ESSAYS IN INNOVATION AND TECHNOLOGY ADOPTION

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The overarching theme of my research is on issues related to innovation, with a focus on how different firms react to technological changes. These include new markets that are developed through international trade agreements, new production technology as a product of research and development (R&D), and even new regulations and standards that change the production process of a firm. We divide these changes into several categories, by whether they are mandatory or voluntary, whether they are 'horizontal' or 'vertical', or whether they are 'direct' or 'secondary' effects of a social change.

First, we look at the responses of countries when mandatory changes are exogenously imposed. In order to do this, we look at the case of how international labor standards impact bilateral trade. Through this estimation, we examine how countries react not only in terms of adopting the standards, but also how they react when their trading partners adopt more standards. The impact of such technological change is heterogeneous across conventions and industries. We find that the international standards significantly explain the extensive margin of trade, but less of the intensive margin of trade.

Second, we look at the endogenous responses of firms to market forces and firm level constraints. We model a firm which has an option to invest and improve their own productivity. A theoretical examination shows that the general equilibrium effect of innovation is positive by increasing consumer welfare through lower prices and added variety of goods. The model also shows policy

implications related to market entry costs such as RD subsidies.

Last, we look at technological changes as an externality. The case we examine is when technology is introduced due to the behavior of other firms. We look at the case of Chile, and examine how foreign direct investment (FDI) impact the exit behavior of firms. We see that survivability of domestic firms is effected by the behavior of multinationals, and that the level of technology of the industry is a significant factor in determining exit rates.

BIOGRAPHICAL SKETCH

Justin Choe is a graduate of the Department of Agricultural Economics and Rural Development at Seoul National University. He continued his studies at the graduate level at the same department, finishing his Master's degree under the tutelage of Dr. Hanho Kim. Shortly after, he continued on to a doctorate degree at the Dyson School of Applied Economics and Management, Cornell University. Under the guidance of Dr. Nancy H. Chau, he worked on various projects that have led to his work in this dissertation. Dr. Ravi Kanbur and Dr. Sharon Poczter, as part of his dissertation committee, have also helped him with crucial elements in his research as well.

For Vivian and Ian

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Above all, to my savior Jesus Christ, for his endless love.

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CHAPTER 1

INTRODUCTION

The overarching theme of my research is on issues related to innovation, with a focus on how different economic agents react to technological changes. Especially, I am interested on the behavior of firms and the process of decision-making that leads to innovation.

I examine the subject of innovation in a variety of ways, related to international economics and development economics. I especially focus on issues of technology adoption, where research and development (R&D) and resulting technological progress impacts individual economic entities. My research also looks into the impact of trickle-down effects, where technologically superior firms aid less advanced firms in terms of productivity and become a significant source of growth and development. I also look beyond the immediate and direct impact of innovation, and examine secondary issues of technological advancement, such questions of consumer welfare and firm exit.

These interests are well represented in the chapters in my dissertation. In Chapter 2, I look into a case where an exogenously imposed change, mandatory in many ways, changes the feasible set of technologies of innovation in the form of labor standards. Specifically, I present a country level examination of how bilateral trade is affected by a common set of labor standards. The implementation of labor standards is regarded to be a state-level choice to innovate and adapt to a changing economic environment. The adjustments that countries show by implementing labor standards and other social institutions, and how they impact the economic interactions between countries in the form of international trade, shows us the importance of adaptation and the impact of social innovation. The results show that there exists a diverse set of impacts that occur from the same set of labor standards, and implementation of such labor standards may lead to a protectionist trade regime where trade becomes more selective.

In Chapter 3, I look at innovation as an endogenous response to market forces and firm level constraint. I discuss how the distribution of firms and the competition level of the market affect the R&D expenditure of individual firms. I also discuss how costs that are not directly related to R&D can also impact innovative behavior of firms. Through this, I show that policies that affect the market entry of firms can also have a secondary effect that influences innovative behavior of incumbent firms as well. We see that when innovation is endogenized in the firm's decision process, consumer welfare increases through an increase of available goods and lower prices. The average profit levels of firms, however, are reduced through expenditure through R&D and more competition in the market. The model also shows that policy measures that increase non-innovation market entry costs may increase firm-level innovation, but end up reducing the number of firms in the economy. This also means a subsidy to reduce entry costs will reduce firm-level R&D, and dampen innovative behavior of firms.

Chapter 4 is dedicated to innovation as an externality, due to the behavior of other firms. For this, I examine how foreign investors impact the behavior of domestic firms, by investigating an overlooked secondary effect of technological externalities: firm exit. In this chapter I examine how foreign direct investment (FDI) into an emerging economy impacts the exit behavior of both domestic and multinational firms. This is an important for economic research, as businesses that are ousted and pushed out of the market change the distribution of the economy and impact other policies. I use the case of the Republic of Chile and examine the changes that occur as more multinationals enter the market over the given time frame. The results show that the technology transfer effect of FDI may be negated by various factors, such as competition and industry characteristics. Especially, we identify the average level of technology in the industry may be an overlooked, but important, factor that impacts firm exit.

CHAPTER 2

THE ROLE OF LABOR STANDARDS ON TRADE: THE CASE OF ILO CORE CONVENTIONS

2.1 Introduction

Issues surrounding the heightening pressure to implement international labor standards in developing countries have been examined in both economic and ethical perspectives for many years (Flanagan (2003)). Recent years have seen further challenges in implementing such labor standards, as anecdotal evidence shows that corporations have been moving their production facilities to countries where government oversight is more negligent (Chau and Kanbur (2006)). These observations not only highlight issues of social justice and ethical importance, but also the economic significance of enforcing international labor standards.

There exists strong support for both those who criticize mandatory implementation of international labor regulations, and those who support it. Critics of enforcing application of common labor standards argue that the costs of implementation will reduce the comparative advantage of developing countries and hinder the terms of trade (Freeman (1996)). The arguments assert that countries that have pre-existing labor standards that are compliant and comparable to the international regulations will have low transition costs compared to countries that do not, and the discrepancy in adjustment costs can lead to protectionist trade policies and are economically and politically unfair to less-developed countries. The arguments further stipulate that the steeper transition cost that countries without compliant labor standards will ultimately hinder export behavior through affecting the comparative advantages of the economy (Brown et al. (1996)).

The other side of the argument highlights the positive impact that labor standards may bring, such as increasing labor productivity in both exporting and non-exporting industries. For instance, the increased allocation of resources to the sector with comparative advantage will affect overall labor conditions, depending on the relative level of labor conditions in the expanding sector (Luinstra (2004), Elliott (2004)). Both analytical work through theoretical models (Yellen (1984), Brown et al. (1996)) and empirical case studies (Berik and Rodgers (2010); Oka (2011)) have been conducted to argue that labor standards ultimately help developing countries through multiple channels, not just economically but also through other areas such as political stability, foreign investment, and consumer demand (Kucera (2002), Brown and Stern (2008)).

This paper contributes to this debate by implementing a cross-country analysis of the impact of labor standards in bilateral trade. In particular, I use a novel measure of labor standards by using a quantitative index created by Cuyvers and Van Den Bulcke (2007), which combines information of implementation, compliance, and ratification of core labour standards of the International Labour Organization (ILO) to measure the level of labor conditions in each country. We create indices for all four sub-categories of ILO labor standards to examine the different affects each type of labor standard has on international trade. This index is useful as it addresses not only the endogenous nature of compliance of ILO core standards, as well as issues of technicality that are found in using the conventional measures of labor standards[1].

[1]Using the count of ratified core conventions can cause some issues. For instance, the United States has not ratified the 6 of the 8 core conventions of the ILO, despite being a country with high labor standards. According the United States Council for International Business (United

2.2 Literature Review

The economic literature on international labor standards and international trade is extensive in both theoretical and empirical studies. The theoretical studies largely focus on two issues; the cost of implementing labor standards, and the productivity enhancement that labor standards bring through application. Brown et al. (1996) argues that labor standards result in an increase of production costs, lowers the profitability of firm exports, and ultimately reduces trade behavior in a country. On the other hand, Krueger (1996) looks at the theoretical arguments linking international labor standards to international trade, and finds that labor standards could enhance the efficiency of the labor market given proper enforcement and management. Rodrik (2000) adds to the discussion by analyzing the advantages of a internationally harmonized standards system and alludes to potential positive outcomes of implementation and harmonization of international labor standards. Palley (2002) also argues that adopting labor standards is a 'win-win' situation for both exporters and importers. The opposing theoretical perspectives on this topic has left the conclusion on this matter ambiguous.

Empirical studies have also delivered an ambiguous set of results through a variety of conclusions. In a widely circulated report, Deléchat et al. (1996) empirically shows that that countries with less stringent standards of Freedom of Association and Collective Bargaining rights did not necessarily perform better in terms of economic efficiency or engage more in trade compared to countries with higher levels of requirements. As a response to this study, Mah (1997) con-

States Council For International Business (2007)), this is due to technical inconsistencies; certain conventions directly conflict with U.S. law and practice, and therefore are not yet ratified by the U.S. Congress.

ducted a similar cross-country study of the export performance of 45 countries using dummy variables of the ratification status the core ILO conventions as a measure of labor standards, adding the real interest rate as a proxy export competitiveness. The empirical results of Mah (1997) differ upon the level of economic development of the economy, but show that the conventions regarding Freedom of Association and Non-Discrimination negatively affected export performance for both developed and developing countries. Hasnat (2002) has updated this approach with recent data, and suggests that other than conventions related to the Freedom of Association, the ratification status of ILO labor standards do not affect the exports of a country.

Other empirical studies have looked at the changes in comparative advantage, rather than export performance, as a measure of impact on international trade. Based on a Hecksher-Ohlin framework, Busse (2002) uses several proxy measures[2] for labor standards for empirical analysis. By asking whether labor standards can impact the comparative advantage in unskilled, labor-intensive goods in developing countries, the author shows that it varies by the type of standard. The results show that Forced Labor and Child Labor regulations lead to an increase in comparative advantage in unskilled-labor-intensive goods, while Gender Discrimination standards show the opposite effect. Related to collective bargaining, weaker trade union rights are shown to be associated with a stronger comparative advantage. These results support the theoretical outcomes for the factor endowment models, and suggest that labor standards can positively impact international trade. Recent studies by Flanagan (2003)

[2] The study uses five indicators for measuring labor standards. Female workforce activity rates are used for gender discrimination, and child labor is measured by the percentage of children between 10 and 14 that are not working. Forced labor is measured using indicators from an ILO study from 2001, and freedom of association and collective bargaining rights are measured using a OECD study. The fifth measure is the total number of ratified ILO core conventions.

and Dehejia and Samy (2004) also use a comparative advantage approach to the topic, but fail to find a clear cut link between labor standards and change in a country's comparative advantage. The former study concludes that a country's ratification choice of labor standards is not likely to influence labor costs, and rather differences in productivity and price levels are the reason for difference in wages. The latter study, which also uses number of ratified ILO core conventions as a measure of labor standards, asserts that it is hard to see lower levels of labor standards as a new source of comparative advantage, and debunks the fear of a 'race to the bottom'.

Alternative models and approaches have been more conclusive. Kucera and Sarna (2006) uses a gravity model to find a positive and robust relationship between stronger trade union rights and higher total manufacturing exports, especially that of labor-intensive nature. The authors assert that they fail to find evidence that strong union rights have an adverse impact on the exports on labor-intensive manufactures.The authors further show that while stronger union rights and total exports are positively linked, they are highly sensitive to the assumptions of the empirical model. Using a dynamic panel approach, Bonnal (2010) uses two measures of labor standards, the rate of work injuries and rate of strikes and lockouts, to find a positive relationship between improved labor conditions and stronger institutions and exports to GDP ratio in both developing and developed countries. Bakhshi and Kerr (2010), using specific measures of labor standards combined with country-specific characteristics[3], show that exports can increase minimally when labor standards are suppressed, im-

[3]The authors use multiple measures for different areas of labor standards. First, a 5 point index is used to measure forced labor, based on the definition of the ILO. Child labor is measured by the percentage of workers between 10 and 14 in the workforce, while gender discrimination is measured by the unemployment rate for women 15 years and older relative the rate of men. The measure of rights regarding Freedom of Association and Collective Bargaining is a 11 point scale, ranging 0 to 10, based on the work of Kucera (2004).

plying a negative relationship between labor standards and exports.

With an inconsistent set of outcomes in the literature, we propose several areas in which this paper can contribute to the argument. First, with the exception of of few studies such as Kucera and Sarna (2006), the majority of studies related to international labor standards and international trade focus on the relationship between an exporter and the rest of the world, rather than a bilateral partnership between two countries. This limits the scope of analysis regarding the impact of labor standards on international trade, as the changes to production factors such as labor impact not only exporting countries, but may also affect the behavior of the importing country as well. In this perspective, an approach using a gravity model that can measure both exporter and importer fixed effects can help in analyzing the bilateral partnership as well as maintain the consistency of trade theory (Anderson (1979), Bergstrand (1985)). This approach also allows us to perform in-depth comparisons of the bilateral partnerships between exporters and importers, rather than solely exporting behavior. This sheds light on different economic aspects between trade partners, and will provide insight on issues on standard harmonization and compliance issues.

Second, an investigation on differences the impact of labor standards across different industries would help the understanding of how trade behavior is affected in different sectors and industries. While some studies have looked into a breakdown of manufacturing industries (Van Beers (1998)), little consideration has been given to other industries such as agriculture, and have not examined if any differences exist. Intuitively, the differences in labor intensity in the production process between industries will lead to different impacts of labor standards, and additional examination in the sectoral differences would provide valuable insight on both the role of labor standards.

Third, examining the impact of labor standards through the margins of trade will provide an additional depth of analysis. Trade liberalization affects trade flows between countries and impacts both margins of trade. The first margin of trade is the extensive margin, which is when more firms are able to engage in trade activity due to lowered trade costs, which results in a larger variety of goods being exported or imported. On the other hand, the intensive margin of trade indicates the change in traded quantities that result from changes in trade costs. Recent studies on this topic, such as Lawless (2010), show that the extensive margin is negatively affected by fixed and variable trade costs, but the determinants of intensive margin is unclear (Coughlin (2012)).

Using the theoretical work on production standards and international trade margins[4] as a starting point, I look to extend the analysis on the extensive and intensive margins and how they change with respect to labor standards for additional understanding on the topic.

[4]Chen and Mattoo (2008) develops a model where the effect of standards on trade are decomposed into two parts; the change in market access and entry through stricter standards, and the change in the number of firms producing and their output. In this specification, firms observe a single fixed cost of production, and firms with more stringent standards provide to countries with identical or lower standards at a higher marginal production cost. Lowering labor standards have the opposite effect, where the number of trading partners reduce. Thus, the change in standards have a direct effect on the number of markets that the firm has access to. The authors continue to argue that if a country has strict standards and changes in standards are minimal, the overall effect of standards on trade depend on the economies of scale, calculated by the fixed cost of production divided across the final number of trading partners. This shows that trading with countries with high fixed costs will increase while trading with countries with low fixed costs are more likely to decrease. When changes in standards are significant, the change in standards proportionately affect the marginal production costs of a firm, and will likely counteract the economies of scale. Whether the overall change is positive or negative depends on country specific cost levels.

2.3 Measuring Labour Standards

One potential reason that explains the inconsistency of results across studies examining the impact of labor standards, is the poor measurement of labor standards. Studies in the literature have used a wide range of proxies for labor standards, but have adopted the number of ratified standards as a conventional measurement. This in particular can be problematic, as empirical evidence suggests that the simple count of ratified labor standards is not a good indicator of a country's real labor conditions. This is seen because the ratification of a convention does not necessarily imply state-wide compliance, as well as issues that stem from the endogeneity of the measure (Van Beers (1998), Salem and Rozental (2012)).

Studies show that indicators of the legal framework and institutions related with the degree of compliance to labor standards are arguably better indicators of labor conditions (Flanagan (2003)). Without a universal dataset with consistent data collection measures, however, it is difficult to measure and compare the legal conditions of countries against each other, especially for the purpose of this study (Barenberg (2011)).

The index proposed by Cuyvers and Van Den Bulcke (2007) can be a solution to this conundrum. The authors propose a measure to quantify the compliance level of a country with ILO core standards, as well as quantify a country's capacity and willingness to adopt and comply with the core standards. This quantitative measure addresses the endogenous nature of ratifying ILO core standards, as it measures a general measure of adoption, implementation, and compliance. This measure adds a qualitative depth to the analysis of labor standards, as well as solve several econometric matters such as measurement issues.

2.3.1 Why ILO Core Labor Standards?

Domestic labor standards vary from country to country, and are not only influenced by the country's economic and diplomatic status, but also by its cultural, historical, and social characteristics (Brown et al. (1998)). For instance, standards such as health, safety, and other product specifications are very specific results of a given industry or product over along history of development (Swann (2010)). Additionally, it could be argued that even if such information on regulations were available, it may be too specific and narrow to obtain any inference on economic behavior.

On the other hand, international labor standards focus on labor rights that are applicable across all industries of an economy. The core labor standards set out by the International Labour Office (ILO) is a set of regulations and principles of minimum standards that are needed to treat workers humanely, which are also recognized by the global community (Sengenberger (2005)). Additionally, the core conventions of the ILO account for the majority[5] of all labor standard ratifications of the ILO. For this reason, I limit the discussion of labor standards to the eight core labor standards of the ILO in this study. The eight core labor standards fall under four large categories. The details are shown in Table 2.1.

As seen in the table, the core conventions can be broken down into four subcategories. Conventions No. 87 and No. 98, shown in the first two rows of Table 1, are related to the Freedom of Association and Collective Bargaining regula-

[5] According to the ILO, the percentage of total ratifications around the world that are related to the core conventions is 86%, as of January 2013.

Table 2.1: The Eight Core Labour Standards of the ILO

Convention Group	Convention Title	Convention No.	Year Announced
FA	Freedom of Association & Protection of the Right to Organize	87	1948
	Right to Organize & Collective Bargaining	98	1949
FL	Forced Labour	29	1930
	Abolition of Forced Labour	105	1957
GD	Discrimination (Employment and Occupation)	111	1958
	Equal Remuneration	100	1951
FL	Minimum Age	138	1973
	Worst Forms of Child Labour	182	1999

tions that allow workers to form unions and promises the right to collective bargaining. We denote this group as FA in this study. Conventions 29 and 105 are related to the Elimination of Forced and Compulsory Labour, which abolishes slavery and other types of inhumane labor practices, and is grouped as FL. The Elimination of Discrimination in Respect of Employment and Occupation regulations, shown as Conventions No. 111 and 100, are grouped as issues of gender discrimination in the workplace (GD), while Conventions No. 138 and No. 182 are targeting the abolition of child labor and are labeled CL. As of December 2012, more than 85 percent of ILO member countries have ratified at least one of these conventions, despite the fact that the ILO relies on voluntary compliance and has no enforcement power. In this aspect, the combination of the legal nature related to the ratification process and the economic role of a trade barrier makes the ILO core standards a good set of standards to test the hypothesis of whether the implementation of such labor standards promote or deter international trade.

Table 2.2: Number of Ratified Countries By Convention Number and Region (as of Dec. 2012)

	FA		FL		GD		CL	
Convention No.	87	98	29	105	100	111	138	182
Total	150	160	174	171	168	169	157	173
Africa	48	52	53	53	51	53	48	50
Americas	33	32	33	35	33	33	30	34
Asia	19	25	37	32	33	32	39	38
Europe	50	51	51	51	51	51	50	51

2.3.2 Labor Standards Index

An important component of this paper lies in the construction of a country-specific measurement of labor standards. Although the count of ratifications of labor standards could function as a proxy measure, as it is treated in other papers with similar multilateral resistance measure (Mah (1997)), it comes with the assumption that all eight of the core standards have equal weight and symmetric affects across all participating parties. This assumption can be very misleading, especially when considering the historical and cultural differences that exist between the conventions (Van Beers (1998)).

The index of labor standards proposed by Cuyvers and Van Den Bulcke (2007), which is a multi-layered statistic which represents country-level indicators for each of the four categories of the ILO's core labor standards, compiles such historical and legal information of each country and allows us to compare different countries on a single plane.

In the study by the authors, each index[6] is calculated based on not only core convention ratification history, but also domestic regulations, as well as other statistics such as gender ratios and child labor ratios. These Labor Standard Indices (LSI) are constructed so that an index of 1 would indicate a country is showing maximum compliance with the ILO core labor standards, where a score of 0 would mean there are no legal restrictions or instruments related to the ILO core labor standards. Thus, the larger the index, the stricter the country implements the enforcement of labour and labour standards based on a strong compliance record. These definitions are further described in the Appendix.

Although the effectiveness of using these indices are not yet proven in the literature, there are several advantages in using this index that are *a priori* recognizable. First, the indices allow us to directly compare the levels of compliance with international labor standards of different countries. Second, the indices add more variance to labor standards indication help us discern the intricate differences between already ratified countries. (Chau et al. (2001)) Third, a simple count of ratified conventions does not give full information on the maturity of the legal system of the said country, whereas the proposed index can aid us in understanding how such legal maturity affects the openness of the economy. Similarly, the ratio or number of ratified conventions, used as a norm in the literature, gives us limited variability in the information of labor standard compliance. The variation in the indices can help with the variability in observations, adding to the empirical analysis.

Following the given formulae, I have constructed the indices for all four ar-

[6]The study includes three types of indices: Formal, Real, and Compound. The Formal indices use legal history and other social mechanisms that are related to the convention. The Real indices use the number reported violations and the severity of punishment for each convention. The Compound indices are a weighted index of the Formal and Real indices. Due to data limitations, I deal only with the Formal indices in this study.

eas of core conventions: Freedom of Association, Freedom of Child Labor, Freedom of Gender Discrimination, and Forced Labor, and are denoted FA, CL, GD, and FL, respectively. We have constructed the four formal indices for the 173 selected countries in which data was available, using ratification history and other legal information from the ILO website. Table 2.3 shows the average level of each index of all countries for each year. The table shows that not only the different general levels of implementation by conventions, but also the changes in trends of each index group.

The index is created by using a weighted measure of country specific characteristics related to the same set of ILO core labor standards. This aspect allows us to use these indices for analysis in comparing and estimating the role of labor standards across different countries. Although the indices do not reflect and take into account actual enforcement levels and reported violations, such as the indices proposed in Mosley and Uno (2007), the indices do show how countries are legally responding to the ILO's demands leading up to ratification. With the observation that legal environments are positively correlated with actual practice of such rules discussed in the ILO conventions (Salem and Rozental (2012)), these indices represent a comprehensive measure on how labor standards affect trade activity.

2.4 Econometric Analysis

In this section I present the empirical strategy in which I implement the LSI in the analysis of the impact of labor standards on international trade.

Table 2.3: Summary Statistics of Labor Standard Index: All sample countries

Year	**FA**	**CL**	**GD**	**FL**
1995	0.485	0.815	0.484	0.286
1996	0.481	0.814	0.485	0.284
1997	0.463	0.806	0.482	0.277
1998	0.455	0.804	0.458	0.238
1999	0.448	0.804	0.449	0.216
2000	0.430	0.798	0.429	0.188
2001	0.401	0.766	0.404	0.148
2002	0.388	0.738	0.383	0.132
2003	0.385	0.719	0.359	0.129
2004	0.382	0.716	0.354	0.120
2005	0.380	0.713	0.351	0.112
2006	0.375	0.705	0.344	0.092
2007	0.363	0.702	0.333	0.079
2008	0.359	0.702	0.330	0.064
2009	0.359	0.700	0.326	0.064
Average	0.407	0.750	0.394	0.156

Source: Author's calculations.

2.4.1 The Gravity Model

In order to examine whether and how ILO Core Labor Standards are affecting a country's trade flow, an empirical framework is needed that enables us to use ratification information of each country, and see how each core convention affects a country's trade volume and value. In this matter, the gravity model is both widely and highly regarded in bilateral trade analysis for its tractability and empirical success, and has been used as a standard approach in the literature (McCallum (1995); Helliwell (1996); Feenstra (2001)).

One advantage that arises when using the gravity model is its success in multilateral resistance terms in international trade, including exporter and importer fixed effects. (Anderson and Wincoop (2003); Chen and Mattoo (2008)) Related to our question, we speculate that the relative ratification status of labor standards of the importing and exporting countries may affect the partnership of the trade. For instance, an importing country with a long history of labor rights and a strong penchant for worker's rights may have less trade with a country known for it's child labor usage than a country with similar if not stronger labor standards. Thus, the exporter and importer fixed effects are of great interest for our analysis, and can be analyzed through the gravity model. Studies such as Chen (2004) and Carrère (2006) have used the gravity model to measure border effects as well as the effect of regional trade agreements, while Bora (2002), Disdier et al. (2008), and Bao and Qiu (2010) all use variations of the gravity model to examine the effect multilateral resistance terms between two trading countries.

Additionally, the gravity model can help discern the extensive and intensive margin of trading partners. Stricter labor standards may have a positive effect on the trade flow between pre-existing partners (intensive margin), but may hinder firms from engaging in exporting activities with new partners (extensive margin). Both intensive and extensive margins carry much importance in determining welfare implications of trade policies. We use a version of the gravity model, based on the work of Helpman et al. (2008), to examine the mentioned margins and compare them between regimes.

As seen, the consistency and the adaptability of the gravity framework allows us to measure the impact of labor standards in both exporters and importers, while controlling for issues such as common borders, language, and other known determinants of trade flows. Based on these advantages, I construct an estimation equation based on the gravity model to determine the affect of labor standards on the trade flow between two partners.

2.4.2 Data

Bilateral Trade Data

The data on bilateral trade is taken from BACI (Base pour l'Analyse du Commerce International), an international trade database developed by the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). The BACI dataset uses various methods to create a full dataset of products coded by the 6-digit Harmonized System (HS6), and creates a bilateral trade datavase based on the UN-COMTRADE system. With information of country-level characteristics and information on bilateral trade for over 200 countries, the BACI is particularly useful in analyzing trade patterns at the product level, as well as other topics such as trade policy, specialization, and competitiveness.

The dataset and the available HS6 codes makes it possible to divide the trade flows into different industries, in which I partition into Manufacturing and Agriculture[7].

ILO Legal Data

Information regarding the history of participation, ratification of conventions, and environments of supporting legislation of each country was found on the ILO website[8]. The databases NATLEX and NORMLEX found on the ILOSTAT website provide information on related labor and human rights legislation, and ratification and reporting requirements of each member country, respectively. Each country has a separate profile which consolidates the information needed to construct the LSI proposed by Cuyvers and Van Den Bulcke (2007).

Gravity Controls

CEPII also offers a gravity dataset for country pairs from the period 1948 to 2009, provided by Head and Ries (2010). This dataset consolidates different variables of different datasets relating to trade costs. The information on distance between countries is from the CEPII database, which contains several definitions of distance[9]. For this analysis, the metric distance between the largest economic centers were used. This is done with the assumption that core economic areas would not change, where administrative capitals may change under different

[7]For further analysis, we assume that products with HS6 codes under the categories Animal and Animal Products, Vegetable Products, and Foodstuffs are agricultural goods, and all other products are manufacturing goods.

[8]www.ilo.org

[9]For instance, distance between countries are measured by the straight line distance between economic centers, the capitals, and borders.

regimes and political climates.

Other gravity controls, that include population and Gross Domestic Product (GDP) that are in the dataset origin from the World Bank's World Development Indicators (WDI). The dataset also includes indicator variables regarding a country's participation in a Regional Trade Agreement (RTA), whether countries are contingent and share a border, have a history of being in a common colony, and whether both countries share a legal origins.

Since in the GDP data in CEPII dataset did not control for inflation, we use information from the Penn World Table (PWT) was used[10]. The advantage of using the PWT is that it features a set of prices, controlled in 2005 prices, in a common currency (US dollars), so that both cross-sectional and time series comparisons can be made. I use the Laspeyres PPP Converted GDP Per Capita, at 2005 constant prices, to account for the economic size of each country.

Overall, among the 183 member countries, we exclude several countries due to data availability[11] Thus, a total of 173 entities were included in the analysis, for 15 years. This gives us 446,340 observations in total.

[10]The PWT is an open dataset that contains a set of national accounts economic time series, for 189 countries and territories, from 1950-2009, with 2005 as reference year.

[11]The countries of Botswana, Lesotho, Namibia, San Marino, and Swaziland were dropped due to missing data in the gravity controls. Simultaneously, for data categorization issues, observations from Luxembourg and Montenegro were respectively merged as the Belgium-Luxembourg group and the State Union of Serbia and Montenegro.The

2.4.3 Empirical Estimation and Results

Baseline Estimation

In this section present the estimation equation used to measure the effect of labor standards on bilateral trade flows. I start with the standard gravity model, using the notations specified by Anderson and Wincoop (2003). The equation is as the following:

$$T_{ijt} = \beta_0 + \beta_1 Y_{it,jt} - \beta_2 D_{ij} + \beta_3 GC_{it,jt} + \beta_4 LSI_{i,j} + \theta_i d_{i,j,t} + \varepsilon_{ijt} \tag{2.1}$$

where T_{ijt} represents the log values of bilateral exports, in common currency (USD) controlled for exchange rates, from country i to j in year t. The same notation applies for $Y_{it,jt}$, which is a vector that contains the log of gross domestic product (GDP) of the exporting (i) and importing (j) countries, respectively, for year t. D_{ij} is the distance between the two countries, measured by the geometric distance between the economic centers of each state. $GC_{it,jt}$ is a vector that contains variables used as controls for the gravity model, which include dummy variables for geographical contingency of the two countries, whether a common language is shared, whether the two countries have any type of colonial linkages, and whether the two partners have agreed upon any type of regional trade agreement. $LSI_{it,jt}$ is a vector that contains the measurement for labor standards for both exporters and importers for each year. As this gravity model specification allows us to specify a multilateral resistance value, including fixed effects for countries and time-specific effects, we add the fixed effects of the model following the vectors $LSI_{ij,tj}$. This includes exporter-specific(d_i), importer-specific(d_j), and year-specific(d_t) terms to capture the multilateral resistance terms. These account for the unobservable effects that occur each year.

Results

Table 2.4: Gravity Model: OLS

Measurement of Labor Standards	Exporter	Importer
No. of Ratified Conventions	-0.0121***	-0.00604*
Freedom of Association (FA)	-0.384***	-0.228***
Child Labor (CL)	0.0199	-0.102***
Gender Discrimination (GD)	0.128***	0.112***
Forced Labor (FL)	-0.105***	-0.059**

***: p<0.01, **: p<0.05, *: p<0.1

The key results from this estimation are shown in Table 2.4. The table shows the estimates of Equation (2.1) using ordinary least squares estimation, with robust standard errors, clustered on country pairs. The analysis includes controls such as distance between countries, GDP of each country, dummy variables for geographical contingency, common language, colonial linkages, and regional trade agreements. We first ran the baseline estimation using the number of ratified core conventions to examine the effectiveness of the specification, and then compared the results to a second round of estimation using the aforementioned LSI of Cuyvers and Van Den Bulcke (2007). The estimates for other variables and controls are relegated to the Appendix.

For a baseline comparison, we examine the coefficients for the number of ratified conventions for both the exporters and importers. In both cases, we see that an increase in the number of ratified conventions will result in a reduction in bilateral trade. It is well argued that increases in costs that are associated with stricter labor standards will reduce export activity. The reduction in bilateral trade from the importers side is also expected, despite the magnitude of the impact is much lower than the exporting case. This may happen as the demand from products from low-standard countries may diminish, and the overall quality of goods may be insufficient.

Looking at the coefficients for the LSI, we see that the signs of each convention are different, which highlights the heterogeneity of each core labor convention. The signs for FA and FL are negative for both importers and exporters, and both are larger in magnitude for exporters compared to the importers. The conventions for Gender Discrimination, in comparison, are both positive which implies that bilateral trade increases these conventions are increasingly implemented. The coefficients for the Child Labor conventions the exporters and importers have different signs, where when importers incorporate child labor laws bilateral trade decreases and exporters increase international trade.

We further look into the differences between industry. We conduct pooled regressions dividing the data into two subcategories based on industry: Agriculture and Manufacturing. The results are shown in Table 2.5.

The results of the estimation by sector continue to show that the gravity control estimates are consistent with the literature (Mah (1997), Otsuki et al. (2001), and Busse (2002)). In similar fashion to the results in 2.4, we see when using the number of ratified core labor standards as a measure of labor conditions, results for both manufacturing and agriculture show that additional ratification of ILO labor standards reduces trade between two countries. The results us-

Table 2.5: Gravity Model: OLS by Industry

Industry	Agriculture		Manufacturing	
Measurement of Labor Standards	Exporter	Importer	Exporter	Importer
No. of Ratified of Conventions	- 0.0166***	-0.0111***	-0.0167***	-0.00919***
Freedom of Association (FA)	-0.383***	-0.170***	-0.388***	-0.293***
Child Labor (CL)	0.0499**	-0.0803***	0.0241	-0.0927***
Gender Discrimination (GD)	0.0726**	0.0524*	0.118***	0.135***
Forced Labor (FL)	-0.0794***	-0.0459*	-0.118***	0.0819***

***: p<0.01, **: p<0.05, *: p<0.1

ing the multidimensional measures of LSI are also consistent with the results in 2.4 for both sectors. The sign for the coefficients are same, but interestingly the magnitude for the importing side is always larger than the coefficients for the exporting side.

Baseline Estimation: Potential Issues

While the results using the LSI show a deeper story than when using a simple count of ratified conventions, we introduce several extensions to further the analysis.

First, the baseline estimation of 2.1 does not provide an understanding or insight on how countries reduce the number of foreign trading partners exporting to their markets, as well as the quantity of each exporting country's exports to these markets. In this paper, we present a two-stage estimation that examines these questions of the number of trading partners and traded quantities of goods, by looking at the extensive and the intensive margins of trade. This approach also helps with the possibility of sample selection bias due to the large mass of observations of trade that are reported as zero[12].

The second area is determining whether the number of ratifications is a good proxy of a country's compliance with international labor standards. This is debatable, especially with the possibility of developing countries ratifying conventions for a political and diplomatic reason[13].

2.4.4 Two-Stage Estimation

Helpman et al. (2008) proposes an international trade model of heterogeneous firms that addresses such issues with zero trade flows. The model is developed into a generalized gravity equation that also accounts for asymmetric trade as well. The model can be estimated using a two-stage modified Heckman procedure with aggregate data, by estimating the predicted probability of a firm in a certain to country to continue engaging in the global market. Based on this model, I use a two-step estimation to measure the effects of labor standards on bilateral trade.

[12]Roughly 36.94% of total observations between trade partners are reported as non-existent.

[13]For instance, the country of Rwanda has ratified all eight core conventions, but it is hard to assume the fact that they are on par with other OECD countries in terms of working conditions.

Stage 1

The first stage is a probit estimation that measures the trade probability of a country.

$$EX_{ijt} = \beta \cdot GRAVITY_1 + \gamma_1 CLS_i + \gamma_2 CLS_j + \theta_i d_i + \theta_j d_j + \theta_i d_t + \varepsilon_{ijt} \tag{2.2}$$

EX is an indicator function which has a value of 1 when there is positive trade between country i and country j in year t, and zero otherwise. The $GRAVITY_1$ term is a vector containing the canonical control variables of a gravity model, which include economic size, distance, and other variables such as language. CLS is the LSI vectors of country i and j, while the terms d_i, d_j, and d_t each respectively denote the fixed effects of the importer, exporter, and year.

Stage 2

The second stage of the estimation directly uses the estimates from Stage 1 to correct for the biases stemming from the zero observations.

$$\begin{aligned} \ln Export_{ijt} &= \beta \cdot GRAVITY_2 + \gamma_1 CLS_i + \gamma_2 CLS_j + \theta_i d_i + \theta_j d_j + \theta_i d_t \\ &+ \theta \hat{\hat{\eta}}^*_{ijt} + \ln\left\{\exp\left[\delta(\hat{z}^*_{ijt}) + \hat{\bar{\eta}}^*_{ijt})\right] - 1\right\} + \varepsilon_{ijt} \end{aligned} \tag{2.3}$$

The notations for all other variables remain the same from the first stage. $GRAVITY_2$ is identical to $GRAVITY_1$ from Stage 1, sans an indicator whether the trade partners share the same official language[14]. The Inverse Mills Ratio, shown as $\hat{\hat{\eta}}^*_{ijt}$, is used to correct the selection biases from the large mass of non-

[14] The difference is needed for the purpose of exclusion restriction, in need for a variable that affects the probability of non-zero trade flow, but not the value of the flow.

observations (Heckman (1976)). The term z^*_{ijt} controls for unobserved firm heterogeneity (i.e., the effect of trade frictions and country characteristics on the proportion of exporters), and is calculated through the inverse distribution of estimates from the Probit estimation of Stage 1.

It is well known that the non-linear estimation with fixed effects may have problems with consistency (Greene (2004)), and the authors propose an alternative linear specification. The linear version of the estimation equation is shown below.

$$\begin{aligned} \ln Export_{ijt} &= \beta \cdot GRAVITY_2 + \gamma_1 CLS_i + \gamma_2 CLS_j + \theta_i d_i + \theta_j d_j + \theta_i d_t \\ &\quad + \theta \hat{\hat{\eta}}^*_{ijt} + \hat{z}^*_{ijt} + \hat{z}^{*2}_{ijt} + \hat{z}^{*3}_{ijt} + \varepsilon_{ijt} \end{aligned} \tag{2.4}$$

The third power multinomial of z^*_{ijt} is inserted to capture the non-linearity of the error terms, which is effectively equivalent to using the non-linear estimation technique. This approach also discerns the effects that propel producers to engage in export behavior, and the actual intensity of trade.

2.4.5 Results: Two-Stage Estimation

Stage 1

The estimation results from the two-stage estimation are shown in this subsection. The first stage Probit estimation results of Total Trade, Agricultural Trade, and Manufacturing Trade are shown in Table 2.6.

The first stage Probit estimation results for Equation 2.2 show how much each variables affect the probability of a country engaging in bilateral trade,

Table 2.6: Estimation Results: Stage 1

Industry	**Agriculture**		**Manufacturing**		**Total**	
Variable	Exporter	Importer	Exporter	Importer	Exporter	Importer
No. of Ratified Conventions	0.0158***	0.0174***	0.0167***	0.0233***	0.0213***	0.0251***
Freedom of Association	-0.217***	-0.069**	-0.147***	-0.0971***	-0.173***	-0.0837***
Child Labor	0.0734***	-0.0221	0.00058	-0.0381*	0.0105	-0.0216
Gender Discrimination	0.08***	0.0709***	0.114***	0.103***	0.137***	0.0746***
Forced Labor	0.114***	0.148***	0.136***	0.154***	0.102***	0.166***

*** p<0.01, ** p<0.05, * p<0.1

in a given year and trade partner. Through this, we are able to see how labor standards are affecting the extensive margin of trade.

The first row of Table 2.6 show the estimation results using the number of ratified conventions as a measure of labor conditions for both the exporting country i and the importing country j. The results show that in both sectors of agriculture and manufacturing, as well as the combined analysis, the number of ratified conventions increase the probability of trade. This means the ratification of ILO conventions increases the probability of a country by engaging with a new trade partner. The fact that it is positive for both exporters and importers implies that a country with a long history of complying with international standards is more likely to engage with a country with similar levels of institutional stability.

Looking at lower part of Table 2.6, which shows the results using LSI for measuring labor conditions, a couple of points stand out. First, we see that the Labor Standard Indices of the Freedom of Association convention is shown to negatively affect the probability of exporting, while the LSI of the other conventions are enhancing the probability of trade. This trend continues throughout both sectors of Agriculture and Manufacturing.

Results for Child Labor, show a discrepancy in the coefficients depending on the exporter and importer, and also industries. The LSI of Child Labor are positive in affecting exporters, but seems to be a negative influence in importers. To be more specific, child labor is a strong positive influence in encouraging trade in the agricultural sector, but positive but insignificant influence in the manufacturing sector, and insignificant in total trade. This asymmetric affect can be seen that child labor is predominantly seen in the agricultural sector, with most child and underage employment coming from production in rural areas[15].

The results for Forced Labor, on the other hand, are shown to increase the probability of trade. Thus, we can speculate that the increased cost from implementing anti-forced labor laws are outweighed by the positive impact.

The results for Gender Discrimination are also positive, regardless of exporter and importer. While some studies such as Busse and Spielmann (2006) show that gender inequality can increase the comparative advantage of in labor intensive industries, the results show that a state with more gender equal policies will have more trading opportunities.

[15]According to several reports from the ILO, over 60 percent of all child laborers in the age group 5 - 17 years work in agriculture, including farming, fishing, aquaculture, forestry, and livestock. This amounts to over 129 million girls and boys. The majority (67.5 percent) of child laborers are unpaid family members. In agriculture this percentage is higher, and is combined with very early entry into work, sometimes between 5 and 7 years of age.

Stage 2

The second stage estimation results of Total Trade, Agricultural Trade, and Manufacturing Trade are shown in Table 2.7.

Table 2.7: Estimation Results: Stage 2

Industry	**Agriculture**		**Manufacturing**		**Total**	
Variable	Exporter	Importer	Exporter	Importer	Exporter	Importer
No. of Ratified Conventions	-0.00525	-0.0106***	-0.0124***	-0.02336***	-0.0206***	-0.0259***
Freedom of Association	0.0875**	0.0338	-0.0265	-0.0561	-0.00243	-0.0405
Child Labor	-0.114***	-0.0215	-0.0328	-0.0247	-0.0293	-0.0449*
Gender Discrimination	-0.0252	-0.0317	0.00	0.00115	-0.0573	0.0277
Forced Labor	-0.00548	-0.0996***	-0.0423	-0.126***	-0.016	-0.153***

*** p<0.01, ** p<0.05, * p<0.1

The results of the second stage regression are reveal information on the effect of labor standards on intensive margin of trade. The results show that when controlling for probability to engage in international trade, the number of ratifications of ILO conventions and the LSI have a smaller overall impact on trade, in both significance and magnitude, compared to what we had seen in the baseline results in Tables 2.4 and 2.5. Thus, the labor standards are effective in engaging countries into participating in international trade, but has less effect on the volume and value traded between partners once they engage with each other.

Once again for comparison, we look at the first row of Table 2.7 for the estimation results using the number of ratifications of ILO conventions. The results show that the more ILO conventions a country has ratified, it has a lower level of bilateral trade between already engaging trade partners. The results also show that regardless whether exporter or importer show compliance, the movement of goods between the two participants will decrease.

Looking at the results using LSI as a measure, we see a mostly insignificant set of results compared to the results in Stage 1. The labor indices for Freedom of Association shows to be positive and significant on agricultural trade, while manufacturing and total trade are negative and insignificant in the exporting country. The same trend holds in the importing country, although the coefficients are not statistically significant. Gender Discrimination scores also seem to have little impact on the intensive margin of trade, in both the exporting and importing countries. The Child Labor conventions and the Forced Labor conventions raise results that are worth noting. In the case of Child Labor ratification in exporting countries, it has a negative impact on agricultural trade, with insignificant effects on manufacturing and total trade. The same effect can be seen in importers, although only the coefficient for total trade is weakly significant. Forced Labor effects are also negatively impacting bilateral trade, especially in the importing country.

Interpretation: Stage 2

In this section, the interpretation of the estimates shown in Table 2.6 and 2.7 are presented. The results cover a large area of information, and thus I focus on individual LSI results.

Freedom of Association Indices The Stage 1 results show a significant and negative impact of FA conventions, which is interpreted as a negative extensive margin of trade. Based on Melitz (2003) and other models of heterogeneous firms, the negative impact the LSI of Freedom of Association insinuates that increased costs of unions and labor associations hinder firms from engaging in trade activity. The results are universally negative, regardless of industry, and the magnitude of impact is measured to be stronger in the agricultural sector compared to the manufacturing sector, which is generally regarded to be more labor intensive. This could mean that the positive impact of lesser labor disputes by allowing collective bargaining may not be as large in the agricultural sector compared to the manufacturing sector. The estimate of FA conventions in the importing country is also shown to be negative, which implies that an importer with stricter union laws will also lower the probability of exporting in country i. This shows that countries with a stronger institutions that support the principles of Freedom of Association are less likely to engage with countries with low FA scores. The implication is that countries with stricter FA rules have a smaller set of countries that they import from and have trade relations with. The results in general not only show that labor standards reduce trade probability, but also can be used as a form of protectionism by reducing the number of trading partnerships and creating a more uneven situation for the global trade regime.

The results from Stage 2, however, are less definitive. Table 2.7 shows the value and quantity traded between countries are shown to be positive for agriculture, but negative for the manufacturing sector, albeit the lack of significance. The FA labor standards positively impact agricultural trade in the exporting country, which is consistent with the findings of Kucera and Sarna (2006). Despite anecdotal evidence that suggest weak enforcement of labor rights in the agriculture sector, the positive effect of FA rights in agriculture production is notable.

Combining the findings for both stages, at least for the agricultural sector, we find that FA rights may deter firms from engaging in exports, but increase the volume of exchange once they engage in trade. This further supports the notion that FA rights will increase the inequality in the global trading regime, and reduce the number of trading countries to a smaller set.

Gender Discrimination, Forced Labor and Child Labor Indices Unlike the FA conventions, the LSI for Gender Discrimination, Forced and Child Labor have positive impacts on trade probability, with the exception of importers in the manufacturing industry implementing Child Labor standards. This implies that the adoption of such conventions may be costly, but have a positive impact on the firm's ability to produce, explained by theories such as efficiency wage (Yellen (1984)) and observed in several case studies (Brown et al. (2013)).

Additionally, the asymmetry of LSI exporter effects in agricultural trade and manufacturing trade are worth noting. While ILO conventions related to Forced Labor seems to be relatively symmetric, the strong impact of CL indices on agricultural trade, and the strong impact of GD indices in manufacturing trade seem to reflect industry characteristics. These conventions are all measured to be stronger in the manufacturing sector, when looking at the importer effects.

The results for the intensive margin once again show an ambiguous set of results, and the only statistically significant results are CL in the agricultural exporters and FL in the importer effects across industries. All other effects are insignificant, meaning a small variability of change. This minimal impact of the intensive margin suggests that when controlling for exports, the labor standard effect on trade flow is ambiguous.

Conclusion

Overall, labor standards have a definitive impact on the extensive margin of trade, but are ambiguous in explaining the intensive margin of trade. These findings are consistent with other studies in the literature, such as Lawless (2010) and Coughlin (2012), in the sense that the common determinants have a much larger impact in the extensive margin, but remain ambiguous in explaining the intensive margin of trade.

The FA standards are negatively affecting the propensity to trade, while remain ambiguous regarding the average volume and value of trade between two countries. The results of the other conventions, such as the GD, FL, and CL conventions show inconsistent results.

A potential explantation for this finding is that FA rights, unlike other conventions, increases in the fixed cost of production, while where other regulations impact the variable production costs by altering the usage of specific labor resources. The Freedom of Association rights, being the latest convention of the ILO core standards, accompany a long process in which the observance does not necessarily imply a higher labor cost of production. (Kucera and Sarna (2006)) Thus, it could be that FA rights affect firm productivity in the same way that language, geography, and infrastructure affect; only affects the propensity to trade. Once the firms are productive enough and willing to engage in international trade, then the bilateral flow of goods are determined by other factors, such as firm-specific productivity and product-specific consumer demand.

2.5 Concluding Remarks

This paper utilizes a labor standard index (LSI) developed by Cuyvers and Van Den Bulcke (2007) to measure the impact of labor standards on bilateral trade. Using the framework of Helpman et al. (2008), we use a two-stage gravity model for estimating the impact of labor standards on trade, using data from 1995 to 2009.

We observe both the impact of the LSI on both the extensive and intensive margins of trade. While the LSI significantly influences the probability to trade, it has minimal impact on the trade volume between two partners. In particular, it is seen that Forced Labor and Child Labor standards of the exporting country negatively affect bilateral trade, across industries. The same standards, however, show asymmetric affects in the importer effects, especially in agricultural goods. The negative sign of the effects are consistent with other findings using other international standards. The findings in different industries, however, highlight the asymmetric nature of demand response in different industries.

The estimates of extensive and intensive margins of trade also suggest that each convention affects firms and trade relationships in a different way. For instance, while FA conventions hinder a firm's probability to export, other LSIs show that in helps engage in the international market. The unsystematic results of the intensive margin emphasizes the need to construct a convention-specific study.

There are several ways to improve this study. First, a dataset consisting of violations and cases must be conducted to create a more robust survey. The current indices are representative of legal structures and institutions, but have contain little information on enforcement and violations. Seeing how the results from such labor standard indices would shed additional light on enforcement and punitive action of each country. This will help examine the diverse effects of different types of labor standards.

Additionally, looking at trade between countries of different stature is under analysis, using criteria to divide the member countries into developing and developed countries. I anticipate to see whether labor standards have a stronger (or weaker) effect on South-South trade compared to trade between OECD countries or South-North trade.

CHAPTER 3

FIRM INNOVATION AND FIRM HETEROGENEITY: AN EXERCISE IN EXTERNALITY

3.1 Introduction

This paper examines the determinants of productivity innovation, and the general equilibrium consequences this decision on the productivity distribution of firms and welfare in the economy. This is done in a heterogeneous firm model where firms engage in research and development (R&D). As a result, we can analyze changes in firm entry and exit, in a setting where exit and entry are both endogenous, and where each firm enjoys market power with firm specific markups.

Innovative activity and how it affects the productivity of firms have been an important topic in the economic literature since the seminal theories of Schumpeter and Fain (1961). This question on the relationship between firm profit, innovation incentives, and market structure introduced the evolutionary and dynamic nature of innovation have spawned several studies such as Loury (1979), Dasgupta and Stiglitz (1980), and Lee and Wilde (1980), have all pointed out the importance of market structure on innovation, while Segerstrom et al. (1990), Aghion et al. (1998, 2001), and Aw et al. (2011) have expanded this strand of literature by constructing non-linear, dynamic models. These studies once again underline how firm innovation and the organization of the industry affect the growth patterns and innovation rates of both leading and laggard firms.

Recent empirical studies have pointed out, however, that the heterogeneity of firms is salient in R&D spending patterns in various industries, even when controlling for the rate of return of R&D investment and the cost of such R&D (Hall et al. (2012)). Another strand of literature has shown the different patterns of innovation between firms of a industry, and has identified sunk costs and entry barriers as a determinant of R&D (Acs and Audretsch (1987) and Hadjimanolis (1999)). Asker and Baccara (2010) shows how, depending on the structure of government subsidy, policies have asymmetrically impacts the R&D intensity and behavior of firms with different productivity levels in the market [1]. Evidence from these papers show R&D proportions are not uniform across firms, and other factors, such as industry characteristics, are crucial in determining the R&D intensity and innovative actives of businesses.

This paper attempts to contribute to these features by creating a heterogeneous firm model which endogenizes the innovation decision of a firm and focuses on the role of market entry costs and other market entry barriers. In particular, building on the framework of Melitz and Ottaviano (2008), I create a model where a firm has the opportunity to make a level of investment to innovation, prior to the realization of the firm's productivity. Specifically, the investment improves the firm's probability to obtain a lower production cost, which in turn expected revenue for each firm. The firm is thus given the uncertain choice in obtaining a high productivity, at the additional costs that accompany R&D. Since both the productivity distribution and non-innovation market entry costs are affected by market characteristics, the model also shows the relationship between the firm level heterogeneity and the market structure and characteristics..

This approach has the following advantages. First, it captures the fact that

[1] Asker and Baccara (2010) examine largely three types of government subsidy: a market entry subsidy which aids new firms in entering the market, and two separate R&D subsidies that address the fixed and variable parts of the R&D.

the realization of R&D investment is heterogeneous between firms. Second, it examines why and how the distribution of R&D and firm productivity will change with the number of firms in the market. Third, it also provides intuition on how the general equilibrium and firm-level productivity jointly affect a firm's decision to innovate, and enter a market.

The findings of this paper are threefold. First, I show the welfare consequences of innovation compared to a hypothetical regime without any innovation. The welfare change that arises from innovation shows that there exists an increase in consumer welfare in a regime with endogenous innovation, compared to a regime without any innovation. Although innovation is costly to firms, the production enhancement effect and the general equilibrium effect made possible by innovation implies that more firms enter the market and producing goods.

Second, I show that non-innovation entry costs affect the firm's decision R&D. Results indicated that while an increase in non-innovation entry costs of country or market will increase firm innovation, this also leads to a drop in consumer welfare by reducing the number of operating firms and by increasing the prices of goods in the market. Third, in a policy exercise with government subsidy, I find the changes in consumer welfare are largely ambiguous. When a government subsidy lowers the entry barriers, more firms are able to enter the market. The added variety and subsequently lower prices of goods suggest a higher level of consumer welfare, but result in lower markups and profit levels for firms. The non-linear nature of the indirect utility function and it's reliance on the parameters of the model, however, makes a direct comparison between the effect of reduced income from taxation and the added welfare from added variety difficult. Thus, the overall direction of welfare change is ambiguous.

This paper is related to the literature that looks at the role of international trade as determinant of R&D behavior as well. In this strand of literature, Grossman and Helpman (1991a,b) show the role of innovative activities in a trade context, and recently Atkeson and Burstein (2010) have constructed a heterogenous firm model that shows firm decisions to operate, innovate, and engage in trade. Costantini and Melitz (2007) also examine the evolution of R&D within an industry in response to trade liberation, using discrete choice variables. In particular, my paper shares some common grounds in modeling the process of R&D of firms with Long et al. (2011). The authors, within a reciprocal dumping model, allow an innovation process for firms to improve their productivity and model the process of innovation similar the R&D decisions shown in the study. Long et al. (2011), however, holds the number of firms constant and does not allow for any general equilibrium change through firm entry. Additionally, the paper examines the changes in firm behavior and welfare levels when an identical market is integrated through trade liberalization. This study, in contrast, allows for an endogenous number of firms, and examines how the changes in non-innovation entry costs and other market factors determine the innovation behavior of firms.

The structure of the paper is as follows: I present the model in the following section, followed by a section that depicts the extension of the model by incorporating R&D. I then show the results of the model and present the interpretations. I conclude the study with some comments on future extensions.

3.2 Base Model

Based on the framework of Ottaviano et al. (2002) and Melitz and Ottaviano (2008), I construct a general equilibrium model that emulates the behavior of firms, trade, and innovation and examine the firm level results. I start with describing the consumer side of the model.

3.2.1 Consumer Preferences

The consumer's utility function is defined as the following quasi-linear utility function with a quadratic sub-utility form, with symmetric preferences among all varieties that are available in the economy.

$$U = q_0 + \alpha \int_i q_i di - \frac{1}{2}\gamma \int_i (q_i)^2 di - \frac{1}{2}\eta \left(\int_i q_i di \right)^2 \tag{3.1}$$

Each variety is indexed as $i \in (0, \Omega]$, where I assume that each number uniquely represents a corresponding product variety. Ω is the set of heterogeneous varieties. Using this index system, q_0 is designated to represent the consumptions of the numeraire good, and q_i represents the consumption of variety $i \in (0, \Omega]$. The parameters $\alpha,\ \gamma\eta > 0$ each denote the nature of preference for the differentiated product, the quadratic consumption of the differentiated product, and the quadratic consumption of the total basket, respectively. Parameter α shows the strength of substitution between the numeraire good and the differentiated good, and parameter γ shows how much the consumer cares about the width of the spectrum of consumption. With positive parameters γ and η, the consumer prefers a dispersed consumption of a wider spectrum of goods, reflecting a 'love of variety' preference[2]. Additionally, the smaller the γ and larger the η, the substitution effects of each variety are larger. This means that each variety of goods become close substitutes for another.

In the model, each individual faces the following budget constraint, where the price of the numeraire good is normalized to 1.

$$\int_{i \in N} (p_i \cdot q_i)\, di + q_0 = w \tag{3.2}$$

Total labor income of an individual consumer is his wage income, w, expressed in units of good 0, q_0. I assume w to be large enough to cover the total expenditure of all varieties so that for every individual the consumption of the numeraire good q_0 is positive[3].

$$w > \int_{i \in N} (p_i \cdot q_i)\, di \Leftrightarrow q_0 > 0 \tag{3.3}$$

This assumes that there is an interior solution for the maximization of (3.1). N is the number of varieties that each individual consumes, meaning that products indexed $i \in (N, \Omega]$ are known to the consumer, but not consumed.

Knowing (3.2), the first order conditions for maximizing the utility of the each individual subject to the budget constraint results in the inverse demand

[2]Ottaviano et al. (2002) shows this characteristic by assuming the consumer buys a fixed amount of goods, and equally divides it by the number of varieties of i. The paper argues if there exists an uniform consumption pattern among all varieties in i, meaning each variety is preferred equally, the consumption for each variety would be the same intensity. Under this setting, we can use equation 3.1 to show that consumer utility increases with a larger variety i for any amount of consumption. Thus, the consumer gains a higher utility to have a larger variety of goods, which represents a preferences that represents a 'love of variety'.

[3]

function for each variety i, where i is an index for all varieties that are positively consumed.

$$p_i = \alpha - \gamma q_i - \eta \left(\int_{i \in N} q_i \, di \right) \tag{3.4}$$

This shows that the willingness-to-pay for a variety is not only affected by the amount of the consumption of the variety itself, but also the total consumption level of all varieties. Since γ and η are positive, the demand of a variety reduces with increased consumption of that good, as well as a wider consumption basket. Denote $\bar{p} = \frac{1}{N} \cdot \int_i p_i di$ as the average price of all varieties in the market. Aggregating (3.4) over an identical L number of consumers, we get the total demand for each variety i in the economy, denoted as Q_i, which is shown below.

$$Q_i = q_i \cdot L = \frac{\alpha L}{\eta N + \gamma} + \frac{\eta N L}{\eta N + \gamma} \frac{\bar{p}}{\gamma} - \frac{L}{\gamma} p_i \tag{3.5}$$

As a result, we have a simple structure where the total demand for each variety in the economy is shown as decreasing function of p_i from a weighted average of the substitution pattern parameter α and the average price level of differentiated goods $\bar{p}$. From (3.5), we know that the demand for variety i is decreasing with its price p_i. Denote the price of the variety which has a demand of zero as p_{max}, which is the y-axis intercept of the demand curve of each variety. This implies that $\alpha > p_{max}$, which tells us that $p_{max} > \bar{p}$. At this price level of p_{max}, we can use $Q_i = 0$ to rewrite (3.5) as a linear combination of α and the average prices of all varieties $\bar{p}$.

$$p_{max} = \frac{\gamma\alpha + \eta N\bar{p}}{\eta N + \gamma} = \alpha\left(\frac{\gamma}{\eta N + \gamma}\right) + \bar{p}\left(1 - \frac{\gamma}{\eta N + \gamma}\right) \tag{3.6}$$

The equation shows that the maximum price p_{max} is a weighted average of α and $\bar{p}$ with weights determined by γ, η, and N. In particular, as the number of varieties increases, the relative constraints of $\bar{p}$ on p_{max} increases.

3.2.2 Production

Based on the demand for each variety, we now look at the production side of the economy. I assume that each firm produces a unique variety such that no two firms produce the same product, and hence each firm has complete monopoly power over it's own variety. Since labor is the only production factor for each and every firm, the marginal cost of variety is determined by the inverse of labor productivity of each firm. With monopoly power over its variety, each firm decides the optimal level of output where its profit is maximized, taking the number of consumers L, the varieties N, and parameters α, γ, η as given. Additionally, the average price of products $\bar{p}$ is assumed to be given to the firm.

The firm's profit maximizing problem can be shown as the following:

$$\max_{p_i} \pi_i = p_i \cdot Q_i - c_i \cdot Q_i \tag{3.7}$$

where c_i is the marginal production costs that each firm observes. The first order conditions of this problem using the demand for each variety following (3.5) and the profit maximizing conditions of p_i show that the aggregate output level is shown as the following:

$$Q_i = \frac{L}{\gamma}[p_i - c_i] \tag{3.8}$$

Using this information with (3.5), we know that any variety that is priced lower than p_{max} will have the inverse demand of

$$p_i = p_{max} - \frac{\gamma}{L} \cdot Q_i \tag{3.9}$$

where the total production of variety i, Q_i, and price of that variety p_i, are endogenously decided depending on the marginal cost level of the firm, represented as c_i. With a given p_{max}, which hinges on the size of variety N and the parameters, the prices, output, and profit levels become a function of a productivity level, or a marginal cost level. Plugging (3.8) into (3.9), we get the profit maximizing prices described in p_{max} and c_i. This expression, coupled with (3.8), derives the following results:

$$\begin{aligned} p_i(c_i) &= \tfrac{1}{2}(p_{max} + c_i) \\ Q_i(c_i) &= \tfrac{L}{2\gamma}(p_{max} - c_i) \\ \pi_i(c_i) &= \tfrac{L}{4\gamma}(p_{max} - c_i)^2 \end{aligned} \tag{3.10}$$

3.2.3 Innovation

As seen in (3.10), the profit levels of each firm is determined by the marginal costs of production, denoted as c. To model firm heterogeneity, I model this productivity level to be determined by a random draw from a given distribution of common knowledge. I expand on this mechanism by introducing an mechanism of innovation, by awarding the firm to increase the probability of drawing a favorable cost levels through increased R&D spending. With the knowledge that the extra investment will help their chances of drawing a favorable, low cost - high productivity level, the firm then must decide the optimal amount of innovation that maximizes the expected profit.

Timeline

The timing of the firm's decision making process is depicted as follows. As a potential entrant, the firm first surveys the market to determine the boundaries of operation, such as the cutoff point for margin. The firm must next decide how much to invest depending on whether it believes spending a positive amount for innovation will be profitable.

Once the innovation costs on top of the market entry costs are spent, all firms are simultaneously revealed their actual cost levels. At this stage, each figures out the expected profit levels upon entering the market. Firms that foresee non-negative profit will remain in production, while firms expected to make negative profit will exit the market.

I use backward induction in the following subsections to depict the optimal strategies of the firms and find the solutions of each stage. We start with the last stage.

Survival or Exit (Stage III) Stage III is when the firm pays an irrevocable, one-time cost of innovation and entry costs which is denoted as ρ. The cost of innovation stems from its determination on how much to invest based on its expected profits upon entry, and the entry cost is given in the market. With the assumption that innovation improves the productivity level and lower the marginal cost, and since all firms are identical, firms will conduct the optimal level of R&D (ρ^*) to improve their production process for higher profit levels. The total entry cost, measured in terms of q_0, is the sum of non-innovation market entry costs and the optimal level of innovation, $f_D + \rho^*$. [4] Based on this setting, we can derive the realized cost level which discerns the remaining firms that make a non-negative profit from the exiting firms that make a negative profit. Each firm will determine whether to remain in the market to produce or exit the market based on the following equation.

$$\pi(c_i) \geq f_D + \rho \iff c_i \leq p_{max} \tag{3.11}$$

Since the profit function of each firm is continuous and monotonically decreasing with respect to c_i, the marginal firm makes zero profit. [5]

Denote the cost level of this marginal firm as c_D. Since this firm makes zero profit, we know that $p_{max} = c_D$ from (3.11). Given the parameters α, γ, η of the utility function are fixed, p_{max} is partly determined by the number of firms selling N. We also know that any firm that has a cost level below c_D will have positive profit, while firms with cost level above c_D will have negative profits. Since I assume that all firm that observe negative profits will exit the market

[4] There are different ways to model the investment proportion. I have adopted the simple additive version in this paper. The assumption of additive costs is advantageous for its simplicity for distinguishing selective costs and exogenous (market-given) costs. See papers such as Bustos (2011) and Lileeva and Trefler (2010) for additional reference.

[5] From the Intermediate Value Theorem, since the profit function is a real-valued, continuous and monotonic on the interval of $c_i = [0, p_{max}]$, we know there exists a single value of c_i in which the profit function equals a value $\pi(0) = \frac{L}{4\gamma}(p_{max})^2$and $\pi(p_{max}) = 0$.

immediately, the firm with marginal costs c_D will represent the 'cutoff' point of firms: the least productive and most costly firm that can survive in the market. Thus, only firms that have a cost level $c \in (0, p_{max}]$ will operate in the market.

Determining Investment and the Cost Draw (Stage II) Stage II is when the firm's productivity levels are revealed from the cost distribution. Based on this production cost, the profit levels are determined in Stage III. The distribution of costs is common knowledge, and firms decide the optimal level of investment based on their expected profits.

In modeling innovation and investment behavior, I assume that the distribution of costs, $G(c)$, changes with the level of investment ρ. Following Melitz and Ottaviano (2008), I assume that the productivity level of each firm, or the inverse of marginal cost, follows a Pareto Type 1 distribution. The distribution of costs can be expressed as the following.

$$\Pr(c_M > \mathbf{c}) = \left(\frac{c}{c_M}\right)^k \text{ for } c \leq c_M \tag{3.12}$$

The parameter $k \geq 1$ represents the shape of the distribution, and the given upper-bound of cost in the economy is denoted as c_M.[6] This level represents the most inefficient level of technology in the economy. In other words, firms with production costs of c_M produce the most expensive product among all varieties in $i \in (0, \Omega]$.

I model innovation by introducing a component where the firm conducts

[6]When $k = 1$ the cost distribution will be uniform, and when k increases the number of high cost firms increase. The advantages of using a Pareto distribution is that it maintains is functional form and shape even when truncated from above.

R&D by paying a one-time fee of ρ, measured in terms of good 0. While innovation covers a broad spectrum of definitions, I specifically focus on process innovation, where a firm endeavors to improve its production measures to produce their goods more efficiently and less costly.

Using this definition of innovation, I model that R&D expenditure of ρ improves the probability to draw a lower cost level c, and increases its expected profit level by shaving off the lower bound of the productivity in the distribution. This mechanism allows firms to have power to affect their productivity levels, but leaves the realization of productivity a random draw. In particular, I assume that the distribution is altered by reducing the original upper-bound c_{max} by a function of $\rho \geq 0$, which results in the following modified upper bound of the production costs in the economy:

$$c_{max} = \frac{c_M}{(1+\rho)^{\beta}} \tag{3.13}$$

where c_{max} is the new lower bound of productivity and the upper bound of costs that the firm faces, and $\beta < 1$ is a parameter which depicts the decreasing marginal effectiveness of investment. When the firm decides not to invest ($\rho = 0$), the lower bound of production remains $c_M = c_{max}$. When R&D investment increases with a positive ρ, the upper-bound c_M reduces, truncating the cost distribution from the upper end of the cost range. From (3.12), the productivity distribution $G(c)$ with R&D can be rewritten as the following.

$$G(c, \rho) = \left(\frac{c}{c_{max}}\right)^k = \left(\frac{c \cdot (1+\rho)^{\beta}}{c_M}\right)^k \tag{3.14}$$

Given this modified distribution, firms determine their investment levels by maximizing the expected profit after investment. The optimal level of investment ρ^* that is determined is paid in Stage III.

$$\max_{\rho} E(\Pi(c,\rho)) = \int_0^{c_D} [\pi(c,\rho)\, dG(c,\rho)] - f_D - \rho \tag{3.15}$$

Determining Survival (Stage I) At the first stage of decision making, all firms scope the landscape of the market, and determine the levels of expected profit. The market structure shown in the first section shows that the profit levels of each firm and each variety depend on the productivity of each firm. Firm level performances are determined by the cutoff points of the market, determined by (3.11).

3.2.4 Optimal Investment and Market Entry

Solving the timeline mentioned in the previous subsection, we first examine the profit maximizing problem the firms faces in Stage II. Based on the information the firm obtains from Stage I, the firms solves the following problem.

$$E(\Pi(\rho)) = \int_0^{c_D} [\pi(c,\rho)\, dG(c,\rho)] - f_D - \rho \tag{3.16}$$

Since the amount of innovation ρ potentially affects the realization of c, both the price, output, and profit become a function of ρ. Thus, we can rewrite the profit function from (3.10) as the following:

$$\pi_i(c_i, \rho_i) = \frac{L}{4\gamma}(p_{max} - c_i)^2 \tag{3.17}$$

After substituting the form of $\pi_i(c_i, \rho_i)$ in to (3.15), and rewrite the maximization problem of all firms as:

$$\max_{\rho} E(\Pi(c, \rho)) = \frac{L}{4\gamma} \int_0^{c_D} \left[(p_{max} - c)^2 dG(c, \rho) \right] - (f_D + \rho) \tag{3.18}$$

For all firms that exhibit production costs between zero and c_D, the expected revenue from distribution $G(c, \rho)$ is shown as the first component of (3.18). I assume that a firm regards c_D to be exogenous to investment ρ, as the effect of a single firm's investment is negligible in the market. Under the condition $\beta k \leq 1$ [7], the optimal amount of investment ρ^*.

$$(\rho^* + 1) = \left[\frac{2\gamma(k+1)(k+2)}{\beta k \cdot L \cdot (p_{max})^{k+2}} \cdot (c_M)^k \right]^{\frac{1}{\beta k - 1}} \tag{3.20}$$

This ex-ante optimal investment is determined by several factors: the size of the economy L, parameter of individual variety demand γ, the distribution shape parameter k, the innovation effectiveness parameter β, the upper-bound of costs c_M, and the upper-bound of sellable prices p_{max}. Clearly, when γ is smaller, demand is more price sensitive, resulting in more incentive to have a lower production cost. When c_M is smaller, the relative technological distance between the market leader and laggard is small. Thus, the same amount of productivity increase would lead to a relatively larger advantage. Both p_{max} and the

[7] This condition is derived to ensure concavity, from the second order conditions of (3.18).

$$\beta k(\beta k - 1)(1 + \rho)^{\beta k} \frac{L}{4\gamma} \frac{c_D^{k+2}}{(k+1)(k+2)\,(c_M)^k} \leq 0 \Leftrightarrow \beta k \leq 1 \tag{3.19}$$

cutoff point of costs c_D are endogenously determined within the market through zero profit condition. It is not clear, *a priori*, how these factors affect investment levels. The changes in k and β are also not clear as well. This leads us to the next section where we look at how the factors are decided in equilibrium.

3.3 General Equilibrium

Given that the optimal investment of each firm is derived as (3.20), we can now examine the general equilibrium effects of this decision. Entry into the market will continue until the expected profit of a firm is zero; that is until the expected revenue equals the total cost of entering the market. This zero-profit condition is shown as the following.

$$\int_0^{c_D} \pi(c,\rho)dG(c,\rho) = f_D + \rho \tag{3.21}$$

The left hand side of (3.21) represents the expected profit of the firm when entering the market, given the distribution of costs $G(c)$. Since the firms make entry and investment decisions based on the expected profit, the cutoff point c_D will be determined when the expected profit is equal to the total amount of overhead cost a firm must put down to enter the market. This relationship enables us to calculate the cutoff point p_{max} as the following:

$$p_{max} = \left[\frac{2\gamma(f_D + \rho^*)(k+1)(k+2)(c_M)^k}{L \cdot (1+\rho^*)^{\beta k}}\right]^{\frac{1}{k+2}} \tag{3.22}$$

This condition shows that when either entry cost f_D or R&D expenditure ρ

increases, the maximum prices of operating firms increases as well. Given $f_D \geq 1$ and $\beta k < 1$ from (3.6), an increase of ρ^* will lead to an increase in p_{max}. This is due to the general equilibrium effect where the increase in total overhead costs reduce the number of firms that operate. The change in the number of firms that are selling in the market leads to an increase in its upper-bound of prices, p_{max}. It can also be interpreted that the fringe firm, which makes zero profit, needs to increase its prices to make ends meet with the increased overhead costs.

Merging (3.22) back into (3.20), we get the following equilibrium result,

$$\rho^* + 1 = \beta k(f_D + \rho^*) \tag{3.23}$$

which we rewrite as the following:

$$\rho^* = \max\left\{0, \frac{\beta k \cdot f_D - 1}{1 - \beta k}\right\} \tag{3.24}$$

Equation (3.24) shows that the ex-post optimal investment levels of each firm are ultimately determined by the combined parameters of internal factor R&D effectiveness β, and the external factors k, which is the productivity distribution parameter, and f_D, which is the market entry cost. Since firms are identical prior to the productivity draw, and thus face the same investment and R&D problems, the realized firm-specific and heterogeneous cost levels do not affect optimal R&D levels. If $\frac{\beta k \cdot f_D - 1}{1 - \beta k}$ is negative, firms will invest nothing.

The distribution parameter k can be interpreted as factors that affects the shape of the productivity distribution. This includes a market's rule of law or market competitiveness, which have been discussed extensively in Eaton and

Kortum (2002). When k is smaller and closer to 1, the probability of drawing each productivity level closer to uniform, meaning there exists a relatively higher chance of drawing higher productivity compared to a situation with a larger k. Thus the firm has less incentive to invest as the high-productivity draws are less scarce. Thus, investment will fall with a lower k and increase with a higher k.

The parameter β, on the other hand, represents the internal returns to enhance and amplify the efforts of an individual firm through R&D, which can range from human resource policies to organizational structure. If β is larger and closer to 1, the returns of R&D are near constant, leading to a larger level of R&D. If β is smaller, the investment ρ is less effective in increasing the chances of productivity improvement and will remain at relatively lower levels. Thus, in a vacuum, an increase in β will also increase firm investment, while a drop in β will decrease investment.

In conclusion, the introduction of the R&D component in the heterogeneous firms model creates a situation where investment affects the heterogeneity of firm productivity, and also is affected by a combination of the internal and external parameters which is represented by βk. By combining the R&D component within the productivity distribution allows us to maintain the Pareto form, which keeps the analytical forms succinct. The equilibrium solutions produce a simple parameter where the internal efforts of a firm are affected by the external factors of the market.

As discussed earlier, the literature on this topic has shown that competition in the market (Aghion et al. (2009)) and the expected return of R&D (Hall et al. (2012)) are significant predictors of innovation activity. These studies show that competition levels between firms in the market, and average R&D returns are determinants of R&D expenditure. The simplicity of this model also increases the tractability of the model, and produces testable hypotheses using numerical measures of R&D effectiveness and market competitiveness found in empirical studies.

3.4 The Impact of Innovation: Regime Comparisons

In this section I examine the changes in the general equilibrium results by endogenizing R&D. Thus, the comparisons are between one regime that does not have investment, to another which has endogenized investment. This section carries over the assumptions that have been used to find general equilibrium solutions of the model. The conditions are shown as the following:

(A1) $0 < \beta k < 1$: This assumption ensures that investment ρ has diminishing returns, and that the profit function of each firm is concave. If the assumption is not met, an interior solution to the firm's profit maximization problem does not exist and an optimal strategy cannot be determined for each stage.

(A2) $\rho^* = \max\left\{0, \frac{\beta k f_D - 1}{1 - \beta k}\right\}$: This ensures that investment ρ^* is non-negative. This condition also implies $\beta k \cdot f_D > 1$. If not met, firms will not engage in investment ($\rho^* = 0$).

(A3) $\sqrt{\frac{2\gamma(k+1)(k+2)}{L} \left(\beta k \left(f_D - 1\right)\right)^{2\beta} \left(1 - \beta k\right)^{2\beta - 1}} < c_M$: This condition limits the cutoff point p_{max} so that it does not exceed the upper-bound of productivity, c_M. If not met, firms may face a negative probability of drawing a productivity level.

The solutions for the regime without innovation can be derived by substituting ρ^* with 0, and are denoted with a superscript 0.

3.4.1 p_{max}: Cutoff Points

The cutoff point of firm survival under no investment, written as $(p_{max})^0$, while the cutoff point with optimal levels of investment is written as p_{max}. Since R&D levels, production levels, and firm level profits all depend on the cutoff points, a comparison of $(p_{max})^0$ and p_{max} will shed insight on the welfare implications of ρ^*.

First, let us rewrite the cutoff point with innovation.

$$p_{max} = \left[\frac{2\gamma(f_D + \rho^*)(k+1)(k+2)(c_M)^k}{L \cdot (1+\rho^*)^{\beta k}}\right]^{\frac{1}{k+2}} \tag{3.25}$$

Comparing this to the cutoff point with no innovation,

$$p_{max} = (p_{max})^0 \cdot \left(\frac{f_D + \rho^*}{f_D \cdot (1+\rho^*)^{\beta k}}\right)^{\frac{1}{k+2}} = \lambda \cdot (p_{max})^0 \tag{3.26}$$

Denote the multiplicative factor $\left(\frac{f_D+\rho^*}{f_D\cdot(1+\rho^*)^{\beta k}}\right)^{\frac{1}{k+2}}$ as λ. This factor λ determines the size of p_{max} compared to $(p_{max})_0$.

Proposition 1 *Given the assumptions A1-A3, an introduction of innovation will reduce the cutoff point* p_{max}.

Proof 1 *See Appendix.*

Appendix shows that $\lambda < 1$, which shows the relationship between the effects of increased entry costs through investing counterbalanced by the increased expected profit stemming from a favorable cost draw. I denote λ as the markup discount as it shows the difference between $(p_{max})^0$ and p_{max}. The markup discount affects the firm's decision to invest in process and productivity improvement, shown in Stage II. Note that in the case $\rho = 0$, the markup discount $\lambda = 1$, which provides the hypothetical base of comparison.

3.4.2 N: The number of varieties

Another angle of comparison can be seen through the number of firms operating. From (3.6), we can see the number of firms selling, which in equilibrium is the number of varieties consumed, as the following:

$$N = \frac{2\gamma(\alpha - p_{max})}{\eta(p_{max} - \bar{c})} = \frac{2\gamma\,(k+1)}{\eta}\left(\frac{\alpha - p_{max}}{p_{max}}\right) \tag{3.27}$$

where $\bar{c} = \int_0^{p_{max}} cdG(c,\rho)/G(c,\rho)$ denotes the average cost levels of operating firms, which can be rewritten as $\bar{c} = \frac{k}{k+1} \cdot p_{max}$ from (3.14). This is important since the number of firms and the varieties sold in the market is linked with the maximum price of the variety that a firm can charge, which by definition is denoted as p_{max} and being discussed as the cutoff point of production. With (3.27), the comparison between N and the number of firms selling with zero innovation N^0 is shown as the following:

$$N = \frac{2\gamma\,(k+1)}{\eta}\frac{\alpha - \lambda\,(p_{max})_0}{\lambda\,(p_{max})_0} = N^0 \cdot \frac{1}{\lambda} \cdot \left[\frac{\alpha - \lambda\,(p_{max})^0}{\alpha - (p_{max})^0}\right] \tag{3.28}$$

where N_0 is the number of firms without endogenous investment.

Proposition 2 *With endogenous investment, the number of firms selling in the economy will increase.*

Proof 2 *We know that $\lambda^{-1} \geq 1$ from Proposition 1 and Appendix. Also, since $\lambda \geq 1$, $\left[\frac{\alpha - \lambda (p_{max})^0}{\alpha - (p_{max})^0}\right] \geq 1$.*

Using this information in (3.28), we see that N can be expressed by N^0 and two multipliers that are both larger than 1. Thus $N \geq N_0$.

From Proposition 1, we know that with endogenous investment, the maximum price that firms can charge is reduced compared to the regime with no innovation. $\left(p_{max} < (p_{max})^0\right)$ This is due to (2), where innovation leads to a higher probability of a lower production cost, which leads to a higher expected profit, conditional on survival, for each firm on market entry. However, this profitability leads to an increased number of firms in the market, which in turn reduces monopoly power of each variety. Simultaneously, the heightened competition and larger overhead cost allows only for the more efficient firms with costs lower than c_D to survive in the market. Thus, innovation allows more firms with higher productivity to enter the market.

3.4.3 Average Prices, Production, and Profit

From the form of λ, we get the condition $p_{max} < (p_{max})^0$. Intuitively, this means an endogenous innovation leads to a downward shift in the demand curve of each variety in equilibrium. This in turn also helps us understand how the average levels of price, production, and profit will look like between the two regimes.

Proposition 3 *Endogenizing innovation leads to lower average levels of prices and higher levels of production for all i. Average profits for firms that enter the market are lower than non-innovation levels.*

Proof 3 *Using λ, the comparisons of economy-wide averages[8] are shown as the following:*

$$\begin{aligned}\bar{p} &= \tfrac{2k+1}{2k+2} \cdot p_{max} = \lambda \cdot (\bar{p})^0 \\ \bar{q} &= \tfrac{L}{2\gamma}\tfrac{1}{k+1} \cdot p_{max} = \lambda^{-k} \cdot (\bar{q})^0 \\ \bar{\pi} &= \left(\tfrac{c_M}{p_{max}}\right)^k \cdot \tfrac{(f_D+\rho)}{(1+\rho)^{\beta k}} = \lambda^{k+2} \cdot (\bar{\pi})^0\end{aligned} \tag{3.32}$$

We know that the average prices will reduce compared to the regime with no innovation, since we know that $\lambda < 1$. Additionally, since $k > 1$, and $\lambda < 1$, we know that $\lambda^{-k} > 1$. In comparison, the average production levels are increasing compared to the non-innovation regime levels. Profits, however, are lower despite the increased production due to the lower prices. The lower prices that are induced by innovation leads to a higher level of demand of each variety, but is outweighed by the increased competition in the market. This leads to a lower level of average profits for firms that enter the market. Thus, on average, firms are losing profit by investing in R&D.

[8] Average values of prices, quantities, and profits are are derived as the following:

$$\bar{p} = \frac{\int^{p_{max}} p_i dG(c,\rho)}{G(p_{max})} = \int^{p_{max}} \frac{p_{max} + c_i}{2} dG(c,\rho) \cdot \left[\frac{c_M}{p_{max}(1+\rho)^\beta}\right]^k \tag{3.29}$$

$$\bar{q} = \frac{\int^{p_{max}} q_i dG(c,\rho)}{G(p_{max})} = \int^{p_{max}} \frac{L \cdot (p_{max} - c_i)}{2\gamma} dG(c,\rho) \cdot \left[\frac{c_M}{p_{max}(1+\rho)^\beta}\right]^k \tag{3.30}$$

$$\bar{\pi} = \frac{\int^{p_{max}} \pi dG(c,\rho)}{G(p_{max})} = \int^{p_{max}} \frac{L \cdot (p_{max} - c_i)^2}{4\gamma} dG(c,\rho) \cdot \left[\frac{c_M}{p_{max}(1+\rho)^\beta}\right]^k \tag{3.31}$$

3.4.4 Welfare: Consumer

Now let us examine the change in consumer welfare with the introduction of innovation.

Proposition 4 *The utility levels of consumers unambiguously increase with endogenous R&D.*

Proof 4 *See Appendix.*

In conclusion, the regime comparison yields the following results.

First, with the introduction of endogenous innovation, the cutoff point of the economy are reduced ($p_{max} < (p_{max})^0$). As a result, the average price of goods ($\bar{p}$) drops, as the average productivity of firms increases. Second, with the increased demand stemming from the lower prices, firms increase the output levels. Third, the cutoff point reduction simultaneously determines that the number of firms operating in the economy increases, which results in a larger variety of goods available to consumers. With increased competition, firm profit levels on average go down, despite the increased output. The additional variety of goods increases the utility of the consumer, which outweighs the drop of utility from reduced variance of prices. Overall, this increases the utility of consumers in the economy, while the producers are facing reduced profit levels.

Table 1 in the Appendix summarizes the results shown in this section.

3.5 The Role of Fixed Costs

In the previous section I have compared two different regimes: one that does not allow innovation and one that allows of endogenous innovation. In this section I look at the comparative statics of the results of the endogenous innovation regime, with respect to the non-innovation entry costs. This will help understand the intuitions and the implications of the model, and help distinguish the differences that stem from innovation and non-innovation costs.

3.5.1 The determinants of the markup discount λ

The changes of λ with respect to f_D is shown as the following:

$$\frac{\partial \lambda}{\partial f_D} = \frac{1 - f_D \cdot \beta k}{(k+2)\, \lambda^{(k+1)}\, (f_D)^2\, (f_D - 1)^{\beta k}} < 0 \tag{3.33}$$

The sign of this effect is determined by whether $f_D \cdot \beta k$ is larger than 1 or not. If $f_D < \frac{1}{\beta k}$, then a larger entry cost will lead to a smaller λ, meaning a larger discount in markups. However, with the assumption that ρ^* is non-negative, it is a corollary that $f_D \cdot \beta k \geq 1$. Thus $\frac{\partial \lambda}{\partial f_D}$ is negative, which means that an increase in the non-innovation entry cost, will result in a smaller markup discount. The interpretation is that the higher the entry costs are, the more concentrated the market is to begin with, and hence the lower the impact of innovation will have on consumer prices.

3.5.2 Cutoff prices: p_{max}

The change in non-innovation entry costs, even with innovation, will effect the cutoff points of the economy. The changes in cutoff points will also affect the average prices of operating firms as well.

Proposition 5 *With increased non-innovation entry costs f_D, the cutoff point p_{max} increases.*

Proof 5 *Using the definition of λ, let us rewrite the cutoff points as the following:*

$$p_{max} = \left[\frac{2\gamma(k+1)(k+2)\,(c_M)^k}{L} \lambda f_D \right]^{\frac{1}{k+2}} \tag{3.34}$$

First, the markup discount λ at the equilibrium will be

$$\lambda^* \equiv \left(\left(\frac{\rho^* + f_D}{f_D} \right) \cdot (1+\rho^*)^{-\beta k} \right)^{\frac{1}{k+2}} = \left[\underbrace{\frac{(f_D - 1)^{1-\beta k}}{f_D}}_{X} \underbrace{\left(\frac{1-\beta k}{\beta k} \right)^{\beta k} \left(\frac{1}{1-\beta k} \right)}_{Y} \right]^{\frac{1}{k+2}} \tag{3.35}$$

Then the change induced by the change of entry costs with respect to the cutoff point of firms can be written as:

$$\frac{\partial p_{max}}{\partial f_D} = \frac{1}{k+2} \left[T \cdot (\lambda + \frac{\partial \lambda}{\partial f_D} f_D) \right]^{\frac{-(k+1)}{k+2}} \tag{3.36}$$

where $T = \frac{2\gamma(k+1)(k+2)(c_M)^k}{L}$. Since $\beta k < 1$, and $f_D > 1$ from the assumptions, we know that $\lambda + \frac{\partial \lambda}{\partial f_D} f_D > 0$, when the condition $f_D \geq \frac{Y\cdot(k+2)-1}{Y\cdot(k+2)-\beta k}$ holds, where Y follows the notation from (3.35). Given the restraints on βk, this condition always holds. Thus, the change in p_{max} with respect to f_D is positive as well.

3.5.3 Number of firms and varieties N, and the price elasticity of demand ε_i

The number of firms is of great interest, as we know from Proposition 3 that endogenizing innovation can increase the number of varieties in the economy. The optimal level investment also increases with f_D[9] , as shown in the previous sections. However, an increased market entry barrier can also limit the number of entrants, which ultimately reduces the number of varieties in the market. These counterbalancing effects makes the change in N ambiguous ex-ante.

Proposition 6 *When non-innovation entry costs f_D increases, the number of firms N decreases.*

Proof 6 *The changes in the number of firms with respect to entry costs is shown as the following:*

$$\frac{\partial N}{\partial f_D} = -\frac{2(k+1)\gamma}{\eta} \cdot \left[(\alpha - p_{max})(p_{max})^{-2} \cdot \frac{\partial p_{max}}{\partial f_D} + (p_{max})^{-1}\frac{\partial p_{max}}{\partial f_D}\right] \tag{3.37}$$

Rewriting (3.37),

$$\frac{\partial N}{\partial f_D} = \frac{-2\gamma(k+1)}{\eta} \cdot \frac{\partial p_{max}}{\partial f_D} \cdot \frac{\alpha}{(p_{max})^2} < 0 \tag{3.38}$$

The sign of this equation depends on the sign of $\frac{\partial p_{max}}{\partial f_D}$, which we know that is positive.

[9] The optimal investment in R&D is shown to be $\rho^* = \max\left\{0, \frac{\beta k f_D - 1}{1-\beta k}\right\}$. This equation shows that ρ^* increases with respect to increases in f_D. This is alternatively shown as $\frac{\partial \rho^*}{\partial f_D} = (1-\beta k)^{-1} \cdot \beta k = \frac{\beta k}{1-\beta k} > 1$.

Thus, the number of firms drop when the entry costs rise.

Additionally, from Proposition 5, we know that larger non-innovation entry cost leads to a higher p_{max}. This in turn increases the price elasticity of aggregate demand of of each variety i, denoted as ε_i, which is always positive[10].

$$\varepsilon_i = \frac{\partial}{Q_i} \partial p_i \cdot \frac{p_i}{Q_i} = \frac{p_i}{p_{max} - p_i} > 0 \tag{3.39}$$

This result stems from (3.5), where p_{max} is the highest point when aggregate demand is 0. Then, from (3.6), we know that $Q_i = \frac{L}{\gamma}(p_{max} - p_i)$. Let us define products with a price elasticity larger than 1 ($\varepsilon_i > 1$) as elastic, and the products of the opposite case ($\varepsilon_i < 1$) as inelastic.

The changes in this prices elasticity with respect to f_D can be shown as the following.

$$\frac{\partial \varepsilon_i}{\partial f_D} = \frac{1}{2} \frac{\partial p_{max}}{\partial f_D} (p_{max} - p_i)^{-1} \left[1 - \frac{p_i}{p_{max} - p_i} \right] < 0 \tag{3.40}$$

Since the aggregate demand of product i is always elastic ($\varepsilon_i > 1$), the changes of elasticity with respect to non-innovation entry costs will be always negative. Since the prices of i depend on the production cost of each firm, this means that firms low productivity, given that they draw the same cost level, will see lower elasticities of demand when entry costs are high. Conversely, low cost firms will see the elasticity of their product increase compared to when entry costs are low.

[10] $\varepsilon_i - 1 = \frac{2p_i - p_{max}}{p_{max} - p_i} > 0$, since $p_i > \frac{p_{max}}{2}$.

This change is due to the reduction in N. With less competition, the goods of unproductive high-cost firms are less substituted to other goods, which gives them additional market share. On the other hand, the products of productive low-cost firms are becoming more substitutable, due to the love-of-variety preference of the consumers.

Thus, with the change in non-innovation entry costs, and through the reduction of variety, all producers gain certain monopoly power from reduced competition as a deterrent to prospective competitors.

3.5.4 Welfare Changes: Consumer

$$V(w, p_i) = w + \underbrace{\frac{1}{2}\left(\frac{N}{\eta N + \gamma}\right)(\alpha - \bar{p})^2}_{LV} + \underbrace{\frac{1}{2\gamma}\int_i (p_i - \bar{p})^2\, di}_{PV} \tag{3.41}$$

Since f_D has no impact on w, the change in consumer welfare with respect to the non-innovation entry costs, $\frac{\partial V(\omega,p)}{\partial f_D}$, can be broken down in to the changes in the 'love of variety' effect, denoted LV, and the change in the price variance, labeled PV. Using the equilibrium solutions of N and $\bar{p}$, we can rewrite LV as

$$LV = \frac{1}{2}\left(\frac{N}{\eta N + \gamma}\right)(\alpha - \bar{p})^2 = \frac{(\alpha - p_{max})}{\eta}\left[\alpha - \left(\frac{2k+1}{2k+2}\right)p_{max}\right] \tag{3.42}$$

and PV as the following.

$$PV = \frac{1}{2\gamma}\int_i (p_i - \bar{p})^2\, di = \frac{p_{max}\,(\alpha - p_{max})}{4\eta\,(k+1)\,(k+2)} \tag{3.43}$$

Thus, we can rewrite the indirect value function as the following.

$$V(\omega; p_i, i \in N) = w + \frac{1}{2\eta}(\alpha - p_{max})\left(\alpha - \frac{k+1}{k+2}p_{max}\right) \tag{3.44}$$

Proposition 7 *Consumer welfare will decrease when non-innovation entry costs increase.*

Proof 7 *Based on (3.44), the change in indirect utility of the consumer is shown as the following:*

$$\frac{\partial V(w)}{\partial f_D} = \frac{\partial w}{\partial f_D} - \frac{1}{2\eta} \cdot \frac{\partial p_{max}}{\partial f_D}\left[(\alpha - p_{max})\left(\frac{k+1}{k+2}\right) + \left(\alpha - \frac{k+1}{k+2} \cdot p_{max}\right)\right] \tag{3.45}$$

With zero income effect ($\frac{\partial \omega}{\partial f_D} = 0$), and positive price effects ($\frac{\partial p_{max}}{\partial f_D} \geq 0$), the change in consumer utility depends on the components between the square brackets. This gives us the following conditions:

$$\begin{cases} \frac{\partial V(w)}{\partial f_D} < 0, & \text{if } \alpha > \left(\frac{2k+2}{2k+3}\right) p_{max} \\ \frac{\partial V(w)}{\partial f_D} \geq 0 & \text{if otherwise} \end{cases} \tag{3.46}$$

Since $\alpha > p_{max} > \left(\frac{2k+2}{2k+3}\right) \cdot p_{max}$, we know that $\frac{\partial V(w)}{\partial f_D} < 0$ will always hold. Thus, consumer utility will always go down with the increase of non-innovation entry costs, despite the fact that f_D increases innovation.

3.6 Policy Analysis: R&D Subsidy

Now let us look at a policy question: what happens when the government decides to provide a subsidy financed by a tax on each consumer? This is an important question to see how government policy will affect optimal levels of subsidy and producer and consumer welfare.

3.6.1 Cutoff points and optimal investment

Let us assume that there is a lump sum subsidy, denoted s, that the government provides the firms when entering the market. Building on the model, the zero profit condition to determine the cutoff points of the economy is shown below:

$$\int_0^{(p_{max})_s} \pi(c,\rho)dG(c,\rho) = f_D + \rho - s \tag{3.47}$$

where all parameters are identical to above. The only immediate change is that the total entry costs drop by s, resulting in a lower entry barrier. As a results, the cutoff point with subsidy will be solved as

$$(p_{max})_s = \left[\frac{2\gamma(f_D + \rho - s)(k+1)(k+2)(c_M)^k}{L \cdot (1+\rho)^{\beta k}}\right]^{\frac{1}{k+2}} \tag{3.48}$$

Since p_{max} is an increasing function with respect to f_D, we know that $(p_{max})_s < p_{max}$. By the same process shown in the previous sections, the optimal investment that maximizes the firm's expected profits is shown as:

$$(\rho^*)_s = \frac{\beta k(f_D - s) - 1}{1 - \beta k} \tag{3.49}$$

which is also smaller than the amount investment without subsidy.

$$(\rho^*)_s < \rho^* \tag{3.50}$$

3.6.2 Welfare Changes: Consumer

Since the government needs to fund the subsidy through public financing, it univocally levies a tax on all consumers to equally burden the subsidies. As a result, the indirect utility function is shown as the following:

$$V_s(w; p_i, s) = w - \frac{N \cdot s}{L} + \underbrace{\frac{1}{2}\left(\frac{N}{\eta N + \gamma}\right)(\alpha - \bar{p})^2}_{LV_s} + \underbrace{\frac{1}{2\gamma}\int_i (p_i - \bar{p})^2\, di}_{PV_s} \tag{3.51}$$

where all consumers, L, share an equal load of the total amount of subsidies $N \cdot s$. The disposable income of each consumer is reduced by the taxation, and this reduces the utility of the consumer. However, with the reduced entry costs, we know that the monopoly power $(p_{max})_s$, average prices $(\bar{p})_s$ will drop, while the number of varieties represented by N_s will increase. As shown above, this leads to show that both the 'love of variety' effect (LV_s) and the price variance (PV_s) will both increase compared to the levels without subsidy.

The change in welfare is shown as the following:

$$\frac{\partial V(w;p_i,s)}{\partial s} = -\frac{1}{L}\left(N + \frac{\partial N}{\partial s}\cdot s\right) - \frac{1}{2\eta}\frac{\partial p_{max}}{\partial s}\left[(\alpha - p_{max})\left(\frac{k+1}{k+2}\right) + \left(\alpha - \frac{k+1}{k+2}\cdot p_{max}\right)\right] \tag{3.52}$$

From (3.48), we know that

$$\frac{\partial p_{max}}{\partial s} = p_{max}\cdot\frac{\beta k - 1}{k+2}\,(f_D - s - 1)^{-1} < 0 \tag{3.53}$$

which shows that the cutoff points reduce with positive subsidies and,

$$\frac{\partial N}{\partial s} = \frac{-2\gamma(k+1)}{\eta}\cdot\frac{\alpha}{(p_{max})^2}\cdot\frac{\partial p_{max}}{\partial s} > 0 \tag{3.54}$$

which shows that the variety of goods will increase with more subsidy.

Thus, the income effect of the subsidy on utility will be negative, while the variety and variance effect will increase the consumer's welfare.

Proposition 8 *The overall change in consumer welfare with respect to R&D subsidy is ambiguous.*

From the equilibrium value of $p_{max}(s)$, we can rewrite (3.52), as the following:

$$\frac{\partial V}{\partial s} = \frac{-1}{L}\left(N + \frac{\partial N}{\partial s}\cdot s\right) - \frac{1}{2\eta}\cdot\frac{\partial p_{max}}{\partial s}\left(\frac{2\,(k+1)}{k+2}\cdot(\alpha - p_{max}) + \frac{\alpha}{k+2}\right) \tag{3.55}$$

where $\frac{\partial p_{max}}{\partial s} = p_{max}\cdot\frac{\beta k-1}{k+2}\,(f_D - s - 1)^{-1}$. The sign of $\frac{\partial V}{\partial s}$ is dependent on many model parameters, including β and k. Simulation results suggest a non-linear relationship, which leaves the change ambiguous.

3.7 Closing Remarks and Discussion

In this paper I have developed a model of heterogenous firms to examine the change in productivity distribution and the welfare consequences with endogenous innovation. The results show that allowing for innovation as opposed to a regime with no innovation lowers average price levels, and increases average firm profits. The model also shows when market entry barriers are increased, the average prices of goods increase, which suggests that the increased barriers hinder more firms from entering the market, as the increased overhead cost makes it difficult to break even. This entry hindrance effect decreases the number of entrants, and ultimately reduces the number of varieties and the competition in the market. The reduced competition and higher entry barriers allow firms with high costs and low productivity to operate in the market, leading to higher average prices and higher average cost levels. Consumers lose welfare from the reduced variety, as well as from increased prices.

The model also suggests that innovation will also increase with market entry costs, independent from their productivity. Thus, the higher the non-innovation entry costs, less firms will enter the market, but the firms that decide to enter will invest more in R&D. This is different from results shown in Griliches (1995), which show that productivity and R&D activity are positively correlated, but not the fixed cost of entry. The findings of Aghion et al. (2005) are also different from the findings of this paper, where higher threats of entry and increased competition are shown to lead to more innovative activity.

However, this result means that when firms are given the chance increase their productivity, with endogenous innovation, it results in a smaller number of firms in the market and closer to a oligopoly. Thus, a subsidy given to firms that effectively reduce the entry barriers to the market, innovation activity will decrease at the firm level. This result is similar to the findings of Acemoglu and Cao (2010), which argues that taxes and entry barriers may increase innovative behavior of firms. The results are also consistent with the empirical evidence shown in Asker and Baccara (2010). Whether the effect of increase in consumer welfare from government subsidy outweighs the positive effect from innovation, which is not yet solved in the current model, is yet to be seen.

CHAPTER 4

MULTINATIONAL AND DOMESTIC FIRM EXIT IN CHILE

4.1 Introduction

Attracting foreign direct investment (FDI) and multinational corporations (MNCs) has become a crucial tool for development for both developing and developed countries (Alfaro et al. (2004)). With investments in China being a leading example, both policymakers and investors increasingly see how important FDI and the entrance of MNCs in the domestic market can help an economy into a upward pattern of growth (Liu et al. (2002), Liu (2008)). This has led to rapidly increasing capital inflows into emerging economies, with the flow of FDI into low income countries growing nearly tenfold over two decades from 2.6 billion USD in 1990 to an excess of 23 billion USD in 2012 (The World Bank (2012)).

Numerous studies have shown that FDI can present a number of benefits to host countries, such as stabilizing domestic financial markets, improving foreign currency holdings, and short term financial standings, but it has been established that the largest benefit perhaps may be using FDI as a method of technology transfer to local domestic firms (Liu (2008)).

Research has shown that foreign investment in local firms, through instruments such as mergers, joint ventures, or establishing local branches are a strong driving force behind technology improvement and growth of domestic firms. Studies such as Findlay (1978) have stipulated foreign firms entering the market through foreign direct investment practices, use their abundance in capital to increase the exposure to advanced technology to domestic firms. Other channels, such as human capital, have been also identified to be impacted by FDI (Wang (1990)), while others issues such as product imitation and associated costs are also pointed to as a key determinants of spillover (Glass and Saggi (2002)). The wide spectrum of channels that are identified to be affected by an influx of foreign investments and increased presence of multinational corporations shows that FDI can impact an economy in various ways.

One area that has been overlooked, however, in this discussion is how foreign investment affects the exit behavior of firms. Firm entry and exit are key components that have been shown to be important in shaping the economic landscape, such as the distribution of firms and composition of the market (Clementi and Palazzo (2013), Dunne et al. (2013)). Thus, the firm's decision to exit the market, and how it is impacted by foreign direct investment, is a question of great interest, especially for policymakers and governments.

In this paper, we implement several different approaches used in the existing literature and simultaneously analyze different aspects of foreign direct investment. Specifically, we focus on three different key effects of FDI which we define as the effect from competition, the effect of horizontal FDI, and the effect of vertical FDI. We characterize the competition effect as any changes in the size and productivity distribution in a given industry that is impacted by FDI. On the other hand, horizontal FDI is defined as the explicit effect on productivity that arises from direct competition of foreign firms, while the measure of vertical FDI gauges the spillover effect of foreign firms through the vertical production chain throughout the economy. These three discrete effects cover the major channels of FDI impact that are discussed in the economic literature.

The novelty of our approach is that we simultaneously consider the horizontal and vertical impact of FDI, and highlight the role of foreign ownership and multinational status in the exit probability of firms. We anticipate that this approach will add a new perspective that was not fully considered in previous studies[1].

We use an extensive firm level dataset from Chile to examine the exit behavior of firms and to estimate the effects of FDI in the context of an emerging economy. Chile is a prime example of an emerging economy with a history of being a strong advocate of foreign investment and trade, and has seen an increase in foreign presence in the last couple of decades. We use the aforementioned multiple definitions of FDI spillovers, while controlling for other common determinants on firm exit, such as size and productivity, and industry-specific and year-specific factors. We include time invariant fixed effects as the composition and distribution of firms in a market may differ across industries, and each industry may experience a unobservable industry-specific shock that affect the exit behavior of firms.

In addition to a pooled analysis, we conduct additional, separate analyses on both domestic and foreign-invested firms to examine the difference in determinants that affect firm exit rates. We also consider the industry specific patterns of exit, especially focusing on the level of technology that represents the industry. We group the markets based on the technological level of the industry, and examine whether different technology groups respond differently to FDI. This will help us gain insight on how the technology and the productivity gap between

[1]For instance, the conflict and competition effects between established foreign firms and local firms that are trying to catchup has been identified in several studies (Chacar et al. (2010); Calvano (2008); Bennett (2002)). These effects are told to affect the decision making process of both types of firms, and may have significant impact.

foreign firms and local firms, as well as the positioning along the production chain, impact firm exit behavior across industries.

The paper is constructed as follows. In Section 4.2, I present a review of studies related to this topic and follow it with a collection of theoretical considerations. After examining the country profile of Chile in Section 4.3, I will show the empirical strategy that I chose and describe the data used for this study, as well as an argument for the factors that are considered in Section 4.4. Section 4.5 contains the results from the analysis, along with the interpretations of the findings. Last, I conclude the study by discussing the implications and potential future developments.

4.2 Literature Review

Firm exit, which we define as a firm's decision to stop operating in a market for given period of time, is a phenomenon explained by many different factors. Many studies have discussed and identified determinants that affect a firm's decision to exit the market by determining whether a specific factor affects the production costs or potential returns of the firm. Several studies have looked at factors unique to each firm[2], while some have looked at the market and industry level dynamics as a determinant to firm exit. (Colantone and Sleuwaegen (2010), Audretsch et al. (2007))

These economic studies stem from a simple question regarding the decision for a firm to exit or not: whether it is profitable for the firm to remain in op-

[2]For instance, individual characteristics such as firm size has been argued as a factor that increases production costs, under the premise that larger firms are more likely to observe negative profit (Ghemawat and Nalebuff (1990, 1985), Whinston (1988), Lieberman (1990))

eration in the future (Hopenhayn (1992)). If a firm is expected to make non-negative profit after dealing with all incurring costs to stay in production, then it is believed that the firm will stay in the market and not exit. On the other hand, if the costs of staying in operation outweigh the expected revenue of the firm, then the firm is assumed to exit the market. The same logic holds true for a dynamic analysis as well, where the total profits across multiple time periods must outweigh the total costs for the firm to stay in the operation. Based on this framework, several studies argue that foreign investment and the increase of multinational corporations increase technological spillovers, which increases the productivity levels of domestic firms (Pavcnik (2002), Alvarez and Crespi (2007)). By obtaining a higher level of efficiency, the domestic firms will show an overall improvement of profitability, and this leads to better chances of firm survival. The nature of these spillovers may be either direct, such as technology transfers, or indirect, such as improvements in production factors or supply chains through FDI (Blalock and Gertler (2008)), but overall seen to lead to higher productivity of domestic firms. This approach is also linked to studies that speculate that firms owned and invested in by foreign entities are less likely to exit the market, due to their superior productivity and more efficient practices (Alvarez and Görg (2009)).

Another approach that examines the impact of foreign investment on domestic firm behavior focuses on the increased level of competition that arises from foreign influence accelerates the exit behavior of both domestic and foreign firms (Hu and Jefferson (2002); Driffield and Love (2007)). These studies show that the foreign investments and the influx of multinational corporations in the market increase the level of competition in the industry, and that the increased competition between firms ultimately make it more difficult for domestic firms to survive (Glass and Saggi (1998)). Thus, the heightened level of competition in terms of product pricing or procurement of production factors leads to lower levels of profit, which in turn leads to higher probability of firm exit.

In order to discern different types of impact by FDI, we look at theoretical deliberations of FDI related to three key areas: market competition, technology spillover, and backward and forward linkages. These arguments are related to the effect of competition, effect of horizontal FDI, and the effect of vertical FDI, respectively, discussed in 4.1. We follow the theoretical findings with any empirical evidence in the literature that either supports or refutes the hypotheses. We then derive our own set of expected results for our analysis and link them to our empirical strategy.

4.2.1 Market Competition

We first start with the relationship between FDI and the competition levels of the market and the implications it has on firm exit. Several studies in the theoretical literature thoroughly discuss and conclude that a higher level of market competition leads to more firm exit (Markusen and Venables (1999)). These studies have shown that an increased number of entrants and competitors elevate the competition level of the market, and ultimately creates a "crowding out" effect that pushes out firms with low productivity. Additionally, increased demand for common production factors such as labor may lead to higher production costs, which in turn lead to higher output prices. These also increases the probability of firms to exit.

With all other factors constant, the increased level of competition reduces the potential returns to the firm, by either forcing the firms to either reduce prices to capture consumer demand, or face random consequences from heightened competition that may result in losing market share and sales. The possibilities that stem from heightened competition lead to a higher probability of negative profit for firms, which leads to the decision to exit. Recent theoretical developments also show that, in the short-run adjustment, more competition in a market results in a stricter selection process (Bernard and Sjoholm (2003), Melitz and Ottaviano (2008)) which also translates into a higher level of exit behavior.

In the context of our study, we know that the entry of multinationals and other firms via joint ventures will increase the competition levels of the market. If we assume that these foreign-invested firms are more productive than their domestic counterparts[3], then the theoretical models further imply that that increased competition from more productive firms increase the break-even point of firms. Thus, in the short run, it is expected that exit rates of firms will increase with more FDI in the market.

4.2.2 Technological Spillover

We now change the focus and look at the technological spillovers of foreign firms on to their domestic counterparts.

We first define technological spillover occurs when the domestic firms are exposed to technological expertise that increases their productivity levels from their foreign competitors. This can occur by the mere presence of multinational corporations in the market, as they provide observations of their practices to

[3] It has long been shown that multinationals are seen to have a productivity premium compared to their local competitors. (Criscuolo and Martin (2009), Helpman et al. (2003))

domestic firms. This includes not only core technology used in production, but also other know-how that is used throughout the foreign firm. (Hu and Jefferson (2002)) Changes in other factors, such as labor turnover from multinationals to local firms can also be considered as spillovers as they extend more advanced and proficient managerial and production practices to domestic firms which improves resource allocation (Pavcnik (2002)).

Empirical evidence in studies related to this question generally show that FDI has a positive impact on domestic firm productivity (Pavcnik (2002), Alvarez and Crespi (2007)). This kind of positive impact of MNCs and technology spillovers on local firms have been documented in both developed (Aghion et al. (2009)) and developing economies (Blalock and Gertler (2008)). Other studies such as Audretsch (1995), Griffith et al. (2004), and Aghion et al. (2009) also posit that MNC and FDI induce positive technological spillovers to domestic firms, and ultimately increase firm-level efficiency of domestic firms. This implies that technological spillover will increase the profit levels of firms and reduce the exit probability.

Counterintuitively, it has also been shown that multinational firms are more likely to exit compared to their domestic competition. Several studies have shown that multinational corporations, which are often more efficient and productive than their local competition, to be more likely to exit from a given market subsequent to an increase in horizontal FDI (Bernard and Sjoholm (2003)). These studies find that affiliates of foreign multinationals are more likely to exit from the market, supporting the 'footloose' notion of MNCs (Alvarez and Görg (2009)). Bernard and Sjoholm (2003) adds to the discussion by showing that, despite the fact that multinationals face a substantial sunk cost by entering the local market, which lowers the liquidation value of the multinational and thus diminishes the incentives to exit, MNCs are in fact more likely to exit the market. These studies argue that the reason why MNCs are more likely to exit may be because they are less integrated into the local economy, and have more flexibility in production and procurement through their international networks. As a result, the MNCs essentially have less to lose and more to gain by exiting the market in emerging economies.

Other studies, on the other hand, have argued that the competition effect that the additional foreign firms bring to the market, may negate the trickle down effect that increases the productivity of domestic firms (Aitken and Harrison (1999)). Other studies use the 'market-stealing' hypothesis (Hu and Jefferson (2002), Driffield and Love (2007)) to argue that FDI does improve the productivity of domestic firms, but the overall impact is mitigated because the foreign-invested firms eventually eat into the domestic firms market shares and push domestic firms out. The findings of these studies would suggest that FDI actually increases the exit rates of domestic firms.

Thus, *a priori* it is ambiguous whether or how horizontal FDI will affect firm exit rates in an economy. We do understand, however, that if the competition effect is outweighed by the trickle down effect the overall impact will be negative, and the overall impact of FDI will be positive if the trickle down effect is larger than the competition effect.

4.2.3 Backward and Forward Linkages

Building on this argument, there exists studies that argue increased foreign presence and more FDI in an industry not only affects the direct competition in the given market, but also affects the industries and markets that supply goods to and purchase products from the market. (Damijan et al. (2003)) We define this the effect as vertical FDI.

Vertical FDI occurs when multinationals provide advanced technology to other domestic suppliers and buyers in the production chain, in order to maintain an efficient workflow, among many reasons. This type of vertical technology spillover may also include human resources practices and managerial method that cannot be quantified. Auxiliary firms such as financial services, accounting services, and other business support firms may also enter the market, which in turn provide services of higher quality to all firms as well. Through these various channels the vertical FDI enhances the productivity of local firms that either buy from or supply to the foreign firms in a market. The existence of such impact have been shown through empirical studies (Kugler (2006), Blalock and Gertler (2008)). Theoretically, it is difficult to discern and separate the vertical impact of FDI (Kokko and Thang (2014)). Studies such as Markusen and Venables (1999) have connected the impact of foreign direct investment on firm exit decisions by showing that the "crowding out" effect of FDI generates a higher level of competition the final stages of the production chain. Recent studies such as Greenaway and Kneller (2008) and Coucke and Sleuwaegen (2008), however, have shown that industries with high intra-industry trade, which represents the level of vertical economic integration through intermediate goods sales, are less likely to exit the market via the diversification of suppliers. Empirical findings of Wang (2013) suggest that the spillover effect in both forward and backward sectors are regarded to be positive in the long run.

From the findings of such studies, we know that if FDI increases at the end of the production chain, downstream firms that purchase and assemble intermediate goods may be crowded out of the market. A larger share of foreign firms in the downstream sectors also trigger foreign suppliers to enter the upstream industries, which leads to an increased demand for intermediate goods. This increases the competition levels in the upstream industries as well, which affects exit rates of both domestic and multinational firms. While part of this effect is captured by the horizontal impact of FDI, the impact of increased investment in the upstream and downstream industries are not fully measured.

On the other hand, increased FDI in the upstream industries that supply intermediate goods to other industries may lead to lower exit rates in other industries. This occurs when the entry of foreign firms result in providing goods with lower costs, while transferring technology through production chains. The technological or quality-related changes induced by such upstream sectors may affect the practices of downstream firms for all types of firms. We anticipate of measure of vertical FDI will capture this interaction through the production chain.

The impact of vertical FDI is also *a priori* ambiguous; the increased business opportunities from FDI may increase the competition and increase exit rates, but a more vertically integrated industry where intermediate goods are provided at a lower cost may exhibit higher survival rates.

4.2.4 Summary and Anticipated Results

From the arguments presented above, we anticipate the following results from our empirical analysis.

First, when market competition increases, firms are more likely to exit the market. This has been shown both theoretically and empirically, in both static and dynamic settings. When competitions increases, firms that are less productive are "crowded out" of the market. Incumbent and surviving firms are able to increase their market share created by this void, which further enhances their survivability. We use a measure of concentration to measure market competition, and anticipate a negative impact on firm survivability.

Second, the impact of FDI on firm exit can be divided in two ways: horizontal and vertical. The horizontal impact of FDI concern the direct competition in which foreign owned firms are pushing out domestic firms in the same market. The horizontal impact carries both positive and negative effects on firm exit; the technological spillover from foreign firms may increase the survivability of domestic firms, but the added competition makes it more likely for firms to exit. The overall horizontal impact of FDI will be determined depending on whether the positive effects outweigh the negative effects of FDI, and therefore is ambiguous.

Third, the vertical impact of FDI concerns the forward and backward linkages of industries, and is the impact that an increase in FDI in an industry part of a production chain affects the other stages. While the theoretical and empirical findings are ambiguous, it is understood that an increase in FDI in the downstream industries are likely to increase competition in the upstream industries.

Increase in foreign investment in the upstream industries have a *a priori* ambiguous impact on the downstream industries.

4.3 Foreign Direct Investment in Chile

To test these hypotheses in the context of an emerging economy, we select the case of the Republic of Chile. Chile is one of the fastest growing, largest attraction countries to foreign direct investment in the world.[4] For over three decades, with the strong, consistent support of the government, coupled with an abundance of natural resources, Chile has steadily increased the amount foreign investment. The estimated foreign investment in Chile between 1990 and 2000 is roughly $ 43.7 billion USD, which grew at an average of 7.3% a year. In 1999, Chile received roughly 10% of all FDI in Latin America, and while this number was driven up by a large number of mergers of key Chilean companies, considering that Chile's GDP and population are only 3.6% and 3%, respectively, of Latin America in the same time frame, the influx of foreign capital and multinationals into Chile is truly notable.

One of the biggest reasons for Chile's popularity as a foreign investment destination is its the government's willingness to embrace economic integration with the global economy. Global economic integration is important is because it acts as a signal of "good behavior" for investors, as it shows that the economy is willing to achieve economic conditions such as macroeconomic stability, transparent financial markets, and favorable taxation issues. In addition to a wide network of free trade agreements (FTA) spanning from Canada and Mexico to

[4] 2013 Investment Climate Statement, Bureau of Economic and Business Affairs, U.S. Department of State

members of the APEC forum, Chile also applies a flat tariff rate to non-FTA countries, and participates in an annual one percentage reduction plan of tariff rates. This has made Chile one of the most open economies in the world with a very diverse library of trading partners. (CIEChile (2013))

Another reason that Chile is a prime destination for investment, as well as a good subject for our study, is that it focuses on improving the fundamentals of the economy instead of a "beauty contest" or "race to the bottom" approach where specific subsidies are given or standards are lifted to land investors. This is because the government prioritizes transparency and nondiscriminatory policies that are market friendly. While some direct incentives exist to improve imbalances in regional economic activity, the governmental focus on economically sound policies benefit both domestic firms and foreign investors, which eliminates the need to deal with unobservable impacts that only benefit either foreign or domestic firms. (OECD (2003))

Specifically related to FDI, the Chilean government is making strides in hosting foreign investment through nondiscriminatory, market-friendly policies. The Foreign Investment Statute, widely known as Decree Law 600 (DL600), is a prime example of such policies. The DL600, coupled with the government's decision to lift the regulations on private investment in the mining industry, led to a massive influx of foreign capital into the mining industry, consisting of almost 47% of the total investments occurring through the Foreign Investment Statute. The DL600 allows foreign investors to sign a legally binding contract directly with the Chilean government, in exchange for a set of investor rights such as non-discriminatory guarantees and favorable tax-horizons, usage of social infrastructure, and property rights. It has been estimated that between 1974 and 2000, the DL600 has channeled over 43.8 billion USD, which is roughly 84% of all foreign investment in Chile. Other channels include Chapter XIV of the Central Bank's Compendium of Foreign Exchange Regulations (CFER), which only requires a succinct registration process but does not guarantee the same set of rights as DL600, and Chapter XIX of CFER, which is no longer available to investors. Once the ban on private investments in the mining industry was lifted, and the deregulation of the financial sector started, other parts of the Chilean economy started to receive more attention from overseas investors. Especially, with the launch of the Infrastructure Concessions program of 1993, more foreign private investors came to participate in the Chilean economy. As a result, investments in the once mighty mining sector was reduced to 28.5% in the early 2000s, and more investment occurred in the transport, communications, and energy sectors.

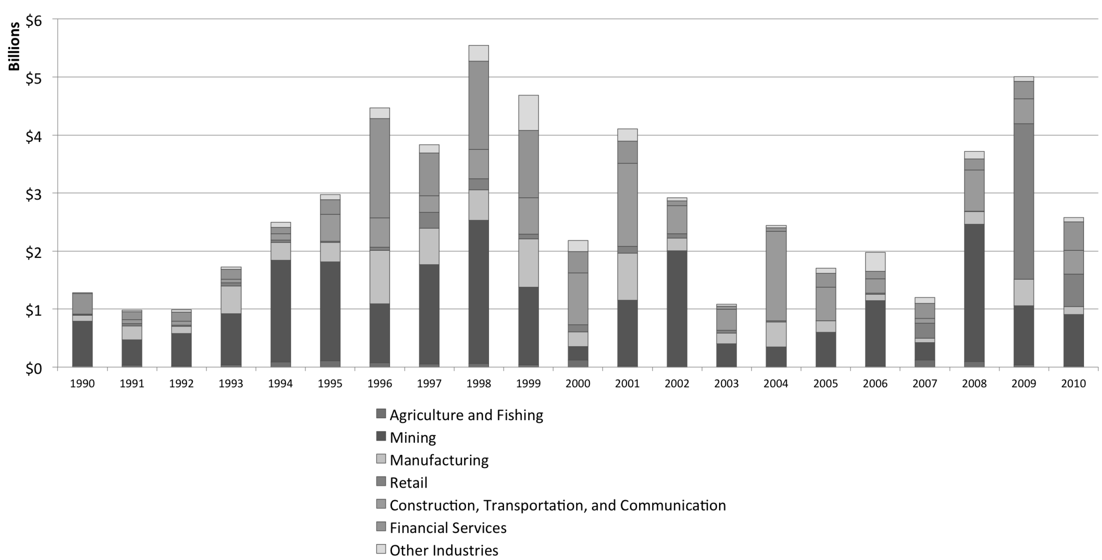

Figure 4.1: FDI into Chile by Sector

In the 2000s, the Chilean Government continued to spur the efforts to host foreign investment through various programs. InvestChile, launched in the year 2000 by the Chilean Production Development Corporation, CORFO, is a good example of such efforts[5]. This program specifically targets investors and projects in high-technology areas, such as information technology and biotechnology, using special incentives provided by the State. These incentives cover not only basic research and development (R&D) programs, but also activities such as pre-investment studies, acquiring assets, and training labor forces. Other programs such as Investment Platform Initiative, which aims multinational corporations to place their headquarters in Chile through tax incentives are also being conducted.

Foreign investment in Chile is relatively simple and a fixed tax horizon is applied for all industries (PriceWaterhouseCoopers (2008)). Industry wise, the mining industry leads all markets regarding FDI, with more than 30 billion USD invested between the years 1974 and 2012, which is roughly twice the amount of the runner-up, the energy industry. Other industries have seen short term spikes in FDI, such as Retail and Wholesale in 2009, and the Communication industry in the early 2000s, but the mining industry continues to be one of the most popular destinations for foreign investment, as well as the energy industry.

In the manufacturing sector, the overall amount of FDI inflow in the industry has reduced since the mid-1990s. This is largely driven by the reduction of FDI in the industry groups of Chemical, Rubber, and Plastic, and Food, Beverages,

[5]CORFO promotes its agenda through four large channels: Entrepreneurship, Innovation, Investment and Financing, and Competitiveness. The Entrepreneurship department coordinates efforts to create and incubate new companies. Policies such as Start-up Chile support a larger part of start-up funds in order to support present and future entrepreneurs. InnovaChile, the innovation department of CORFO, focuses on technology transfer and supporting high-risk projects. Policies create consortiums and ecosystems that fund all activities related to innovation for a variety of entities. While this department focuses on businesses, it also supports universities and individual entrepreneurs as well. The Investment and Financing Department and the Competitiveness Department also facilitate and support the development of companies through a variety of instruments.

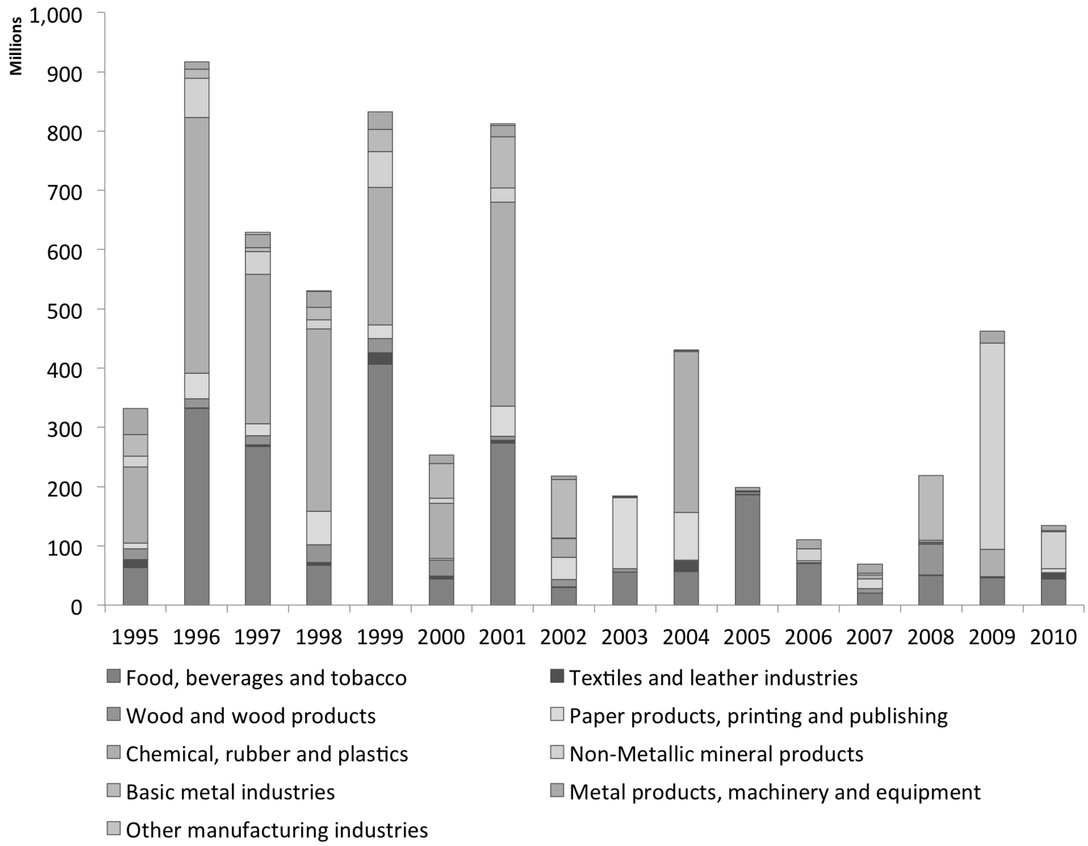

Figure 4.2: FDI into Chile by Sector: Manufacturing Subsectors

and Tobacco. While FDI in the other manufacturing groups are relatively steady, investment in the non-mineral sector has increased in the late 2000s.

4.4 Empirical Estimation

4.4.1 Framework

We start our analysis with assuming that the long-term expected profits of the firm are decided by the following function:

$$\pi_{i,j,t} = \Gamma_{i,j,t} \cdot \beta + \varepsilon_{i,j,t} \tag{4.1}$$

where profit π for firm i, in industry j, in year t is determined by a matrix of determinants Γ and the corresponding coefficients in β. The determinants of Γ include firm-level characteristics, information regarding foreign investment, and also industry- and time-specific fixed effects. ε is an error term that represents unobservable and random shocks that affect the profit levels. To be specific with the determinants of Γ, we can rewrite equation 4.1 as the following:

$$\pi_{i,j,t} = \alpha \cdot FDI_{j,t} + \gamma Z_{j,t} + \beta X_{i,t} + DV + \varepsilon_{i,j,\Delta t} \tag{4.2}$$

where FDI represents a vector that contains information related to foreign investment for firm i in industry j for year t. This terms includes both the horizontal and vertical effect of FDI. X is a collection of firm level characteristics by year which includes variables such as size, productivity, and exports. Vector Z is a collection of industry level characteristics which include measurements of market competition. The term DV includes industry, region, and year specific terms that capture the unobservable fixed effects.

We do not directly observe the subjective long term expected profit levels that each firm uses to determine their exit behavior in the future. We do, however, observe when the firm exits the market. Using this information, we assume that firms decide to exit the market when the firm believes that their long term profit levels are negative. This allows us to rewrite 4.2 and express the exit function as the following:

$$\Pr\left(\text{Exit=}1_{i,j,\Delta t}\right) = \Pr\left(\Gamma_{i,j,t} \cdot \beta + \varepsilon_{i,j,t} < 0\right) \tag{4.3}$$

The dependent variable on the left hand side, is a binary variable that denotes 1 when firm i exits the market after time gap of Δt years, and shows 0 if the firm is observed and existing in the economy after the same time gap. This specification of the profit and exit function allows us to estimate the coefficients of the variables of interest through a binary estimation method, such as linear probability models and Probit estimations. For this study, we use a Probit estimation, as a full characterization of the joint distribution of the underlying latent variables is possible with this approach.

4.4.2 Data

Chilean Manufacturing Data

The primary source of the data used for this analysis is the the Annual National Industrial Survey (ENIA), provided by the National Institute of Statistics of Chile (INE). This survey is sampled and conducted among Chilean manufacturing plants with 10 or more workers, to recreate the manufacturing atmosphere of Chile. The version that is used in this study is from 1995 to 2007[6], with an average of 5392 firms per year. The survey tracks all plants and firms that were surveyed in the previous year, and only drops the observations for previous entries if the entity stopped manufacturing or is not available for any reason[7]. Using this information, we define a firm has exited the market if a firm is not surveyed in a specific year. We use this information to create the binary left hand side variable in Equation 4.3.

4.4.3 Firm level Characteristics

The ENIA dataset contains detailed information on various aspects of the firm. A summary of key variables that are used for analysis are shown in Table 4.1.

[6]Additional years from 2008-2013 are available, but the methodology that tracks the surveyed firms is not consistent with the previous dataset.

[7]Firms may not be surveyed because the size of the firm drops below a size of 10 people, which is the minimum threshold for industrial registration and taxation. This leads to incidents where a firm is observed after a extended period of hiatus, where a firm became too small to observe, and later grew back over the threshold size. We still regard this as an event of market exit.

[8]Over 93% of the the firms in the manufacturing data have no foreign ownership, while roughly 3% of the firms are wholly owned by foreign entities. For a robustness analysis, we have tested for numerous thresholds but did not see any significant impact on the estimation results. We believe that a 10% foreign ownership, which consists of 5% of the population, gives us the preferred set of results for this study.

[9]Industry is defined by two-digit ISIC codes, which span through the manufacturing sector. This includes food processing, food manufacturing, beverage manufacturing, tobacco processing, textile, garments and other fiber products, leather (including furs and related products), timber processing, furniture, paper and paper products, printing and record medium, educational and sports goods, petroleum processing, chemical material and products, medical and pharmaceutical products, chemical fiber, rubber products, plastic products, nonmetal mineral products, processing of ferrous metals, processing of nonferrous metals, metal products, ordinary machinery, special purpose equipment, transportation equipment, electric equipment and machinery, electronic and telecommunications equipment, instruments, and other manufacturing.

Table 4.1: Definitions of Key Variables

Variable	Definition
Size	Total number of employees calculated by the sum of contractual and non-contractual employment for each year.
Productivity	Levinsohn-Petrin TFP measure, using electricity usage (kwh) and fuel purchases (local currency) for intermediate instruments.
Exporter Status	A binary variable which is 1 if firm has positive (>0) overseas sales in the previous year, and 0 if there is none.
MNC Dummy	A binary variable which indicates 1 if firm ownership by foreign entities exceed a 10% and 0 if the ownership is less than that.[8]
Herfindahl Index	The Herfindahl–Hirschman Index, which measures the relative size of firms in relation to the total industry[9], and is used as an indicator of the amount of competition. The total output in local currencies are used as the measure of size for this index.
Horizontal Impact	The measure of horizontal impact of FDI, which examines the direct competition between foreign firms and domestic firms. We use the percentage of MNC employees to the total number of employees in the industry for a given year.
Vertical Impact	The measure of vertical impact of FDI, which looks at the impact of FDI has on forward linked industries in the host country. We use a proxy measure that shows how a given industry is impacted by FDI through its integration with other markets.

Firm Size First, we construct a measure for firm size. Firm size has been regarded as an important determinant of firm exit in the economic literature. In constructing the measure for firm size, we follow Alvarez and Görg (2009) and use the total number of employees. We use the sum of both contractual and non-contractual employees for a given year as the proxy for firm size.

Productivity The dataset also contains information on firm output in both current and constant (2000) prices, as well as information on the production factors such as labor, raw materials, capital, and so forth. To estimate and obtain a measure of productivity, we use the methodology of Levinsohn and Petrin (2003)[10].

Exporter Status Since exporters are assumed to be less reliant on the domestic market and be able to survive negative shocks (Alvarez and Görg (2009)), we include a dummy variable that denotes the exporter status. Exporters are defined as firms which have a positive amount of foreign sales in the previous year.

Multinational Status Unfortunately for the purpose of our study, the ENIA dataset does not explicitly indicate whether the firm is a multinational firm or not. The dataset, however, did contain the share of foreign ownership for each year. Using this information, I define an MNC as a firm which is owned more than 10% by a foreign entity.[11] This is important as the ownership balance has

[10]We use the value-added amount at constant prices as the output measure, and follow the definitions of Fernandes and Paunov (2012) and denote skilled workers as the total number of owners, managers, administrative workers and specialized personnel, and unskilled labor as the total of direct, indirect, and home workers. The total cost generated from the usage of electricity and raw fuel is used as a proxy.

[11]Robustness checks for 1%, 5%, 15%, 20% and 50% were also conducted and show that the definition of MNC does not significantly affect the estimation results.

been shown as a significant determinant of firm level decisions, such as R&D[12] and innovation(Zhou and Li (2008)). Table 4.2 presents the percentage of multinationals observed in the dataset for each year.

Table 4.2: Ratio of foreign-owned firms in sample

Year	**Number of MNCs**	**Total Number of Firms**	Percentage (%)
1995	286	5,512	5.19
1996	290	5,854	4.95
1997	315	5,635	5.59
1998	302	5,440	5.55
1999	298	5,308	5.61
2000	299	5,161	5.79
2001	280	5,088	5.50
2002	306	5,416	5.65
2003	304	5,377	5.65
2004	327	5,600	5.84
2005	315	5,516	5.71
2006	306	5,273	5.80
2007	274	5,037	5.44

[12]Research and development (R&D) impacts the future of the firm, as R&D and investments are often made with a multi-year window which affects the firm's decision to exit or remain in the market in a given year. Heavy investment and high sunk costs may diminish the liquidation value of the firm, which in turn lowers the value of exiting the market. (Blanchard et al. (2013), Pavcnik (2002)) We have defined the research and development of firms as total of purchases of new vehicles, machinery, land, or patented technology in a given year, but do not involve the analysis in this paper.

4.4.4 Market Competition

We use the Herfindahl – Hirschman Index (HHI) as a measure for market competition. The formula for HHI is the following:

$$HHI_{j,t} = \sum_{j}^{N} s_{j,t}^{2} \tag{4.4}$$

where s_j is the market share of a single firm for a given year, for industry j. The index measures the size of firms relative to the industry and measures the amount of competition between the firms. The normalized version of the index ranges from 0 to 1, where 0 represents a very large number of small firms and 1 represents a monopoly. An increase in the Herfindahl index indicates a decrease of competition, while a decrease in the Herfindahl index represents a more competitive market[13]. We use the size of firm output, measured by the total value of sales in local currencies, adjusted for inflation.

4.4.5 Foreign Investment

As discussed in Section 4.2, we examine the two distinct effects of FDI on firm exit. The first effect is the horizontal impact, which we measure through the multinational presence that poses direct competition to the local firms. The second measure is the vertical impact, which is defined by the level of integration of foreign owned firms in both the forward and backward stages of the produc-

[13]The guidelines from the Horizontal Merger Guidelines (2010) by the U.S. Department of Justice Antitrust Division, classifies markets into three types. A market with a Herfindahl Index below 0.15 is considered an unconcentrated markets, while a market with a HHI above 0.25 is considered highly concentrated.

tion chain. We follow the methodology of Blalock and Gertler (2008) to construct the indices for both measures.

The Horizontal Effect of FDI For the horizontal impact, we calculate the percentage of employment by multinational firms and plants related to the total employment[14] by each firm i, for industry j and year t. The formula for this measure is shown as the following.

$$Horizontal\_FDI_{j,t} = \frac{\sum_{i \in j,t} ForeignEMPLOYMENT_{i,t}}{\sum_{i \in j,t} EMPLOYMENT_{i,t}} \tag{4.5}$$

By showing the portion of workers employed by foreign firms and multinationals, we seek to measure the presence of foreign competitors in the domestic market. The larger the index $Horizontal\_FDI_{j,t}$ is, the larger the horizontal presence of foreign firms is in the market. This measure allows us to see the relationship between foreign employment share and exit rates in a market.

The Vertical Effect of FDI The measure for the vertical effect of FDI is a two-step process. Following Blalock and Gertler (2008), we first construct a measure for horizontal impact using firm level output. This is defined as the percentage of output by a foreign firm relative to the total output for a given industry for a given year. For firm i in industry j in year t, the horizontal FDI is measured as the following:

[14]Other versions of this index using output, value-added, and other measures have been created as well, but we feel like employment best represented the horizontal impact of FDI for this study.

$$MNC\_Share_{j,t} = \frac{\sum_{i\in j,t} ForeignOUTPUT_{i,t}}{\sum_{i\in j,t} OUTPUT_{i,t}} \tag{4.6}$$

The impact of vertical FDI is the measured by the share of a firm output that is sold to foreign-owned firms. This shows how much of the foreign firm is attributing to the production and sales of a sector for a given year[15]. Since the dataset does not contain information on purchases or sales to foreign owned entities, I follow Blalock and Gertler (2008) and calculate the vertical impact of FDI by using the share of MNC output in the industry as a proxy for the total sales to foreign firms. The following equation shows this process:

$$D\_FDI_{j,t} = \sum_k \alpha_{j,k,t} MNC\_Share_{k,t} \tag{4.7}$$

where $\alpha_{j,t}$ denotes the percentage of industry j production that is consumed by industry k. The parameters $\alpha_{j,k,t}$ are collected from information from the OECD Stat Database for Chile[16]. This measure takes the input-output ratio of each industry and multiplies it with the portion of output produced by MNCs in the given industry. This gives us a measure of how each industry is intertwined with each other, and how FDI impacts different industries across the economy.

Table 4.3 shows the average levels of both horizontal FDI and vertical FDI measures in the data, and how it changes over the given time frame. The results of horizontal FDI represents the average ration of employment by multi-

[15]For instance, let us assume that the output of a sector A is consumed by three different sectors B, C, and D. Denote the percentage of sales to each sector is at $b\%$, $c\%$, and $d(= 100 - b - c)\%$. Let us denote the proportion of output by foreign firms in sectors B, C, and D as x, y, and z. Then, the total vertical impact of FDI on sector A would be $x * b + y * c + z * d$.

[16]The Input-Output table for Chile was available for the years 1996 and 2003. The observations of years before from 1996 and after 2003 are linear extrapolations of these tables, while the year from 1997 to 2002 are interpolations of the I-O tables.

Table 4.3: The Horizontal and Vertical Impacts of FDI

	Horizontal FDI		Vertical FDI	
Year	**MNCs**	**Domestic**	**MNCs**	**Domestic**
1995	.1272	.0874	.0675	.0436
1996	.1715	.1114	.0887	.0568
1997	.1699	.1191	.0921	.0590
1998	.2002	.1323	.1004	.0639
1999	.1979	.1371	.0998	.0659
2000	.2029	.1439	.0990	.0660
2001	.2083	.1411	.0995	.0602
2002	.2024	.1279	.1336	.0782
2003	.1898	.1273	.0887	.0515
2004	.1989	.1311	.0921	.0565
2005	.2084	.1414	.0844	.0517
2006	.1989	.1248	.0860	.0522
2007	.1942	.1483	.0754	.0536
Total	.1903	.1283	.0836	.0529

Source: Author's Calculations

nationals, and is shown to generally increase over time. Horizontal FDI is also higher for multinationals then domestic firms, which means that multinationals in general are more likely to operate in industries with a strong multinational presence. This tendency of MNCs to cluster with other multinationals relative to domestic firms is consistent throughout the dataset. Vertical FDI, which represents the ratio of transactions with foreign firms, shows a different pattern. The overall trend is increasing until 2002, where vertical FDI for both MNCs and domestic firms spike sharply, and subsequently decrease slowly[17] over time. MNCs are shown to have a higher level of vertical FDI, meaning multinationals are more likely to engage with other multinationals, or industries that have a strong multinational presence, compared to the domestic firms. The ratio of vertical FDI of multinationals to that of domestic firms generally increases over time, peaking in 2003, then decreases to around 1.4.

Table 4.4 shows the average levels of horizontal and vertical FDI for different industry groups. We divide the industries by the two-digit ISIC code and group them by characteristics. Starting with horizontal FDI, the Chemical and Rubber manufacturing industry has a very high level foreign employment, followed by the food and tobacco industries and the mineral and base-metal industries. This is anticipated as the mining sector of Chile is one of the most heavily invested market by FDI, and it is likely that relevant industries in the manufacturing sector also see a high percentage of foreign firms. Firms that manufacture machinery and equipment see less competition from foreign firms than the firms in paper and printing. In general, about 13% of the employment in the total

[17]There are several reasons that may explain such acute changes in vertical FDI in the Chilean economy around 2002. The first is the policy measures (Capital Markets Reform) related to Chilean financial liberalization in 2001, which may have lead to a sharp increase in the share of foreign owned firms. Another reason is a measurement issue from the input-output table used to create the vertical FDI measure. Both theories, however, fail to explain the drop in vertical FDI in the latter years.

Table 4.4: The Impact of FDI: By Manufacturing Subsector

Industry	**Horizontal FDI**	**Vertical FDI**
Food and Tobacco	.1732	.0462
Textiles	.0669	.0527
Wood and Furniture	.0703	.0155
Paper and Printing	.1089	.0562
Chemical and Rubber	.2296	.1221
Non-metallic Minerals and Base-Metals	.1234	.0642
Machinery and Equipment	.0861	.0349
Total	.1317	.0546

Source: Author's Calculations

manufacturing sector is employed by a firm denoted as a MNC. The average levels of vertical FDI show the Chemical and Rubber industries are also most likely to interact with foreign owned firms, as well as the mineral and metal industries. The vertical FDI in the Food and Tobacco industries, however, are less likely than average to deal with foreign firms in the production chain despite have the second highest measure of horizontal FDI. The textiles industries, in comparison, show a strong connection with MNCs through vertical linkages in the economy. The different patterns and characteristics shown in Table 4.4 highlights of the importance of discerning horizontal and vertical FDI, and also the significance of industry characteristics in analysis.

4.5 Results

4.5.1 Baseline Estimation

We start our empirical analysis with an estimation of equation (4.3) and present the results in Table 4.5. The estimation equation is shown as the following:

$$
\begin{aligned}
\Pr\left(\text{Exit=}1_{i,j,t+\Delta t}\right) =& \alpha + \beta_1 \cdot \text{Size}_{i,j,t} + \beta_2 \cdot \text{Productivity}_{i,j,t} + \beta_3 \cdot D_{\text{Export}} \\
&+ \beta_4 \cdot D_{MNC} + \beta_5 \cdot \text{HHI}_{j,t} + \beta_6 \cdot \text{Horizontal Impact}_{j,t} \\
&+ \beta_7 \cdot \text{Vertical Impact}_{j,t} + FE_{j,t} + \varepsilon_{i,j,t} \qquad (4.8)
\end{aligned}
$$

where Size, Productivity, HHI, Horizontal and Vertical Impact represent the measures shown in Section 4.4.2 for firm i, industry j, year t. The terms D_{Export} and D_{MNC} represent dummy variables for exporter status and multinational status, respectively. FE is a vector of regional, year, and industry fixed effects.

The binary variable on the left hand side of the equation shows 1 if a firm has exited after a time gap of Δt years from year t, and 0 if otherwise. We have conducted analysis for multiple values of Δt, and present the results when $\Delta t = 3$.[18]

The two columns in Table 4.5 represent different specifications of the estimation. The first column uses only industry-specific fixed effects but does not use

[18] Other studies have approached this question using time gaps of 2, 3, and 5 years. We believe that three years is a sufficient amount of time for FDI to impact a firm's decision to exit or remain in the market. Results from a five year gap will be presented in the Appendix.

regional fixed effects, while the second column uses both regional and industry level fixed effects. We show this to present the low significance of regional fixed effects in the analysis, as well as the consistency of estimation. The errors are clustered over industries, measured at the 2 digit level of ISIC ver 3.1.

Pooled Estimation

Table 4.5: Baseline Estimation: 3 Year Gap

VARIABLES	**(1)**	**(2)**
Size	-0.000**	-0.000**
Productivity	-0.089**	-0.088**
Exporter Dummy	-0.078**	-0.082**
MNC Dummy	0.077**	0.058*
HHI	-0.890	-1.079
Horizontal Impact	0.048	0.052
Vertical Impact	-0.186	-0.145
Constant	0.204**	0.285**
Region FE	N	Y
Industry FE	Y	Y
Observations	54,308	54,308

- ** p<0.01, * p<0.05, + p<0.10

The results of the baseline estimation are consistent with previous studies, such as Görg and Strobl (2003) and Alvarez and Görg (2009), in the sense that the results show that more productive firms in the market are less likely to exit, and exporters are also likely to survive in the market. It also so shown that multinationals are seen to be more likely to exit compared to their local competitors, which supports the notion of 'footloose' MNCs. These results support the theoretical discussion and the expected outcomes outlined in Section 4.2. The baseline results differ, however, from previous studies in that regional fixed effects do not largely affect the coefficients the estimation results and firm size[19] is shown to have minimal impact on firm exit.

The three variables of interest that involve the impact of FDI, namely HHI, the horizontal impact of FDI, and the vertical impact of FDI, are all seen to be statistically insignificant in the baseline estimation. The measure of concentration, HHI, appears to have a negative impact on firm exit. This is counterintuitive as firms are less likely to exit a market with more competition. On the other hand, while not significant, the measure of horizontal impact of FDI seems to increase the exit rates, while the vertical impact of FDI works in the opposite direction and is suggested to decrease exit rates and improve firms survivability. These results are consistent with the expected outcome suggested in Section 4.2. The results show that direct foreign competition is more likely to result in a higher level of firm exit, but more economic integration with foreign investment throughout the production chain is likely to keep firms in operation in the market.

Estimation by MNC Status

These findings of the baseline regression continue when we conduct separate estimations of domestic firms and multinational firms. Using both regional and

[19]Results are shown to be identical across other measures of size, including output, average output, average employment and other.

industry-specific fixed effects, Table 4.6 shows that domestic firms with low foreign ownership are shown to be following an opposite path of MNC firms, especially with respect to FDI levels. Additionally, while not statistically significant, multinationals are more likely to exit when there is more horizontal impact, while domestic firms are more likely to stay. This is consistent with the 'footloose' notion shown in the previous baseline estimation.

Table 4.6: Baseline Estimation: 3 Year Gap: MNC vs Domestic

VARIABLES	**MNC**	**Domestic**
Size	-0.000+	-0.000**
Productivity	-0.034**	-0.094**
Export Dummy	-0.189**	-0.065**
HHI	-0.365	-1.399+
Horizontal Impact	0.875	-0.046
Vertical Impact	-0.469	0.764
Constant	-0.231	0.371**
Region FE	Y	Y
Industry FE	Y	Y
Observations	3,007	51,301

- ** p<0.01, * p<0.05, + p<0.10

Estimation by Industry Group

Following the definitions of Jaegers et al. (2013), we also divide the manufacturing firms into three groups based on their technology levels[20]. The first group consists of "low-tech" products in the manufacturing industry, including food and tobacco, textiles, wood and furniture, paper and printing. The second group includes industries that are defined as the "medium-low" technology manufacturing industry, which includes production of recorded media, coke and petroleum products, rubber and plastic, as well as non-metallic minerals and basic metal manufacturing. For simplicity, we label this group as the "mid-tech" sector. The last group, which includes manufacturing of chemicals, electrical equipment, machinery, all types of vehicles, and medical instruments, is labeled as the "high-tech" group. The reason why we employ the division of technology groups is to see the relationship between different levels of technology gaps between multinationals and domestic firms and firm exit behavior. The assumption is that domestic firms that produce "low-tech" goods have a lower technological gap between the foreign-invested firms compared to the mid- and high-tech groups[21]. This analysis will also help us understand whether firms in different positions along the production chain react differently to foreign competition and FDI.

Results show a stark contrast between technology groups. In Table 4.7, while Productivity and Exporter Status continue to have a negative impact on the exit

[20] The grouping was conducted by converting ISIC ver 3.1 industry codes to the NACE Rev. 2 industry codes. Further detail regarding the industries and divisions can be found at the EuroStat website.

[21] Testing of this assumption shows that this is not necessarily the case. A productivity gap measured by the mean TFP levels of each group show that Group 2 actually has the highest difference, followed by Group 1 and Group 3. Additional testing using R&D expenditure and patent filing will be augmented in future versions of this paper.

Table 4.7: Baseline Estimation: 3 Year Gap: By Technology Level

VARIABLES	**Low-Tech**	**Mid-Tech**	**High-Tech**
Size	-0.000	-0.001**	-0.000**
Productivity	-0.093**	-0.088**	-0.077**
Export Dummy	-0.051*	-0.153**	-0.052
MNC Dummy	-0.028	0.117+	0.117*
HHI	-8.187**	-0.165	-3.518**
Horizontal Impact	1.661*	0.258	-0.044
Vertical Impact	-4.278**	2.470	-2.201+
Constant	0.372**	1.742**	0.126*
Observations	34,433	11,083	8,874

- ** p<0.01, * p<0.05, + p<0.10

rates of firms across all technology levels, we see some differences between the coefficients of key variables. First, while only the high-tech group is shown to have a significant coefficient, the impact of competition measured by HHI is shown to increase firm exit across all technology groups. Second, the horizontal impact of FDI is shown to increase firm exit probability in the low- and mid-tech industries, while the same variable is shown to decrease firm exit rates in the high-tech industry. While not statistically significant, the results suggest that an increased level of direct competition from foreign investment is likely to result in exiting of firms in the food, wood, printing, and similar industries, as well as the rubber and basic metals markets. On the other hand, firms in heavy industries with more complex technologies will show a higher level of survival when there is more direct competition. The results for the vertical impact of FDI depicts a different story. The vertical impact of FDI, which is the measure of vertical integration with foreign firms in the market, is seen to be making firms in the low-tech and the high-tech market more likely to survive, while firms in the mid-tech groups are more likely to exit. The results highlight the heterogeneity of FDI impact in industries of different technology levels, as well as paint a consistent story where regardless of the industry, firms are more likely to exit when competition is low, and less likely to exit when the vertical impact of FDI is increasing.

4.5.2 Empirical Issues

The results from the baseline estimation of Equation 4.8 are presented in the previous chapter, but come with several econometric issues. In this subsection, we examine these challenges that may be sources of estimation biases, and present remedies that we have implemented.

Measurement Issues of Firm Exit

A common subject of criticism associated with using datasets from emerging economies is the reliability of data entries. Especially, with relatively loose definitions in manufacturing surveys, it has been questioned whether sampling techniques fully capture the economic landscape, and whether the dataset from emerging economies reflect actual behavior of economic entities in the country.

In this context, the variable that we have constructed to represent firm exit may face measurement issues. To be specific, the exit variable may erroneously tracking incidents where firms are simply not being detected by the agencies due to various reasons, rather than actual exiting of the market. For instance, even though a firm is no longer observable at the start of a given year, this may be a result of occurrences other than closing or bankruptcy. These include when firms change production types from manufacturing to service, when entries were randomly omitted, firms were not located at the time of investigation, there was no movement and change in capital, when the firm or plant was merged or acquired by another firm or plant, when operations were paralyzed by external agencies such as the Internal Tax Service or other governing offices, or when the number of employees fell under the minimum size of 10 workers. As a result, the current construction of the firm exit variable may be overestimating firm exit[22].There are two methods that we employ to deal with this issue.

Firm Filtering The first is to follow the filtering process of Micco (1995) to eliminate some of the measurement errors in the data. The details of this filter are shown in Table 4.9.

The Production Criteria is applied to ensure that the plant is engaged in production activity, and should be considered an active economic entity. The size filters are applied to ensure that plants are not considered to be exited because they are truncated by the minimum employment cutline for ENIA (10 employees.) Following Micco (1995), we use a slightly stringier filter by eliminating

[22]While this is theoretically plausible, Benavente and Ferrada (2003) shows that through a comparison with the Chilean Internal Tax Service (SII) the average rate of exit in the SII data is actually greater in the data of SII in 32 of the 36 sectors-year considered, which insinuates underestimation of firm exit.

firms with less than 15 total workers. Additionally, the ISIC (industry) criteria is applied to eliminate industries which are difficult to observe stark firm entry and exit. Creating a new sample by following these filters, the authors define firm "death" only when a plant is not observed in the following year of an observation, but only acknowledges "survival" when the production criterion holds in both years, employment (size) criterion is fulfilled in at least one of the years, and fulfills ISIC criterion for the current year.

Table 4.8: Micco (1995) Filtering Criteria

Category	**Description of Entries**
Production Criteria	• Worked Days = 0 • Gross Value of Production < 0.1 • Added Value < 0.1 • Added Value > Gross Value of Productions • Sales < Exports
Size Criteria	• Number of Total Workers ≤ 15 • Remuneration of Workers = 0 • Total Remuneration ≤ 0 • (Administrative Employment + Productive Process Employment = 0) and (Remuneration of Workers + Remuneration of Workers on a Commission Basis ≠ 0) • (Administrative Employment + Productive Process Employment ≠ 0) and (Remuneration of Workers + Remuneration of Workers on a Commission Basis = 0) • Total employment - Productive Process Employment - Administrative Employment =0
Industry Criteria	• If Industry ISIC (3 digits) = 372 or ISIC (2 digits) = 39

As a result, the filter impacts the dataset mostly by leaving off the smallest firms, in terms of number of employees, from its Size criteria. The total number of observations are reduced to 44,503, which is a 36% decrease of total observations. This filtering eliminates the group of firms that may bias the estimation result by being "too small" for the survey to track. The results using the filtered dataset is shown in Table 4.9.

Table 4.9: Baseline Estimation: Post-filtered Results

VARIABLES	Baseline	Low-Tech	Mid-Tech	High-Tech	MNC	Domestic
Size	0.000	0.000	-0.000	-0.001*	-0.000	0.000
Productivity	-0.120**	-0.127**	-0.119**	-0.056+	-0.032	-0.130**
Export Dummy	-0.039*	-0.001	-0.138**	-0.069	-0.192**	-0.023
MNC Dummy	0.028	0.112	0.104	-0.078	0.106	-0.091
HHI	-0.952	3.577+	0.982	0.581	-7.024+	1.493
Horizontal Impact	0.153	0.711	-0.399	-2.271*	0.289	-0.165
Vertical Impact	-0.077	-0.350	2.001	4.492	-0.366	0.235
Constant	0.604**	0.652**	1.879	-0.032	-0.008	0.685**
Observations	34,906	24,791	7,492	2,623	2,530	32,376

- ** p<0.01, * p<0.05, + p<0.10

The filtering eliminates a large number of small firms, the estimation results are largely consistent with the results using the total dataset. While the results of the baseline estimation are mostly unchanged, the results for HHI and MNC dummy show opposite signs from the previous results. This is due to the fact that the eliminated observations mostly consist of domestic firms, and thus impact the coefficients. The other coefficients regarding individual firm characteristics and the horizontal and vertical impact of FDI remain consistent with our findings above. This assures us that the structure of the model, as well as the sampling technique of the Chilean Manufacturing Survey, is reliable and sufficient for our analysis.

Industry Entry Costs The second method is an industry specific approach, using the average level of entry costs of a given industry. Instead of finding additional proxy measures of for firm entry and exit, we focus our analysis on industries that are traditionally known to have large overhead costs and thus have little re-entry behavior. If we examine whether estimation results from high entry cost industries, and compare them to the baseline results from equation 4.1, we can have better understanding whether the measurement of firm exit in the current version of the dataset is erroneous or not.

Since we do not have explicit information on the overall levels of entry costs of firms in Chile, we use the findings of entry costs of firms in the US (Dunne et al. (1988)) and use them as proxy measures. In the US, the industries with the lowest exit rates are industries related to Chemicals, Petroleum, Paper, and Rubber and Plastics. We use the two-digit ISIC (version 3.1) numbers that correspond with these industries[23], and run the estimation of (4.1). This specification is different from the discernment from the definitions in 4.5.1.

Using data from manufacturing firms that participate in these specific industries, we see that the results are generally consistent with the baseline results, confirming that firm entry and re-entry issues are not significant to our results.

4.5.3 Endogeneity of FDI: Instruments

One of the challenges in the analysis regarding the impact of FDI is controlling for the endogeneity of foreign investment. Studies have implied that FDI flows and the profitability of recipients are correlated, which further implies that the relationship between FDI and growth of the economy are correlated as well (Li and Liu (2005)). This leads to an understanding that foreign direct investments and firm exit behavior are also strongly intertwined.

[23] The corresponding two-digit ISIC codes are 21, 23, 24, and 25.

Table 4.10: Baseline Estimation: 3 Year Gap in High Entry Cost Industries

	Baseline	**MNC**	**Domestic**
Size	-0.000**	-0.000**	-0.000**
Productivity	-0.101**	-0.054*	-0.113**
Exporter Dummy	-0.070+	-0.072	-0.068
MNC Dummy	0.127**	-	-
HHI	-2.439*	-5.137	-2.349*
Horizontal Impact	-0.045	-5.221	0.025
Vertical Impact	-3.046+	-6.689	-3.350+
Constant	0.983**	0.305	1.091**
Observations	10,096	1,119	8,975

- ** p<0.01, * p<0.05, + p<0.10

There are largely two explanations why firm exit and FDI are strongly linked. First, from the investor's perspective, it is argued that FDI naturally flows into more productive sectors with high growth potential. This results in a 'cherry-picking' behavior of investors, where investment is biased towards industries and firms with the highest productivity (Javorcik and Spatareanu (2005)). Related to foreign direct investment in growing emerging economies, the overall exit rate of firms may be low as they observe long term earning potential by staying in operation, despite losses in the short run. If this is the case, then the productivity spillover effect of FDI which increases the productivity of domestic firms, measured by the horizontal effect of FDI in our estimation, is overestimated and would lead to an upward bias of coefficients[24] in the estimation.

[24]We also have considered the scenario of controlling for the endogeneity for the vertical impact of FDI, opposed to instrumenting for the horizontal impact. Theoretical contemplations regarding economic integration and direct competition lead is to believe that the chosen instru-

(Hale and Long (2011))

An alternate theory is that exit rates of domestic firms increase as a result of a ‘crowding out’ effect, where the production factors and demand allocated for domestic firms are taken over by foreign firms. Studies such as De Backer and Sleuwaegen (2003) show that foreign investment discourages firm entry, and increases exit of domestic entrepreneurs, not only by taking over market share in the end product market, but also increasing costs in production factors such as labor. In this case, the horizontal impact of FDI will see a downward bias, as it would underestimate the horizontal impact of FDI by failing to accommodate the changes in the prices in product factor markets and changes in demand in the end product market.

In order to deal with such issues, we use an instrument variable approach to remedy endogeneity of the horizontal effect of FDI. We use a instrument variable used in Xu and Sheng (2012), which uses the number of visiting foreign tourists, weighted by the ratio of Gross Domestic Product of each industry to total GDP. This assumes an increase of business-related foreign visitors can be positively related to a higher level of FDI, but not related to individual firm level characteristics such as productivity levels. While foreign visitors to a country may not be fully assigned to business and investment and related purposes, it can be speculated that tourists who visit for pleasure may bring second hand experiences back to their home countries, which further improves the recognition and awareness of the country for investments.

Following Xu and Sheng (2012), we create a dataset of annual foreign visitors to Chile, and weigh them by GDP contribution. We use the World Development

ment is a better fit for the horizontal impact.

Indicators, provided by the World Bank, to obtain the total number of foreign visitors in a given year to Chile. The GDP contribution weight of each sector j for each year t is derived from information on the Bank of Chile Statistics Portal. We construct the instrument by using the following formula.

$$Visitor_{j,t} = \frac{GDP_j}{\sum_j GDP_j} \cdot Tourist_t \tag{4.9}$$

We implement this instrument of weighted foreign visitors on the horizontal FDI measure in an instrument variable Probit estimation of equation 4.1, by different technology groups. The results are shown in Table 4.11.

Table 4.11: IV Estimation by Tech level: Tourist Instrument

VARIABLES	**Low-Tech**	**Mid-Tech**	**High-Tech**
Size	-0.000	-0.000**	-0.000**
Productivity	-0.093**	-0.076**	-0.047*
Export Dummy	-0.051*	-0.102*	0.177*
MNC Dummy	-0.031	0.139*	0.288**
HHI	5.047	2.511*	-3.182*
IV:Horizontal Impact	4.314+	-14.594**	-3.024*
Vertical Impact	-9.150*	43.067**	-3.369*
Constant	0.650**	-0.084*	0.901**
Observations	34,433	11,084	8,874
Exog.test p-value	0.235	0.006	0.109

- ** p<0.01, * p<0.05, + p<0.10

The IV regression results reveal several interesting points.

First, the p-value of Wald exogeneity test suggests that the horizontal impact of FDI is endogenous in the mid- and high-tech industry groups, but the horizontal impact of FDI in low-tech industries need not be treated as endogenous. This result shows that either the “cherry-picking” behavior or crowding out effect discussed earlier do not show up in industries with lower technological levels.

Second, the sign of the coefficients are generally consistent with the results shown in Table 4.7. Focusing on the coefficients in the Mid-Tech and High-Tech columns, we see that firm size continues to be a non-factor in firm exit behavior, and productivity also remains a significant factor that reduces the probability of exit of firms in these sectors. The estimate of the impact of Exporter Status on firm exit is now shown to be positive in the High Tech industry. The positive sign of the coefficient on MNC status in the mid- and high-tech industry supports the notion of “footloose” multinationals, as well.

Also consistent with the results in Table 4.5, the coefficient of HHI continues to be negative in the high-tech industry. The HHI coefficient changes signs from an insignificant results in both the low- and mid-tech industry groups, causing difficulties in interpretation. The horizontal impact of FDI, which is instrumented for in this estimation, is now significant in the mid- and high-tech industries. The results now strongly suggest that firms in the mid- and high-tech industries are less likely to exit with increased foreign competition in the market. Thus, the results suggest that the coefficients of the baseline Probit estimations from Table 4.5 have been underestimating the horizontal impact of FDI. The coefficient for the vertical impact of FDI also continues to be negative in the high-tech industries as well.

The results of this IV estimation gives us a better snapshot of how firms of different technology groups and different positions along the production chain differ. The differences, especially between the mid-tech and the high-tech industries, are highlighted in the difference in vertical FDI. Controlling for the direct competition from foreign firms, we see that the mid-tech industries, with higher levels of vertical FDI, are more likely to exit when additional foreign investment occurs in vertically related industries. High-tech industries, however, show a tendency to remain in the market when vertical FDI increases. Thus, an industry group with an already high level of integration with foreign firms, the mid-tech group, will be pushed out of the market when integration increases. We speculate that this is because the market is near saturation, and additional competition will lower the firm survival probability. On the other hand, the industry group with low levels of vertical FDI, the high-tech group, will benefit from the entry from foreign firms throughout the vertical production chain and have lower levels of exit rates.

To understand better these results, we include MNC status to the analysis in inspect whether foreign ownership has impact on the exit rates and leads to different patterns of firm exit. The results are shown in Table 4.12.

First, we look at the low-tech group divided into MNCs and domestic firms. The difference between the two types of firms is visible in several areas. First, the p-value of the exogeneity test shows us that the horizontal impact of FDI is endogenous for MNCs, but should be considered exogenous to domestic firms. This insinuates that the FDI levels measured through direct competition is correlated only with multinational firms, which means that domestic are exiting the

Table 4.12: IV Estimation by Tech level and MNC Status: Tourist Instrument

VARIABLE	Low Tech		Mid-Tech		High-Tech	
	MNC	**Domestic**	**MNC**	**Domestic**	**MNC**	**Domestic**
Size	-0.000	-0.000+	-0.001+	-0.000**	0.000	0.001**
Productivity	-0.027+	-0.099**	-0.056	-0.079**	0.017	-0.085**
Export Dummy	-0.074	-0.039+	-0.146	-0.100*	-0.157	0.012
HHI	-25.934+	5.497+	-5.263	3.060+	-10.048*	-2.794*
IV: Horizontal Impact	-14.230	5.039*	11.028	-13.960**	-2.935	-2.917+
Vertical Impact	35.533	-10.656*	22.804	31.349*	-9.405	-2.659+
Constant	-0.175	0.697**	0.304	-0.393	1.445*	0.926**
Observations	1,389	33,044	630	10,453	987	7,887
Exog. test p-value	0.0679	0.125	0.497	0.0123	0.507	0.167

- ** p<0.01, * p<0.05, + p<0.10

market at a higher pace than expected. Further, the MNCs are shown to be more likely to remain in the market with more competition, and with a larger foreign presence. Additionally, the coefficient for the vertical impact of FDI for domestic firms is negative, which is consistent with our expectations. As discussed in the previous sections, increased levels of foreign investment and integration in other industries may affect firms in other industries through channels such as costs and productivity. These changes, in turn, increase the survival rates of domestic firms, and is reflected in the estimation results.

The contrast between MNCs and domestic firms continue in the mid-tech industries. While the productivity measures and the export status measure are both reducing the likelihood of firm exit, the measure of competition is opposite in both types of firms. Domestic firms in the mid-tech industry show a higher tendency to exit with less competition. Looking at the coefficients of the horizontal impact of FDI, the results strongly imply that domestic firms are not exiting with increased foreign competition. This result is in line with cherry picking behavior of FDI, where FDI enters markets where long terms growth and better survivability is expected. Additionally, the coefficient for vertical FDI is strongly positive for domestic firms and appears to be driving the increase in exit probability. This supports our speculation that domestic firms are being pushed out by the MNCs in the related industries.

The firms of the high-tech group show a different type of behavior. Both productivity and exporter status show opposite behavior patterns between MNCs and domestic firms. MNCs may be more likely to exit the market when more productive, but more likely to stay when it is an exporter. Domestic firms are more likely to remain in the market when more productive, but more likely to exit if an exporter. Even controlling for the endogeneity of FDI, we see that domestic firms in the high-tech group are less likely to exit with more foreign competition. The growth potential as well as the signaling effect of FDI encourages domestic firms to stay in operation. Domestic firms are less likely to exit with increased levels of vertical impact, which shows that better suppliers and better prices from upstream firms lead to more competitiveness and better survivability.

In conclusion, the instrument variable regression shows us results consistent with Table 4.7. The signs of the coefficients, with the exception of the HHI in the low-tech industry, are all consistent with the previous regressions. The increase of the magnitude of the coefficients shows a downward bias of the previous estimates shown in 4.5.1, which insinuates an overestimation of the competition effect of FDI. We also confirm that the impact of FDI is dependent on technology levels and and MNC status.

Summary

The results shows that an influx of foreign direct investment may have diverse effects on different part of the economy. First, the Low-tech industries will see domestic firms increasingly exiting as FDI increases, and as the market becomes more concentrated. While more investment in the vertical production chain may provide intermediate goods at lower prices or of better quality, leading to less likelihood of exit, these results insinuate that more foreign firms, larger in size and productivity, will push out the smaller domestic forms in the Low-tech industries.

The economic impact of FDI in the Mid- and High-tech industries are shown to be a little different. Unlike the case of Low-tech industries, domestic firms in both Mid- and High-tech industries are more likely to stay in operation when foreign investment increases, presumably benefitting from the technology transfer from FDI. The domestic firms in the Mid-tech sector, however, are likely to exit when vertical FDI increases, which is opposite from the case in the High-tech sector. From the coefficients of HHI, which show that domestic firms that likely to exit with less competition, we can infer that the Mid-Tech industries also have a smaller number of firms that take up a larger portion of market share. Thus in the Mid-Tech sectors, even with the exogeneity of FDI, we can conclude that the domestic firms are on par, or even more productive then their foreign counterparts. Firms in the High-Tech industry, however, are all increasing in survivability when FDI increases. The endogeneity of FDI for both MNCs and domestic firms suggest an overall increase of domestic and foreign investment in the industries, and higher expectation of growth in the High-tech sectors.

4.6 Conclusion

This paper investigates the impact of foreign investment on exit behavior of Chilean firms during the time frame of 1995 to 2007. We examine the determinants of firm exit, and add additional measures of FDI to see how the horizontal and vertical impact of such investment affects the exit behavior of firms. We discern the type of firms by foreign ownership, and also by technology levels to examine how different types of firms react to foreign competition.

The findings of the study are consistent with the literature, in that exporters that have multiple markets of operation have a lower likelihood of exit (Bernard and Jensen (2007)). Finding regarding firm size, however, are shown to be negligible and do not follow the results presented by Ghemawat and Nalebuff (1985) or Whinston (1988). The productivity of a firm, however, is a significant factor in determining the exit probability of a firm.

We find strong evidence that multinational firms and domestics firms do not have different exit patterns, but do react differently to FDI. The exit patterns of domestic firms are highly correlated to FDI, and are likely to decrease with more foreign investment. We posit that this is due to a signaling effect of foreign investment that increases the expected profit level for domestic firms. Multinationals, on the other hand, are more likely to exit the market with increased FDI, as the increased competition from highly productive firms reduce long term profit levels for the firm.

Our results also show that the level of technology may be an overlooked, but important, factor that impacts firm exit. Using the level of technology as a proxy for the technological distance between MNCs and domestic firms, we find that firms of different technology groups exhibit different patterns of exit.

The three key determinants that we focus on this study reveal interesting aspects of firm exit. First, measuring the level of market competition through the degree of concentration, we confirm that a more competitive market leads to a higher likelihood of firm exit. This trend is especially strong in the case of domestic firms and firms in the High-tech industries.

The results also show that the impact of horizontal FDI is ambiguous in general, but an examination by industry group reveals different trend in the Low-tech industries compared to the Mid- and High-tech industries. Results show that domestic firms in Low-tech industries are more likely to exit with higher horizontal FDI, which suggests that the productivity trickle down effect is outweighed by competition from foreign firms. We speculate the industries in the Low-tech group, which include textiles, food and tobacco, and wood products, have a smaller technology gap in which minimizes the impact of technology transfer, while the firms in the Mid- and High-tech industries gain more from direct competition.

Vertical FDI, depending on the industry group, reveals to reduce the probability of exit of domestic firms in the Low-tech and High-tech industries. Domestic firms in the Mid-tech industry group, however, are more likely to exit when the ratio of foreign firms in the vertically linked industries increase. We speculate that increased foreign competition in both forward and backward linkages create intermediate goods and production factors of better quality at lower prices, which leads to higher survivability in the Low- and High-tech industries. If the costs to adjust to the regulations of foreign firms and cultivate business partnerships are very high, it may outweigh the advantages in procuring intermediate goods and lead to higher exit rates of firms. Given that the manufacturing industries in the Mid-tech sector are closely related to the mining sector if Chile, which is highly populated by foreign-owned corporations, an argument can be made where foreign mining multinationals have a very exclusive relationship with select firms in the Mid-tech sector. This would explain the different impact of vertical FDI in the Mid-tech sector compared to the Low- and High-tech sector. Future research will shed light on this hypothesis.

APPENDIX A

APPENDIX FOR CHAPTER 2

A.1 List of Countries

Afghanistan, Albania, Algeria, Angola, Antigua and Barbados, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium-Luxembourg, Belize, Benin, Bolivarian Republic of Venezuela, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cote d'Ivoire, Cambodia, Cameroon, Canada, Cape Verde, Central African, Chad, Chile, China, Colombia, Comoros, Congo, Costa Rica, Croatia, Cuba, Cyprus, Czech Republic, Democratic Republic of the Congo, Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Estonia, Ethiopia, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hungary, Iceland, India, Indonesia, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kiribati, Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Marshall Islands, Mauritania, Mauritius, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Republic of Korea, Republic of Moldova, Romania, Russian Federation, Rwanda, Saint Kitts and Nevis, Saint Lucia, Saint Vincent an, Samoa, San Marino, Sao Tome and Principe, Saudi Arabia, Senegal, Serbia and Montenegro, Seychelles, Sierra Leone, Singapore, Slovakia, Slovenia, Solomon Islands, Somalia, South Africa, Spain, Sri Lanka, Sudan, Suriname, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Tanzania (United Republic of), Thailand, Macedonia, Timor-Leste, Togo, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Tuvalu, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Uzbekistan, Vanuatu, Viet Nam, Yemen, Zambia, Zimbabwe, the Islamic Republic of Iran

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A.2 Data Sources

Data Description	Source
Bilateral Trade Data	BACI Database, CEPII
Labor Standards Ratification Information and History	NATLEX, ILO
Country Specific Legal Data	NORMLEX, ILO
Gravity Control Measures	Gravity Factors Database, CEPII World Development Indicators, World Bank Penn World Table
Labor Standard Indices (LSI)	Author's Calculations

A.3 Constructing the Indices

The Formal Index of Freedom of Association, is constructed by look at an value which is constructed by a weighted average of indictor functions of the ratification of Convention No. 87 and Convention No. 98, as well as the number of ratification reports requested and received as part of the member country's responsibility as an ILO member, according to Article 19.

The weights for constructing the indices follow Cuyvers and Van Den Bulcke (2007), as they show through a sensitivity analysis in which the weights carry relatively little importance.

$$FFAI = 1 - \sum_{i \in \{87,98\}} [\omega_i \delta_i - \omega_{19} \delta_{\delta_i}] \tag{A.1}$$

- ω_i = weighting coefficient for Convention No. 87 and 98
- ω_{19} = weighting coefficient for Article 19 of the ILO constitution

- δ_i = a dummy variable which equals 1 in case country j did not ratify Convention No. *i* and equals 0 in case it did ratify the Convention
- δ_{δ_i}= a dummy variable which equals 1 in case the $\delta_i = 1$ AND if the non-ratifying country concerned did however send their report stating their legislation and practice regarding Convention *i*. On the other hand, $\delta_{\delta_i} = 0$ when $\delta_i = 0$.

The index for Child Labor has a similar structure. The Formal Indices for the remaining categories are more complex, as they include indicator functions for the legal framework for each respective country. For instance, the Formal Child labor Index not only looks at ratification, but also minimum age requirements for different types of labor.

$$FCLI = 1 - \left[\sum_{(i,j)\in\Omega} \omega_i(\delta_i\delta_j + \frac{1}{2}(1-\delta_j)) + \sum_{k\in\Gamma}(\omega_k\delta_k) \right] \tag{A.2}$$

- $\Omega = \{(138, 4), (bs, bf), (hs, hf)\}$
- $\Gamma = \{1, e, 182\}$
- ω_i = weights for convention *i*
- δ_i = a dummy variable for the following criteria
  - δ_{138} = equals 1 in the case of a formal violation of Convention No. 138 and equals 0 in the case of a formal respect regarding ratification of Convention No. 13

- δ_4 = equals 0 when country j has ratified at least 4 previous Conventions on minimum age and equals 1 when country j has not done so
- δ_{bs} = equals 0 when country j respects the basic mini- mum age set at 15 years as stated in Convention No. 138 and equals 1 when it is set at a lower age
- δ_{bf} = equals 0 when country j has a basic minimum age of 14 years (instead of 15) and equals 1 when it is set at a lower age
- δ_l = equals 0 when country j has, for light work, a minimum age of at least 13 years and equals 1 when country j has a lower minimum age
- δ_{hs} = equals 0 when country j has, for hazardous work, a minimum age of at least 18 years and equals 1 when a country has set a lower one
- δ_{hf} = equals 0 when country j has, for hazardous work, set their minimum age at 16 or 17, and equals 1 when it has set a lower age limit
- δ_e = equals 0 when country j has, for compulsory education, set an age limit that at least equals the country's basic minimum age and equals 1 when it is lower
- δ_{182} = equals 0 when country j has ratified Convention No. 182 and 1 in the case of non-ratification

The Gender Discrimination Index looks at the incremental progress of the issue, by looking at how a country has responded to related ILO conventions up to ratifying Convention 100 and 111.

$$FGDIj = 1 - \left[\omega_1 \left(\sum_{i \in \{100,111\}} \omega_i \delta_i \right) + \omega_2 \left\{ \delta_F \left(\sum_{j \in \{3,4,45\}} \omega_j \delta_j \right) + \sum_{k \in \{156,175\}} \omega_k \delta_k \right\} \right] \tag{A.3}$$

- ω_1 = a weighting coefficient (0.7) relating to Convention No. 100 and Convention No. 111
- ω_2 = a weighting coefficient (0.3) relating to Convention No. 3, Convention No. 4, Convention No. 41, Convention No. 45, Convention No. 89, Convention No. 103, Convention No. 156 and Convention No. 175, when ω_1 is not applicable.
- δ_F = a dummy variable which equals 1 when the two Conventions Convention No. 111 and Convention No. 100 were not ratified and equals 0 if at least one, or both, were ratified.
- δ_i = a dummy variable which equals 1 in the case of non-ratification of Convention No. *i* and equals zero when Convention *i* is ratified. The criteria for each *i* is presented as the following:
  - $\delta_{3/103}$ = a dummy variable equals 1 if either Convention No. 3 or Convention No. 103 (or both), about the protection of maternity, were not ratified and equals 0 if they were ratified
  - $\delta_{4/41/89}$ = a dummy variable that equals 1 if either Convention No. 4, Convention No. 41 or Convention No. 89 (or all), about night work for women, were not ratified and equals 0 if they were ratified
  - δ_{45} = a dummy variable equals 1 in the case of non-ratification of Convention No. 45 with respect to underground work for women and equals 0 if ratified.

- δ_{156} = a dummy variable equals 1 in the case of non-ratification of Convention No. 156 with respect to workers with family responsibilities and equals 0 if ratified.
- δ_{175} = a dummy variable equals 1 in the case of non-ratification of Convention No. 175 with respect to part time work and equals 0 if Convention No. 175 was ratified.

Finally, the Forced Labor Index is a weighted average of ratification of the relevant conventions.

$$FFLI = 1 - [\sum_{i \in \{29,105\}} \omega_i \delta_i] \tag{A.4}$$

- ω_i = weight assigned for Convention No. i
- δ_i = dummy variable which equals 1 if a country has not ratified ILO Convention No. i, and equals 0 if the country has ratified that Convention

APPENDIX B

APPENDIX FOR CHAPTER 3

B.1 Comparison of Equilibrium Values

Table B.1: Comparison of equilibrium values

Component	w/o Innovation	w/ Innovation
Cutoff points	$(p_{max})^0 = \left[\frac{2\gamma(f_D)(k+1)(k+2)(c_M)^k}{L\cdot}\right]^{\frac{1}{k+2}}$	$p_{max} < (p_{max})^0$
Average Profit	$(\bar{\pi})^0 = f_D \cdot \left(\frac{c_M}{p_{max}}\right)^k$	$(\bar{\pi})^0 < \bar{\pi}$
Number of Varieties	$N^0 = \frac{2\gamma(\alpha - p_{max})}{\eta(p_{max} - \bar{c})}$	$N^0 < N$
Consumer Welfare	$V(w;p_i)^0 = w + \frac{1}{2\eta}\left(\alpha - (p_{max})^0\right)\left(\alpha - \frac{k+1}{k+2}(p_{max})^0\right)$	$V(w;p_i)^0 < V(w;p_i)$

B.2 Proof of Proposition 1

When all firms that survive in the economy take the cutoff point p_{max} as given, and spend the optimal amount of innovation ρ^*, we can rewrite λ into an expression consisting only of entry costs and market parameters.

$$\lambda^* \equiv \left(\left(\frac{\rho^* + f_D}{f_D}\right) \cdot (1+\rho^*)^{-\beta k}\right)^{\frac{1}{k+2}} = \left[\underbrace{\frac{(f_D - 1)^{1-\beta k}}{f_D}}_{X} \underbrace{\left(\frac{1-\beta k}{\beta k}\right)^{\beta k}\left(\frac{1}{1-\beta k}\right)}_{Y}\right]^{\frac{1}{k+2}} \tag{B.1}$$

Since $k > 1$, we know that λ^* is an increasing function, of components denoted X and Y.

First, we know that component X will always smaller than 1, given that $f_D > 1$. If the assumptions hold, then $f_D > \beta k^{-1} > 1$.

Second, Y depends on the value of βk. Component Y has an inverse-U shape, and has maximum value of $Y = 2$ when $\beta k = \frac{1}{2}$. When βk gets asymptotically closer to zero, Y becomes infinitely closer to 1 from above. This shows that the value of λ^* at $\beta k = 0$ is smaller than 1. When βk is asymptotically closer to 1, the component Y is shown to be infinitely closer to 1, which makes λ^* smaller than 1. Thus, we know that λ^* has values of less than 1 at both extremes values of βk. Additionally, the maximum value of Y when $\beta k = \frac{1}{2}$, leads to a value of $X \cdot Y = \frac{2\sqrt{f_D - 1}}{f_D}$. This equation is concave in f_D, and has a maximum value of 1 when $f_D = 2$, and is smaller than 1 for all other values of f_D.

Thus, for all $f_D > 1$ and all $\beta k < 1$, we know that $X \cdot Y \leq 1$ for all values of f_D. This shows us that $\lambda \leq 1$ for all value of $f_D > 1$.

B.3 Proof of Proposition 4

The indirect utility function is shown as the following:

$$V(w; p_i) = w + \underbrace{\frac{1}{2}\left(\frac{N}{\eta N + \gamma}\right)(\alpha - \bar{p})^2}_{LV} + \underbrace{\frac{1}{2\gamma}\int_i (p_i - \bar{p})^2 \, di}_{PV} \tag{B.2}$$

where w is the total labor income of the consumer. This welfare is uniquely determined with the change of p_{max}. As seen above, endogenizing R&D simultaneously changes both N and $\bar{p}$. Since we know that $N \geq N_0$ and $\bar{p} \leq (\bar{p})_0$, we can use this information to determine the change in consumer welfare.

Consumer welfare is divided into two parts. The first part is the utility that comes from the 'love of variety', which is labeled LV. The second part of utility comes from the variance of prices of all varieties that are consumed. This part is labeled PV in the equation.

First, looking at LV, we know that the first part of LV is increasing with a larger N. ($\frac{\partial\left[N\cdot(\eta N+\gamma)^{-1}\right]}{\partial N} = \frac{\gamma}{(\eta N+\gamma)^2} > 0$). Since N is increasing with the introduction of innovation, we know that $\frac{1}{2}\left(\frac{N}{\eta N+\gamma}\right) > \frac{1}{2}\left(\frac{N_0}{\eta N_0+\gamma}\right)$.

Additionally, $(\alpha - \bar{p})^2$ in a decreasing function in $\bar{p}$, given that $\alpha \geq \bar{p}$. Since $\bar{p}$ is reduced, $(\alpha - \bar{p})^2$ is increasing. The combination of these two results suggest that LV is increasing with endogenous innovation ($LV \geq LV^0$).

Second, we look at the price variance component, PV. From the distribution of costs $G(c)$, the variance of costs can be determined as follows.

$$Var\,(c_i) = \frac{\int^{p_{max}} (c_i - \bar{c})\, dG(c)}{G(c)} = \frac{k}{(k+1)^2\,(k+2)}\,(p_{max})^2 \tag{B.3}$$

From (3.10), in equilibrium, the prices of all varieties are determined by c_i. Thus we can calculate that the variance of prices through the variance of costs. Since we know $p_i = \frac{1}{2}(p_{max} + c_i)$, we can write the variance of prices as

$$Var\,(p_i) = Var\left(\frac{1}{2}c_i + \frac{1}{2}p_{max}\right) = \frac{k}{4\,(k+1)^2\,(k+2)}\,(p_{max})^2 \tag{B.4}$$

Rewriting PV,

$$PV = \frac{N}{2\gamma}\cdot\frac{1}{N}\int_i (p_i - \bar{p})^2\, di = \frac{N}{2\gamma}\cdot Var(p_i) = \frac{Nk}{8\gamma\,(k+1)^2\,(k+2)}\,(p_{max})^2 \tag{B.5}$$

Since we know $p_{max} < (p_{max})^0$, the price variance component will also be smaller with endogenous innovation. Thus, the direction of LV and PV are moving in opposite directions.

However, using the equilibrium solutions of N and $\bar{p}$, we can rewrite LV as

$$LV = \frac{1}{2}\left(\frac{N}{\eta N + \gamma}\right)(\alpha - \bar{p})^2 = \frac{(\alpha - p_{max})}{\eta}\left[\alpha - \left(\frac{2k+1}{2k+2}\right)p_{max}\right] \tag{B.6}$$

and PV as the following.

$$PV = \frac{1}{2\gamma}\int_i (p_i - \bar{p})^2\, di = \frac{p_{max}\,(\alpha - p_{max})}{4\eta\,(k+1)\,(k+2)} \tag{B.7}$$

Using this, we can rewrite the indirect value function as the following.

$$V(w; p_i, i \in N) = w + \frac{1}{2\eta}\,(\alpha - p_{max})\left(\alpha - \frac{k+1}{k+2}p_{max}\right) \tag{B.8}$$

A comparative statics analysis shows that the change in the indirect utility with respect to p_{max} is negative.

$$\frac{\partial V(w; p_i)}{\partial p_{max}} = \frac{1}{2\eta}\left(\frac{2\,(k+1)}{k+2}p_{max} - \frac{2k+3}{k+2}\cdot\alpha\right) < 0 \tag{B.9}$$

Thus, when p_{max} changes, the LV effect outweighs the change in PV. This results in when p_{max} decreases with endogenous innovation, then LV increases more than the decrease in PV, resulting in a net increase in welfare. Thus, the overall welfare of consumers increase.

B.4 Proof of Proposition 8

By the envelope theorem, the changes in the indirect utility function $V(w; p_i, s)$ with respect to s can be represented as the partial derivative of the utility function with respect to s. The utility of each consumer can be represented by the following:

$$U(w, p_i) = w - \frac{N \cdot s}{L} + \int_i p_i q_i di \tag{B.10}$$

When there is no subsidy ($s = 0$),

$$\frac{\partial V}{\partial s}|_{s=0} = \frac{\partial U}{\partial s}|_{s=0} = \frac{-1}{L}N - \frac{1}{2} \cdot \frac{\partial p_{max}}{\partial s} (N \cdot q_i) \tag{B.11}$$

Rewriting this, we get the following:

$$\frac{\partial U}{\partial s}|_{s=0} = N \cdot \left[\frac{(1 - \beta k)}{2(k+2)} \cdot (f_D - 1)^{-1} \cdot q_i \cdot p_{max} - \frac{1}{L} \right] \tag{B.12}$$

Thus, when the following condition

$$L > \frac{2\gamma(k+2)(f_D - 1)(\eta N + \gamma)}{(1 - \beta k) p_{max} \left[\gamma\alpha - p_i (\eta N + \gamma) + \eta N \cdot \bar{p} \right]} \tag{B.13}$$

holds, the change in consumer welfare will be positive. This means when the size of the economy (number of consumers) is sufficiently large, the negative effect of taxation on the welfare diluted as the subsidy cost is shared by many.

BIBLIOGRAPHY

Acemoglu, D. and D. V. Cao (2010). Innovation by entrants and incumbents. Technical report.

Acs, Z. J. and D. B. Audretsch (1987, 11). Innovation, market structure, and firm size. *The Review of Economics and Statistics 69*(4), 567–574.

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt (2005). Competition and innovation: An Inverted U relationship. *The Quarterly Journal of Economics 120*(2), 701–728.

Aghion, P., R. Blundell, R. Griffith, P. Howitt, and S. Prantl (2009). The effects of entry on incumbent innovation and productivity. *The Review of Economics and Statistics 91*(1), 20–32.

Aghion, P., C. Harris, P. Howitt, and J. Vickers (2001). Competition, Imitation and Growth with Step-by-Step Innovation. *The Review of Economic Studies 68*(3), 467–492.

Aghion, P., P. Howitt, and C. Peñalosa (1998). *Endogenous growth theory*. MIT press.

Aitken, B. J. and A. E. Harrison (1999). Do domestic firms benefit from direct foreign investment? Evidence from Venezuela. *The American Economic Review*, 605–618.

Alfaro, L., A. Chanda, S. Kalemli-Ozcan, and S. Sayek (2004). FDI and economic growth: the role of local financial markets. *Journal of International Economics 64*(1), 89–112.

Alvarez, R. and G. Crespi (2007). Multinational firms and productivity catching-up: the case of Chilean manufacturing. *International Journal of Technological Learning, Innovation and Development 1*(2), 136–152.

Alvarez, R. and H. Görg (2009). Multinationals and plant exit: Evidence from Chile. *International Review of Economics & Finance 18*(1), 45–51.

Anderson, J. E. (1979). A Theoretical foundation for the Gravity equation. *The American Economic Review 69*(1), 106–116.

Anderson, J. E. and E. v. Wincoop (2003). Gravity with gravitas: A solution to the border puzzle. *The American Economic Review 93*(1), pp. 170–192.

Asker, J. and M. Baccara (2010). Subsidies, entry and the distribution of R&D investment. *International Journal of Industrial Organization 28*(3), 254–270.

Atkeson, A. and A. T. Burstein (2010). Innovation, Firm Dynamics, and International Trade. *Journal of Political Economy 118*(3), 433–484.

Audretsch, D. B. (1995). Innovation, growth and survival. *International Journal of Industrial Organization 13*(4), 441–457.

Audretsch, D. B., I. Grilo, and A. R. Thurik (2007). Explaining entrepreneurship and the role of policy: a framework. *The Handbook of Research on Entrepreneurship Policy*, 1–17.

Aw, B. Y., M. J. Roberts, and D. Y. Xu (2011, June). R&D Investment, Exporting, and Productivity Dynamics. *The American Economic Review 101*(4), 1312–44.

Bakhshi, S. and W. A. Kerr (2010). Labour standards as a justification for trade barriers: Consumer concerns, protectionism and the evidence. *eJADE: electronic Journal of Agricultural and Development Economics 11*(1).

Bao, X. and L. D. Qiu (2010). Do technical barriers to trade promote or restrict trade? evidence from china. *Asia-Pacific Journal of Accounting and Economics 17*.

Barenberg, M. (2011). Formulating and aggregating indicators of labor rights compliance. Technical report, Bureau of International Labor Affairs Department of Labor.

Benavente, J. M. and C. Ferrada (2003). Probability of survival of new manufacturing plants: the case of Chile. *Unpublished manuscript, Universidad de Chile*.

Bennett, J. (2002). Multinational corporations, social responsibility and conflict. *Journal of International Affairs 55*(2), 393–414.

Bergstrand, J. H. (1985). The gravity equation in international trade: Some microeconomic foundations and empirical evidence. *The Review of Economics and Statistics 67*(3), pp. 474–481.

Berik, G. and Y. V. D. M. Rodgers (2010). Options for enforcing labour standards: Lessons from Bangladesh and Cambodia. *Journal of International Development 22*(1), 56–85.

Bernard, A. B. and J. B. Jensen (2007). Firm structure, multinationals, and manufacturing plant deaths. *The Review of Economics and Statistics 89*(2), 193–204.

Bernard, A. B. and F. Sjoholm (2003). Foreign owners and plant survival. Technical report.

Blalock, G. and P. J. Gertler (2008). Welfare gains from foreign direct investment through technology transfer to local suppliers. *Journal of International Economics 74*(2), 402–421.

Blanchard, P., E. Dhyne, C. Fuss, and C. Mathieu (2013). Firm Dynamics and Employment Adjustment: Multinational vs Domestic Firms. *Recherches économiques de Louvain 79*(1), 59–81.

Bonnal, M. (2010). Export performance, labor standards and institutions: Evidence from a dynamic panel data model. *Journal of Labor Research 31*(1), 53–66.

Bora, Bijit Aki Kuwahara, S. L. (2002). Quantification of non-tariff barriers. *United Nations Conference of Trade and Development: Policy Issues in International Trade and Commodities, Study Series No. 18*.

Brown, A. G. and R. M. Stern (2008). What are the issues in using trade agreements to improve international labor standards? *World Trade Review 7*(2), 331–357.

Brown, D., R. Dehejia, and R. Robertson (2013). Is there an efficiency case for international labor standards?

Brown, D. K., A. V. Deardorff, and R. M. Stern (1996). International labor standards and trade: a theoretical analysis. *Fair trade and harmonization: Prerequisites for free trade 1*, 227–280.

Brown, D. K., A. V. Deardorff, and R. M. Stern (1998). Trade and labor standards. *Open Economies Review 9*, 171–194.

Busse, M. (2002). Do labor standards affect comparative advantage in developing countries? *World Development 30*(11), 1921 – 1932.

Busse, M. and C. Spielmann (2006). Gender inequality and trade. *Review of International Economics 14*(3), 362–379.

Bustos, P. (2011). Trade Liberalization, Exports, and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinian Firms. *The American Economic Review 101*(1), 304–340.

Calvano, L. (2008). Multinational corporations and local communities: a critical analysis of conflict. *Journal of Business Ethics 82*(4), 793–805.

Carrère, C. (2006). Revisiting the effects of regional trade agreements on trade flows with proper specification of the gravity model. *European Economic Review 50*(2), 223 – 247.

Chacar, A. S., S. Celo, and Y. Thams (2010). The performance of multinational affiliates versus domestic firms. *Journal of Management Policy & Practice 11*(4), 47–59.

Chau, N. H. and R. Kanbur (2006). The race to the bottom, from the bottom. *Economica 73*(290), 193–228.

Chau, N. H., R. Kanbur, A. Harrison, and P. Morici (2001, 01). The Adoption of International Labor Standards Conventions: Who, When, and Why? *Brookings Trade Forum*, 113–156.

Chen, M. X. and A. Mattoo (2008). Regionalism in standards: good or bad for trade? *Canadian Journal of Economics/Revue canadienne d'économique 41*(3), 838–863.

Chen, N. (2004). Intra-national versus international trade in the european union: why do national borders matter? *Journal of International Economics 63*(1), 93 – 118.

CIEChile (2013). Foreign Investor Guide: Key information for investing in Chile.

Clementi, G. L. and B. Palazzo (2013). Entry, exit, firm dynamics, and aggregate fluctuations. Technical report.

Colantone, I. and L. Sleuwaegen (2010). International trade, exit and entry: A cross-country and industry analysis. *Journal of International Business Studies 41*(7), 1240–1257.

Costantini, J. and M. Melitz (2007). The dynamics of firm-level adjustment to trade liberalization.

Coucke, K. and L. Sleuwaegen (2008). Offshoring as a survival strategy: evidence from manufacturing firms in Belgium. *Journal of International Business Studies 39*(8), 1261–1277.

Coughlin, C. (2012). Extensive and intensive trade margins: a state-by-state view. *Federal Reserve Bank of St. Louis Working Paper No.*

Criscuolo, C. and R. Martin (2009). Multinationals and us productivity leadership: evidence from great britain. *The Review of Economics and Statistics 91*(2), 263–281.

Cuyvers, L. and D. Van Den Bulcke (2007). The quantification of respect for selected core labour standards: Towards a social development index? In D. Kucera (Ed.), *Qualitative Indicators of Labour Standards*, Volume 30 of *Social Indicators Research Series*, pp. 115–144. Springer Netherlands.

Damijan, J. P., M. Knell, B. Majcen, and M. Rojec (2003). The role of FDI, R&D accumulation and trade in transferring technology to transition countries: evidence from firm panel data for eight transition countries. *Economic systems 27*(2), 189–204.

Dasgupta, P. and J. Stiglitz (1980). Uncertainty, industrial structure, and the speed of R&D. *The Bell Journal of Economics*, 1–28.

De Backer, K. and L. Sleuwaegen (2003). Does foreign direct investment crowd out domestic entrepreneurship? *Review of Industrial Organization 22*(1), 67–84.

Dehejia, V. H. and Y. Samy (2004). Trade and labour standards: theory and new empirical evidence. *The Journal of International Trade & Economic Development 13*(2), 179–198.

Deléchat, C., O. for Economic Co-operation, and Development (1996). *Trade, Employment and Labour Standards: A Study of Core Workers' Rights and International Trade*. Organisation for Economic Co-operation and Development.

Disdier, A.-C., L. Fontagné, and M. Mimouni (2008). The impact of regulations on agricultural trade: evidence from the SPS and TBT agreements. *American Journal of Agricultural Economics 90*(2), 336–350.

Driffield, N. and J. H. Love (2007). Linking FDI motivation and host economy productivity effects: conceptual and empirical analysis. *Journal of International Business Studies 38*(3), 460–473.

Dunne, T., S. D. Klimek, M. J. Roberts, and D. Y. Xu (2013). Entry, exit, and the determinants of market structure. *The RAND Journal of Economics 44*(3), 462–487.

Dunne, T., M. J. Roberts, and L. Samuelson (1988). Patterns of firm entry and exit in US manufacturing industries. *The RAND Journal of Economics*, 495–515.

Eaton, J. and S. Kortum (2002). Technology, geography, and trade. *Econometrica 70*(5), 1741–1779

Elliott, K. A. (2004). Labor standards, development, and CAFTA. Technical report.

Feenstra, R. C. (2001). Using the gravity equation to differentiate among alternative theories of trade. *Canadian Journal of Economics 34*, 430–447.

Fernandes, A. M. and C. Paunov (2012). Foreign direct investment in services and manufacturing productivity: Evidence for Chile. *Journal of Development Economics 97*(2), 305–321.

Findlay, R. (1978). Relative backwardness, direct foreign investment, and the transfer of technology: a simple dynamic model. *The Quarterly Journal of Economics*, 1–16.

Flanagan, R. J. (2003). *Labor Standards and International Competitive Advantage*, pp. 15–59. Stanford University Press.

Freeman, R. B. (1996). International labor standards and world trade: Friends or foes. *The world trading system: Challenges ahead*, 87–114.

Ghemawat, P. and B. Nalebuff (1985). Exit. *The RAND Journal of Economics*, 184–194.

Ghemawat, P. and B. Nalebuff (1990). The devolution of declining industries. *The Quarterly Journal of Economics*, 167–186.

Glass, A. J. and K. Saggi (1998). International technology transfer and the technology gap. *Journal of development economics 55*(2), 369–398.

Glass, A. J. and K. Saggi (2002). Multinational firms and technology transfer. *The Scandinavian Journal of Economics 104*(4), 495–513.

Görg, H. and E. Strobl (2003). 'Footloose' multinationals? *The Manchester School 71*(1), 1–19.

Greenaway, D. and R. Kneller (2008). Exporting, productivity and agglomeration. *European Economic Review 52*(5), 919–939.

Greene, W. (2004). The behaviour of the maximum likelihood estimator of limited dependent variable models in the presence of fixed effects. *The Econometrics Journal 7*(1), 98–119.

Griffith, R., S. Redding, and J. V. Reenen (2004, 11). Mapping the Two faces of R&D: Productivity Growth in a Panel of OECD Industries. *The Review of Economics and Statistics 86*(4), 883–895.

Griliches, Z. (1995). *R&D and Productivity: Econometric Results and Measurement Issues*. Handbook of the Economics of Innovation and Technological Change. Oxford, UK and Cambridge, Mass., Blackwell.

Grossman, G. M. and E. Helpman (1991a, 05). Quality ladders and product cycles. *The Quarterly Journal of Economics 106*(2), 557–586.

Grossman, G. M. and E. Helpman (1991b). Quality ladders in the theory of growth. *The Review of Economic Studies 58*(1), 43–61.

Hadjimanolis, A. (1999, 9). Barriers to innovation for SMEs in a small less developed country (Cyprus). *Technovation 19*(9), 561–570.

Hale, G. and C. Long (2011). Are there productivity spillovers from foreign direct investment in China? *Pacific Economic Review 16*(2), 135–153.

Hall, B. H., F. Lotti, and J. Mairesse (2012). Evidence on the impact of R&D and

ICT investments on innovation and productivity in Italian firms. *Economics of Innovation and New Technology*.

Hasnat, B. (2002). The impact of core labour standards on exports. *International Business Review 11*(5), 563–575.

Head, K., T. M. and J. Ries (2010). The erosion of colonial trade linkages after independence. *Journal of International Economics 81*(1), 1–14.

Heckman, J. J. (1976). The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models. *Annals of Economic and Social Measurement, Volume 5, number 4*, 475–492.

Helliwell, J. F. (1996). Do National Borders Matter for Quebec's Trade? *The Canadian Journal of Economics / Revue canadienne d'Economique 29*(3), pp. 507–522.

Helpman, E., M. Melitz, and Y. Rubinstein (2008). Estimating trade flows: Trading partners and trading volumes. *The Quarterly Journal of Economics 123*.

Helpman, E., M. J. Melitz, and S. R. Yeaple (2003). Export versus FDI. *National Bureau of Economic Research*.

Hopenhayn, H. A. (1992). Entry, exit, and firm dynamics in long run equilibrium. *Econometrica: Journal of the Econometric Society*, 1127–1150.

Hu, A. G. and G. H. Jefferson (2002). FDI impact and spillover: evidence from China's electronic and textile industries. *The World Economy 25*(8), 1063–1076.

Jaegers, T., C. Lipp-Lingua, and D. Amil (2013). High-technology and medium-high technology industries main drivers of EU-27's industrial growth. *EUROSTAT, Industry, Trade and Services, Statistics in Focus 1*, 2013.

Javorcik, B. S. and M. Spatareanu (2005). Disentangling FDI spillover effects: what do firm perceptions tell us? *Does foreign direct investment promote development*, 45–72.

Kokko, A. and T. T. Thang (2014). Foreign Direct Investment and the Survival of Domestic Private Firms in Viet Nam. *Asian Development Review 31*(1), 53–91.

Krueger, A. (1996). Observations on international labor standards and trade. *NBER Working Paper W*(5632).

Kucera, D. (2002). Core labour standards and foreign direct investment. *International Labour Review 141*(12), 31–69.

Kucera, D. (2004). Measuring trade union rights: a country-level indicator constructed from coding violations recorded in textual sources. *Available at SSRN 908487*.

Kucera, D. and R. Sarna (2006). Trade Union Rights, Democracy, and Exports: a Gravity Model Approach. *Review of international economics 14*(5), 859–882.

Kugler, M. (2006). Spillovers from foreign direct investment: within or between industries? *Journal of Development Economics 80*(2), 444–477.

Lawless, M. (2010). Deconstructing gravity: trade costs and extensive and intensive margins. *Canadian Journal of Economics/Revue canadienne d'économique 43*(4), 1149–1172.

Lee, T. and L. L. Wilde (1980, 03). Market structure and innovation: A reformulation. *The Quarterly Journal of Economics 94*(2), 429–436.

Levinsohn, J. and A. Petrin (2003). Estimating production functions using inputs to control for unobservables. *The Review of Economic Studies 70*(2), 317–341.

Li, X. and X. Liu (2005, 3). Foreign direct investment and economic growth: An increasingly endogenous relationship. *World Development 33*(3), 393–407.

Lieberman, M. B. (1990). Exit from declining industries: "shakeout" or "stakeout"? *The RAND Journal of Economics*, 538–554.

Lileeva, A. and D. Trefler (2010). Improved access to foreign markets raises plant-level productivity... for some plants. *The Quarterly Journal of Economics 125*(3), 1051–1099.

Liu, X., P. Burridge, and P. J. Sinclair (2002). Relationships between economic growth, foreign direct investment and trade: evidence from China. *Applied Economics 34*(11), 1433–1440.

Liu, Z. (2008). Foreign direct investment and technology spillovers: Theory and evidence. *Journal of Development Economics 85*(1), 176–193.

Long, N. V., H. Raff, and F. Stähler (2011). Innovation and trade with heterogeneous firms. *Journal of International Economics 84*(2), 149–159.

Loury, G. C. (1979). Market structure and innovation. *The Quarterly Journal of Economics*, 395–410.

Luinstra, A. (2004, January). Labor standards and trade.

Mah, J. S. (1997). Core labour standards and export performance in developing countries. *World Economy 20*(6), 773–785.

Markusen, J. R. and A. J. Venables (1999). Foreign direct investment as a catalyst for industrial development. *European economic review 43*(2), 335–356.

McCallum, J. (1995, June). National Borders Matter: Canada-U.S. Regional Trade Patterns. *The American Economic Review 85*(3), 615–623.

Melitz, M. J. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica 71*(6).

Melitz, M. J. and G. I. P. Ottaviano (2008, 01). Market size, trade, and productivity. *The Review of Economic Studies 75*(1), 295–316.

Micco, A. (1995). *Creation, Destruction and Job Reallocation in Chile*. Ph. D. thesis, University of Chile.

Mosley, L. and S. Uno (2007). Racing to the bottom or climbing to the top? Economic globalization and collective labor rights. *Comparative Political Studies 40*(8), 923–948.

OECD (2003). OECD Global Forum on International Investment: Attracting International Investment for Development.

Oka, C. (2011). *Does Better Labour Standard Compliance Pay?: Linking Labour Standard Compliance and Supplier Competitiveness*. International Labour Office.

Otsuki, T., J. S. Wilson, and M. Sewadeh (2001). Saving two in a billion: : quantifying the trade effect of European food safety standards on African exports. *Food Policy 26*(5), 495 – 514.

Ottaviano, G., T. Tabuchi, and J.-F. Thisse (2002). Agglomeration and trade revisited. *International Economic Review*, 409–435.

Palley, T. I. (2002). The Child Labor Problem and the Need for International Labor Standards. *Journal of Economic Issues 36*(3), pp. 601–615.

Pavcnik, N. (2002). Trade liberalization, exit, and productivity improvements: Evidence from Chilean plants. *The Review of Economic Studies 69*(1), 245–276.

PriceWaterhouseCoopers (2008). Doing Business in Chile: Investment Guide.

Rodrik, D. (2000). How far will international economic integration go? *The Journal of Economic Perspectives 14*(1), pp. 177–186.

Salem, S. and F. Rozental (2012). Labor standards and trade: A review of recent empirical evidence. Technical report, United States International Trade Commission.

Schumpeter, J. A. and G. Fain (1961). *Capitalisme, socialisme et démocratie*. Payot París.

Segerstrom, P. S., T. C. Anant, and E. Dinopoulos (1990). A Schumpeterian model of the product life cycle. *The American Economic Review*, 1077–1091.

Sengenberger, W. (2005). *Globalization and social progress: The role and impact of international labour standards*. Friedrich-Ebert-Stiftung.

Swann, G. P. (2010). International Standards and Trade: A Review of the Empirical Literature. *OECD Trade Policy Working Papers*.

The World Bank (2012). *World Development Indicators*. The World Bank.

United States Council For International Business (2007). U.S. Ratification of ILO Core Labor Standards.

Van Beers, C. (1998). Labour standards and trade flows of OECD countries. *The World Economy 21*(1), 57–73.

Wang, J. Y. (1990). Growth, technology transfer, and the long-run theory of international capital movements. *Journal of International Economics 29*(3), 255–271.

Wang, Y. (2013). Exposure to FDI and new plant survival: evidence in Canada. *Canadian Journal of Economics/Revue canadienne d'économique 46*(1), 46–77.

Whinston, M. D. (1988). Exit with multiplant firms. *The RAND Journal of Economics*, 568–588.

Xu, X. and Y. Sheng (2012). Productivity spillovers from foreign direct investment: Firm-level evidence from China. *World Development 40*(1), 62–74.

Yellen, J. L. (1984, 05). Efficiency Wage Models of Unemployment. *The American Economic Review 74*(2), 200–205.

Zhou, C. and J. Li (2008). Product innovation in emerging market-based international joint ventures: An organizational ecology perspective. *Journal of International Business Studies 39*(7), 1114–1132.