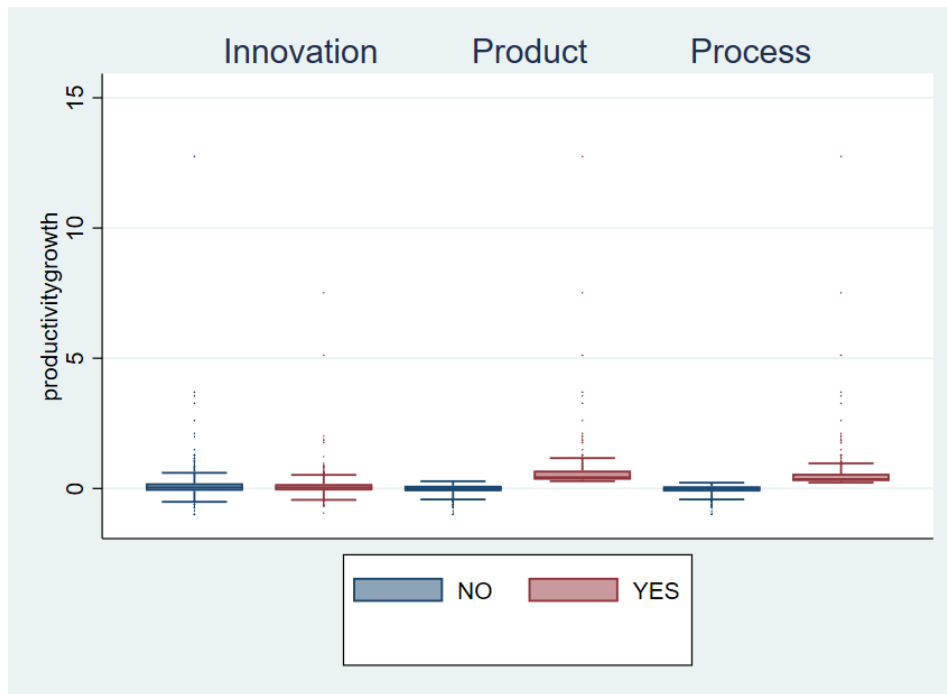
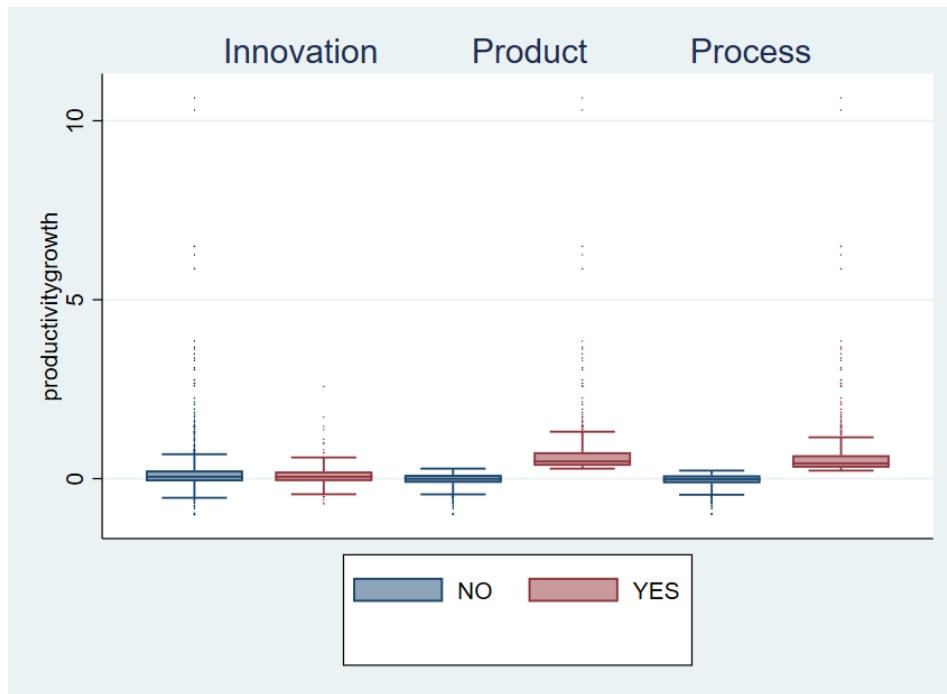


Figure 6: Firm productivity by innovation execution for S&M firms



## Annex 4 : Productivity growth by technological level

Figure 7: Firm productivity by innovation execution for Low&Medium low technological manufacturing firms

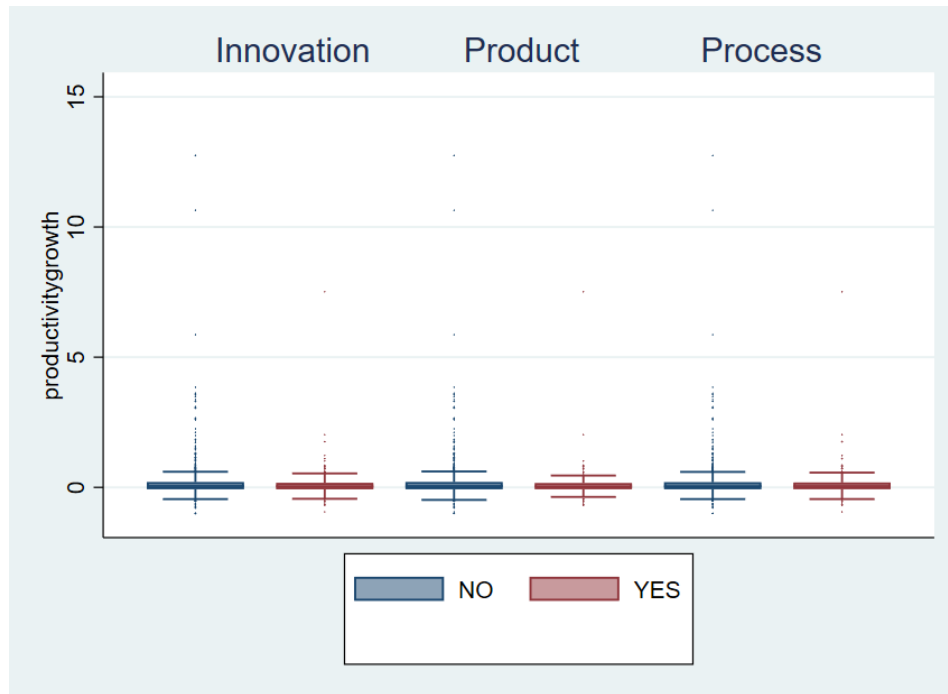
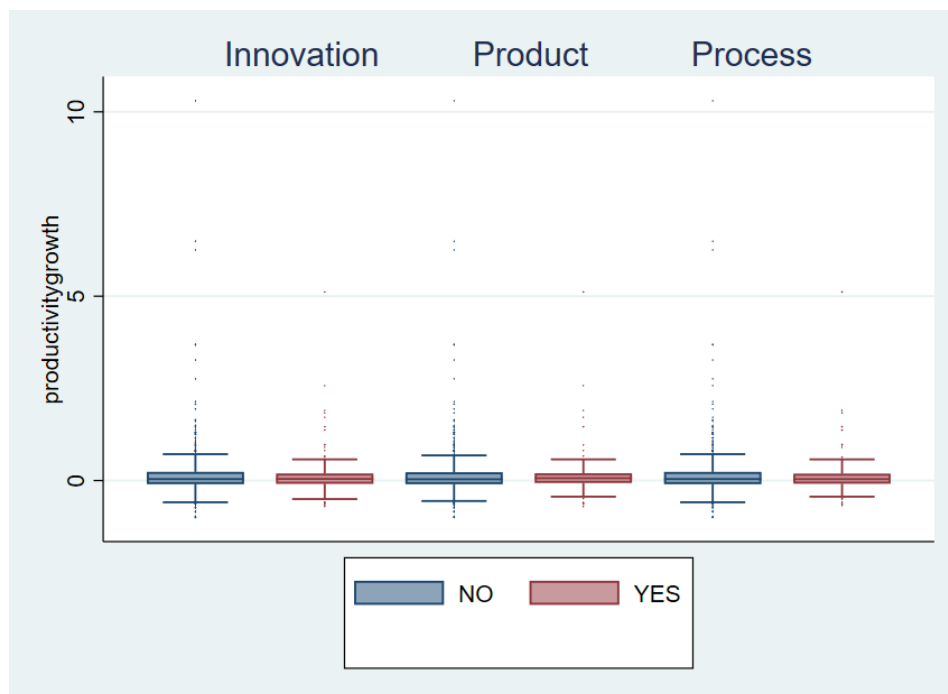


Figure 8: Firm productivity by innovation execution for High&Medium high technological manufacturing firms



## Annex 5: Robustness check

Table 1: **Panel Fixed Estimation**<sup>a b</sup>

Variable	Salesgrowth (Model 9)	Salesgrowth (Model 10)
pProduct	0.035 (0.020)	
pProcess	-0.032 (0.018)	
MakeOnly		-0.097 (0.059)
BuyOnly		-0.068 (0.057)
Make&Buy		0.034 (0.038)
SizeSales		-0.006 (0.004)
SizeSalMakeOnly		0.078 (0.065)
SizeSalBuyOnly		0.016 (0.068)
SizeSalMake&Buy		-0.024 (0.040)
SkillsWork	0.019 (0.078)	-0.004 (0.075)
ExportIntensity	-0.010* (0.005)	-0.001*** (0.000)
Const	0.045* (0.022)	0.098 (0.051)
Number of obs	2,701	2,701

<sup>a</sup>The reduction in the sample it is due to some missing values in the dependent variable”

<sup>b</sup>Robust standard errors in brackets \* p<0.05, \*\* p<0.01, \*\*\* p<0.001

## Part 4

# Chapter III: R&D cooperation, Innovation and Firm Performance: Evidence from Chile 2009-2016

## 4.1 Introduction

The firm R&D cooperation or alliances strategy has increased steadily in the 90s, especially in fast developing technologies such as in pharmaceutical, chemical, biotechnology sector. Nowadays, more academic discussions about motivations and incentives behind innovative cooperating activities and efforts are observed in both developing and developed countries. Innovation is a process that can not be done alone, but rather depends on collective actions. Firms are in need of external sources that complement internal sources. R&D cooperation allows firms to obtain expertise in managing in-house sources. Moreover, risks, costly projects, skills, opportunities to access to higher technological resources, higher R&D global networks, and the internalization of more R&D cooperation benefits are some of the reasons why firms are opting for R&D cooperation rather than going alone (Belderbos et al., 2004; Becker et al. 2004).

Nowadays, the idea that networking and linkages between firms and partners can increase numbers and quality of innovation is supported by policy makers. Policy instruments that promotes join R&D can allow firms to obtain benefits due to cultural and spatial proximity's, complementing firms internal resources. Chilean authorities aware of the necessity of establishing R&D cooperations that allow firms to have a larger and more differentiated basket of knowledge, have also pushed on R&D collaboration through some public programs such as the Science and Technology Development Fund (FONDEF). R&D collaboration with research institutions increase Chilean firm performance, this R&D partnering has also spillover effects for firms that are close in geographical and technological terms (Koschatzky & Sternberg, 2000; Crespi et al., 2020).

Moreover, firms have considered R&D cooperation because of its importance such as mechanism in the development, application, and transfer of scientific knowledge. Knowledge required for the successful creation of new or significantly improved products and processes. For this reason, innovation partnership or cooperation is a key tool for the development of firm performance. The firms' decision to cooperate gives a variety of technological options to be implemented. Companies can cooperate in the share of R&D activities with different type of partners such as other firms, customers, institutions, universities, organizations, etc. Type of partner, firm structure, and market dynamism can impact the effect of R&D cooperation (Belderbos et al., 2004; Becker et al. 2004; Hagedoorn, 2002).

Another reason why R&D collaboration has attracted the firms' attention during the last years is the presence of knowledge spillovers during innovation alliances. Literature distinguishes between involuntary and voluntary (Belderbos et al., 2004). The first one is present in the absence of R&D cooperation and depends on the nature of the technology. Firms returns of R&D efforts are producing a positive spillover effects on competitors or rivals. These makes firms investing in R&D to lose incentives in R&D investment, moreover, they can also lose their relative market position. Firms do not want other firms or rivals to profit of their R&D investment without any effort. On the other hand, under R&D cooperation firms are more able to internalize R&D returns and, minimizing transaction costs. Reducing the investment in knowledge protection and exploiting the acquisition and investment of new technologies. Here, the R&D cooperation

brings out voluntary spillovers translated into higher levels of R&D investment levels, new innovations, higher quality products, and processes (Belderbos et al., 2004; Cassiman et al. 2002).

If R&D cooperation brings out all of these positive impacts on firms, why not all firms are cooperating? Firms who want to establish R&D cooperation can require or need prior knowledge bases, capabilities and network. Moreover, R&D cooperation generates adaption cost such as: coordinating, managing and controlling. Capacity constraints and capability to search for cooperation partners, establish cooperation agreements are also potential reasons behind firms for not establishing R&D cooperation. Even though R&D cooperation can offer firms a promising innovation perspective, firms may not be ready to establish this R&D cooperation. If benefits of R&D cooperation are greater than cost of cooperation then, firms could opt for joining R&D rather than only internal R&D sources. In other words, their innovation activities are going to be shared with other partners only if firm can afford this. Firms face the question of whether or not to establish R&D cooperation and which R&D cooperation partner to choose (Becker & Dietz, 2004; Aschhoff & Schmidt, 2008).

The main aim of this empirical analysis is to investigate the effect of R&D cooperation and the different types of R&D cooperation such as R&D partnering with customers, competitors, suppliers, universities and institutions on Chilean firms performance both in terms of innovation and productivity. Is R&D cooperation translated into firm innovation activities? Are some types of R&D cooperation more effective than others? Is R&D cooperation effective in increasing productivity? Are there some firms' characteristics systematically correlated with R&D cooperation and firm performance?

The present paper contributes to the empirical microeconomic literature by examining the role of R&D cooperation and the heterogeneity between R&D collaboration on Chilean firm performance in terms of both innovation and productivity. This is one of the first empirical studies about R&D cooperation for Chile. We explore a panel data set to examine the effects of R&D cooperation and different type R&D cooperation on innovation and productivity at the firm level for the Chilean economy. Having a panel data allows to control potential endogeneity and unobserved firm specific effects. To do that, we perform a linear probability model with firm fixed-effects over the period 2009-2016, combing different surveys of Encuesta de Innovacion en Empresa (ENI) elaborated by the Instituto Nacional de Estadísticas (INE). We worked exclusively on manufacturing firms that represents in terms of value added to a third of Chilean GDP. Finally, we get a sample of about 746 firms observed between 2009 and 2016.

Results show that the R&D cooperation is increasing the likelihood of product and process innovation. The positive effects of R&D cooperation seems stronger in product innovation, an innovation outcome that often requires research, design and investment in patenting. On the other hand, results are not robust once considering five different types of R&D cooperation partners (i.e. Competitors, Customers, Suppliers, Institutions and Universities). These types of R&D partners are not affecting the likelihood of innovation. However, once considering R&D partners classified according to the position a partner has in the knowledge stream, we observe that: (i) R&D cooperation with partners in upstream position, such as Suppliers and Universities, are having a positive impact on general innovation and process innovation; (ii) R&D cooperation with partners downstream, as Competitors and Customers can decrease the likelihood of product innovation, the reason behind this negative impact can be some reluctance in the transfer of information and knowledge.

Finally R&D cooperation is not affecting firms productivity. The need of a longer period of analysis becomes crucial to observe the robustness of results. Moreover, another measure of firms productivity such as labor productivity or valued added should be used. Other variables such R&D intensity to measure the level of investment in R&D projects also increase the likelihood of innovation outcomes, and has a positive impact on productivity of firms.

The article is organized as follows: Section 2 reviews the existing evidence on R&D cooperation; Section 3 discusses the data; Section 4 methodological issues; Section 5 presents the results on the Chilean case; Section 6 concludes and gives suggestions for further research.

## 4.2 Literature Review

Since the late 1980s, the interest in R&D spending has increased in Latin American and Caribbean countries with an increasing set of policy experiments granting fiscal incentives to promote private investment in R&D. The main goal of such public policies is to overcome the market failures due to under investment in R&D in the private sector. Among the different strategies a firm can adopt in order to innovate, R&D collaboration is one the option in order to develop internal capacities thanks to the use of external sources. R&D cooperation or alliances consist in the share of cost, risk, skills, and benefits of R&D investment. Firms chose to join R&D rather than going alone if they are prepared in terms of prior structure and knowledge bases. If benefits of cooperation overcome cost of it (Aschhoff & Schmidt, 2008). The rest of the section aims to review the literature analyzing reasons behind R&D cooperation, when and why firms decide or not to cooperate in R&D, how this decision and the results of it can change according to the type of innovation outcome and R&D partners.

### 4.2.1 Reasons of R&D cooperation: Under which circumstances firms have an incentive to cooperate?

R&D alliances may have a positive impact on innovation and firm performance. Firms may engage in R&D alliances to profit more of internal resources, there is the need of external sources to build up competitive advantages. Expensive, complex or risky projects needs R&D cooperation to profit more of external sources, reducing cost and increasing the expertise in the use of new technologies. In other words, the quantity and quality of R&D affects both propensity of R&D cooperation and the profile of R&D chosen partner. But in what circumstances firms have an incentive to cooperate? Some reasons of R&D cooperation are: firms distance to the technological frontier, innovation environment and dynamism, firm size and age. Cooperation on R&D is higher for firms with high and medium R&D intensity, firms near to the technological frontier mainly focused on scientific resources such as chemical, pharmaceutical, biotechnology sectors, sectors with stronger absorptive capabilities to capture the benefits of the R&D cooperation decision. Moreover, high profile innovators are likely to have R&D cooperation even with rivals or distant partners (Miotti & Sachwald, 2003).

Moreover, the increase of the competitive environment and innovation dynamics have contributed with firms to consider R&D cooperation as way to increase the innovation process at the firm level. Firms are incorporating both formally and informally R&D cooperation activities but informal R&D cooperation without contracts is often the most used due to less time, capacities, and monitoring restrictions and an easy flexible transfer of information. In other words; the cost of formal cooperation is higher than informal cooperations.

Large firms with costly or expensive R&D projects cooperation tend to establish formal R&D cooperation to limit positive spillovers to rivals (for high levels of appropriability) and to promote the effectiveness in exploiting inventions. Firms focus on the development of new products, process or radical innovation have higher probability of R&D cooperation with customers and suppliers (Bönte & Keilbach, 2005). R&D

cooperation is a source of competitive advantages and capabilities, reduces uncertainties and information asymmetries. Startups that have integrated R&D alliances have a better performance (here measured by patenting and R&D spending growth) due to an efficient network, more access to information and cost reduction. Moreover, alliances can help firms to overcome juridical problems. For authors, the importance of R&D cooperation in startups firms suggest, firms should build up partners relationship and moreover they should choose differentiated partners that provide firms a bigger pool of information and reduce the risk of rivalry. The type of R&D cooperation depends on prior work network, limiting the range cooperation partners (Baum et al., 2000).

#### 4.2.2 Global competitiveness has modified firms' relationship with partners

Moreover, Global competitiveness has modified firms' relationship with partners. Strategically outsourcing component parts and services makes suppliers to compete. Outsourcing of parts with the most advanced and competitive suppliers (those with low-cost strategies, high differentiation, labour flexibility, cooperation and technological skills) is positive related to manufacturing's renewed gains in productivity for small and medium-sized manufacturing American Firms (Kaufman et al., 2000). The success of Japanese automobile and electronics during the 1980s was attributed to the firm cooperation with suppliers. Suppliers were involved from the beginning of the product design, and price targets, performance monitoring, competition. Authors analyse also the US market and they found that even though US firms were trying to apply the "Japanese model" based on suppliers involvement in the all development of products (from the first to the last stage), the absence of infrastructure, discipline and technical processes limited the US automobile firm performance (Liker et al., 1996).

Internal and external sourcing of innovation in R&D can be seen as complement rather than substitutions. Based on the Portuguese Third Community Innovation Survey and a probit selection model. De Faria et al. (2010) found internal innovation activities can be complemented with firm agreements with universities, institutions, etc. Authors suggest a spillover trade-off between cooperation partners. Firms invest in internal activities such as absorptive capacity to profit more of spillovers of R&D cooperation. High-technological industries, high levels of absorptive capacity and innovation intensity, with an important role of incoming spillovers management are the main determinants behind the probability of cooperation. Moreover, cooperation with partners closer to the firms in the level of operational knowledge and firms resources such as firms from the same group or with suppliers are more effective than cooperation with other partners.

Moreover, science and academic knowledge are at the core process in the development of major innovations. By using the Community Innovation Survey conducted in France in 1997 and a probit estimation Monjon & Waelbroeck (2003) found R&D cooperation with universities has a positive impact on firm innovation. Authors distinguish between R&D cooperation with national and foreign universities. Results stress the role of spillovers R&D cooperation for firms imitating existing technologies and they found firms far from the technological frontier can catch up leaders by benefiting from spillovers generated by R&D cooperation with national universities, these spillovers comes from informal meetings, publications and conferences. While for firms close to the technological frontier, the academic knowledge obtained by R&D cooperation with foreign universities is crucial. We observe R&D cooperation with universities plays two roles: creating new ideas and knowledge but also helping in the development of existing projects. By using a sample of 2,342 UK firms and a logistic regression Tether (2002) notice even though the increase of R&D cooperation most firms are still not doing formal cooperative agreements, firms are doing informal cooperation because is less expensive. Authors defined R&D cooperation such as participation in R&D or technological projects with different partners but this R&D cooperation that does not necessarily implies that partners experiences commercial benefits. Firms pursuing radical innovation or innovation new to the market and who have a higher level of R&D investment tend to have more R&D cooperation. The impact of this cooperation depend on the type of characteristics of firms such as size, technological level, and the innovation indicator used such

as product or new process.

Appropriability of its innovations (the fact of obtaining all benefits from R&D investment and avoid other firms to take advantages of this investment), absorptive capacity, organizational structure of R&D, and industries'innovation dynamics are the main reasons behind R&D cooperation (Bönte & Keilbach, 2005). Authors use the German Mannheim Innovation Panel (MIP) in 1993 and 1994 and they apply a multinomial logit analysis. They notice informal cooperation is more important and frequent than formal cooperation. Large firms with high levels of dynamism (the creation of new products for firms and to the market), high absorptive capacity where appropriability is a key factor tend to establish formal cooperation with customers and suppliers, and informal cooperation is driven by time restriction, cost saving, and flexibility in the transfer of information. Firms with higher levels R&D cooperation with external partners are more likely to be large, with higher R&D employees, and more spending in monitoring external activities, especially in the case of complex or expensive technologies to be developed (Fritsch & Lukas, 2001).

#### **4.2.3 Are some types of R&D cooperation more effective than others? Is the R&D cooperation effect changing across innovation outcomes?**

On the other hand, can R&D cooperation effect vary according to the type of partner? A broader range of external partners according to position in the value chain or geographical location can offer firms a complementarity in knowledge and more synergies, facilitating innovation performance. The choice of partners in R&D cooperations affects not only technology innovation and knowledge but also complement resources already available in firms, promote more access to market information, and allow firms to obtain more benefits of innovation efforts. Prior partners relationship is a key factor to determine new R&D cooperation partners because firms learn from previous experiences. R&D cooperations with partners that are in a different knowledge position are having a positive impact of in radical innovation, this effect is even stronger in manufacturing sectors than services, while geographical position of partners seems to be more related with incremental innovation or product adjustment to satisfy customers needs, products that are new to the firms but not new to the market (Van & Zand,2014).

Literature suggests the impact of R&D cooperation depends not only on the type of partner such as: Competitors, Customers, Suppliers, Institutions and Universities, but also on the type of innovation output (product or process innovation) (Aschhoff & Schmidt, 2008; Van & Zand, 2014). By using the Mannheim Innovation Panel (MIP) German survey in 2004 that collects information between 2001 and 2003 of about 1,900 firms and a Tobit estimation Aschhoff & Schmidt (2008) studied the effect of R&D cooperation on sales of innovative products, and cost reductions due to innovative processes. Authors found past R&D cooperation with competitors has a positive impact on the current cost reduction affecting process innovation. On the other hand, past R&D cooperation with research institutions are used when trying to focus on current new products on long-term oriented research. R&D cooperation with customers and suppliers does not have any impact in product or innovative process. Finally, general R&D cooperation has a positive effect on process innovation but not on sales of new products.

Un et al. (2010) found the impact on the likelihood of product innovation depends on the type of R&D collaborations. By using a sample of 781 manufacturing firms during 1998 and 2002, authors found R&D collaborations with suppliers and universities generate a positive impact on product innovation likelihood. R&D cooperation with suppliers had the highest positive impact on product innovation, followed by collaboration with universities. Authors incorporate additional time lags of R&D cooperation to observe if results are sustained on the long run. Both partners are characterized by easier knowledge access. However, the smaller knowledge difference between suppliers and firms seems a key reason behind the positive impact on product innovation. On the other hand, R&D collaborations with customers do not affect product in-



novation, and collaborations with competitors have a negative impact on product innovation on the short run, both collaborations have a difficult knowledge access in common. Moreover in the case of cooperation with competitors they may wish not to share information with firms. Results suggest that the facilities of knowledge transfers are more important than the knowledge basket offer. Firms first start by acquiring the knowledge and then it is easier to implement if the partners are close in terms of operation knowledge. The analysis was restricted to manufacturing firms.

By using a sample of 2,900, German manufacturing industry and a probit estimation. Becker & Dietz (2004) considered an input/output framework of innovation, authors found R&D cooperation is a complement of internal resources in the innovation process. The increase R&D intensity has a positive impact on the likelihood of R&D cooperation and it also increase in the number of R&D partners. Considering the output side of innovation, R&D cooperation increase the probability of product innovation, highlighting the role of networking effects, the duration R&D cooperation, intensity of transfer knowledge and resource exchange.

In addition, by using a Community Innovation Survey (CIS) from Sweden collected in 2001 between the period 1998 to 2000 for both manufacturing and services sector, with 2,114 firm and matching techniques that allow to have a control group and distinguish between innovation outputs from collaborators who would have experienced it, if they have not collaborated. Lööf & Broström (2008) focus on industry-university linkages and they found collaboration with universities has a positive impact in the propensity to innovate specifically in the propensity to patent and it also has a positive impact on innovation sales for large manufacturing firms with 100 or more employees, but not in the case of service firm. Academic knowledge is providing new techniques and skills improving firms innovation.

Moreover, by using a sample of about one-hundred fifty Indonesian furniture Small and Medium Enterprises (SMEs), a sector that is increasing its export orientation and absorbed thousands of workers. Karno & Purwanto (2017) found the inter-firm cooperation (i.e. cooperation with customer, supplier), cooperation with public institutions and universities have a positive impact on product innovation making it increase the market access opportunities. The effect of this innovation is also positive on firms'productivity levels. Innovation can not be based in internal resources but there is the need of external knowledge and technologies to complement firms' resources and build R&D in the future. Cooperation allows firms to reach the needs of consumers at the global market and get a better position in the market competition.

On the other hand, considering four types of R&D collaborations: R&D collaborations with universities, suppliers, competitors, and customers. And introducing two knowledge dimensions (1.Position in the knowledge chain of the industry and 2. Knowledge distance between partners and firm in terms of operations) reflecting the external knowledge firms can get from outside collaborations. A sample size of 781 firms between 1998 and 2002 and a probity estimation Un & Asakawa (2015) found R&D collaborations with suppliers have the highest and most positive impact on process innovation, followed by R&D collaborations with universities. R&D collaboration with competitors have a negative impact on process innovation. R&D collaboration with customers have no impact on process innovation. It seems different knowledge bases obtained trough R&D collaboration with suppliers and universities are key factor for process innovation. One of the main contributions of this paper it is the use of another innovation outcome as process. Process is internal and tacit. Most of papers focus on product innovation, characteristic and features that apply to product innovation may not apply to process innovation. According to this result, the main driver of process (improvements in efficiency and quality) is supplier R&D collaboration that is part of upstream R&D collaborators in the knowledge chain of the industry.

In addition, collaboration in outsourcing parts of the innovation process guarantee quality improvements, reducing cost. In this type of R&D cooperation with suppliers, firms are likely to have low share of value added to turnover substituting internal R&D for cooperation with suppliers. In cases when there is both

high share of value added to turnover and high R&D cooperation with suppliers it may be due to the need to implement knowledge absorptive capacities (Fritsch & Lukas, 2001). Finally, by using a Spanish manufacturing firms sample of about 1,300 firms across 5 years between 1998 and 2002 and a methodology base on a multivariate choice. Santamaria & Surroca (2011) found R&D collaboration with customers and suppliers are increasing the likelihood of both product and process innovation. Collaboration with institutions such as universities and technological institutions are mainly driven for firms who are pursuing radical innovation (product innovation) but it is also having a positive impact on process innovation. While cooperation with competitors which it is used when trying to explore new ideas is not having an impact in the likelihood to innovate neither in product nor in process.

Table 1 sums up the main features behind R&D cooperation and the effects of R&D cooperation on innovation by type of partner and type of innovation outcome. Table 1 is ordered according to how authors are presented in the literature, listing with some information tracing the papers such as name, year.

Article	R&D cooperation partner	Product Innovation	Process Innovation	Determinants of R&D cooperation and/or main innovation channels
Miotti & Sachwald, 2003	Cooperation Suppliers Customers Competitors Institutions Foreigners			High levels of R&D and techno. Lower risk Crucial information High-tech sectors Close to the technological frontier Comparative advantage/ high-tech
Bönte & Keilbach, 2005	Cooperation		Positive	Environment and Innovation dynamics
Baum et al., 2000.	Cooperation	Positive		Type of R&D cooperation depends on prior work network
Kaufman et al., 2000	Outsourcing component parts and services		Renewed gains in productivity	
Liker et al., 1996	Suppliers	Positive		Infrastructure and technical processes limit firm performance
De Faria et al., 2010				Technological level Absorptive capacity Innovation intensity Incoming spillovers
Monjona & Waelbroeck, 2003	Universities	Positive		Emphasis on spillovers R&D cooperation for imitating firms.
Tether, 2002	More R&D cooperation	If Pursing radical innovations		Size Technological level innovation indicator
Fritsch & Lukas, 2001	Outsourcing		Positive	Large firms High R&D employees More spending in monitoring Complex/expensive projects
Van & Zand, 2014	Position in the value chain Geographical location	Positive Positive		Prior experience, patenting Information technology Infrastructure.

Table 1: The following table sums up the main features behind R&D cooperation and the effects of R&D cooperation on innovation by type of partner

Article	R&D co-operation partner	Product Innovation	Process Innovation	Determinants of R&D cooperation and main channels
Aschhoff & Schmidt, 2008	Cooperation Competitors Institutions Customers Suppliers	No No Positive No No	Positive Positive No No No	New technology and adaptation Large size Younger firms tend to imitate
Un et al. 2010	Suppliers Universities Customers Competitors	Positive Positive No Negative		Large firms tend to collaborate Knowledge access Lack of information
Becker & Dietz, 2004	Cooperation Increase in the number of R&D partners	Positive		Complementarity with external res. Newtworking
Löf & Broström, 2008	Universities	Positive		Larger R&D intensity More human capital Larger export intensity Larger firm size
Karno & Purwanto, 2017	Customer Supplier Institutions Universities	Positive Positive Positive Positive		Complementarity with external resources
Un & Asakawa, 2015	Suppliers Universities Competitors Customers		Positive/highest Positive Negative No impact	Position in Knowledge Chain Knowledge Distance Learning by doing
Santamaria & Surroca, 2011	Suppliers Institutions Competitors Customers	Positive Positive No impact Positive	Positive Positive No impact Positive	Large firms with high absorptive capacity High and medium-low technology industries

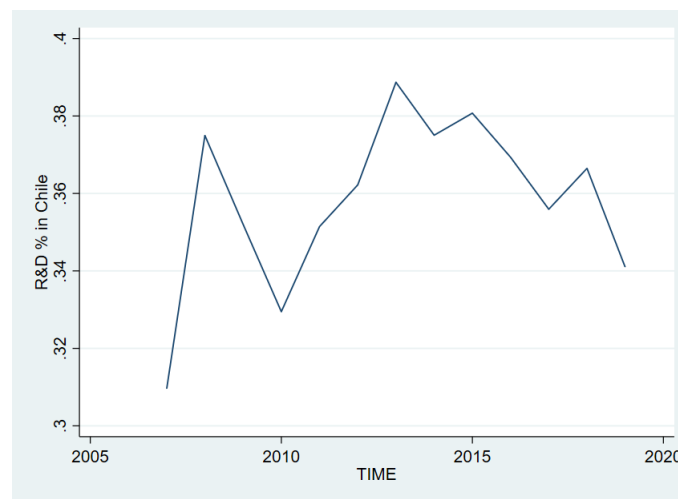
**Table 1 (Continuation):**The following table sums up the main features behind R&D cooperation and the effects of R&D cooperation on innovation by type of partner

## 4.2.4 Chilean case

### 4.2.4.1 A simple framework and some hypothesis to be tested

Literature about Chilean R&D collaboration is limited. However, Chilean policy makers have pushed on R&D collaboration. Some programs such as The National Productivity and Technological Development Fund (FONTEC) or the Science and Technology Development Fund (FONDEF) finances R&D carried out in investment and collaboration with research institutions. By using the Annual Manufacturing Survey from 1990 to 2006, a random treatment analysis (Crespi et al., 2020) found public programs that promote R&D collaboration with research institutions increase Chilean firm performance. Moreover, there is the presence of spillover effects for firms that are both geographically and technologically close. In Figure 1 we observed the increase of R&D as percentage of GDP. Under this framework, our paper contributes to the microeconomic literature by evaluating the effect of R&D collaboration in innovation and firm performance.

Figure 1: **Chilean R&D investment over the time**



These considerations have relevant implications for the empirical analysis we intend to carry on.

- *First*, we should expect that R&D cooperation has a positive and significant impact on the probability of innovation.
- *Second*, we should expect the impact of R&D cooperation on innovation varies across R&D cooperation partners.
- *Third*, we should expect a positive impact of R&D cooperation on firms productivity.

R&D cooperation is having a positive impact on innovation and productivity. Our hypothesis is based on previous empirical evidence such as Kaufman et al., 2000 and Karno & Purwanto, 2017. Following the lines of previous works such as Un et al. 2010 and Un & Asakawa (2015). We expect heterogeneity on the impact of different R&D cooperation partners.

## 4.3 Data and variable description

### 4.3.1 Data

In order to analyse the role of R&D cooperation and type of R&D cooperation partner on innovation and productivity in Chilean firms, we used the Encuesta de Innovación en Empresa (ENI) elaborated by the Instituto Nacional de Estadísticas (INE). ENI survey is a questionnaire made to owners and managers of firms from different economic sectors that provide innovation information following the OECD and the Eurostat Community Innovation Survey (CIS) standards according to the OSLO innovation manual (OECD/Eurostat, 2005).

This data is the same used in chapter 2 of the present thesis. It is a survey available online for general public for years 2007-2008, 2013-2014 and 2015-2016. However, it is not possible to identify firms across time. However, thanks to the Ministerio de Economía, Fomento y Turismo collaboration. We are able to establish a panel data <sup>1</sup> between 2009 and 2016 in other words ENI 7, 8, 9 and 10 are merged.

The main filter to obtain the final sample to be used, is the choice of manufacturing firms, a sector that represents in terms of value added a third of Chilean GDP. Specifically, we made use of seven manufacturing sectors chosen considering previous empirical works and data availability. We consider: Food products, Metals and Furniture as low-technological industries and Chemical substances and products, Pharmaceutical products, Electrical equipment, and others machinery and equipment as high - technological manufacturing. This technological classification is defined according to OECD, 2016 standards.

After this firm selection, we observed firms across time. We finished with a total of 2,710 observations, an unbalanced panel sample of 1,852 firms observed in four rounds of innovation surveys, containing innovation information for Chilean manufacturing firms between 2009 and 2016. As we mentioned in chapter 2 of the present thesis one of the limitations of this final unbalanced panel sample it is that about 70% of those firms are only observed in one of the four surveys. Readers can find a detail description of survey in Chapter 2 section “Data, Sample and Variables description” page 87.

### 4.3.2 Sub-sampling, Variables description and Stylized factors

Given this context, here I pretend to give some tracks of firm R&D cooperation behaviour. We start with some variable description that made us redefine our sample, then some stylized facts. Table 2 presents a detailed description of variables and manufacturing sectors used to investigate the effect of R&D cooperation and type of R&D cooperation partner on innovation and productivity for Chilean manufacturing firms.

Each survey covers two years of firm information. Specifically, most of questions related to innovation consider directly two years. For instance, each survey ask to firms if they have implemented R&D cooperation in  $t$  and/ or  $t+1$ . In other words, we are not able to identify if R&D cooperation was made in  $t$  or  $t+1$  or in both periods. On the other hand, to measure R&D cooperation and type of R&D cooperation partner we used dichotomies variables.

- R&D cooperation is defined by <sup>2</sup> a variable that considers firms who established any type of cooperation

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<sup>1</sup>Survey 2011(ENI 7), 2013(ENI 8), 2015(ENI 9), and 2017(ENI 10).

<sup>2</sup>Cooperation with firms inside the same business group was excluded from the analysis. Because, if there is a conglomerate or holding company and some cooperate with each other, both would answer yes. Then they are companies linked by those

in R&D. 1 if yes 0 otherwise in  $t$  and/ or  $t+1$ . The coefficient of this variable will tell us how much the probability of innovation increase or decrease for firms who apply R&D cooperation compared to those who do not apply R&D cooperation at all.

Moreover once considering the type of R&D cooperation partners. We work with five type of R&D cooperation partners. These categories were chosen following the lines of some authors such as: Miotti & Sachwald (2003); Aschhoff & Schmidt (2008); Karno & Purwanto (2017); Un & Asakawa (2015); Santamaria & Surroca (2011). According to this the five types of R&D cooperation are: *Competitors*, *Customers*, *Suppliers*, *Institutions* and *Universities*.

- *Competitors* consider innovation activities developed with competitors or others firms from the same sector in  $t$  and/or  $t+1$ . (equals to 1 if yes, 0 otherwise). The coefficient of this variable will tell us how much the probability of innovation increase or decrease for firms who apply R&D cooperation with competitors compared to those who do not .
- *Customers* for firms that have introduced cooperation with customers in  $t$  and/or  $t+1$ . (equals to 1 if yes, 0 otherwise). The coefficient of this variable will tell us how much the probability of innovation increase or decrease for firms who apply R&D cooperation with customers compared to those who do not.
- *Suppliers* for firms that have introduced cooperation with suppliers in  $t$  and/or  $t+1$ . (equals to 1 if yes, 0 otherwise). The coefficient of this variable will tell us how much the probability of innovation increase or decrease for firms who apply R&D cooperation with suppliers compared to those who do not.
- *Institutions* includes firms that have cooperation in R&D with consultants, laboratories or private R&D institutes or government or public research institutes in  $t$  and/or  $t+1$ . (equals to 1 if yes, 0 otherwise). The coefficient of this variable will tell us how much the probability of innovation increase or decrease for firms who apply R&D cooperation with institutions compared to those who do not.
- *Universities* for firms that have introduced cooperation with universities and 0 otherwise in  $t$  and/or  $t+1$ . (equals to 1 if yes, 0 otherwise). The coefficient of this variable will tell us how much the probability of innovation increase or decrease for firms who apply R&D cooperation with universities compared to those who do.

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who own them.

Variable	Description
Productivitygrowth	Measure of firm productivity: difference between the ratio sales over number of employees in t+1 minus the same ratio in t, this difference over the ratio sales over number of employees in t .
Salesgrowth	Measure of firm performance: Difference in natural log of sales between t+1 and t.
Innovation	Successful introduction of product and/or process innovation. 1 if yes 0 otherwise in t and/ or t+1.
Product	Successful introduction of new products or services (new or significantly improved). 1 if yes 0 otherwise in t and/ or t+1.
Process	Successful introduction of a new process for support of goods or services (new or significantly improved) . 1 if yes 0 otherwise in t and/ or t+1.
Cooperation	Firm cooperation with national/foreign companies. 1 if yes 0 otherwise.
Competitors	Firm cooperation with national/foreign competitors or other companies in your sector. 1 if yes 0 otherwise.
Customers	Firm cooperation with national/foreign customers or consumers. 1 if yes 0 otherwise.
Suppliers	Firm cooperation with national/foreign suppliers of equipment, materials, components or software . 1 if yes 0 otherwise.
Institutions	Firm cooperation with national/foreign consultants, laboratories or private R&D institutes or government or public research institutes. 1 if yes 0 otherwise.
Universities	Firm cooperation with national/foreign with universities. 1 if yes 0 otherwise.
Up	1 if cooperation with <i>Suppliers</i> and <i>Universities</i> and <i>Institutions</i> and 0 if not.
Down	1 if cooperation with <i>Competitors</i> , <i>Customers</i> and 0 if not.
Close	1 if cooperation with <i>Suppliers</i> , <i>Competitors</i> and 0 if not.
Far	1 if cooperation with <i>Customers</i> , <i>Institutions</i> and <i>Universities</i> and 0 if not .
R&DIntensity	The log of (the addition of share of R&D spending over total of sales in t and t+1 over 2)+0.01).
D.Size	1 if enterprise=big 0 if enterprise=small&medium according to the level of income. Big firms are those who have more than Unidad de Foment (UF) 100000.01 of income in t.
SizeSales	Log of sales uses as a way to capture variability in the size of firms in t and t+1. Log of Sales in t + Sales in t+1 over 2.
R&DIntensityColab	R&DIntensity multiplied by Cooperation variables.
D.Y	Year dummy.
D.Sector	Sector dummies.

**Manufacturing sectors:**

15\* Food products, 20 \*Chemical substances and products, 21\* Pharmaceutical products, 24\* Metals Common, 27\* Electrical equipment, 28\* Machinery and equipment nec, 31\* Furniture

Table 2: **Variable description**



It is important to highlight that in the survey firms who are having any kind of innovation <sup>3</sup> are only those who can respond to the question about R&D cooperation implementation. In other words, the fact of having experienced innovation is a filter question. According to this, about 36% of firms have responded if they have or they have not experienced R&D cooperation. So, we finish with a total of 987 observations, and an unbalanced panel sample of 746 firms observed in four rounds of innovation surveys. Moreover, from this final sample less than 25% of firms are observed in more than one period between 2009 and 2016.

From this final sample of 746 Chilean firms between 2009 and 2016 we observe about 25% experience R&D cooperation. This R&D cooperation was mainly driven for big firms (more than 80%). The size of firms is defined according to the level of income. Big(I) are firms who have more than Unidad de Fomento (UF) 100000.01 of income in  $t$  and S&M (I) are small & medium firms who are under the reference threshold. We consider a dummy variable that takes the value of 1 if firms are big and 0 if firms are small & medium. This firm size definition was already elaborated by the Instituto Nacional de Estadísticas (INE). See Table 3.

No. of firms	% R&D cooperation	% Cooperative firms-size(I)	
		Big(I)	S&M(I)
746	23%	85%	15%

Table 3: % of R&D cooperation in final sample

Moreover, firms who have experienced R&D cooperation are mainly cooperating with *Universities*, followed by *Institutions*, then *Suppliers*, *Customers* and *Competitors* (61%, 21%, 11%, 5% and 2% respectively). If we consider again firm size, we observe the same pattern. Most of cooperation is made by big firms. For instance, from the 2% of firms who have established general R&D cooperation with *Competitors*, about 75% was done by big firms and 25% by small firms. From the 61% of firms who established R&D cooperation with *Universities*, about 91% was done by big firms and 9% by S&M firms. See 4.

No. of firms	Type of R&D co-operation	% R&D	% Cooperative firms-size(I)	
			Big(I)	S&M(I)
746	<i>Competitors</i>	2%	75%	25%
	<i>Customers</i>	5%	73%	27%
	<i>Suppliers</i>	11%	80%	20%
	<i>Institutions</i>	21%	73%	27%
	<i>Universities</i>	61%	91%	9%

Table 4: % of R&D cooperation by type of R&D cooperation partner, by size in the final sample

Once considering the manufacturing sector level of technological sophistication. Food, Metals and Chemicals are the sectors who have the highest rate of R&D cooperation (26%, 24% and 26% respectively). Moreover, we observed at a sectoral level the behaviour in general does not change most of the firms are having R&D cooperation with *Universities*, followed by *Institutions*, then *Suppliers*, *Customers* and *Competitors*. For instance, the Food sector is mainly having R&D cooperation with *Universities* in about 54%, then with *Institutions* in 29%, then *Suppliers* in 9%, then *Customers* and *Competitors* in 5% and 3% respectively. The exception is for firms who are in the Electrical equipment sector where the most used type of R&D cooperation is the one established with *Suppliers* (about 44%), then *Universities* and *Institutions* in

<sup>3</sup>Product, Process, Organizational, Marketing and social innovation .

33% and 22% respectively. See Table 5.

<b>Techno. level</b>	<b>Sector</b>	<i>Cooperation %</i>	<i>Competitors %</i>	<i>Customers %</i>	<i>Suppliers %</i>	<i>Institutions %</i>	<i>Univ. %</i>
Low&Medium-Low	Food	26%	3%	5%	9%	29%	54%
	Metals	24%	-	-	5%	11%	84%
	Furniture	19%	-	-	30%	30%	40%
	Chemical	26%	-	11%	-	15%	74%
	Pharmacy	18%	-	-	20%	7%	73%
High&Medium-High	Electrical equipment	16%	-	-	44%	22%	33%
	others	18%	4%	11%	16%	19%	50%
	Mach. and equip.						

Table 5: **R&D cooperation and type of R&D cooperation partner in % by manufacturing sector**

(0)

Moreover, if we consider another types of R&D cooperation inspired in the classification according to position in the knowledge chain of the industry and knowledge distance between partners and firm, developed by Un & Asakawa (2015). We observe most of R&D cooperation is with those who are in the upper part of the chain (about 93% "Suppliers, Institutions and Universities"), only 7% of R&D cooperation is with those who are in the down part of the chain (*Competitors* and *Customers*). On the other hand, we also notice most of firms are having R&D cooperation with those who are further in the knowledge distance between partners and firm (about 91% "Customers, Institutions, and Universities"), only 9% of R&D cooperation is made with those who are close in the knowledge distance (*Competitors* and *Suppliers*). The fact that *Universities* and *Institutions* R&D cooperation are in both classifications, and they have also the highest rate of R&D cooperation, it may be telling us that firms who want to establish R&D cooperation are working with partners who are advanced in knowledge even though there is a clear distance in knowledge between them. In other words, it seems the effect of a wider basket of knowledge is stronger in the development of innovation than potential differences between R&D partners. See Table 6.

<b>Position in the knowledge chain of the industry</b>	
Up ( <i>Suppliers</i> and <i>Universities</i> and <i>Institutions</i> )	93%
Down ( <i>Competitors</i> , <i>Customers</i> )	7%
<b>Knowledge distance between partners and firm</b>	
Close ( <i>Competitors</i> and <i>Suppliers</i> )	9%
Far ( <i>Customers</i> , <i>Institutions</i> and <i>Universities</i> )	91%

Table 6: **R&D partner cooperation in % by position in the knowledge chain of the industry and knowledge distance between partners and firm**

On the other hand, we measure innovation outcomes by using different dichotomous variables indicating whether the firm has experienced innovation or not.

- *Innovation* variable considers firms that have either product and/or process innovation in  $t$  and/or  $t+1$ . (equals to 1 if yes, 0 otherwise).

- *Product* variable considers firms who have experienced the successful introduction of new products or services (new or significantly improved) in t and/or t+1. (equals to 1 if yes, 0 otherwise).
- *Process* variable considers firms who have experienced the successful introduction of new process for support of goods or services (new or significantly improved) in t and/or t+1. (equals to 1 if yes, 0 otherwise).

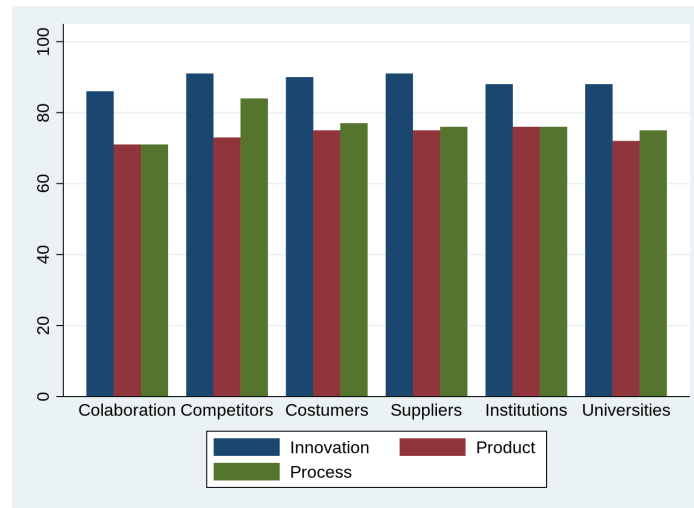
Even though organizational, marketing, and social innovation are innovation outcomes included in the ENI survey, they were excluded from the analysis due to some data limitations. Moreover this allows us to identify the main channels of *Product* and *Process* innovation. In addition, we are going to have some variability in the innovation outcomes variables since some of the firms who respond "yes" to the filter innovation question in the survey and by consequence they responded to the question of R&D cooperation may or may not have product or process innovation. According to this, the firms who has experienced *Innovation* are about 75%, *Product* and *Process* about 49% and 60% respectively. See Table 7.

No. Firms	Experience	% Yes	% No
	<i>Innovation</i>	75%	25%
	<i>Product</i>	49%	51%
746	<i>Process</i>	60%	40%

Table 7: Firms sampling by innovation experience

Once establishing the relationship between R&D cooperation and firm innovation performance for Chilean manufacturing firms, as it was expected we observe most of firms who have R&D cooperation are also having innovation (about 86%). Firms who have R&D cooperation and product or process innovation are about 71%. A similar behaviour is observed once considering the type of R&D cooperation partner (*Competitors*, *Customers*, *Suppliers*, *Institutions* and *Universities*). See Figure 2.

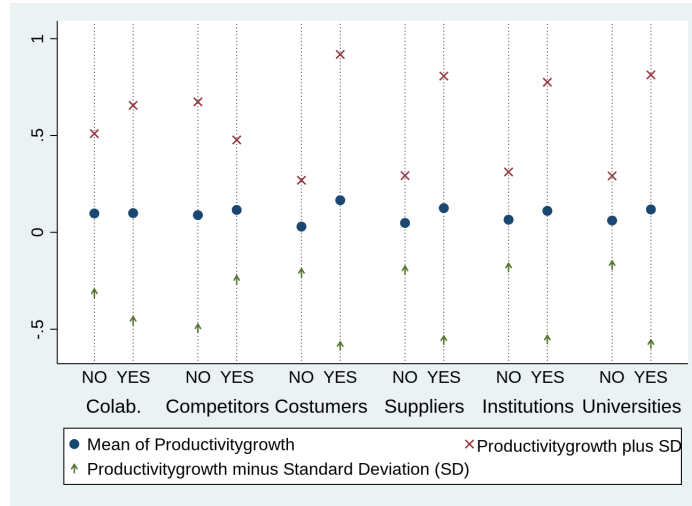
Figure 2: %Firms who have experienced Innovation, Product and Process innovation by R&D cooperation execution



On the other hand, once linking R&D cooperation and firm productivity, where firm productivity growth is measure trough a proxy variable called *Productivitygrowth* that considers difference between the ratio sales over number of employees in t+1 minus the same ratio in t, this difference over the ratio sales over number

of employees in  $t$ . We made an unconditional comparisons of the *Productivitygrowth* variable. These unconditional comparisons of firm productivity does not require anything to be done by other firms in exchange (they are completely independent). We do not observe a significant difference in the average productivity between firms who are having R&D cooperation or not. If we consider unconditional comparisons in *Productivitygrowth* between types of R&D cooperation partners (Competitors, Customers, Suppliers, Institutions and Universities). We again notice none of average productivity overlaps the standard deviation limits, meaning difference in the average productivity between firms who are having R&D cooperation or not are not significant.<sup>4</sup> See Figure 3.

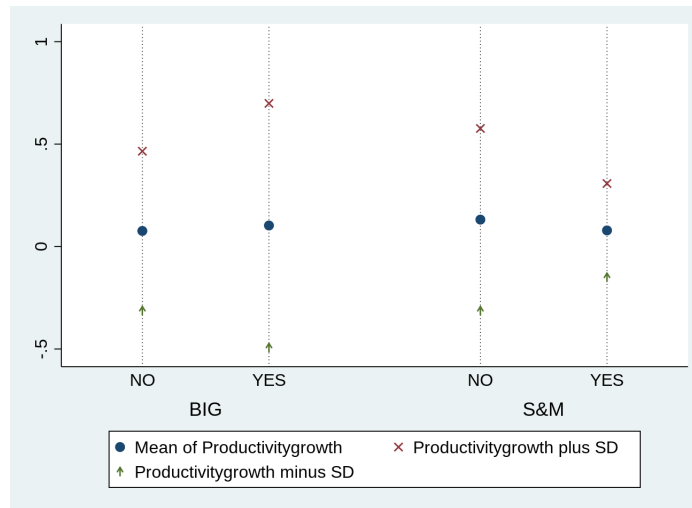
Figure 3: **Productivity by R&D cooperation execution**



Once considering unconditional comparisons in *Productivitygrowth* according to the firms size (big and small&medium). Again, we do not observe average productivity overlaps the standard deviation limits, meaning difference in the average productivity are not significant. Firms are having the same level of productivity independently of size the belong to. Figure 4.

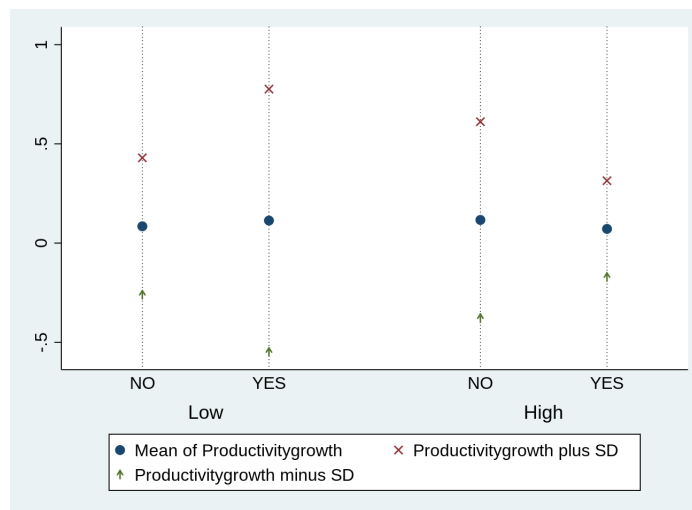
<sup>4</sup>See Annex 1 for productivity growth for firms by R&D cooperation execution by knowledge position in chain industry and knowledge distance between partner and firm.

Figure 4: **Productivity by R&D cooperation execution by size**



Moreover, there are some differences in unconditional comparisons in *Productivitygrowth* according to the level of technological sophistication (low or high) for firms who have or not R&D cooperation but this differences are not statistically significant. See Figure 5.

Figure 5: **Productivity by R&D cooperation execution by manufacturing technological level**



## 4.4 Econometric Model

In this section, we present the specification of the main model and extensions used. We also explain methodology and its limitations, dependent and independent variables considered for each model specification.

We explain the methodology used to evaluate the role of R&D cooperation and different types of R&D partner on innovation and firm productivity in Chile. Our paper follows the line of some authors such as Ascoff & Schmidt (2008); Un et al. (2010); Un & Asakawa (2015) and Karno & Purwanto (2017); Santamaria & Surroca (2011). Authors focus on R&D cooperation projects but also on the potential heterogeneity between different R&D partners.

### 4.4.1 Main Model

In a first part, we start the analysis by linking R&D cooperation with firm's innovation performance or innovation outcomes. We are interested in observing if R&D cooperation activities are generating innovation benefits. Are firms R&D cooperation activities translated in new or significantly improved process or products? To model this, inspired in the authors above mention. We defined *Product*, *Process* and *Innovation* as innovation outcomes (our dependent variables).

As we mentioned in previous section *Product* is a dummy that takes the value of 1 if firms experienced a new or significantly improved product innovation and 0 otherwise. *Process* a dummy that takes the value of 1 if firms experienced a new or significantly improved process innovation and 0 if not. Moreover, we add *Innovation* variable that is the interaction between *Product* and *Process*. In all the cases, variables are compared with non-innovative firms as baseline. The idea of including these indicators, is to observe if there are some differences in the impact of R&D cooperation across innovation outcomes. In other words, to observe how the effect of R&D cooperation can vary once considering some dimensions of the analysis such as the objective of innovation, competitive impact, valuation of innovation, degree of novelty, imitability and substitutability that varies across innovation outcomes (Un & Asakawa, 2015).

Then we consider R&D cooperation as our main independent variable (*Cooperation*). Dichotomy variable above explained that takes the value of 1 for firms who are cooperation in R&D and 0 if not. Other variables such as intensity of R&D (R&DIntensity), firm size (D.Size), and sector(D.Sector) are also included in the model. These variables were included to control for firms technological environment and structure. See Table 2 for a detail variable description.

Since the dependent variables *Innovation*, *Product* or *Process* take the values of 0 and 1. There is the need of an estimation method that allows us to work with categorical responses. A logistic regression allows us to handle with dichotomous dependent variables. This method allows us to calculate the probability of different outcome: the probability to have Innovation, Product innovation or Process innovation. When independent variables take on lower values, the probability approaches to zero. Conversely, if independent variables increase, the probability approaches to 1. In the Logit, error terms follows a logistic form, a distribution with slightly fatter tails. One of the main advantages of logit model compared to a linear probability model is predicted probabilities are between 0 and 1. Finally, in Logit estimation is common to report the marginal effects instead of odds ratios to make models comparable. Marginal effects can be problematic, when the dependent variable is continuous, it makes sense to have marginal effects at the means of each value of your predictors but here since our dependent variable are categorical, probabilities are evaluated the marginal

average logits (the “typical” individual). (Fernandes et al., 2021).

Our baseline econometric model considers the final unbalanced sample of 746 firms observed in four rounds of innovation surveys between 2009 and 2016. Here we run the logit estimation but considering the sample as a **pooled**, excluding the timing perspective increasing the sample size to 987. One of the disadvantages of this basic first approach is that it does not discriminate between units in other words, it ignores or mishandle the variability of firms, causing a potential problem of biased estimators. According to this, our baseline model is going to be defined by the following three specifications, one for the case of innovation, another for product and process innovation:

$$Innovation_i = \beta_1 Cooperation_i + \beta_2 R\&DIntensity_i + \beta_3 D.Size_i + \beta_4 D.Sector_i + e_{1i} \quad (1)$$

$$Product_i = \beta_1 Cooperation_i + \beta_2 R\&DIntensity_i + \beta_3 D.Size_i + \beta_4 D.Sector_i + e_{2i} \quad (2)$$

$$Process_i = \beta_1 Cooperation_i + \beta_2 R\&DIntensity_i + \beta_3 D.Size_i + \beta_4 D.Sector_i + e_{3i} \quad (3)$$

Our second specification considers the data as **cross section**. Here, we run the same model for every year of survey (2011 (ENI 7), 2013(ENI 8), 2015(ENI 9), and 2017(ENI 10), excluding again the firm observation, to notice if estimation are affected for the survey year sample. We are running four specifications for all the three innovation outcomes. One of the disadvantages of this estimation is that the timing of analysis does not guarantee to have representative results, furthermore it cannot be used to analyze firm behavior over a period of time, which generates again biased estimators. Our second model of reference is going to be defined by the following specifications:

$$Innovation_i = \beta_1 Cooperation_i + \beta_2 R\&DIntensity_i + \beta_3 D.Size_i + \beta_4 D.Sector_i + e_{1i} \quad (4)$$

$$Product_i = \beta_1 Cooperation_i + \beta_2 R\&DIntensity_i + \beta_3 D.Size_i + \beta_4 D.Sector_i + e_{2i} \quad (5)$$

$$Process_i = \beta_1 Cooperation_i + \beta_2 R\&DIntensity_i + \beta_3 D.Size_i + \beta_4 D.Sector_i + e_{2i} \quad (6)$$

Our last specification considers firms'observation across time a **panel analysis**. We may be tempted to run a *panel data conditional fixed effect logit model*. The key advantage of this estimation is to control all the time invariant omitted variables. We are able to control variables impossible to observe. This allows us managing for potential endogeneity and including the firm specific features, helping us to overcome the bias problem. For this reason, our last specification excludes two time invariant dummies such firm size (D.Size) and technological manufacturing level(D.Sector). However, due to the significant and positive impact of firm size in cross section and pooled estimation. We incorporate (SizeSales) a firm size variable that changes

over the time, defined such log of sales in t plus sales in t+1 over 2. Moreover, another important thing to consider it is that in the panel data conditional fixed effect logit model, firms who are observed in different years always “innovating” or “non innovating” cannot be used to identify our parameters. If we run conditional panel data conditional fixed effect logit specification, we have a reduction of sample to about 200 observations. (Table 13 presents the results of panel data conditional fixed effect logit specification).

In order to overcome this situation, in our last and final specification we run a *Linear probability model with firm fixed-effects*. This model also allows us to work with binary dependent variables. It is used as OLS method to calculate the probability of the outcome. The main problem of this model is that there is no guarantee the probability value lie between 0 and 1 and there is the need of error term following a normal distribution. If the dependent variable takes only values of 0 and 1 (such in this case) then it follows a binomial distribution and estimated coefficients are biased.

Considering our size sample restriction and similarities in coefficients between the conditional fixed effect logit model and linear probability model with firm fixed-effects. We keep the *Linear probability model with firm fixed-effect* as our final and main model to be analyzed (See Table 13). According to this, the final specifications chosen to explain the link between R&D cooperation on innovation performance or outcomes, or the chosen specifications to test our first hypothesis: A positive and significant impact R&D cooperation in the probability of innovation. It is going to be defined by the following equations<sup>5</sup>:

$$Innovation_i = \beta_0 + \beta_1 Cooperation_i + \beta_2 R\&DIntensity_i + \beta_3 SizeSales_i + \beta_4 D.Y_i + e_{1i} \quad (7)$$

$$Product_i = \beta_0 + \beta_1 Cooperation_i + \beta_2 R\&DIntensity_i + \beta_3 SizeSales_i + \beta_4 D.Y_i + e_{2i} \quad (8)$$

$$Process_i = \beta_0 + \beta_1 Cooperation_i + \beta_2 R\&DIntensity_i + \beta_3 SizeSales_i + \beta_4 D.Y_i + e_{3i} \quad (9)$$

---

<sup>5</sup>A dummy of year is included to consider the time perspective.



#### 4.4.2 Extensions and other specifications

After this, in another specification considering the positive and significant impact of R&DIntensity in most of previous estimations. We add the interaction of R&D Intensity with R&D cooperation, a variable called (R&DCoop). The idea behind this, it is to observe if the effect of collaboration is stronger for firms investing more in R&D intensity. This relationship is going to be defined by the following equations (Annex 2 presents the results of this estimation):

$$\begin{aligned} Innovation_i &= \beta_0 + \beta_1 Cooperation_i + \beta_2 R\&DIntensity_i + \beta_3 SizeSales_i \\ &\quad + \beta_4 R\&DCoop_i + \beta_5 D.Y_i + e_{1i} \end{aligned} \quad (10)$$

$$\begin{aligned} Product_i &= \beta_0 + \beta_1 Cooperation_i + \beta_2 R\&DIntensity_i + \beta_3 SizeSales_i \\ &\quad + \beta_4 R\&DCoop_i + \beta_5 D.Y_i + e_{2i} \end{aligned} \quad (11)$$

$$\begin{aligned} Process_i &= \beta_0 + \beta_1 Cooperation_i + \beta_2 R\&DIntensity_i + \beta_3 SizeSales_i \\ &\quad + \beta_4 R\&DCoop_i + \beta_5 D.Y_i + e_{3i} \end{aligned} \quad (12)$$

Finally, in another specification we focus on the effect of different R&D partners on innovation for Chilean firms. We consider the same dependent variables: *Innovation*, *Product* or *Process*. However now our main independent variables are five R&D cooperation partners. They are: *Competitors*, *Customers*, *Suppliers*, *Institutions*, *Universities*. Dichotomous variables above explained. These variables were chosen again following the line of authors such as Ascoff & Schmidt (2008); Un et al. (2010); Un & Asakawa (2015) and Karno & Purwanto (2017); Santamaria & Surroca (2011). In most of the cases authors use a dummy variable that takes the value of 1 if the firm has established a particular R&D cooperation with a specific partner, the exception is Karno & Purwanto (2017) that use an indicator to define R&D cooperation partner. Moreover, again, other variables such as R&D intensity (R&DIntensity), and firm size (SizeSales) are also included in the model as independent variables to control for firms structure and innovation dynamics. The specifications chosen to explain the impact of different R&D partners on innovation for Chilean firms, or the specifications chosen to test our second hypothesis: The impact of R&D cooperation on innovation varies across R&D cooperation partners. It is described by the following equations:

$$\begin{aligned} Innovation_i &= \beta_0 + \beta_1 Competitors_i + \beta_2 Customers_i \\ &\quad + \beta_3 Suppliers_i + \beta_4 Institutions_i + \beta_5 Universities_i \\ &\quad + \beta_6 R\&DIntensity_i + \beta_7 SizeSales_i + \beta_8 D.Y_i + e_{1i} \end{aligned} \quad (13)$$

$$\begin{aligned} Product_i &= \beta_0 + \beta_1 Competitors_i + \beta_2 Customers_i \\ &\quad + \beta_3 Suppliers_i + \beta_4 Institutions_i + \beta_5 Universities_i \\ &\quad + \beta_6 R\&DIntensity_i + \beta_7 SizeSales_i + \beta_8 D.Y_i + e_{2i} \end{aligned} \quad (14)$$

$$\begin{aligned}
Process_i &= \beta_0 + \beta_1 Competitors_i + \beta_2 Customers_i \\
&+ \beta_3 Suppliers_i + \beta_4 Institutions_i + \beta_5 Universities_{iy} \\
&+ \beta_6 R\&DIntensity_i + \beta_7 SizeSales_i + \beta_8 D.Y_i + e_{3i}
\end{aligned} \tag{15}$$

#### 4.4.2.1 What about if we consider R&D cooperation according to knowledge position and distance?

In another specification we use the type of R&D cooperation partners inspired in the classification according to position in the knowledge chain of the industry and knowledge distance between partners and firm in terms of operation, developed by Un & Asakawa (2015). To define position in the knowledge chain of the industry we use two dummy variables, they are:

- *Up*, 1 if firms have R&D cooperation with partners who are up (*Suppliers* and *Universities* and *Institutions*) and 0 if not. The coefficient of this variable will tell us how much the probability of innovation increase or decrease for firms who apply R&D cooperation with up partners compared to those who do not.
- *Down* 1 if firms have R&D cooperation with partners who are down (*Competitors*, *Customers*) and 0 if not. The coefficient of this variable will tell us how much the probability of innovation increase or decrease for firms who apply R&D cooperation with down partners compared to those who do not.

According to this, the specifications used to define the relationship between R&D cooperation with partners in a different knowledge position in the chain value of the industry and innovation outcomes are:

$$Innovation_i = \beta_0 + \beta_1 Up_i + \beta_2 Down_i + \beta_3 R\&DIntensity_i + \beta_4 SizeSales_i + \beta_5 D.Y_i + e_{1i} \tag{16}$$

$$Product_i = \beta_0 + \beta_1 Up_i + \beta_2 Down_i + \beta_3 R\&DIntensity_i + \beta_4 SizeSales_i + \beta_5 D.Y_i + e_{2i} \tag{17}$$

$$Process_i = \beta_0 + \beta_1 Up_i + \beta_2 Down_i + \beta_3 R\&DIntensity_i + \beta_4 SizeSales_i + \beta_5 D.Y_i + e_{3i} \tag{18}$$

On the other hand, to defined R&D partners according to the knowledge distance between them and firms in terms of operation. We also use two dummy variables, they are:

- *Far* that takes the value of 1 if partners are far (*Customers*, *Universities* and *Institutions*) and 0 if not. The coefficient of this variable will tell us how much the probability of innovation increase or decrease for firms who apply R&D cooperation with far partners compared to those who do not.

- *Close* 1 if partners are close in knowledge (*Suppliers, Competitors*) and 0 if not. The coefficient of this variable will tell us how much the probability of innovation increase or decrease for firms who apply R&D cooperation with close partners compared to those who do not.

The effect of R&D cooperation with partners close or far in terms of operations knowledge on innovation outcomes for Chilean manufacturing firms are going to be defined the following equations:

$$Innovation_i = \beta_0 + \beta_1 Close_i + \beta_2 Far_i + \beta_3 R\&DIntensity_i + \beta_4 SizeSales_i + \beta_5 D.Y_i + e_{1i} \quad (19)$$

$$Product_i = \beta_0 + \beta_1 Close_i + \beta_2 Far_i + \beta_3 R\&DIntensity_i + \beta_4 SizeSales_i + \beta_5 D.Y_i + e_{2i} \quad (20)$$

$$Process_i = \beta_0 + \beta_1 Close_i + \beta_2 Far_i + \beta_3 R\&DIntensity_i + \beta_4 SizeSales_i + \beta_5 D.Y_i + e_{3i} \quad (21)$$

#### 4.4.2.2 What about R&D cooperation and firms productivity?

Finally, once established the specifications to measure the role of R&D cooperation and the type of R&D partner on innovation. We now focus on testing our last hypothesis: A positive impact of R&D cooperation on firm productivity. Here our dependent variable is defined by *Productivitygrowth* above already defined. Then we consider *Cooperation* as our main independent variable. Other variables such as R&D intensity (*R&DIntensity*), and firm size (*SizeSales*) are also included in the model as independent variables to control for firms features and innovation dynamics. Since our dependent variable is not binary anymore we consider a **panel fixed effects estimation**. The relationship between R&D cooperation and Chilean firms productivity is defined by the following equation:

$$Productivitygrowth_{iy} = \beta_0 + \beta_1 Cooperation_{iy} + \beta_2 R\&DIntensity_{iy} + \beta_3 SizeSales_{iy} + e_{1iy} \quad (22)$$

Where  $y \in 2011, 2013, 2015, 2017$  because of four rounds of ENI surveys.

## 4.5 Results and discussion

Considering the final unbalanced panel of 746 firms between 2009 and 2006. In this section, we present the empirical analysis about the effect of R&D cooperation and the type of R&D partner on innovation and firm productivity in Chile.

We start analysing the results of our base line model (specification 1, 2 and 3). The effect of R&D cooperation on innovation for Chilean firms. We observe that firms who collaborate have greater probability to innovate than those who do not implement R&D cooperation. This behaviour is independent from the innovation outcome used. Firms who have established R&D cooperation are more likely to have innovation, (0.15) compared to firms who do not have R&D cooperation. The effect in product innovation seems stronger than in process innovation (0.24 and 0.13 more likelihood respectively). The fact of having a clearer, concrete and independent knowledge (product innovation) allows to obtain more benefits of R&D cooperation. Moreover, other variables such as R&D intensity (the level of investment in R&D projects) is also increasing the likelihood of innovation outcomes. An increase in 1 percentual point of R&D intensity increase the likelihood to have product and process innovation in about 0.09 and 0.011 respectively. Big firms are also more likely to experience firms innovation. R&D intensity and firms size are affecting innovation behaviour of Chilean firms supporting results of authors such as Tether (2002); Fritsch & Lukas (2001); Lööf & Broström (2008); Aschhoff & Schmidt (2008); Un et al. (2010); Santamaria & Surroca (2011). See Table 8.

Table 8: **Logit estimation: Pooled Data**

<b>Variable</b>	<b><i>Innovation(Model 1)</i></b>	<b><i>Product(Model 2)</i></b>	<b><i>Process(Model 3)</i></b>
Cooperation	0.153*** [0.0372]	0.244*** [0.0347]	0.134*** [0.0376]
R&DIntensity	0.116*** [0.0215]	0.0908*** [0.0182]	0.116*** [0.0212]
D.Size	0.101*** [0.0286]	0.174*** [0.0327]	0.0972*** [0.0335]
D.Sector	YES	YES	YES
N	987	987	987

Robust standard errors in brackets \* p<0.10, \*\* p<0.05, \*\*\* p<0.010

Once considering the cross section analysis (specification 4,5 and 6). In most of cases we observe a similar behavior. Firms who have R&D cooperation are more likely to have innovation independently of the innovation outcome used. The effect of R&D cooperation seems again stronger in product than process (except in the case of ENI 7 where the positive effect of R&D cooperation affect process innovation the most). See Table 9, 10, 11 and 12.

Table 9: **Logit estimation: Cross section Data - ENI 7 (2011)**

<b>Variable</b>	<b><i>Innovation(Model 4)</i></b>	<b><i>Product(Model 5)</i></b>	<b><i>Process(Model 6)</i></b>
Cooperation	0.245*** [0.0748]	0.222*** [0.0646]	0.253*** [0.0673]
R&DIntensity	0.147*** [0.0390]	0.118*** [0.0317]	0.124*** [0.0333]
D.Size	0.0830 [0.0557]	0.147** [0.0618]	0.0689 [0.0624]
D.Sector	YES	YES	YES
N	263	263	263

Robust standard errors in brackets \* p<0.10, \*\* p<0.05, \*\*\* p<0.010

Table 10: **Logit estimation: Cross section Data - ENI 8 (2013)**

<b>Variable</b>	<b><i>Innovation(Model 4)</i></b>	<b><i>Product(Model 5)</i></b>	<b><i>Process(Model 6)</i></b>
Cooperation	0.100 [0.0699]	0.282*** [0.0724]	0.0414 [0.0726]
R&DIntensity	0.0390 [0.0316]	0.0531* [0.0300]	0.0987*** [0.0372]
D.Size	-0.0558 [0.0578]	0.00102 [0.0633]	0.0219 [0.0631]
D.Sector	YES	YES	YES
N	307	307	307

Robust standard errors in brackets \* p<0.10, \*\* p<0.05, \*\*\* p<0.010

Table 11: **Logit estimation: Cross section Data - ENI 9 (2015)**

<b>Variable</b>	<b><i>Innovation(Model 4)</i></b>	<b><i>Product(Model 5)</i></b>	<b><i>Process(Model 6)</i></b>
Cooperation	0.0841 [0.0621]	0.242*** [0.0632]	0.0892 [0.0703]
R&DIntensity	0.274*** [0.0607]	0.0806* [0.0468]	0.238*** [0.0530]
D.Size	0.200*** [0.0491]	0.278*** [0.0667]	0.253*** [0.0581]
D.Sector	YES	YES	YES
N	238	238	238

Robust standard errors in brackets \* p<0.10, \*\* p<0.05, \*\*\* p<0.010

Table 12: **Logit estimation: Cross section Data - ENI 10 (2017)**

<b>Variable</b>	<b><i>Innovation(Model 4)</i></b>	<b><i>Product(Model 5)</i></b>	<b><i>Process(Model 6)</i></b>
Cooperation	0.265*** [0.0941]	0.268*** [0.0749]	0.172** [0.0810]
R&DIntensity	0.0750 [0.0471]	0.0979** [0.0476]	0.0205 [0.0502]
D.Size	0.196*** [0.0616]	0.354*** [0.0664]	0.0514 [0.0819]
D.Sector	YES	YES	YES
N	169	179	179

Robust standard errors in brackets \* p<0.10, \*\* p<0.05, \*\*\* p<0.010

Once considering our linear probability model with firm fixed-effects (specification 7, 8 and 9). That is our final and main specification to explain the link between R&D cooperation and innovation for Chilean firms. we observe R&D cooperation increase the probability of product and process innovation. Firms who are applying R&D cooperation have 0.158 more likelihood of product innovation than those who are not applying R&D cooperation. Moreover, firms who are applying R&D cooperation have 0.146 more likelihood of process innovation than those who are not applying R&D cooperation. The effect in product innovation seems stronger than in process innovation (0.158 and 0.146 more likelihood respectively). Again, clearer, concrete and independent knowledge (product or radical innovation) are experiencing more benefits of R&D cooperation than tacit or internal innovation (process innovation). Table 13 shows the results of LPM with firm fixed effects. Results are in line of previous empirical works such as Bönnte & Keilbach (2005); Baum et al. (2000); Tether (2002); Fritsch & Lukas (2000); Aschhoff & Schmidt (2008); Becker & Dietz (2004). Our empirical analysis is in favor of our first hypothesis: R&D cooperation has a positive and significant impact on the probability of innovation outcomes.

If we observe the results of a panel data conditional fixed effect logit model, R&D cooperation is having a slightly positive impact only on process but not in product innovation. This behaviour can be explained due to our sample size restriction. Other variables such as investment in R&D projects also increase the likelihood of innovation outcomes. An increase in 1 percentual point of R&D intensity increase the likelihood to have product and process innovation in about 0.129 and 0.107 respectively. These results support findings of some authors such as Fritsch & Lukas (2001); Lööf & Broström (2008). See 13<sup>6</sup>.

<sup>6</sup>Annex 3 presents the results of Linear probability model with pooled data framework.

Table 13: Panel analyses

Variable	Conditional fixed effects logit model			LPM with firm fixed effects		
	<i>Innovation</i>	<i>Product</i>	<i>Process</i>	<i>Innovation</i> ( <i>Model 7</i> )	<i>Product</i> ( <i>Model 8</i> )	<i>Process</i> ( <i>Model 9</i> )
Cooperation	0.00139 [0.00279]	0.0304 [0.0425]	0.159* [0.0865]	0.0874 [0.0587]	0.158** [0.0678]	0.146** [0.0721]
R&DIntensity	0.00540 [0.00849]	0.0271 [0.0213]	0.0843** [0.0387]	0.133*** [0.0340]	0.129*** [0.0393]	0.107** [0.0417]
SizeSales	0.000285 [0.000553]	-0.000323 [0.00130]	0.0160 [0.0107]	0.0669 [0.0434]	0.0358 [0.0501]	0.0907* [0.0533]
D.Y				YES	YES	YES
N	139	183	203	987	987	987

Robust standard errors in brackets \* p<0.10, \*\* p<0.05, \*\*\* p<0.010

On the other hand, considering our second hypothesis, where we expect the impact of R&D cooperation on innovation varies across R&D cooperation partners such as *Competitors*, *Customers*, *Suppliers*, *Institutions*, *Universities* (specifications 13, 14 and 15). We observe, there is not heterogeneity on the impact of cooperation on innovation outcomes. R&D cooperation with different partners are not having a statistically significant impact on innovation outcomes. These results again may be related to our sample size restriction, in most of the cases firms are only applying one of the five categories of R&D cooperation, reducing even more the sample. See Table 14.

Table 14: Linear probability model with firm fixed-effects

Variable	<i>Innovation</i> ( <i>Model 13</i> )	<i>Product</i> ( <i>Model 14</i> )	<i>Process</i> ( <i>Model 15</i> )
Competitors	-0.00400 [0.106]	0.0205 [0.125]	0.0913 [0.176]
Customers	-0.0538 [0.0951]	-0.174 [0.112]	0.000577 [0.157]
Suppliers	-0.0577 [0.0823]	-0.134 [0.0971]	-0.113 [0.136]
Institutions	-0.0132 [0.108]	-0.0661 [0.128]	0.207 [0.179]
Universities	0.0708 [0.0951]	0.0513 [0.112]	0.0847 [0.157]
R&DIntensity	0.109 [0.0708]	0.100 [0.0835]	0.282** [0.117]
SizeSales	-0.000924 [0.0796]	-0.0108 [0.0940]	-0.0534 [0.132]
D.Y	YES	YES	YES
N	237	237	237

Robust standard errors in brackets \* p<0.10, \*\* p<0.05, \*\*\* p<0.010

However, if in a similar analysis, Un & Asakawa (2015) introduced an interesting classification of partners according to their position in knowledge stream. They distinguish between upstream and downstream partners. The former *Suppliers* and *Universities* and *Institutions* will be in our case, the latter are *Competitors*, *Customers*. Un & Asakawa argue that this distinction is important because the upstream partners can help firms in the flow of materials. Moreover, the high level of knowledge that partners have can facilitate the adaption to the characteristics of the firm, and how to make changes in cost and quality of productive system, facilitating the innovation process. See specification 16, 17 and 18. We observe R&D cooperation with *Up* partners such as (*Suppliers* and *Universities* and *Institutions*) is having a positive and significant impact on general innovation and process innovation. Which is not the case of R&D cooperation with partners that are behind in knowledge *Down* such as (*Competitors* and *Customers*), this type of R&D cooperation is even decreasing the likelihood of product innovation in about 0.2, which may be related to knowledge and information transfer reluctance by partners . See Table 15.

Table 15: **Linear probability model with firm fixed-effects**

<b>Variable</b>	<b><i>Innovation</i> (Model 16)</b>	<b><i>Product</i> (Model 17)</b>	<b><i>Process</i> (Model 18)</b>
Up	0.266* [0.139]	0.192 [0.168]	0.486** [0.232]
Down	-0.0281 [0.0883]	-0.210* [0.106]	0.101 [0.147]
R&DIntensity	0.0848 [0.0628]	0.0793 [0.0756]	0.240** [0.105]
SizeSales	-0.0474 [0.0745]	-0.0733 [0.0898]	-0.0649 [0.124]
D.Y	YES	YES	YES
N	237	237	237

Robust standard errors in brackets \* p<0.10, \*\* p<0.05, \*\*\* p<0.010 ,

On the other hand, Un & Asakawa (2015) also distinguish between close and far partners in terms of operations knowledge. The former *Suppliers* and *Competitors* will be in our case, the latter are *Customers*, *Universities* and *Institutions*. Un & Asakawa argue superiority of close over far partners because close partners can help firms to improve efficiency in operations and to increase quality. Moreover, sharing a similar organizational framework facilitates adaption of new process and the understanding of partners knowledge. See specification 19, 20 and 21. We do not observe heterogeneity between partners who are close or far in operations knowledge. R&D cooperation with those who are *Far* or *Close* in knowledge is not having a significant impact on innovation outcomes. See Table 16.



Table 16: **Linear probability model with firm fixed-effects**

<b>Variable</b>	<b><i>Innovation</i> (Model 19)</b>	<b><i>Product</i> (Model 20)</b>	<b><i>Process</i> (Model 21)</b>
Close	-0.0510 [0.0768]	-0.0835 [0.0948]	-0.0627 [0.132]
Far	-0.277 [0.188]	-0.242 [0.232]	0.0340 [0.323]
R&DIntensity	0.106* [0.0610]	0.0663 [0.0754]	0.300*** [0.105]
SizeSales	-0.00250 [0.0708]	-0.00508 [0.0874]	0.00476 [0.122]
D.Y	YES	YES	YES
N	237	237	237

Robust standard errors in brackets \* p<0.10, \*\* p<0.05, \*\*\* p<0.010 ,

Finally, once testing our last hypothesis, where we link R&D cooperation and firms productivity for Chilean manufacturing firms (See specification 22). We observe that *Cooperation* does not have a significant impact on productivity of firms. Results are similar even once considering another measure of firms performance such as sales growth of firms, here defined as the difference in natural log of sales between t+1 and t. However, considering our small database, it is suggested to check the robustness of results in a longer period of analysis. Moreover, it is interesting to notice that another variable such as R&D intensity seems to positively affect productivity of firms, an increase in share of R&D intensity in 1 percentual point increase the productivity growth in about 0.066. See Table 17.

Table 17: **Panel fixed effects estimation**

<b>Variable</b>	<b><i>Productivity</i> (Model 22)</b>	<b><i>Salesgrowth</i> (Model 22)</b>
Cooperation	0.037 (0.060)	0.011 (0.032)
R&DIntensity	0.066** (0.029)	0.026 (0.017)
SizeSales	-0.008* (0.005)	-0.003 (0.003)
Cons	0.444*** (0.146)	0.176** (0.077)
N	986	986

Robust standard errors in brackets \* p<0.10, \*\* p<0.05, \*\*\* p<0.010 ,

## 4.6 Conclusions

The empirical research about the impact R&D cooperation and types of R&D cooperation partners on firm innovation indicators and firm productivity is limited, even more in the case of developing countries. By using an unbalanced panel data of 746 firms between 2009 and 2016 obtained from the Chilean Encuesta de Innovación en Empresas(ENI). This micro-level econometric research tries to evaluate the impact of R&D cooperation and types of R&D cooperation partners on innovation and productivity for Chilean manufacturing firms.

For this purpose, we use a linear probability model with firm fixed-effects. Results are in line of previous works from some authors as Bönte & Keilbach (2005); Baum et al. (2000); Tether (2002); Fritsch & Lukas (2000); Aschhoff & Schmidt (2008); Becker & Dietz (2004). We found there is a positive and significant effect of R&D cooperation on product and process innovation. Firms who have R&D cooperation have greater probability to innovate than those who do not established R&D cooperation. The effect is even stronger in case of pursuing radical innovation. An innovation outcome where novelty, market feedback and external value are highly required (Un & Asakawa, 2015). However, there is not impact of R&D cooperation on firms productivity. Another measure of firms productivity such as labor or value added are required. Moreover, our period of analysis is too short to evaluate the effect of R&D cooperation on productivity for Chilean firms.

Once considering different R&D cooperation partners such as *Competitors, Customers, Suppliers, Institutions, Universities*. Different R&D cooperation partners is not affecting innovation outcomes. However, R&D cooperation with advanced knowledge partners, (*Suppliers and Universities and Institutions*) is increasing the probability to have process innovation, while R&D cooperation with partners behind in the knowledge stream (*Competitors, Customers*) has a negative impact on product innovation, which may be related to problems in transfer of knowledge and information and rivalries between competitors. Moreover, R&D cooperation with partners that are close or far to the firms in knowledge terms is not affecting innovation. It seems knowledge basket offer is more relevant than differences and accessibility across firms and R&D partners.

The relevance of other variables such as R&D intensity and size of firms on the innovation firm performance found by authors as Tether (2002); Fritsch & Lukas (2001); Lööf & Broström (2008); Aschhoff & Schmidt (2008); Un et al. (2010); Santamaria & Surroca (2011); it is supported again. Technological dynamic and firm structure is affecting innovation performance. R&D intensity seems to have a positive impact in innovation outcomes and productivity. Moreover, big firms tend to innovate more than small and medium companies at least in a pool and cross section data framework.

The linear probability model with firm fixed-effects allow us to incorporate the individual firm effect, however, this study is far of being without limitations. One of the main limitation of this study it is the sample size. Even if we are able to build a panel data, the fact that there is a filter question in the survey that allows us to give R&D cooperation information only to firms who presents any kind of innovation generates a potential sample selection bias.

Finally, these findings shed some lights on the innovation economic literature at a firm level and to give support to Chilean policy makers to put emphasis in external sources of innovation such as R&D cooperation to improve firm performance. The promotion of network relationships among firms and partners is a key for firm success.

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# Appendices

## Annex 1: Productivity by R&D cooperation execution

Figure 1: Position in the knowledge chain

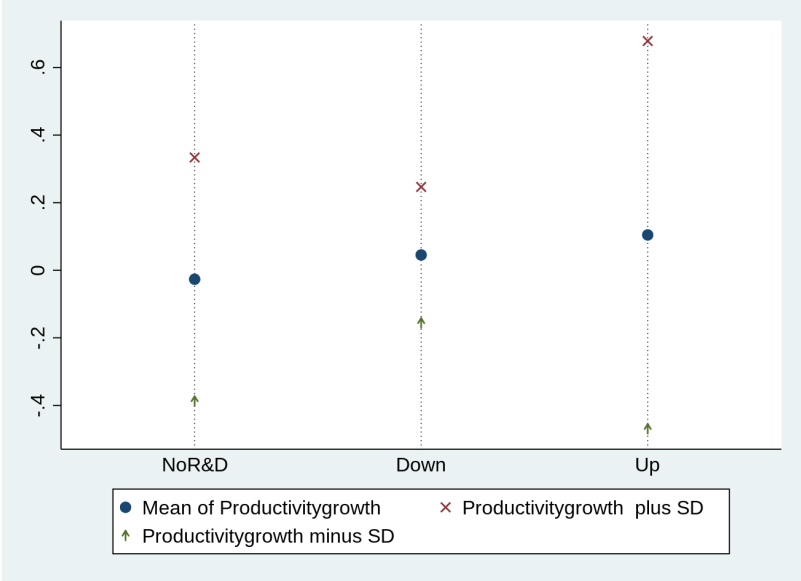
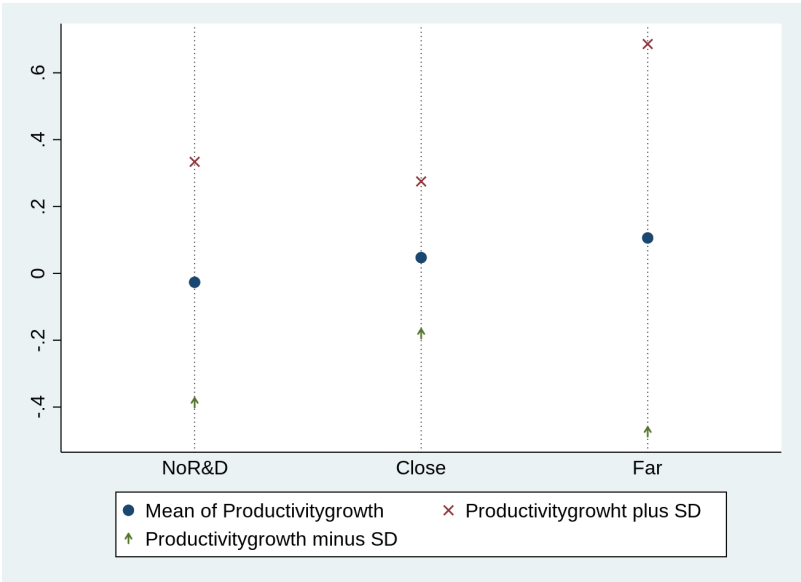


Figure 2: Knowledge distance



**Annex 2: Linear probability Model with firm fixed effects with interaction between R&D intensity and cooperation**

**Annex 3: Linear probability model with pooled data**

Table 1: **Linear probability model with pooled data**

<b>Variable</b>	<b><i>Innovation</i></b>	<b><i>Product</i></b>	<b><i>Process</i></b>
Cooperation	-0.0373 [0.328]	0.333 [0.378]	0.420 [0.402]
R&DIntensity	0.139***	0.121***	0.0949**
SizeSales	0.0676 [0.0435]	0.0348 [0.0502]	0.0892* [0.0534]
R&DCoop	-0.0303 [0.0784]	0.0427 [0.0905]	0.0666 [0.0962]
D.Y	YES	YES	YES
N	987	987	987

Robust standard errors in brackets \* p<0.10, \*\* p<0.05, \*\*\* p<0.010 ,

Table 1: **Linear probability model with firm fixed effects**

<b>Variable</b>	<b><i>Innovation</i></b> <b><i>(Model 10)</i></b>	<b><i>Product</i></b> <b><i>(Model 11)</i></b>	<b><i>Process</i></b> <b><i>(Model 12)</i></b>
Cooperation	0.0793** [0.0317]	0.212*** [0.0369]	0.0736* [0.0380]
R&DIntensity	0.000628 [0.0142]	0.0480*** [0.0145]	0.0284* [0.0147]
SizeSales	0.0645*** [0.00588]	0.0629*** [0.00635]	0.0624*** [0.00632]
D.Y	YES	YES	YES
N	987	987	987

Robust standard errors in brackets \* p<0.10, \*\* p<0.05, \*\*\* p<0.010 ,