Aix-Marseille School of Economics AMSE
Aix-Marseille Université

PhD Thesis

INTERNATIONAL TRADE AND LABOR MARKETS:
EMPIRICAL AND THEORETICAL EVIDENCE

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A dissertation submitted to the Aix-Marseille School of Economics AMSE
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy in Economics

One sunny fall day, 2019
Marseille, France

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EMPIRICAL AND THEORETICAL EVIDENCE

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One sunny fall day, 2019
Marseille, France

Printed in Marseille, France.
Aix-Marseille School of Economics AMSE, Aix-Marseille Université.
5-9 boulevard Maurice Bourdet.
13001 Marseille, France.

amse
école d'économie d'aix-marseille
aix-marseille school of economics

To my beloved wife, my family and my friends,

Acknowledgement

I acknowledge the excellent, patient and inspiring advisory support of Professor Federico TRIONFETTI, I could hardly have a better supervisor. Likewise, the comments of Professors Anne-Célia DISDIER, Pierre-Philippe COMBES, Christian SCHLUTER, Patrick SEVESTRE, Stephen BAZEN, Juan-Carlos GUATAQUI, Brian McCAIG, Marco DUEÑAS, as well as Dr Christian-Manuel POSSO from Banco de la República de Colombia, Mrs Sara-Patricia RIVERA from the National Department of Planning, classmates within the AMSE PhD seminar; and specially Professors of the PhD Committee, who carefully read and made significant contributions to each of the thesis chapters: Dr Ricardo ARGÜELLO, Dr Ivan LEDEZMA and Dr Karolien DE BRUYNE. Many thanks to Mrs Louise DUCKLING for proofreading the thesis and to Mrs Karol-Marcela CUERVO, Mr Luis-Alejandro CUERVO and Mrs Diana LEAL for writing assistance.

I also acknowledge the financial support of COLCIENCIAS, COLFUTURO, and Jorge Tadeo Lozano University (specially to Mrs Elizabeth TORRES, Dr Jaime TENJO, Mrs Sandra DURÁN, Mr Carlos-Eduardo HERNÁNDEZ, Mrs Natalia RONDEROS, Mr David CÁRDENAS, Dr Salomón KALMANOVITZ, Mr Fernando COPETE and Dr Carlos BRANDO).

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International trade and labor markets: Introduction

Some authors in the 90s stated that international trade policies should be debated in terms of its impact on economic and resource efficiency instead of in terms of jobs created or lost. On the contrary, others have observed in integrated countries a relationship between trade and labor markets, generating increasing wage inequality within countries and within sectors and employment reshuffling within sectors rather than across sectors. There exists as well a link between the tariffs schedule, the foreign direct investment and the change in the skill premium.

Across emerging countries, people show a great concern about the persistent inequality and unemployment, along with worsening of labor conditions; all this, despite the economic growth and increasing international trade. For instance, at the end of 90 years the Colombian case shows a deep economic recession, while during 2000 years, historical unemployment levels were observed, between 12% and 18%. However, since typical international trade theories, as the Hecksher-Ohlin setup, are built on the assumption of full employment and perfect labor markets, they cannot explain the relationship between trade and unemployment. Despite this, policy makers around the world usually have seen trade opening as a tool to create new jobs, regardless the quality of such new jobs, the effect on the informal informal or wage inequalities.

In accordance with some authors, there exists a strong relationship between trade openness policy and labor market informalization [Goldberg and Pavcnik, 2004], as corporations and governments have increased labor flexibility to enhance competitiveness and boost foreign investment. Regarding the level of employment, other studies show that international trade generates more jobs for unskilled workers in developing countries, though it has brought as well unskilled job losses in developed countries. [Geishecker et al., 2012]. At a political level, the World Trade Organization WTO considers itself not competent on labour issues, as it is pointed in the Singapore Ministerial Declaration in 1996: "The international Labour Organization ILO is the competent body to set and deal with core labor standards". Which is reaffirmed in the Doha Development Agenda in 1999, by excluding negotiations on labor standards.

Conversely, according with Granger and Siroën [2009], countries around the world have included in regional and bilateral trade agreements references to labour standards, for instance: the United States Trade Act of 2002, the European Union's Decent Work Communication of 2006, as well as Mercosur Social Declaration, the Free Trade Agreement Canada-Chile, FTA Canada-Costa Rica, FTA Chile-Colombia, FTA Peru-USA, FTA

Colombia-USA, FTA South Korea-Japan and FTA Japan-Philippines. These social clauses imply either sanctions or any kind of cooperation. The authors highlight the following reasons to explain why countries are so keen on including such social clauses in trade agreements: a) protection against "social dumping" b) promotion of universal rights, c) dealing with FTA's undesirable effects, and c) supporting decent work and sustainable development.

Indeed, negative facts regarding the relationship between trade policies and labor markets have been documented. Chan and Ross [2003], for instance, state that competition in the world having the historic North-South direction has stopped, and so, competition has shifted to become South-South. To illustrate this phenomenon, the authors compare the case of the textile industry with intensive unskilled labor in China and Mexico. They find that workers of these industries are mostly immigrant women from the poorest regions of each country, which allow firms to increase production and profits by reducing fixed labor costs. To illustrate, whilst apparel imports penetration in the US increased from 2% to 60% between the 60s and the 90s, respectively, the employment rate decreased by half in the same period (a loss of 600.000 jobs). Likewise, the main apparel seller countries to the US, China and Mexico, decreased wages and increased exports, after the NAFTA (North American Free Trade Agreement) implementation in 1994.

In the same way Sanyal and Bhattacharya [2010] argue that the "racing to the bottom" of developing countries has been unleashed due to the threat of investment funds moving to and from places where returns are greater based on low wages and labor flexibility, whereas that workers are tied to specific geographical locations. Although informal jobs are not a new issue in developing countries, the authors conclude that globalization boosts this phenomenon in a two way direction process: first, firms in the manufacturing sector are engaged in a cost cutting battle, where competition encourages outsourcing, lower wage costs, and lower costs associated with labor and environmental standards. Second, the inflow of cheaper imports triggers a contraction of the importing industries, since people do not find easily a new job at the exporting sector. However, at the same time, the new global network of production based on outsourcing and subcontracting, is giving some bargaining power to workers, since global capital becomes vulnerable to disruptions in the global circuit of production and commercialization, informalization seems to be the clue to understand these potentially new forms of labor activism.

Evidence found by Attanasio et al. [2004] in Colombia, support the hypothesis that trade liberalization brings about more intense competition, and consequently, a stronger pressure on large and medium size firms to cut costs, by replacing permanent for temporary workers, or outsourcing activities to small informal firms, including home-based and self-employed micro-entrepreneurs. In fact, they found that when the average level of tariffs were around 50% in 1984, the probability of any worker in the manufacturing sector of having an informal job, when tariffs reduced to 0%, were 4.4 percentage points; but this effect diminished to 1.1 percentage points in 1998 when tariffs was around 13%.

The aim of this research is contributing to the literature in the field by delivering new theoretical and empirical evidence on the relationship between international trade and labor markets. To do that I identify the mechanisms how international trade impacts wage inequality, unemployment and informal employment. I divide the analysis in three interconnected chapters: 1) analyzing empirically the relationship between trade and wage inequality for the emblematic case of Colombia; 2) analyzing theoretically the relationship between international trade and the informal labor market; and 3) analyzing empirically the effect of the so-called Dutch-Disease with unemployment and the informal labor.

In the first chapter, I merge the theory of Acemoglu [2003] and the empirical methodology of Haskel and Slaughter [2002] to estimate the sector-specific bias of the Skill-Biased Technical Change SBTC generated by the interaction of the skill intensity with trade integration in the context of the labor reform. I implement such methodology to study the case of Colombian manufacturing sectors between 2000 − 2012. The case of Colombia is interesting because an openness policy was implemented simultaneously with a labor market reform in the 90s, affecting equally all formal sectors in the economy, reducing firing costs and increasing formal employees. Consequently, temporary workers, hired either directly or indirectly through agencies, rose in importance across industrial sectors. Both policies led to confounding results on wage inequality. More specifically, I attempt to answer two research questions: does international trade bring about more or less wage inequality in the Colombian case? and, what is the effect of implementing simultaneously the openness and labor reform policies on the skill premia in Colombia?

Acemoglu [2003] developed a theory to analyze the impact of the interaction between international trade (expressed as the world relative skill supply) and the relative skill supply of the country, on the Skill-Biased Technical Change (SBTC), and therefore, on wage inequality between skilled and unskilled workers. Acemoglu shows that such an impact is always positive for developed countries, while in the case of developing countries it is ambiguous, depending on their relative technology level or skill abundance compared to other country competitors.

By endogenizing SBTC in this way, the impact of international trade on wage inequality is explained by the interaction of two mechanisms in the model: the price effect and the market size effect, which make innovations more profitable to firms. The first effect corresponds to the higher relative price (in developed countries) of skill-intensive goods due to international trade increment; while the second effect refers to the clientele increase for technology or the higher relative skill supply. Therefore, the SBTC expands the supply of skill-intensive goods, thereby compensating for the price effect in the long run and keeping prices relatively stable or letting them to grow by a limited amount in the short term.

This paper contributes to the empirical literature on the impact of international trade on wage inequality in developing countries by including the interaction of these two variables on the sector SBTC, widening the empirical methodology of Haskel and Slaughter [2002]. Additionally, to separate the confounding impacts on SBTC of trade and labor reforms, I control in the empirical model for a measure of temporary workers by sector, which relates to the effects of the labor market flexibilization.

The sector skill intensity is defined as the ratio of non-production workers over production workers by sector, obtained from the Annual Manufacturing Survey, a source of information that has not been exploited before in this topic in Colombia. Trade integration is measured by various proxies, collected from different sources: traded volume by country of origin and destination; changes in tariffs from their actual level with respect to the former level in 1980; and the share of exporters by subsector. The idea of including these different measures is to check for robustness, as well as capturing specific impacts of trade with developed and developing countries.

The main results of the research are that interaction of sector skill intensity with trade integration causes a decrease in the sector-specific bias of SBTC for sector tariff reductions and sector exporting firms, with respect to the non-interaction specification. Likewise, the sector-specific bias is positive in practically all econometric models, generating wage inequality in many sectors. However, that effect is moderated when the sector skill intensity increases (fixing trade with developing countries and sector exporters) bringing about less skill premia. Furthermore, the control variable for temporary workers had negative effects on the SBTC, decreasing wage inequality and offsetting the positive effect in terms of both the rise of the sector skill intensity and trade integration.

In the second chapter, I analyze the effect of trade openness in a theoretical model of international trade with heterogeneous firms, assuming that the government introduces in the economy a regulatory threshold in terms of a firm's size to distinguish formal from informal firms (e.g. a minimum quantity of workers $\bar{l}$). According to Hussmanns [2004] an informal sector enterprise is characterized by being below such a threshold and additionally it is a private unincorporated entity, production is for sale or barter, and it is involved in non-agricultural activities.

In practice, such a regulatory threshold can be expressed in terms of the probability of a firm being monitored by the government and being forced to have only formal workers. In the theoretical structure I suggest in this article, as in Davies and Paz [2011], that this probability is equal to 1 when the firm is above the threshold ($\bar{l}$), and 0 when it is below.

Alternatively, ILO [2016] states that other policies may establish as well, in law or in practice, some labor regulatory thresholds: e.g. minimum hours of work or certain level of wages, in the case of casual jobs, or short-term jobs. Those policies can separate informal from formal workers, as firms are required to pay for the additional labor costs associated with the latter group. As informal workers do not benefit from national labor legislation, informal firms also do not pay income taxation or payroll taxes, social security contributions or specific social protection such as advance notice of dismissal, severance pay, paid annual leave or sick leave. In contrast, formal firms pay additional marginal and fixed labor costs for their workers. Because of the feasibility of the theoretical analysis, I examine the case in which the government sets a threshold level $\bar{l}$ as a minimum quantity of workers, to determine whether the firm is informal, according to its size.

According with the benchmark model used in this chapter of the research (Melitz [2003]), the welfare is a function of the love for varieties, prices of domestic goods and national income (including wages and production). Thus, by introducing the new regulation threshold ($\bar{l}$) in the model, I evaluate another trade policy effect on welfare, specifically, on employment opportunities in the formal or informal sectors, in the framework of heterogeneous technological performance by firm. Indeed, the results contrast with the original model without the labor regulation, where trade policy brings about an improvement in welfare.

The main results of the paper are obtained by numerical methods. I undertake an exercise of numeric comparative statics to evaluate the effect of the changes in various parameters on the main variables of the model. I find that there exists *informal selection* and export market selection; namely, the less productive formal firms become informal, while the most productive formal firms become exporters. Furthermore, unlike the case with similar models, there is a kind of new loser: the less productive formal firm who becomes an *mpi* firm, and the *mpi* firms who become *lpi* firms. The winners are the most productive exporting firms. Likewise, in the labor market, though there are fewer firms in the economy, workers reallocate towards formal and exporting firms, improving average wages. Lastly, the impact of the trade policy on welfare under these theoretical conditions is negative, due to the exit of some *lpi* firms and the consequent rise in the level of formal and exporting employment, as well as in the price index because there are more workers earning formal wages, and a decrease in varieties.

Regarding the exercise of comparative statics, the following results should be highlighted: first, a reduction in the regulatory threshold forces many informal firms to pay formal costs, reducing the informal sector, whilst the formal and exporting sectors increase, making *mpi* eventually disappear. Under full employment, such a policy raises welfare due to the better wages of an increasing quantity of formal workers and the increasing availability of varieties. Second, higher levels of the formal wage premium (marginal labor costs) moderately decreases welfare. This policy makes informal firms expand, as well as informal workers with low wages, compensating for the rise of formal wages. And third, when the formal fixed cost grows, *lpi* firms rise in number, while *mpi* tend to disappear. However, the higher fixed costs makes formal firms' selection more demanding, which forces them to hire more workers too. As more workers become formal, prices rise significantly, and varieties increase and welfare rises.

In the third chapter, I implement an impact evaluation exercise (a Difference in Differences methodology) to test the hypothesis that the Dutch disease occurred in many countries, between 2003 and 2015, brought about significant outcomes in terms of employment in different economic sectors, informal labor, aggregate production and trade of products other than oil and mining.

The Dutch disease refers to the relation of the increase in an specific economic sector, with the contraction of others [Corden and Neary, 1982]. For instance, an important growth in oil and mining sectors against a reduction in the manufacturing and agricultural. The reason why this happens, is because exports of the growing sector and the higher revenues of the country, beget an appreciation of the local currency, measured by the exchange rate.

Therefore, imports become cheaper while exports become more expensive. The existence of the Dutch disease is linked with interaction between higher natural resources revenues, the real-exchange rate, and a decline in a lagging sector.

According to the US Energy Information Administration, crude oil WTI prices per barrel went from an average of US$31 in 2003, to a maximum of US$141 in July 2008, while in 2014 the price still was around US$100. This fact is very important for the developing world, as an important portion of the main oil producers are developing countries: such as China, Brazil, Mexico, Colombia, Indonesia, Argentina, Egypt, the OPEC countries, others in Africa, Asia and Latin-America, are among the first 30 producers (in 2016). Albeit less dramatic, a similar situation occurred with other mining products as gold, coal and nickel. These facts bring about important effects in the real exchange rate and therefore, in the trade balance, and other variables in the labor market and sectoral production.

My intend in this chapter is contributing to the literature bringing the empirical analysis of the relationship between the resource boom and labor markets, by expanding the analysis in Arguello et al. [2016] to various developing countries affected by the changes in oil prices, which can actually change conclusions. Specifically, I study the recent oil and mining boom which have not been related with formal and informal employment and unemployment at this international scale.

The difference in difference analysis on the employment variables yields that the existing negative trend of agricultural employment was deepened during the Dutch disease. That was also the case for the industrial employment prior the resource boom, but during the phenomenon, employment increased more in the treatment group. In services sector the employment presented a positive trend before and after the Dutch disease. Regarding unemployment and informal employment, I find evidence that both variables are smaller in countries with Dutch disease and that people with basic and intermediate education level, and women are the most benefited.

With respect to trade and production variables, the evidence suggest that the resource windfall increases GDP per capita and manufacturing production mainly in countries affected by the Dutch disease, while the effect on services sector is negative, as well as the effect on agriculture production, though in both, the treatment and control groups. The impact of the treatment on net exports is negative for countries with Dutch disease, despite the decrease in imports. Likewise, exports of agriculture and raw materials, and manufactures, but high-tech, decrease in the control group.

1

International trade, temporary workers and wage inequality in Colombia: the manufacturing sector

Using a panel of 66 Colombian manufacturing sectors, during the period 2000-2012, I deliver empirical evidence about the interaction of two variables: trade integration and sector skill intensity, on wage inequality between skilled and unskilled workers. I bring forward different measures of Skill-Biased Technical Change (SBTC) and regress them against the skill intensity variable, various measures of international trade, and interaction of both. As the openness and the labor flexibility reforms occurred almost simultaneously in the 1990s, I control for the share of temporary workers in each manufacturing subsector. I find evidence that the positive effect of the SBTC on wage inequality decrease before high levels of sector skill intensity and before interaction with international trade. However, such effect is counterbalanced by a negative impact of temporary workers on wage inequality.

1.1 Introduction

The trade tariffs reform in Colombia, the so-called "openness" policy, was implemented officially in the 1990s, although it had already begun some years earlier. The simple average nominal tariff decreased steadily from 31% in 1985 to 12% in 1994.[1] Furthermore, such policy was strengthened during the 2000s and 2010s with the negotiation and execution of Free Trade Agreements with a wide range of countries; among the most representative of these agreements are those with the United States of America (2012), the European Union (2013) and the Pacific Alliance (2015). To date, 20 Trade Agreements exist; only four of them were signed before 2000.

As a result, according to the World Bank, real GDP has increased by more than double between 1990 and 2014 (an average annual growth rate of 3.6%). The volume of international trade grew on average at an annual rate of 7%, although it has run on a deficit trade balance for most of the period (2.7% of the GDP on average). Likewise, according to CEPAL, the income inequality index Gini barely decreased during the whole period: on average, the index fell from 0.568 between 1991 and 1999, to 0.555 between

[1] See Escobar [2017].

2002 and 2010, and to 0.538 between 2011 and 2014.[2]

Even without studying the Gini index, such results can be explained by Acemoglu [2003], who has developed a theory to analyze the impact of the interaction between international trade (expressed as the world relative skill supply) and the relative skill supply of the country, on the Skill-Biased Technical Change (SBTC), and therefore, on wage inequality between skilled and unskilled workers. Acemoglu shows that such an impact is always positive for developed countries, while in the case of developing countries it is ambiguous, depending on their relative technology level or skill abundance compared to other country competitors.

By endogenizing SBTC in this way, the impact of international trade on wage inequality is explained by the interaction of two mechanisms in the model: the price effect and the market size effect, which make innovations more profitable to firms. The first effect corresponds to the higher relative price (in developed countries) of skill-intensive goods due to international trade increment; while the second effect refers to the clientele increase for technology or the higher relative skill supply. Therefore, the SBTC expands the supply of skill-intensive goods, thereby compensating for the price effect in the long run and keeping relatively good prices stable or letting them grow by a limited amount in the short term. In line with this theory, the first research question to be posed is: does international trade bring about more or less wage inequality in the Colombian case?

The Colombian case is interesting because, in addition to the openness policy, the government implemented almost simultaneously a labor market reform, affecting equally all formal sectors in the economy, reducing firing costs and increasing formal employees. As a consequence, temporary workers, hired either directly or indirectly through agencies, rose in importance across industrial sectors. This labor reform, together with the openness policy, led to confounding results on wage inequality. Therefore, the second research question is: what is the effect of the implementation of both policies on the skill premia in Colombia?

Another characteristic of the Colombian case is that, historically, a very small percentage of exports has corresponded to high and medium technology manufactures. Álvarez and Bermúdez [2010] calculate those percentages as 2.1% and 10.3%, respectively, for 2010. The rest of the exports were spread as follows: primary 59%, resource-based manufactures 16.3%, low technology 6.8%, and others 5.5%. Further, more than 70% of high and medium technology goods are exported to developing countries, while a similar percentage of primary, resource-based and low technology go to developed countries. This structure characterizes Colombian exports mainly as unskill-intensive goods.

More recent theories, such as the one proposed by Acemoglu and Autor [2011], explain wage inequality as a result of the interaction of workers' skills, job tasks, evolving technologies and shifting trading opportunities. Those theories explain very well the new facts of trade within the developed world, as they analyze intra-industry and intra-firm trade, offshoring and automation. Even though Colombia is not completely excluded from these new trends in international trade, still, according to the simple percentages presented

[2]See Figures 1 and 2 in the Appendix.

above, the most important pattern in trade is inter-industry. Indeed, Caicedo-Marulanda and Mora-Rodríguez [2011] calculate that only 9% of the total trade between the US (its most important trade partner) and Colombia represents intra-industry trade.

Empirically, one of the most comprehensive studies about the openness effects in Colombia is by Attanasio et al. [2004]. Using National Household Survey data, they find evidence linking tariff reductions and a small increase in wage inequality, during the period 1984-1998. Such effect is driven by three factors: the SBTC, measured as the relative skilled workers ratio, which is affected by the increased foreign competition; the negative relation between industrial wage premia and tariff cuts (as an economy-wide phenomenon instead of by sectors); and the reallocation of workers towards the informal sector before the labor flexibility reform.

This paper contributes to the empirical literature on the impact of international trade on wage inequality in developing countries by complementing Attanasio et al. [2004] in three aspects. Firstly, I present other measures of SBTC related to the technology component of the production function, whereas Attanasio et al. [2004] focus on the proportion of skilled workers. Following Haskel and Slaughter [2002], I present 4 different measures to check for the robustness of estimations of the relation of SBTC with trade, sector relative skill intensity and the share of temporary workers.

Secondly, revisiting the results of Acemoglu [2003], the SBTC in a country is a function of both its relative skill intensity and its trade integration level with respect to the world. Therefore, I adapt the empirical model in Haskel and Slaughter [2002] to include the interaction of these two variables on the sector SBTC. Additionally, to separate the confounding impacts on SBTC of trade and labor reforms, I control in the empirical model for a measure of temporary workers by sector, which relates to the effects of the labor market flexibilization.

Thirdly, I extend the analysis to the period after 2000, when the openness policy was deepened by the signing and entering into force of many new bilateral trade agreements, which probably had an acceleration effect of international trade on the SBTC. All these three contributions deliver new evidence in the Colombian context, explaining also the small impacts of the trade reform on the labor market obtained by Attanasio et al. [2004].

Summarizing, I merge the theory of Acemoglu [2003] and the empirical methodology of Haskel and Slaughter [2002] to estimate the sector-specific bias of the SBTC generated by the interaction of the skill intensity with trade integration in the context of the labor reform.

The sector skill intensity is defined as the ratio of non-production workers over production workers by sector, obtained from the Annual Manufacturing Survey, a source of information that has not been exploited before in this topic in Colombia. Trade integration is measured by various proxies, collected from different sources: traded volume by origin country and destination; changes in tariffs from their actual level with respect to the former level in 1980; and the share of exporters by subsector. Again, the idea of including these different measures is to check for robustness, as well as capturing specific impacts of trade with developed and developing countries.

The main results of the research are that the interaction of sector skill intensity with trade integration causes a decrease in the sector-specific bias of SBTC, with respect to the non-interaction specification, for sector tariff reductions and sector exporting firms. Likewise, the sector-specific bias is positive in practically all econometric models, generating wage inequality in many sectors. However, that effect is moderated when the sector skill intensity increases (fixing trade with developing countries and sector exporters) bringing about less skill premia. Furthermore, the control variable for temporary workers had negative effects on the SBTC, decreasing wage inequality and offsetting the positive effect in terms of both the rise of the sector skill intensity and trade integration.

The structure of the article is organized as follows: Section 2 discusses relevant literature in terms of the impact on SBTC of trade, relative skill demand and wage inequality; Section 3 delivers some details about the data used in the research and provides estimates to understand the issue; results of the empirical estimates are related in Section 4; and a conclusion is presented in Section 5.

1.2 Literature review

This article is based on Acemoglu [2003]. Initially, without endogenous technology, the author describes how the Heckscher-Ohlin international trade model explains the impact of international trade on increases in US wage inequality, since the price equalization generated by trade with developing countries generates an increase in both the relative skill factor and skill-intensive goods' prices. After trade openness, world wage inequality depends solely on the world relative skilled productivity. However, Acemoglu relates how many studies in the US show evidence contrary to these expected results, and the findings are summarized in four arguments: the relative prices of skill-intensive goods did not increase; there was steady skill-biased technical change during many decades;[3] similarly to the US, many developing countries also experienced increasing wage inequality; and, trade between the US and developing countries did not have significant effects on labor and product market prices.

Therefore, Acemoglu develops a model to endogenize the SBTC, allowing it to depend on international trade and domestic relative skill supply. The author extends the Heckscher-Ohlin model to include a production function with endogenous technology, following a research and development process of innovation, in accordance with Grossman and Helpman [1993] and Aghion and Howitt [1992]. He shows that international trade brings about SBTC, generating in turn an increase in the skill premia in the US as well as in developing countries (depending on their comparative technical level). All these changes occur without a rise in the relative prices of skill-intensive goods in the US in the long run. Such theoretical findings fit the evidence of increasing wage inequality and relative skill supply during the

[3] Acemoglu [2003] defines SBTC as "any change in technology that increases the aggregate demand for skills".

1980s and 1990s in the US.

On the other hand, Acemoglu and Autor [2011] outline the work of critics whose theories are based on the "canonical model" (with exogenous technology), and state that, in general, those models cannot explain several empirical facts in the US labor market.[4] In such a model, wage inequality between high and low skilled workers is shaped by the supply of skills and the technical change, which is exogenously biased towards high skilled workers. Technology is factor-augmenting change, complementing both kinds of labor. Nevertheless, empirical evidence suggests that in the nineteenth century, technical change usually replaced skilled artisans. Nowadays, offshoring, outsourcing and automation are substituting workers in some domestic tasks; likewise, in recent decades intermediate-skilled workers' wages have fallen while high skilled and low skilled occupations have risen, in favor of wage and job polarization.

While Acemoglu [2003] neither explains labor market polarization nor workers' substitution in certain activities and tasks, the theoretical structure he suggests is valid enough to describe the relation of international inter-industry trade and wage inequality between developed and developing countries at industrial sector level, explaining very well the trade relations between Colombia and its main developed trade partners. However, authors like Medina et al. [2010] have evaluated empirically the polarization theory for the Colombian case (1984-2009), as well as for Mexico (1990-200) and Brazil (1981-2001). By using task intensities related to the adoption of computer technologies, they find evidence in favor of polarization except for in the case of Brazil.

Regarding the empirical methodology of this study, I follow Haskel and Slaughter [2002] for two reasons: first, because the authors develop a general equilibrium model of Technical Change to support their empirical econometric specification, showing that the sector bias of SBTC can influence the relative factor prices, not only the factor bias. Therefore, SBTC in skilled-intensive sectors may cause positive changes in skill premia, while SBTC in unskilled-intensive sectors may cause a negative change in skill premia: this is the sector-bias hypothesis. As a result of the process to obtain the different measures of SBTC, in the first step they eliminate the influence of wage changes on the SBTC, addressing a potential endogeneity problem in the second step, and estimating the sector bias of the SBTC.

Second, this approach is favored because the econometric model Haskel and Slaughter [2002] suggest is similar to the theoretical results found by Acemoglu [2003]. The latter states that the relative productivity of skilled workers (technical change) is endogenous under the conditions of trade opening and are shaped by the interaction between domestic skill intensity and world skill intensity (or international trade). The main difference between Acemoglu's theory and Haskel-Slaughter's empirical model is that the former includes the proxy of international trade. Therefore, I propose in this research to create interaction within an empirical model between both variables, the sector skill intensity and the sector

[4] Among others, Acemoglu and Autor highlight the research of Tinbergen [1974, 1975], Welch [1973], Katz and Murphy [1992], and Card and Lemieux [2001] to introduce the "canonical model".

international trade. Additionally, I control by the effect of the labor reform using the information relating to temporary workers.

Haskel and Slaughter [2002] conclude in their research that the sector-bias hypothesis matters to explain the direction of the TC effect on relative wages. Such a result holds in a small country world-prices taker, in a multisector context, regardless of the kind of technology change. In contrast, big countries influence world prices by moving the world relative supply, causing two effects: 1) the wage direct effect, which corresponds to the sector-bias hypothesis; and 2) an indirect wage effect which may offset or reinforce the direct effect, depending on the relative world endowment of skilled labor and on technology. If the latter is small enough, the sector-bias hypothesis also holds for big countries.[5]

Haskel and Slaughter [2002] tested the hypothesis in ten OECD countries over the 1970s and 1980s, finding supporting evidence. Comparable results were found by Esposito and Stehrer [2009] for three Central and Eastern European transition countries, using a similar methodology. However, unlike Acemoglu [2003], Haskel and Slaughter [2002] do not study the influence of international trade on the SBTC (and the subsequent relation with wage inequality), as it is assumed to be exogenous.

The relation of international trade and wage inequality, as an expression of the more general topic of globalization and income inequality, has been analyzed in many countries. According to Goldberg and Pavcnik [2007], it is not possible to say that international trade has favored the less fortunate; on the contrary, there is an increase in income inequality within countries, and this is particularly high in some instances, as in the cases of Mexico or Argentina. As literature does not show evidence of labor reallocation from declining to growing sectors in the economy, Goldberg and Pavcnik [2007] state that wage effects are much larger than the employment effects.

Such wage effects are country and time-specific and, thereby, simple theoretical predictions hardly hold when considering the heterogeneity of developing countries, with their specific policies and globalization experience. Goldberg and Pavcnik [2007] argue that the lack of sectoral income reallocation is due to at least three facts: constrained labor mobility (labor market rigidities) prior to the trade reforms as well as capital market rigidities; trade barriers reductions concentrated in intermediate goods which are unskilled intensive; and the SBTC that can interact with or is induced by globalization. Likewise, the relation between industry tariff changes and probability of employment in the informal sector depends more on country labor market flexibility rather than on trade policies.[6]

Now, looking at the Colombian case specifically, most of the literature agrees there is a positive effect of exogenous SBTC, or the workers relative skill supply, on wage inequality (for instance, see Méndez and Torres [1998] and Arango-Thomas et al. [2006]).

[5]This occurs in three cases: when the world relative demand elasticity is high (the small country case), or when there is no substitutability between factors of production (as in Leontief technology), or when a non-traded sector is absorbing factor supplies from a tradable sector.

[6]In Brazil, there is no evidence regarding the impact of tariff declines on the probability of employment in the informal sector, whilst in Colombia, evidence suggests a positive impact. Such different results across the two countries seems to be related with labor market institutions, which in Brazil are much more flexible than in Colombia (before the labor flexibilization reform).

Furthermore, some authors study the impact of trade openness reform and other significant variables on skill premia, finding similar results: for instance, for the period 1976-1996, Cardenas et al. [1999] investigate occupational categories and macroeconomic variables,[7] such as private investment, public expenditure, exports, capital inflows, inflation, and currency overvaluation. All of these studies explain wages inequality as a consequence of the package-reforms implementation at the beginning of the 1990s,[8] enabling investment in skill complementary technologies within all economics sectors.[9]

In contrast, Santamaría et al. [2004], using information from the National Household Survey, for the period between 1978 and 1998, find that wage inequality is associated mainly with shifts within the relative skill labor supply and technological change; whilst international trade (especially imports) has an equalizing modest effect, as it induces an increasing demand for unskilled workers. Additionally, it is argued that unemployment growth in the 1990s reduces inequality, since the new unemployed population previously had the lowest jobs, most of the unemployed were high skilled, and firms were demanding more skilled workers. Santamaría et al. [2004] also find evidence that a higher relative skill supply grows in line with the growth in relative skill demand.

Some authors, such as Attanasio et al. [2004] and Goldberg and Pavcnik [2005], critique the typical measures of trade integration, such as imports, exports, and price indices, with the argument that trade affects wages through prices; therefore, using those variables as regressors to explain wages is controversial, because of simultaneity bias. They propose therefore a new identification strategy, exploiting information on worker's earnings, characteristics and industry affiliation from the National Household Survey and merging it with industry-level tariff changes, to explore empirically the effect of openness reform on the SBTC and wage inequality. They find that relative skilled workers (SBTC) increase in all sectors, and by more in those sectors with larger tariff reductions, suggesting SBTC endogeneity, and that trade protection increases relative skill wages. Other interesting findings are that changes in skill premia are neither correlated to changes in tariffs, nor vary across industry sectors, discouraging labor reallocation across sectors; likewise, statistics show that sectors with a larger decrease in tariffs are mainly unskilled intensive; and that informal sector expansion occurred before the labor market reform, since foreign competition drove both large and intermediate firms to reduce labor costs.

Medina et al. [2010] also critique the existing literature about the Colombian case, since the SBTC model is not able to explain two key facts of the labor market in relation to the so-called labor market polarization: the fall of middle-income workers' wages (routine tasks) and the increasing income inequality among the skilled workers (abstract task workers), alongside a stable level of inequality for unskilled workers (routine task and

[7]Occupational categories correspond to the National Household Survey definitions: private employee, public employee, self-employed, domestic service, employer, and family worker without monetary income.

[8]Among the most relevant reforms, between 1991 and 1994, authors highlight the following: average tariffs and non-tariff restrictions decrease, Free Trade Agreement with the Andean Pact, Mexico and Chile, labor market reform (1990), foreign investment reform, (1990), financial market reform (1991), exchange rate regime reform (1991) and pension system reform (1993).

[9]Robbins [2003] reports similar results, mainly for the exchange rate effect on wage inequality.

manual task workers). Hence, the authors estimate the Task-Biased Technical Change for Colombia, Mexico and Brazil, finding evidence of polarization except for in the case of Brazil. They also discover that inequality reduction within the unskilled workers, and increasing inequality with respect to skilled workers, do not offset the effects of the economic recession in 1999.

I differ from these studies in three aspects: 1) by using information from the Annual Manufacturing Survey, which has been under-used in this topic, for the period (2000-2012), giving a more recent perspective on the effects of economic reforms that were started in the 1990s. 2) Following the theoretical explanations of Acemoglu [2003] regarding SBTC endogeneity in developing countries, with respect to trade integration, I modify accordingly the methodology of Haskel and Slaughter [2002], by including into the sector bias of SBTC the interacted effect of both trade integration (or tariff reductions) and relative skill intensity over the sector wage inequality. 3) I analyze the impact of labor reform on SBTC, by controlling for sector temporary workers.

1.3 Data and stylized facts

The basic database I use in this study is built using information from two sources: the Annual Manufacturing Survey (EAM), undertaken by the National Department of Statistics [DANE], and the Administrative Records concerning destination and origin country of trade, compiled by the National Department for Tax and Customs (DIAN).[10] The database consists of 66 manufacturing subsectors for the period 2000-2012 classified according to the International Standard Industrial Classification ISIC, Adapted to Colombia version 3, at 3-digit level. During the period 1993-1999, EAM sector classification was ISIC-AC version 2, and after 2012 the EAM classification changed to ISIC-AC version 4. Therefore, obtaining a longer database requires collapsing the 66 subsectors to 29, losing detailed recent information on manufacturing subsectors. Furthermore, information on wages and workers' activities are not disaggregated during 1995-1999. All these changes in subsector classifications hinder the construction of a longer database.[11]

According to the available information in the database, I consider different variables to measure the relative skill demand and the skill premia, and also to calculate the skill-labor share of the total wage bill, employing three variables for each category, which allows for the robustness of the econometric results to be checked. Skilled workers are defined as comprising professional workers, technicians and technologists, as well as sellers and

[10] Information from DANE is available on their website, while DIAN's information was obtained from the National Department of Planning - DNP, after a direct request to the Directorate of Innovation and Business Development - DIDE. This information is also used in Cortés-Villafradez and Hernández-Luna [2013].

[11] Despite the mentioned difficulties in constructing a longer database, I built a preliminary database for the period 1993-2012 and applied the methodology suggested in this paper, finding similar results. However, estimates with data for such a period are not directly comparable with a shorter dataset (2000-2012), as differences in periods of time and in the number of subsectors should reflect different adjustment mechanisms to trade shocks. Furthermore, results can be affected by different sector aggregation levels. Therefore results for the long databases are not presented.

administrative staff, while unskilled correspond to laborers and production workers. Such categories can be disaggregated by the kind of labor contract, Permanent (Perm or Pe), Temporary (Te or Temp) and Agency (agen or ag). The three variables I use in estimations to proxy labor are: Total Occupied Personnel (Pr), which comprises all workers with or without fixed remuneration; Permanent workers only; and an aggregation of Permanent, Temporary and Agency workers (Pe-te-ag).

Similarly, I present three definitions of wages: Total Wages, Salaries and Social Security (Pr) for Total Occupied Personnel except agency workers; Wages and Salaries (W-S) of permanent workers only; and Wages and Social Security for permanent, temporary and agency workers (W-SC).

Table 1 reports the descriptive statistics of the variables used in this study. Although it covers a relatively short period of time, the database allows for more sector variations which is more productive for an analysis of the sector bias hypothesis.

Table 1.1: Descriptive statistics. 2000-2012 (real variables in COP prices of 1999 and thousands)

Variable	Obs	Mean	Std.Dev.	Min	Max
Sk wage Pr	748	13,908	5,446	5,898	40,881
Uk wage Pr	748	6,184	3,657	1,648	25,726
Tot wage Pr	748	8,875	4,440	3,083	30,956
Sk wage Perm	748	12,316	3,977	4,491	36,459
Uk wage Perm	748	5,993	2,256	2,962	14,220
Tot wage Perm	748	18,309	5,890	7,636	42,935
Sk wage Pe-te-ag	748	5,933	2,855	1,553	26,270
Uk wage Pe-te-ag	748	4,372	2,125	1,128	17,000
Tot wage Pe-te-ag	748	10,305	4,816	3,147	37,702
Assets*	748	9,722	18,000	211	142,000
Production*	748	16,300	32,100	509	312,000
Sk Perm	748	2,661	3,518	21	27,015
Uk Perm	748	3,471	3,833	25	22,318
Tot Perm	748	6,132	6,960	47	41,415
Sk temp	748	495	785	0	5,248
Uk temp	748	1,418	3,058	0	25,995
Tot temp	748	1,913	3,751	0	30,727
Sk agen	748	573	985	0	7,402
Uk agen	748	1,779	2,622	0	21,943
Tot agen	748	2,352	3,357	0	25,210
Sk Pr	748	3,849	5,173	23	38,837
Uk Pr	748	6,730	8,837	94	67,858
Tot Pr	748	10,579	13,189	118	86,511

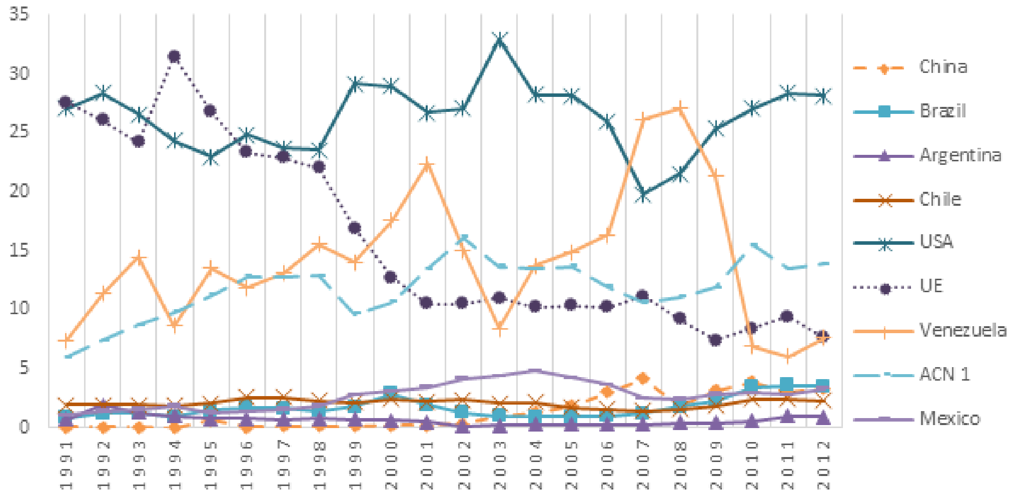
Source: Own calculations. Based on DIAN and DANE. *Million COP.
Notes: all wages in per worker averages and assets and production in per firm averages. Sk: skilled, Uk:unskilled, Tot: total, Pr: total occupied personnel (except agency in the case of wages), Perm: permanent workers, Pe-te-ag: permanent, temporary and agency workers, agen: agency workers.

Regarding information on exports and imports, I divide the total trade by manufacturing subsector into imports and exports by country of origin and destination. Figures 1 and 2 show the most important trade partners of Colombia: in particular, the United States, the European Union, China, Venezuela and the Andean Community of Nations stand out. Furthermore, these partners are classified as either Developed Countries (DC) or Less Developed Countries (LDC).[12] The US and the EU are classified as DC, while Venezuela,

[12] According to Acemoglu [2003], all developing countries have the same technology level; they may differ only in terms of relative skill abundance. I chose GDP per capita as a proxy of this variable, which allows for better classification of countries as DC and LDC groups. See Table 1 in the Appendix.

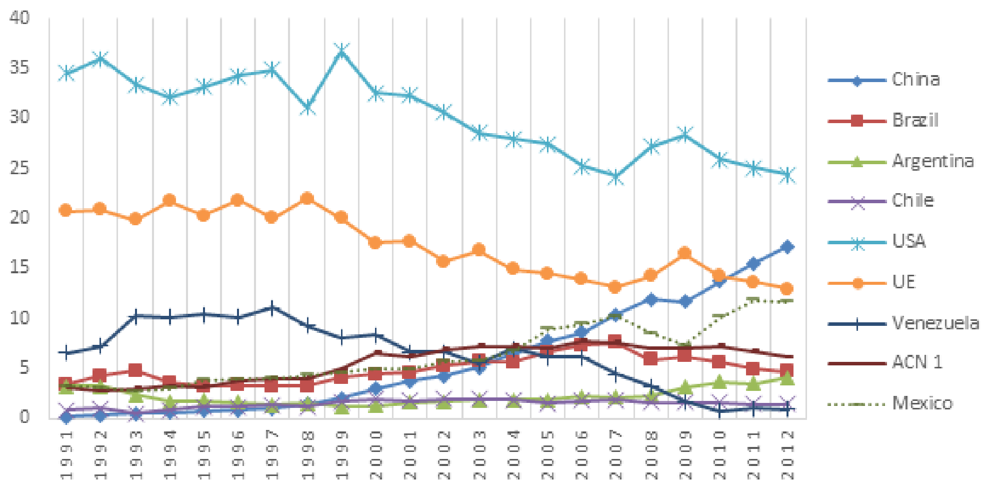
the Andean Community of Nations, and China are shown as LDC.

Figure 1.1: Share of manufacturing exports, 1991 - 2012. Colombia trade partners



Source: DIAN (Administrative records). Own calculations.
Note: 1 Andean Community of Nations (Ecuador, Peru, Bolivia, Colombia).

Figure 1.2: Share of manufacturing exports, 1991 - 2012. Colombia trade partners



Source: DIAN (Administrative records). Own calculations.
Note: 1 Andean Community of Nations (Ecuador, Peru, Bolivia, Colombia).

As stylized fact, I estimate the skill-biased wage gap, namely, the effect of the sector relative skill intensity on the real sector average wage, following Boeri and van Ours [2013]. The results of this exercise show some useful correlations to be understood and interpreted later, alongside the findings from the analysis of the sector-specific bias of SBTC in the next section. Details of the methodology and estimates are presented in section one of the Appendix.

I highlight four stylized facts observed in Table A1 in the Appendix. First, there exists a positive and significant average wage gap, around 17% - 20%, between the most skill intensive and the less skill-intensive sectors (depending on the trade integration variable used in the regression). Such evidence is consistent with the hypothesis of sector bias of SBTC, according to which, the more technologically advanced the sector, the higher the skill premia. However, it is still necessary in the next section to explore the causality of trade integration and skill intensity on this observed fact regarding the wage gap.

It is possible to establish other relations looking at the elasticities in Table A1. Second, as expected, sector average assets are significant and have a positive impact on sector average wages, as soon as the former variable can be an indicator of the economic performance and productivity of the sector. Third, the quantity of permanent workers by sector has a significant and positive effect on the sector average wage, while temporary and especially agency workers have a negative impact. Such a result illustrates the correlation between the kind of labor contract and labor costs by sector, with permanent contracts being more expensive than temporary and agency ones.

Fourth, among the different measures of trade integration, total trade with Developed Countries, as well as imports and exports separately, and exports to Less Developed Countries and number of exporters by sector are positive and significant, though the magnitude of elasticities are very low. Conversely, total trade with Less Developed Countries, as well as imports, and tariff changes, are not significant. This interesting set of results shows that it is probable that different measures of trade, other than tariff changes, may overestimate the impact of trade integration on sector average wages, as has been explained by Goldberg and Pavcnik [2005].

1.4 Empirical Methodology

In this section, I link the estimation process suggested by Haskel and Slaughter [2002] and Esposito and Stehrer [2009] with the theory outlined by Acemoglu [2003]. This is achieved by including into the empirical methodology the interaction effect between sector skill intensity and trade integration on the SBTC, while controlling for the sector's share of temporary workers, while also considering the effect of labor flexibilization policy, and then, analyzing the relation of the SBTC"s sector-specific bias with wage inequality.

Firstly, I obtain different measures of SBTC based on an estimation of the next expression:[13]

$$\Delta\omega_{jt} = a_0 + a_1\Delta\log\frac{W_{jst}}{W_{jut}} + a_2\Delta\log\frac{K_{jt}}{Y_{jt}} + \varepsilon_{jt} \tag{1.1}$$

In which $\omega_{jt} = \frac{W_{jst}S_{jt}}{W_{jst}S_{jt}+W_{jut}U_{jt}}$ is the skill-labor share of the total wage bill, and $\Delta\omega_{jt}$ represents its level change. W_{jst}/W_{jut} denotes the wage skill premia for skilled with respect to unskilled in sector j and time t. Y represents production and K capital, and ε the error term, while a_0 corresponds to the cross-sector SBTC average and $a_0+\varepsilon_{jt}$ are interpreted as SBTC sectoral distribution. Hence, variations in relative wage bill that are not explained by

[13]This expression comes from Binswanger [1974] and Berndt and Wood [1981], who assume that sectors minimize labor costs using a translog production function with constant returns to scale and quasi-fixed capital.

sector skill premia and the ratio of capital are attributed to SBTC.[14] a_1 can be positive or negative depending on whether the elasticity of substitution between skilled and unskilled workers is below or above one. a_2 represents capital skill complementarity.

Besides the measure of SBTC derived from equation (1), in a similar approach to the authors of the expression, I suggest four additional definitions to provide robustness checks: a) excluding the skill premia to avoid non-observed skill-mix variations in the regression, then, the SBTC is defined as the error term and the wage effect common to all sectors is captured by the constant coefficient; b) again, skill premia is discarded, and sector fixed effects and time dummies are included, while SBTC is still measured as the error term; c) I instrument the skill premia with explanatory variables of the skill mix, such as experience, experience squared, age and sex, where in this specification SBTC is the constant plus the error term;[15] and d) I simply use the skill-labor share of the total wage bill measure ω_{jt}.

Secondly, I use the different measures of SBTC to estimate equations (2) to (4) outlined below, in which S_{jt}/U_{jt} represents the skill intensity, showing skilled over unskilled workers in sector j and time t, TI_{jt} corresponds to the Trade Integration variable, and $temp_{jt}$ is the share of temporary workers (direct + agency) over total workers (direct + agency + permanent):

$$SBTC_{jt} = b_0 + b_1 \frac{S_{jt}}{U_{jt}} + \upsilon_{jt} \tag{1.2}$$

$$SBTC_{jt} = c_0 + c_1 \left(\frac{S_{jt}}{U_{jt}} * TI_{jt} \right) + c_2 \frac{temp_{jt}}{tot_{jt}} + \upsilon_{jt} \tag{1.3}$$

$$SBTC_{jt} = d_0 + d_1 \left(\frac{S_{jt}}{U_{jt}} * TI_{jt} \right) + d_2 \frac{S_{jt}}{U_{jt}} + d_3 TI_{jt} + d_4 \frac{temp_{jt}}{tot_{jt}} + \upsilon_{jt} \tag{1.4}$$

Computing the derivative of the sector SBTC with respect to the sector skill intensity (or relative skill demand), we obtain b_1, which is interpreted as the sector bias of the SBTC.[16] According to the sector bias hypothesis, positive values of b_1 should be associated with positive changes (rise) in skill premia, while negative b_1 should correspond to negative changes (fall) in skill premia.

Inclusion of the second term in equations (3) and (4) is supported theoretically by Acemoglu [2003], who concludes in his model that endogenous technology causes an interaction between the relative skill intensity and trade integration, shaping changes in the SBTC and therefore in the skill premia. The reason is that increases in the relative skilled workers supply induces SBTC, bringing about a rise in the relative skill demand; this is *the market size effect.* Such effect is reinforced in a free trade framework, because

[14] SBTC, when estimated in this way, allows us to obtain a reliable index free of the sector skill premia, and capital and production influence, which should avoid potential endogeneity problems in the second step of the methodology.

[15] These variables are available in the Colombian Household Survey conducted by DANE. I acknowledge Tenjo et al. [2017] for generously sharing this data with me.

[16] Haskel and Slaughter [2002] follow Lawrence et al. [1993] to define equation (3). The latter estimate a similar expression to find the sector bias of product-price changes.

the increasing *price effect* of the exporting products correspondingly increases the relative skilled demand as well. Trade always increases wage inequality in developed countries, but the effect in developing countries depends on their relative technology level with respect to other developing countries.

I control in equations (3) and (4) for the effect of share of temporary workers on the SBTC, both direct and agency, in the third and fifth terms respectively. With the objective to reduce firing costs and increase workers' turnover, the labor market flexibilization reform in 1990 introduced two important changes regarding temporary workers: a) the duration of fixed term contracts changed from a minimum of a year to any duration less than that; and b) the creation of agency labor, or indirect temporary work.[17] Goldberg and Pavcnik [2007] highlight the relevance of these kinds of institutional changes, demonstrating that tariff reductions had a significant effect on informal jobs in Colombia before the labor reform, while in Brazil, where labor market is flexible, there was no impact. Indeed, temporary workers are skilled or unskilled, and in either case cheaper than permanent staff, while also having negative effects on firms' performance and on SBTC, as I show for the Colombian case.[18]

Therefore, controlling for the effects of the labor reform is relevant in this model, to avoid problems of consistency, or biased estimated parameters or even endogeneity for omitted variables, since the share of temporary workers may affect simultaneously SBTC, together with the interaction of skill intensity and trade integration. By including the two regressors in the model I assume to find some degree of correlation between them, though not a linear relationship to an exact or extreme degree. Equation (4) extends the econometric model and measures the effect of each interacted variable separately.

While coefficient b_1 in equation (2) represents the sector bias of the SBTC across sectors, derivatives of SBTC with respect to the sector skill intensity and trade integration are sector and time specific in equations (3) and (4):

In equation (3):

$$\frac{\partial SBTC_{jt}}{\partial (S_{jt}/U_{jt})} = c_1 TI_{jt} \tag{1.5}$$

and

$$\frac{\partial SBTC_{jt}}{\partial (TI_{jt}/U_{jt})} = c_1 \frac{S_{jt}}{U_{jt}} \tag{1.6}$$

In equation (4):

$$\frac{\partial SBTC_{jt}}{\partial (S_{jt}/U_{jt})} = d_1 TI_{jt} + d_2 \tag{1.7}$$

and

$$\frac{\partial SBTC_{jt}}{\partial (TI_{jt}/U_{jt})} = d_1 \frac{S_{jt}}{U_{jt}} + d_3 \tag{1.8}$$

[17]For details on the labor market reform, see Kugler [1999].
[18]For a discussion on the effect of nonstandard employment in firm performance, see ILO [2016].

According to Goldberg and Pavcnik [2007], one of the main drawbacks of the empirical literature on the relation between trade integration (typically measured with international trade) and inequality, is that international trade is an endogenous variable (because of potential simultaneous causality), therefore it is not useful to explain wage inequality. To avoid this issue, I consider the trade integration variable as the change in tariffs in time t and sector j, with respect to the former level in 1980, before the tariff reform, following Attanasio et al. [2004] and Goldberg and Pavcnik [2005].[19]

Likewise, I evaluate trade integration using the number of exporting firms by ISIC sector, for the period 2007-2012, using the Exporter Dynamics Database from the World Bank. I evaluate as well the effect of trade with developing and developed countries, whilst taking into consideration that I am not regressing trade integration against wage inequality and that I can compare the results with other measures of trade to assess the possible bias. Those alternative measures for trade integration allow for the capture of different effects on the sector-specific bias of SBTC and the ability to check for robustness of the results.

Tables 3 and 4 in section two of the Appendix present descriptive statistics of the variables. Table 3 shows the average of the relative exports (exports/imports) by developing (Ldc) and developed countries (Dc) by sector, as well as the annual percentage change. Table 3 also displays the trade integration variables I am studying: tariff reductions in 2000 and 2012 with respect to the 1980 levels,[20] as well as the average reduction for the whole period, average exporters and their annual change by sector, and average share of trade with developing (shtradeldc) and developed (shtradedc) countries, alongside the level of change in those shares within the period.

Some relevant facts can be observed in Tables 3 and 4 in the Appendix. For instance, on average, 60% of the sectors have a positive balance trade with developing countries, whilst, with respect to developed countries, the percentage decreases to 38%. Most of the sectors (83%) have a decreasing trend in the relative exports towards developing countries, while 57% have the same trend towards developed countries. Likewise, on average, tariffs have decreased by 20 percentage points, with a standard deviation of 13 percentage points. There is also an important variation in exporters across sectors, and a decreasing trend during the whole period (2007-2012) at an average annual rate of 2.7%; only 30% of the sectors show a positive trend. Regarding the share of total trade with developing and developed countries, we can observe that 67% and 19% of the sectors, respectively, experience a positive change during the period 2000-2012.

Table 4 summarizes the average skill premia measured with the three variables of wages - Pr total occupied personnel except agency, wages and salaries WS, and wages and social security W-SC - as well as the annual percentage change within the respective period.

[19] I thank the authors for kindly and generously sharing information on the sector average nominal tariffs of 1980, at 3-digit CIIU. That data was collected by the National Department of Planning (DNP). The tariffs between 1993-2012 come from the World-Bank and correspond to the MFN applied tariffs at 3-digit ISIC.

[20] Changes in tariffs correspond to the difference between the 1980 tariff level with respect to the actual level of tariff.

Taking the simple average across sectors, we find that the Pr variable (2.52) is 52% bigger than WS (1.66) and 90% bigger than W-SC (1.39). The sectors experiencing a positive annual percentage change within the period are similar for the Pr (29) and W-SC (27) categories, while in 50 sectors (out of 58) WS increases. These statistics suggest that the increase in skill premia in the period 2000-2012 was mainly among permanent workers.

The skill intensity variable (or in this case, the relative skill demand) is again measured by the (Pr) total occupied personnel variable, permanent workers (Perm) and the sum of permanent, temporary and agency (Pe-Te-Ag), and they have almost the same average at 0.6 across sectors, except for Perm (0.78). There is also an increasing trend in most of the variables across the whole period, corresponding to 74%, 82% and 67% of the 58 sectors, respectively.

Unlike the skill premia, which presents relatively high variability between the wages variables, the skill-labor share of the total wage bill (Sh-tot-wb) average, across the sectors, is stable: the results are 0.55, 0.59 and 0.41 for Pr, the W-S and the W-SC, respectively. Likewise, there is a positive trend in most of the sectors as well, amounting to 79% for Pr, 86% for W-S and 62% for W-SC. Following Haskel and Slaughter (2002), the variability in the sector Sh-tot-wb illustrates the changes in the SBTC.

Regarding the econometric model, I follow Roodman [2009], who states that the System Generalized Method of Moments delivers an estimator designed for panels of few T periods and many N individuals, with not strictly exogenous independent variables, fixed effects, heteroskedasticity and autocorrelation. In the case of equation (1), as both dependent and independent variables are expressed in first differences, fixed effects is not a major concern.[21] However, serial correlation tests show evidence of correlation in different specifications of equation (1), while all of them present heteroskedasticity. Similarly, all specifications of equations (2) to (4) show evidence of fixed effects and heteroskedasticity, while there is no evidence of serial correlation.

Even though the Haskel and Slaughter [2002] methodology may isolate the SBTC component of the wage bill in equation (1), the empirical model and the variables used in estimations can still be affected by potential endogeneity, since I am including variables of wages and quantity of workers; therefore, despite the theoretical support of equation (1), I prefer to use the Arellano-Bond estimator to address the possibility of endogeneity. Likewise, there is a similar concern with equations (2) to (4) since the econometric models also use data on quantity of workers, consider the error term obtained from equation (1) and include as a control variable the share of temporary workers. Therefore, I use the Arellano-Bond estimator in all specifications in the 4 equations, which allows to correct for the issues mentioned above and also potential endogeneity between the dependent and

[21] These fixed effects can be for instance the impact of the exchange rate or the international oil prices on the sector skill premia, the skill intensity, or even on the sector SBTC. Though the Arellano-Bond estimator is useful to obtain reliable estimates by including lags of the dependent variables as control, and a set of instrumental variables obtained from the independent variables, it is important to take into account that such specific effects do not change significantly across the period, which coincides with the time of the oil boom.

independent variables, and compare results across the different estimates.[22]

Another concern with regard to including the share of temporary workers in equations (3) and (4) is that such a variable can be strongly correlated with the sector skill intensity, or more probably with the trade integration variable. Indeed, a sector that is more exposed to international competition would hire more temporary workers in order to decrease labor costs and survive. According to Wooldridge [2009], estimates could be biased if perfect collinearity exists, namely, when any independent variable is constant or when exact linear relationships exist among them. Following the author, to evaluate this issue I regressed the different measures of trade integration, as well as the measures of sector skill intensity, against the share of temporary workers, finding in all cases significant parameters in favor of including this variable as a control in equations (3) and (4) and an R-square less than 0.1, a level that is too low to be evidence of perfect collinearity.

1.4.1 Estimate of Equation (1) to obtain the SBTC

Table 2 shows the estimates of equation (1), in which only the better specifications are included. The specification using the skill-mix instrument variables (sex, experience and education) to explain the wage premia is not good, since the *goodness of fit*, measured by the R-squared, is very low, and the instrument variables in general do not pass validity and identification tests. The specification discarding the skill premia but including time and sector dummies is not included, because the latter variables were not significant, according to the Hausman test. This fact about time effects can be explained by Figure 3 in the Appendix, where we observe that employment in the manufacturing sector barely changed during 1990 and 2014, especially if compared to the situation in agriculture and services, which in contrast was significantly affected by the recession in 1999.

Coefficients of the different measures of wage premia are significant and show the expected positive sign, as we observe in Table 2. The results generated in the table are necessary in order to calculate two of the three remaining measures of the SBTC: the first measure corresponds to the error terms plus the constant terms ($a_0 + \varepsilon_{jt}$) in columns 1-3, the second measue is denoted by the error terms (ε_{jt}) in columns 4-6 of Table 4, and the third is simply the first difference of the skill share of the total wage bill (ω_{jt}). Those measures are used as dependent variables in equations (2) to (4).

[22]Typically the Arellano-Bond estimator is used in dynamic specifications with the lagged dependent variable in the right-hand side of the econometric model. However, Roodman [2009] states that this estimator is designed for general use, being Ordinary Least Squares and Two Stage Least Squares special cases of the linear General Method of Moments (the process implemented in the estimator); therefore, it uses internal instruments in the database to address for endogeneity. When no instruments are declared, the estimation uses variables in levels. Particularly, estimations of equations (1) to (4) were made with the command xtabond in Stata with the option of robust standard errors, from which I obtain asymptotically efficient estimates.

Table 1.2: Estimate Equation 1, 2000-2012

Dep. Variable	(1) D.wage bill Pr	(2) D.wage bill W-S	(3) D.wage bill W-SC	(4) D.wage bill Pr	(5) D.wage bill W-S	(6) D.wage bill W-SC
D.ln(Capital/Prodbr)	0.02903*	-0.00557	0.03235*	0.03485	0.01288	0.03439*
	(2.064)	(-0.991)	(2.219)	(1.875)	(0.837)	(2.173)
D.ln(av sk premia Pr)	0.15460***					
	(5.456)					
D.ln(av sk premia W-S)		0.21540***				
		(17.281)				
D.ln(av sk premia W-SC)			0.19759***			
			(7.439)			
Constant	0.00538**	0.00038	0.00408**	0.00587**	0.00732***	0.00435*
	(3.225)	(1.102)	(2.822)	(2.858)	(3.755)	(2.120)
Obs	571	571	571	571	571	571
RSS	1.883	0.107	2.05	2.434	2.425	3.079

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
Source: own calculations based on DANE and DIAN data.
Arellano-Bond Estimation with robust standard errors. RSS: Residual sum of squares. Variables in first difference. Lagged variables not included.
Notes: t-statistics in brackets. av: average, sk: skill, Prodbr: gross production, Pr: total occupied personnel (except agency in the case of wages), W-S: wages and salaries of permanent workers, W-SC: wages and social security of permanent, temporary and agency workers.

1.4.2 Estimate of Equation (2) to obtain the sector bias of the SBTC

Columns in Table 3 relate the measures of the SBTC obtained from estimation of equation (1), according to the different measures of wage bill. Interestingly, all the significant b_1 coefficients are positive, and the magnitude of the bias is very similar for each category of workers, providing evidence that the results are robust to the different measures of SBTC. This result means that the sector skill intensity has a positive impact on the SBTC, shaping in turn the higher skill premia.

Likewise, it can be noted that the magnitude of the sector bias, when considering the sector skill intensity within permanent workers only, is smaller with respect to the other two categories. Such a result means that permanent workers have a smaller impact on the sector SBTC and therefore on the sector wage inequality; namely, wages are slightly better distributed between permanent workers than in the other categories of workers.

1.4.3 Estimate of Equations (3) and (4) sector skill intensity and trade integration

Tables (5) and (6) in the Appendix show the significant estimates of the equations. The titles of the columns relate to the SBTC measure and include the interacted trade integration variable. Initially, we can compare the coefficients obtained by estimations of equations (3) and (4) with those of equation (2). The results are all positive and very similar in the case of the interaction of tariff decreases with the different measures of skill intensity. However, the magnitude of coefficients falls noticeably, giving evidence that this interaction decreases the impact of the sector skill intensity on the SBTC; the coefficient is still significant though smaller, and even more so for interaction with permanent workers.

Coefficients of interactions of trade with developing and developed countries in equation (3) are all higher than equation (2) and bear a similarity between each other. On average,

Table 1.3: SLS Estimate of equation 2. 2000-2012

Dep Var	(1) SBTC(1)	(2) SBTC(2)	(3) SBTC(3)	(4) SBTC(4)	(5) SBTC(5)	(6) SBTC(6)	(7) D.wage bill Pr	(8) D.wage bill W-S	(9) D.wage bill W-SC
Skill Int Pr	0.15659***			0.15781***			0.16191***		
	(4.047)			(4.679)			(4.859)		
Skill Int Perm		-0.01325			0.13068***			0.13299***	
		(-0.908)			(4.398)			(4.923)	
Skill Int Pe-te-ag			0.16210***			0.15040**			0.15881***
			(3.644)			(3.219)			(3.667)
Constant	-0.09101***	0.01091	-0.09259***	-0.09849***	-0.10710***	-0.08979***	-0.09430***	-0.10002***	-0.09147***
	(-4.764)	(0.913)	(-4.145)	(-6.089)	(-4.743)	(-3.471)	(-6.167)	(-5.085)	(-3.971)
Obs	513	513	513	513	513	513	571	571	571
RSS	1.035	0.065	1.051	1.648	1.553	2.170	1.861	1.772	2.414

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ Source: own calculations based on DANE and DIAN data. Arellano-Bond Estimation with robust standard errors. Lagged variables not reported. SBTC(1) to SBTC(6) are estimated from models (1) to (6) in Table 2. D: first difference. Notes: t-statistics in brackets. skill int: skill intensity, Pr: total occupied personnel (except agency in the case of wages), W-SC: wages and social security of permanent, Perm: Permanent workers, Pe-te-ag: temporary and agency workers.

the effect of trade with developing countries is slightly higher for the whole category of workers, except for the permanent group, which actually increases the interaction effect when trading with developed countries.[23]

In the case of quantity of exporters per sector (in logs) when interacted with the skill intensity, I find a significant effect on the sector SBTC, and its magnitude is in the middle of the tariffs change and trade variables, evidence of the relevance of the sector to explain the SBTC. It can be noted also that when skill intensity and the trade integration variable are included separately in equation (3), the estimated results in table (6) show that the only significant trade variable is sector exporters, together with the sector skill intensity of permanent workers and the interaction of both. The shorter period of time for sector exporters makes it difficult to compare the results from equations (2) and (3). Indeed, although there is a positive effect of skill intensity within permanent workers on SBTC, the result becomes negative when interacted with sector exporters.[24]

According to these new specifications, it is suggested that the sector-specific bias of SBTC depends on sector and time. Hence, following the derivatives obtained above (expressions (5) to (8)), the sign of the effect of trade integration or skill intensity on the SBTC is determined by the coefficients in equations (3) and (4), but, the magnitude of the effect of trade integration or skill intensity on the SBTC depends on the sector average values of those variables. Taking averages during the respective periods of these variables, from Tables (3) and (4) in the Appendix, to compute derivatives, I find that for the whole manufacturing sector (on average), in both periods, the bias decreases, except for the exporters variable, which increases the effect on the SBTC.

Regarding the control variable included in the equations, I find significant and negative coefficients, fluctuating in a similar degree when trade is measured as the change in tariffs, providing evidence that the labor reform was mainly unskilled biased, counterbalancing the positive impact of trade integration on wage inequality. This effect becomes ambiguous when considering the trade with developed and less developed countries. For some measures of the SBTC the effect of share of temporary workers is not significant or even positive in the case of trade with developed countries, suggesting that labor flexibilization could reinforce the wage inequality in sectors more open towards developed countries than in those more open towards developing countries.

1.4.4 Wage inequality and sector-specific bias of SBTC

In the previous section I estimated the parameters describing the relation between the sector SBTC, and both the sector skill intensity and the sector level of trade integration. Now, it is possible to compute the elasticities of equations (5) to (8) and compare them with the annual average changes of the skill premia, from Tables 3 and 4 in the Appendix.

[23]These results can be affected by the endogeneity of the trade variable, which may increase the effect on the SBTC, in comparison with the other measures of trade integration.

[24]I estimate equations (3) and (4) without the control variable of temporary workers, finding very similar coefficients to Tables (5) and (6) in the Appendix.

Given that almost every bias is positive, following the theory we should expect accordingly only positive changes in the skill premia.[25] Even though this is not always the case, we can see that this condition holds for many of the sectors, and that, in general, there is a positive correlation between the two variables across most of the definitions of SBTC and skill premia. Figures 4 to 10 in the Appendix show these relations.

The pattern of the relation between the sector bias of SBTC shaped by trade integration, in the presence of skill intensity and with respect to the change in skill premia (Figures 4, 5 and 6 in the Appendix), is very similar regardless of the definition of trade, the SBTC, or the skill premia. There is a positive correlation and most of the sectors are in the positive axis of the plane.

The correlation of the sector bias of SBTC shaped by the Skill Intensity, in the presence of trade integration and the change in skill premia, is more heterogeneous (Figures 7, 8, and 9 in the Appendix). The correlation is negative when skill intensity interacts with trade with developing countries, and with exporters by sector, suggesting that this positive sector bias shapes less wage inequality. When there is interaction with tariff reductions or trade with developed countries, the correlation is positive or near to zero.

The relation obtained from equation 4 (Figure 10 in the Appendix), suggests that the impact of including the exporters variable, separately from the interaction, produces a negative correlation between the sector-specific bias and the skill premia, while the derivative of SBTC with respect to the skill premia (interacted with exporters too) does not alter the correlation to a significant degree.

1.5 Conclusion

The Colombian manufacturing sector has experienced important changes since the openness policy was introduced in 1990 and during the deepening of the policy with new bilateral trade agreements signed after 2000. I estimate the skill bias wage gap in this second phase of the opening policy, finding that in sectors with relatively more skilled workers, between 2000-2012, the real average wage gap is around 17%-20% higher than in less skill-intensive sectors. Indeed, during the 2000s, 87.5% of the manufacturing sectors increase international trade with developed countries, while only 8.3% increase trade with developing countries.

Likewise, the creation of agency workers in 1990 and the introduction of labor costs flexibilization to hire direct temporary workers resulted in a decrease in the real average wage after the 2000s, in which the increasing trade with developed countries would force firms to rise the share of temporary workers to increase competitiveness and survive in the market. This policy has had negative effects on the SBTC, decreasing, in turn, wage inequality between skilled and unskilled workers, and counterbalancing the positive effect of interaction between sector skill intensity and trade integration.

[25] As mentioned in the literature review, Acemoglu [2003] offers a theoretical explanation for the sectors with negative skill premia changes and positive sector-specific bias of SBTC, according to which, technological level differences across sectors (or countries) would produce less wage inequality in those which are less advanced and more inequality in those which are more advanced.

Even though the magnitude of the impact of sector skill intensity on SBTC is alone very important, the impact decreases when interacting with tariff reduction across the sectors, or exporting firms, while it barely changes when interacting with international trade with developed and developing countries. Likewise, most of the sector bias of SBTC is positive, either after changes in trade integration or the sector skill intensity, which corresponds to positive changes on wage inequality in many manufacturing sectors. Nevertheless, I highlight some negative correlations between the sector-specific bias and changes of skill premia; for instance, trade with developing countries, and quantity of exporters by sector, tend to shape less wage inequality when the sector skill intensity increases.

The estimates presented in this paper can be refined in different ways, in terms of the measure of SBTC, which has been controversial because of endogeneity. For future research, it remains the empirical explanation in terms of providing the evidence of negative skill premia changes and positive sector-specific bias, which could be related to technological heterogeneity across manufacturing sectors.

1.A Appendix chapter 1

1.A.1 Estimating the average wage gap

Following the methodology of Boeri and van Ours [2013], originally used to estimate the so-called union wage gap, I adapt the econometric method to estimate the *skill bias wage gap*. The model is as follows:

$$\log(\overline{W}_{st}) = \alpha D_{st} + X'_{st}\gamma + \varepsilon_{st} \tag{1.9}$$

where D_{st} is a dummy variable equal to 1 when the sector is relatively more skilled intensive, measured as the ratio of skilled workers over unskilled workers, i.e. if the sector relative skill intensity is higher than the total (annual) average across subsectors of 0.57, corresponding to 29 subsectors out of 67. X'_{st} is a matrix of specific characteristics affecting a sector's real average wage. In this case the matrix includes sector real average assets, sector real average production, sector average permanent, temporary and agency workers, as well as several measures of trade integration: total trade with Developed and Less Developed Countries, imports and exports with Developed and Less Developed Countries, change in actual tariffs with respect to 1980 levels, and the number of exporters by sector. $\hat{\alpha}$ represents the skill intensity sector's average wage gap, such that $\hat{\alpha} = log(\overline{w}^{HA}) - log(\overline{w}^{LA}) \approx \frac{\overline{w}^{HA} - \overline{w}^{LA}}{\overline{w}^{LA}}$ where $\overline{w}^{HA}$ and $\overline{w}^{LA}$ represent the average wage of the skilled intensive sector (H) and the less skilled intensive sector (L). Table A1 presents the coefficients obtained by OLS.

Table A.1: Skill sector wage gap, 2000-2012. OLS (real variables)

Dep Var: ln(real av wage)	(1)	(2)	(3)	(4)
Dummy skill intensity	0.19237***	0.17569***	0.20160***	0.16900***
	(12.686)	(8.923)	(12.466)	(6.616)
Ln(real av assets)	0.11068***	0.10406***	0.10984***	0.06136**
	(7.318)	(6.505)	(7.569)	(2.779)
Ln(real av production)	0.07653***	0.09708***	0.07758***	0.14502***
	(4.524)	(5.585)	(4.746)	(6.865)
Ln(Perm)	0.13433***	0.19386***	0.12261***	0.24976***
	(8.288)	(10.846)	(7.554)	(9.838)
Ln(Temp)	-0.02477*	-0.03079*	-0.02355*	-0.02578
	(-2.225)	(-2.555)	(-2.136)	(-1.586)
Ln(Agen)	-0.13835***	-0.15511***	-0.13999***	-0.26183***
	(-11.761)	(-10.406)	(-12.033)	(-11.161)
Ln(trade dc)	0.03476***			
	(5.590)			
Ln(trade ldc)	0.01438			
	(1.684)			
Tariff change		-0.00158		
		(-1.872)		
Ln(imports dc)			0.02583***	
			(5.057)	
Ln(exports dc)			0.00826*	
			(1.994)	
Ln(imports ldc)			-0.00717	
			(-1.278)	
Ln(exports ldc)			0.02699***	
			(3.497)	
Ln(exporters)				0.05318***
				(4.653)
Constant	5.22324***	5.63282***	5.29104***	5.43735***
	(46.391)	(37.570)	(45.026)	(27.530)
Obs	720	604	708	273
R2	0.823	0.781	0.829	0.789
F	208.408	154.166	197.023	178.527

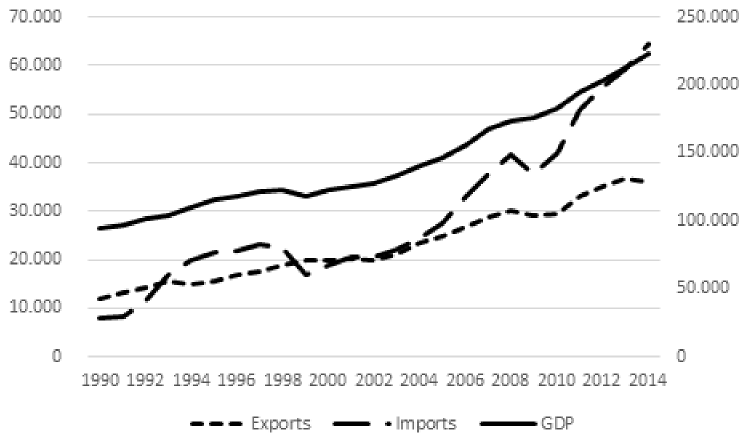
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Own calculations. Based on DIAN, DANE and the World Bank data.

Notes: t-statistics in brackets, av: average, Pr: total occupied personnel (except agency in the case of wages), Perm: permanent workers, Temp: temporary workers, Agen: agency workers, dc: developed countries, ldc: developing countries, tariff change with respect to 1980 level. Sector 314 is not included in tables and it is discarded of estimations because data for most of the variables was very scarce. Sector 353 is merged with sector 354 and and sector 361 is merged with sectors 362 and 369. Time dummies not reported.

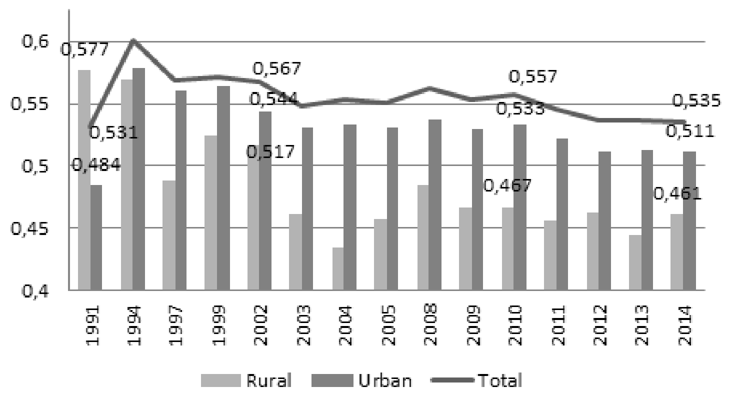
1.A.2 Figures and tables

Figure A.1: GDP at market prices, imports and exports of goods and services, 1990-2014. (constant 2005 Million USD)



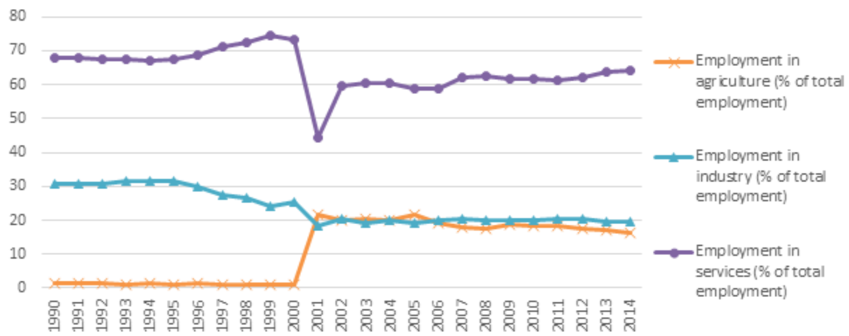
Source: World Bank.

Figure A.2: Gini index by geographic area. Colombia, 1991-2014



Notes: "From 2002 on, the income figures are not comparable with those of earlier years, owing to the application of new methodological criteria developed by the National Administrative Department of Statistics (DANE) and the National Planning Department (DNP) in the framework of the Mission for the splicing of employment, poverty and inequality series (MESEP)". Source: CEPAL CEPALSTAT.

Figure A.3: % of total employment in Colombia, by sector. 1990-2014



Source: World Bank.

Table A.2: Most important Colombian trade partners, GDP per capita. Constant 2005 US$

Country	1991	2000	2010	Average (20 years)
Austria	28,717	35,027	38,803	34,266
Belgium	28,485	34,009	36,742	33,237
Bolivia	857	965	1,177	983
Bulgaria	2,648	2,707	4,461	3,173
China	499	1,122	2,869	1,368
Colombia	2,841	3,074	3,938	3,276
Cyprus	16,321	20,890	23,157	20,591
Czech Republic	8,661	10,379	14,174	11,110
Denmark	36,822	45,340	46,293	43,841
Ecuador	2,698	2,613	3,251	2,856
Estonia	-	7,134	10,393	8,106
Finland	26,292	33,217	38,065	32,649
France	28,019	32,392	33,898	31,621
Germany	29,113	32,662	36,127	32,369
Greece	15,707	18,041	21,309	18,831
Hungary	7,448	8,810	10,926	9,188
Ireland	22,484	41,954	44,583	38,400
Italy	25,952	29,872	29,163	28,861
Latvia	4,747	4,571	7,391	5,407
Lithuania	6,304	5,098	8,829	6,256
Luxembourg	54,251	72,394	80,276	70,035
Malta	10,136	15,002	16,050	13,723
Netherlands	29,762	37,547	41,110	36,282
Peru	2,014	2,487	3,835	2,674
Poland	4,380	6,790	10,036	6,900
Portugal	14,402	17,891	18,648	16,987
Romania	3,356	3,327	5,635	4,086
Slovak Republic	7,626	8,957	14,263	9,967
Slovenia	11,394	15,033	19,054	15,338
Spain	19,242	23,921	25,318	23,217
Sweden	30,267	36,576	42,826	36,265
United Kingdom	25,520	34,059	37,611	33,519
United States	32,504	40,965	43,952	39,794
Venezuela, RB	5,661	5,256	6,010	5,567
EU (Average)	19,156	23,467	26,487	23,160
CAN1(Average)	1,856	2,022	2,754	2,171
CAN2(Average)	2,103	2,285	3,050	2,447

Source: World Bank. Own calculations Notes: CAN1. Andean Community of Nations without Colombia (Bolivia, Ecuador and Peru). CAN2. Andean Community of Nations with Colombia. EU, European Union 27 countries.

Table A.3: Trade balance share and trade integration variables. 2000-2012

	Relative exports						Trade Integration								
CIIUR3	Av X/M Ldc	Annual Δ %	Av X/M Dc	Annual Δ %	Av X/M Totc	Annual	Δ tar 00	Δ tar 12	Av Δ tariffs	Av Exporters	Annual Δ %	% Av shtradeldc	Δ %	% Av shtradedc	Δ %
151	1.29	17.61	2.10	-9.13	1.58	-4.86	09.06	9.93	7.71	334.33	-5.54	36.75	2.11	30.79	-22.16
152	0.25	-11.20	1.19	-2.14	0.54	-2.55	9.17	-12.48	3.17	38.50	-4.84	34.87	-43.55	26.61	04.02
153	48.97	-23.85	0.25	20.26	4.41	-18.57	8.30	10.76	6.94	147.17	-1.86	58.77	-42.10	17.12	-5.09
154	0.72	4.73	0.07	3.59	0.34	-0.98	8.58	13.49	9.37	312.17	-1.83	45.57	-32.32	35.50	18.54
155	1.62	NA	02.05	NA	1.75	NA	8.77	13.17	9.50	65.67	-3.79	45.48	-21.14	18.01	17.39
157	40.42	-23.05	150.54	29.86	26.13	-5.49	NA	NA	NA	NA	NA	27.22	-2.41	10.29	-0.08
158	4.32	6.83	0.75	0.61	1.93	2.25	NA	NA	NA	NA	NA	38.61	-3.83	24.54	3.64
159	1.88	-10.32	0.18	-4.51	0.57	-9.42	NA	NA	NA	NA	NA	36.00	-16.25	39.67	12.98
160	3.13	40.80	152.73	-21.28	4.48	25.94	1.20	6.20	1.97	8.50	2.71	27.13	-44.81	29.80	0.89
171	0.92	-1.27	0.05	-24.54	0.64	-2.45	38.99	51.12	40.60	208.67	-3.85	27.32	-17.84	9.59	-8.74
172	0.76	-10.00	0.06	-3.71	0.46	-3.52	38.92	46.88	40.03	658.17	-5.48	43.48	35.34	18.36	-15.78
173	NA	NA	NA	NA	NA	NA	36.93	48.37	38.63	536.67	-8.27	NA	NA	NA	NA
174	1.97	-14.81	01.04	-7.52	1.40	-10.02	NA	NA	NA	NA	NA	33.79	21.22	33.54	-29.29
175	4.25	-18.32	2.36	01.03	3.12	-12.89	NA	NA	NA	NA	NA	51.90	15.12	27.22	-7.46
181	5.18	-22.41	11.80	-4.95	7.29	-16.69	52.11	57.16	52.89	1299.17	-8.44	38.23	30.99	40.92	-40.42
182	5.88	-1.45	27.17	14.11	12.25	4.88	54.54	64.18	58.24	32.75	NA	06.06	04.04	84.66	-8.11
191	41.03	0.07	17.93	3.13	25.16	2.80	21.37	26.51	22.41	681.83	-8.04	32.77	8.50	41.38	-21.55
192	0.45	-10.42	1.67	-15.70	0.51	-12.45	36.92	42.01	37.92	515.67	-7.37	65.44	9.20	07.06	-11.49
193	0.38	-19.68	11.15	-7.61	1.56	-15.68	NA	NA	NA	NA	NA	40.37	31.85	38.71	-17.98
201	8.24	-1.28	0.36	11.59	1.66	3.62	27.59	35.11	28.54	74.33	-11.81	36.69	-15.29	34.82	-17.57
202	0.21	-10.01	1.79	-32.74	0.49	-20.26	22.69	29.71	23.63	355.67	-12.81	47.45	18.45	19.14	-36.92
203	23.73	-35.31	0.13	-27.22	0.78	-21.19	NA	NA	NA	NA	NA	28.19	-12.67	33.61	24.49
204	57.20	-17.28	0.37	16.05	2.50	14.48	NA	NA	NA	NA	NA	34.30	9.62	36.92	-68.69
209	0.96	-27.59	01.08	-6.63	0.92	-23.08	NA	NA	NA	NA	NA	57.89	5.40	21.36	-11.15
210	7.63	0.41	0.06	-7.10	0.81	4.58	13.12	20.18	14.08	680.83	-1.80	30.85	10.66	35.46	-14.98
221	11.49	-11.06	0.38	1.80	1.24	-0.61	18.13	19.82	18.03	772.17	-6.65	26.85	5.37	33.91	0.57
222	1.72	-11.19	0.32	8.66	01.09	-6.05	8.58	13.89	9.37	646.33	-4.21	55.47	20.28	11.35	-4.26
223	12.56	NA	0.01	12.17	0.05	-8.55	NA	NA	NA	NA	NA	7.90	2.31	70.78	-22.22
232	1.68	16.82	5.43	-24.88	2.74	-16.05	1.40	9.10	2.00	NA	NA	8.40	-13.15	59.89	-3.48
241	0.86	-0.11	0.06	3.00	0.20	1.64	12.21	17.59	12.85	533.33	2.22	18.40	-1.34	49.72	-13.14
242	2.78	-0.92	0.11	-19.97	0.53	-7.38	7.62	11.94	8.18	1016.50	-2.24	24.94	-0.08	39.36	-6.15
251	0.36	-13.61	0.03	-3.90	0.20	-11.33	25.32	34.75	26.53	47.67	-1.21	31.44	-4.04	19.72	-7.12
252	1.54	-10.17	0.51	10.93	0.89	-1.40	31.46	42.54	33.04	1323.50	-1.40	36.29	8.70	28.94	-8.78
261	2.66	-9.73	01.06	4.25	1.50	-1.74	27.99	35.96	28.97	291.83	-5.45	30.19	3.39	34.18	-11.74
269	1.55	-5.95	2.69	-13.68	2.14	-9.64	27.54	35.87	28.77	466.33	-9.40	32.00	26.87	38.52	-27.69
271	0.74	10.04	2.12	-5.81	1.26	0.01	9.89	17.14	10.78	236.50	6.87	27.55	03.07	32.59	-13.47
272	0.50	11.60	16.76	36.89	2.77	27.59	10.76	17.06	11.62	209.67	0.00	28.42	-39.02	40.54	36.99
281	2.13	-6.99	1.11	3.11	1.19	-2.44	21.25	31.02	22.52	NA	NA	24.31	1.89	38.74	17.49
289	0.97	-12.53	0.21	-3.49	0.48	-7.51	21.05	29.31	22.20	1105.50	-2.49	33.64	8.26	35.00	-7.92
291	1.42	-14.79	0.02	4.87	0.12	-0.59	10.53	18.43	11.56	886.00	1.85	14.31	11.09	59.72	-14.07
292	0.88	-19.78	0.02	-5.41	0.07	-6.20	13.25	18.73	13.89	792.00	1.22	7.86	8.26	62.95	-16.25
293	0.73	-18.74	0.10	-10.12	0.53	-14.50	3.57	8.82	4.59	134.17	-0.29	57.26	24.66	9.54	-10.87
311	1.60	-15.76	0.10	-12.31	0.34	-3.80	19.73	28.48	20.92	237.60	NA	23.97	15.62	47.12	-28.71
312	2.13	-8.94	0.03	12.44	0.27	2.70	18.13	26.55	19.34	232.17	2.54	21.46	9.34	51.60	-18.80
313	1.27	-6.04	0.11	-8.60	0.44	-4.73	17.13	26.26	18.50	107.50	7.20	28.84	-1.19	33.95	-8.99
314	1.79	-4.95	0.13	29.88	0.77	3.57	22.09	29.35	23.27	47.67	-1.14	39.78	22.21	24.44	-13.18
315	0.31	-14.82	0.05	-2.61	0.18	-9.47	18.56	21.11	18.80	191.17	-4.88	49.26	30.28	30.83	-13.94
319	0.59	-21.47	0.02	11.81	0.11	-7.36	21.71	28.70	22.45	252.17	4.27	21.15	21.56	43.60	-12.27
331	0.91	-22.98	0.03	3.41	0.06	-1.13	16.93	21.47	17.43	104.00	0.74	7.62	7.91	66.72	-9.91
332	0.23	-8.72	0.01	-0.53	0.06	-3.01	17.39	21.02	17.63	75.33	0.56	19.94	15.32	48.77	-5.05
341	0.62	-13.38	0.01	-17.64	0.49	-14.27	9.98	11.82	10.14	55.33	-0.35	49.22	-32.36	9.50	1.58
342	3.74	-41.77	0.05	-8.26	0.21	-17.74	13.74	22.49	15.14	33.83	-2.95	37.23	31.90	39.70	-59.48
343	2.45	-17.51	0.06	7.31	0.38	-1.90	18.47	24.00	19.41	247.50	-1.83	26.49	17.74	39.06	-9.72
351	02.06	0.41	0.03	9.66	0.04	10.25	20.11	29.01	21.28	15.67	-8.78	06.07	8.43	71.19	-33.70
353	6.30	-22.48	0.05	8.44	0.05	-3.66	25.74	30.50	26.24	51.83	-7.35	0.34	-1.73	85.70	-0.82
359	0.31	-12.29	0.03	-20.17	0.27	-12.42	13.87	17.46	14.26	85.83	-2.27	30.75	01.08	3.33	-1.79
361	2.70	-22.83	1.24	-8.91	1.50	-14.67	33.73	38.50	34.47	544.67	-7.00	39.67	21.76	31.20	-23.06
369	0.31	-10.11	1.58	-4.58	0.78	-9.57	20.49	25.58	21.23	870.83	-5.69	35.92	28.81	37.82	-18.62

Source: own calculations based on DANE, DIAN, World Bank and DNP.
Notes: NA. Not available information. In the case of the annual percentage change it is not calculated because data was not available for the whole period. In other cases, information was not available for the specific sector. Ldc: developing countries, Dc: developed countries, totc: all countries, Δ %: annual percentage change, tar: tariffs reduction with respect to the 1980 level, Av: average, shtradeldc: share of trade to developing countries, shtradeldc: share of trade to developed countries. Sectors 156, 231, 243, 273, 300, 321, 322 and 323 are not included in tables and are discarded of estimations because data for most of the variables is very scarce.

Table A.4: Skill premia, skill intensity, wage bill. 2000-2012

	Skill Premia						Skill Intensity						Wage Bill					
CIIUR3	Av Pr	Annual Δ %	Av W-S	Annual Δ %	Av W-SC	Annual Δ%	Av Pr	Annual Δ %	Av Perm	Annual Δ %	Av Pe-Te-Ag	Annual Δ %	Av Pr	Annual Δ %	Av W-S	Annual Δ %	Av W-SC	Annual Δ
151	2.61	-0.12	1.49	0.33	1.33	-0.37	0.49	-0.98	0.68	-0.50	0.48	-1.40	0.56	-0.50	0.60	0.14	0.39	-1.07
152	2.28	1.14	1.56	0.38	1.57	0.56	0.64	-0.31	0.75	0.19	0.62	-0.75	0.59	0.32	0.61	0.14	0.49	-0.09
153	1.47	01.01	1.60	3.89	1.28	1.38	0.91	1.88	0.93	2.17	0.89	1.58	0.57	1.17	0.61	1.40	0.53	1.37
154	2.61	0.37	2.68	03.02	1.53	1.33	0.88	2.77	01.08	1.91	0.86	2.28	0.69	1.00	0.73	0.88	0.56	1.67
155	1.51	0.83	1.26	1.59	1.21	0.43	0.77	-0.32	0.80	0.03	0.75	-0.60	0.54	0.24	0.56	0.73	0.48	-0.09
157	1.87	-1.68	01.09	1.44	1.61	-1.70	0.60	03.04	0.64	2.50	0.57	2.33	0.53	0.64	0.52	0.72	0.48	0.30
158	2.73	1.47	1.91	2.30	1.39	1.38	0.62	-0.15	0.84	0.45	0.61	-0.39	0.63	0.49	0.66	0.78	0.46	0.52
159	1.41	-1.53	2.33	0.87	1.47	-1.44	1.64	3.52	1.46	4.20	1.62	3.38	0.69	0.58	0.70	0.27	0.70	0.53
160	1.44	-0.41	1.11	15.28	1.23	0.91	0.67	17.06	0.66	16.88	0.65	16.92	0.44	7.51	0.48	6.61	0.40	8.61
171	3.10	0.35	0.73	2.66	1.58	-1.06	0.24	1.57	0.30	1.41	0.23	1.33	0.42	1.14	0.42	1.58	0.27	0.18
172	2.30	1.49	0.63	2.23	1.44	4.92	0.29	1.75	0.36	-0.79	0.28	1.43	0.40	02.01	0.39	1.38	0.29	4.28
173	3.16	3.55	01.06	8.28	1.18	-1.33	0.24	02.05	0.47	06.09	0.23	1.55	0.41	3.65	0.50	4.78	0.21	0.15
174	3.16	0.59	1.47	2.80	1.17	1.78	0.37	2.61	0.62	2.79	0.37	2.29	0.54	1.46	0.59	1.10	0.30	2.95
175	2.47	0.39	1.32	3.71	1.48	-0.31	0.43	0.71	0.55	2.35	0.43	0.37	0.51	0.55	0.56	1.67	0.39	0.04
181	2.38	-1.48	1.29	02.07	1.16	-0.22	0.33	2.44	0.58	2.15	0.32	2.17	0.44	0.53	0.56	0.93	0.27	1.40
182	6.39	08.02	1.62	12.44	0.87	1.70	0.23	4.85	0.71	10.33	0.21	4.68	0.57	6.35	0.59	5.64	0.16	5.53
191	3.30	-3.71	2.46	2.46	1.28	-1.31	0.30	0.04	0.87	5.15	0.29	-0.73	0.50	-2.06	0.70	0.91	0.27	-1.59
192	2.54	-0.74	01.07	2.92	1.24	-0.78	0.30	1.14	0.48	3.51	0.29	0.78	0.43	0.23	0.51	1.41	0.26	-0.01
193	2.50	-0.44	1.12	3.98	1.30	-3.55	0.34	1.88	0.49	5.82	0.33	1.63	0.46	0.75	0.53	1.84	0.30	-1.40
201	3.35	-2.37	1.42	-4.63	2.21	1.18	0.39	-2.57	0.48	-3.02	0.38	-2.87	0.56	-2.28	0.58	-2.15	0.45	-0.93
202	2.43	-0.47	01.05	1.57	1.49	-3.14	0.40	1.92	0.53	5.36	0.40	1.75	0.49	0.69	0.51	0.73	0.37	-0.87
203	2.12	-0.50	0.68	-1.37	01.08	-2.32	0.29	-3.11	0.38	-0.36	0.28	-3.46	0.37	-2.20	0.40	-0.79	0.23	-4.20
204	1.64	-0.78	0.59	-3.67	0.98	0.98	0.20	0.34	0.35	-3.47	0.20	-0.15	0.25	-0.32	0.36	-2.37	0.16	0.68
209	2.00	-0.93	01.03	3.33	01.04	-8.35	0.35	-1.25	0.55	3.64	0.35	-1.70	0.41	-1.43	0.50	1.91	0.26	-7.55
210	1.93	0.01	01.05	0.72	1.45	-1.03	0.53	0.41	0.59	0.62	0.51	-0.15	0.50	0.21	0.51	0.36	0.43	-0.65
221	1.79	1.97	5.88	7.00	1.52	3.40	3.25	4.64	3.44	3.34	3.22	4.48	0.84	1.21	0.84	1.25	0.81	1.60
222	2.11	-1.65	1.39	-0.70	1.48	-0.05	0.62	1.70	0.72	1.43	0.61	1.49	0.56	0.01	0.58	-0.29	0.47	0.77
223	1.89	2.53	1.62	2.85	1.22	1.77	0.77	-1.30	0.90	-0.23	0.76	-1.43	0.58	0.58	0.61	1.26	0.47	0.21
232	1.58	1.22	1.56	10.75	1.38	1.47	0.83	9.72	0.95	8.11	0.81	9.11	0.55	5.79	0.60	4.99	0.51	6.15
241	2.46	2.54	2.37	4.29	1.73	02.06	0.96	1.82	1.14	2.79	0.94	1.47	0.70	1.38	0.70	1.34	0.62	1.44
242	3.38	-0.42	4.72	0.98	1.58	-0.26	1.32	0.81	1.76	1.29	1.30	0.55	0.82	0.08	0.82	0.19	0.67	0.09
251	2.32	-1.30	1.32	0.78	1.49	0.04	0.57	2.52	0.64	1.67	0.56	2.27	0.57	0.53	0.57	0.35	0.45	1.24
252	2.89	-0.19	1.47	1.00	1.45	-1.02	0.47	0.62	0.63	1.28	0.46	0.14	0.58	0.18	0.60	0.41	0.40	-0.53
261	1.69	1.46	0.76	7.44	1.11	-0.54	0.39	3.84	0.51	6.32	0.37	3.42	0.39	3.27	0.43	4.26	0.29	02.05
269	2.71	-0.82	0.93	-1.75	1.59	-0.55	0.34	-0.95	0.42	-0.60	0.33	-1.36	0.48	-0.94	0.48	-0.93	0.34	-1.21
271	2.41	5.71	1.59	11.34	1.65	5.30	0.58	5.58	0.70	07.01	0.57	5.20	0.55	4.56	0.57	4.31	0.46	5.29
272	3.22	0.14	1.34	0.83	1.28	-0.07	0.41	0.60	0.69	-1.07	0.40	0.38	0.56	0.30	0.57	0.33	0.33	0.19
281	2.60	0.30	1.37	0.29	1.13	-1.91	0.44	-1.54	0.66	0.73	0.43	-1.73	0.53	-0.60	0.58	0.12	0.33	-2.28
289	2.82	01.02	1.33	02.08	1.38	-0.91	0.41	-0.18	0.57	2.10	0.40	-0.48	0.54	0.39	0.57	0.90	0.36	-0.87
291	2.66	-0.32	1.69	0.01	1.33	0.01	0.57	0.43	0.77	0.57	0.56	0.19	0.60	0.04	0.63	0.00	0.43	0.11
292	1.98	-0.75	1.17	1.80	1.17	-0.27	0.52	1.32	0.68	2.10	0.52	1.00	0.51	0.28	0.54	0.84	0.38	0.45
293	2.57	-1.29	1.57	2.22	1.39	0.05	0.45	1.72	0.60	2.72	0.42	0.80	0.53	0.19	0.61	0.84	0.37	0.54
311	2.78	-5.36	2.75	-5.85	1.73	-5.93	0.99	-1.21	1.18	0.20	0.97	-1.57	0.71	-1.65	0.71	-1.46	0.61	-3.03
312	3.28	3.37	2.47	5.19	1.68	2.42	0.65	1.28	0.90	2.88	0.64	1.12	0.67	1.66	0.70	1.63	0.51	1.69
313	1.98	-1.72	1.46	0.39	01.08	-2.57	0.69	2.38	0.89	1.96	0.68	1.96	0.58	0.27	0.59	0.16	0.42	-0.38
314	3.62	-2.58	02.05	4.57	01.09	-1.93	0.54	06.09	0.87	5.92	0.53	6.15	0.65	1.41	0.66	1.85	0.36	2.79
315	2.55	1.13	1.71	1.41	1.42	1.97	0.54	02.02	0.74	0.54	0.52	1.74	0.57	1.27	0.63	0.50	0.42	1.97
319	3.50	-2.24	2.99	13.11	1.60	-4.82	0.34	4.42	01.02	15.60	0.33	4.11	0.51	1.12	0.67	4.86	0.33	-0.59
331	2.52	-1.17	1.36	5.97	1.52	-2.94	0.51	5.52	0.59	06.07	0.50	5.20	0.56	1.80	0.57	2.36	0.43	1.18
332	2.12	-0.75	1.65	-2.24	2.00	1.29	0.77	-1.71	0.79	-2.31	0.75	-1.96	0.61	-0.96	0.62	-0.90	0.59	-0.26
341	1.97	1.97	2.35	7.77	1.35	3.61	0.59	7.34	0.88	4.62	0.55	7.10	0.52	3.65	0.68	2.49	0.41	5.00
342	2.89	-0.97	1.50	1.26	0.96	-0.49	0.37	0.14	0.72	3.21	0.37	-0.19	0.52	-0.40	0.60	0.56	0.26	-0.50
343	2.67	-0.81	1.41	2.98	1.17	-0.97	0.49	3.34	0.66	3.63	0.48	3.23	0.56	1.10	0.58	1.24	0.36	1.35
351	2.44	7.37	1.92	-1.49	1.64	3.41	0.70	-8.83	0.90	-6.80	0.71	-8.88	0.59	-0.70	0.64	-0.43	0.50	-2.69
353	1.73	6.29	0.88	20.29	1.82	6.14	0.67	20.77	0.63	19.74	0.65	20.45	0.44	9.71	0.42	8.95	0.45	9.98
359	3.14	1.88	3.17	0.90	1.28	-0.32	0.80	-0.68	1.37	0.96	0.79	-0.92	0.71	0.34	0.76	0.23	0.50	-0.59
361	2.46	0.76	1.38	3.33	1.23	2.60	0.43	1.93	0.64	1.75	0.43	1.67	0.52	1.37	0.58	1.50	0.34	2.86
369	2.46	1.26	1.50	3.26	1.38	0.53	0.50	0.70	0.66	2.51	0.49	0.39	0.55	0.91	0.59	1.36	0.40	0.53

Source: own calculations based on DANE, DIAN, World Bank and DNP.
Notes: av: average, Pr: total occupied personnel (except agency in the case of wages), W-S: wages and salaries of permanent workers, W-SC: wages and social security of permanent, temporary and agency workers, Perm: permanent workers, Pe-Te-Ag: permanent, temporary and agency workers. Sectors 156, 231, 243, 273, 300, 321, 322 and 323 are not included in tables and are discarded of estimations because data for most of the variables is very scarce.

Table A.5: Estimates of Eq. (1) with instrumental variables 2000-2012

Dep Var	(1) D.wage bill Pr	(2) D.wage bill W-S	(3) D.wage bill W-SC
D.ln(av sk premia Pr)	0.20571*		
	-2.128		
D.ln(kapital/Prodbr)	3.709	-558	0.03598*
	-1.899	(-1.170)	-1.989
D.ln(av sk premia W-S)		0.22148***	
		-14.430	
D.ln(av sk premia W-SC)			9.052
			-340
Constant	0.00618***	17	0.00551**
	-3.337	-238	-2.605
Obs	516	516	516
R2	326	964	273
Overid	1.255	2.787	496
Overid P	534	248	780
Underid	10.744	3.648	1.319
Underid P	13	302	725
Weakid	4.166	1.387	456

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: own calculations based on DANE and DIAN data. First difference estimator. Instrumental variables: average experience, experience square and sector share of women. Estimation with robust standard errors. Overid test: H0 equation is underidentified, H1 equation is identified. Underid test: H0 instruments are valid, Weakid test: H0 instruments are weak, Stock-Yogo critical value at 5%: 13.91. Notes: t-statistics in brackets. av: average, sk: skill, Prodbr: gross production, Pr: total occupied personnel (except agency in the case of wages), W-S: wages and salaries of permanent workers, W-SC: wages and social security of permanent, temporary and agency workers.

Table A.6: Estimates of Eq. (3) 2000-2012

Dep. Var:	SBTC(1)	SBTC(3)	SBTC(4)	SBTC (5)	SBTC (6)	D.wage billPr	D.wage billW-S	D.wage bill W-SC	SBTC(1)	SBTC(3)	SBTC(4)	SBTC (5)	SBTC (6)	D.wage bill Pr	D.wage billW-S	D.wage billW-SC
Tr Var:	tariffs	tariffs	tariffs	tariffs	tariffs	tariffs	tariffs	tariffs	Trade ldc	Trade ldc	Trade ldc	Trade ldc	Trade ldc	Trade ldc	Trade ldc	Trade ldc
SI-Pr* Tr Var	0.0052***		0.0051***			0.0054***			0.275**		0.252*			0.242*		
	(-6.071)		(-6.306)			(-6.875)			(-2.653)		(-2.456)			(-2.312)		
Sh-tem	-0.262***	-0.308***	-0.177*	39	-0.334***	-0.129*	68	-0.250***	-152	-0.184*	-95	87	-0.225*	-75	127	-0.171*
	(-4.002)	(-4.684)	(-2.487)	(-0.509)	(-4.219)	(-2.461)	(-0.566)	(-3.554)	(-1.503)	(-2.060)	(-0.738)	(-0.711)	(-2.410)	(-0.727)	(-1.104)	(-2.220)
SI-Perm*Tr Var				0.0043***			0.0043***					0.177**			0.168**	
				(-4.194)			(-5.088)					(-3.136)			(-3.009)	
SI-Pe-te-ag*Tr Var		0.0054***			0.0048***			0.0053***		0.283**			0.264*			0.249*
		(-5.163)			(-4.322)			(-4.102)		(-2.697)			(-2.565)			(-2.406)
Const	0.051	0.067*	0.012	-0.08**	0.080*	-0.003	-0.082*	0.044	0.011	0.023	-0.012	-0.081	0.038	-0.0125	-0.084	0.022
	(-1.866)	(-2.323)	(-0.455)	(-2.936)	(-2.223)	(-0.158)	(-2.146)	(-1.326)	(-0.276)	(-0.646)	(-0.239)	(-1.749)	(-0.964)	(-0.285)	(-1.941)	(-0.649)
Obs	423	423	423	423	423	471	471	471	504	504	504	504	504	561	561	561
RSS	1.068	1.092	1.608	1.465	2.034	1.805	1.688	2.304	1.311	1.293	1.972	1.961	2.286	2.249	2.223	2.711
Z-statistic	3.911	3.521	4.524	4.250	3.114	4.720	3.567	4.524	-1.075	-1.064	-875	-731	-1.008	-1.013	-143	-806
Tr Var:	Trade dc	Trade dc	Trade dc	Trade dc	Trade dc	Trade dc	Trade dc	Trade dc	Exporters	Exporters	Exporters	Exporters	Exporters	Exporters	Exporters	Exporters
SI-Pr* Tr Var	0.188***		0.204***			0.216***			0.034***		0.037***			0.04***		
	(-7.824)		(-7.216)			(-7.662)			(-3.658)		(-4.194)			(-4.168)		
Sh-tem	-0.253***	-0.266***	-0.197**	30	-0.319***	-0.141**	85	-0.251***	-0.193**	-0.274***	-120	147	-0.389***	-0.11	153	-0.360**
	(-4.180)	(-4.518)	(-2.835)	(-0.542	(-4.815)	(-3.076)	(-1.107	(-4.557)	(-3.203)	(-4.039)	(-1.276)	(-1.132	(-3.347)	(-1.039)	(-1.127	(-2.905)
SI-Perm*Tr Var				0.198***			0.205***					0.023***			0.024***	
				(-9.359)			(-8.849)					(-3.568)			(-3.57)	
SI-Pe-te-ag*Tr Var		0.180***			0.164***			0.185***		0.036***			0.032**			0.034**
		(-7.237)			(-4.865)			(-4.632)		(-3.629)			(-3.108)			(-3.181)
Constant	0.063*	0.070**	31	-0.068**	0.089**	13	-0.083**	0.059*	-36	-5	-0.088*	-0.175**	49	-0.094*	-0.173**	36
	(-2.456)	(-2.771)	(-1.114)	(-3.003)	(-3.11)	(-0.687)	(-2.732)	(-2.402)	(-1.405)	(-0.190)	(-2.298)	(-3.232)	(-1.106)	(-2.085)	(-2.946)	(-0.764)
Obs	504	504	504	504	504	561	561	561	230	230	230	230	230	231	231	231
RSS	1.16	1.217	1.737	1.585	2.262	1.938	1.761	2.591	0.588	0.552	0.936	0.845	1.084	1.011	0.894	1.2
Z-statistic	-0.691	-0.360	-1.061	-1.847	-0.249	-2.135	-0.956	-0.458	3.063	2.762	3.443	3.518	2.470	3.221	0.039	3.641

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: own calculations based on DANE and DIAN data. Arellano-Bond Estimation with robust standard errors. SBTC(1) to SBTC(6) are estimated from models (1) to (6) in Table 5. D: first difference. Notes: t-statistics in brackets, SI: skill intensity, Pr: total occupied personnel (except agency in the case of wages). W-SC: wages and social security of pe-te-ag workers, W-S: wages and salaries of permanent workers, Perm: permanent workers, Pe-te-ag: permanent, temporary and agency workers, tariffs: tariff reductions between the actual level and the one in 1980, ldc: developing countries, dc: developed countries. Tr Var: trade integration variable, Sh-term: temporary over Pe-te-ag workers. Z-statistic tests the null hypothesis that b1-c1=0, from equations (3) and (4).

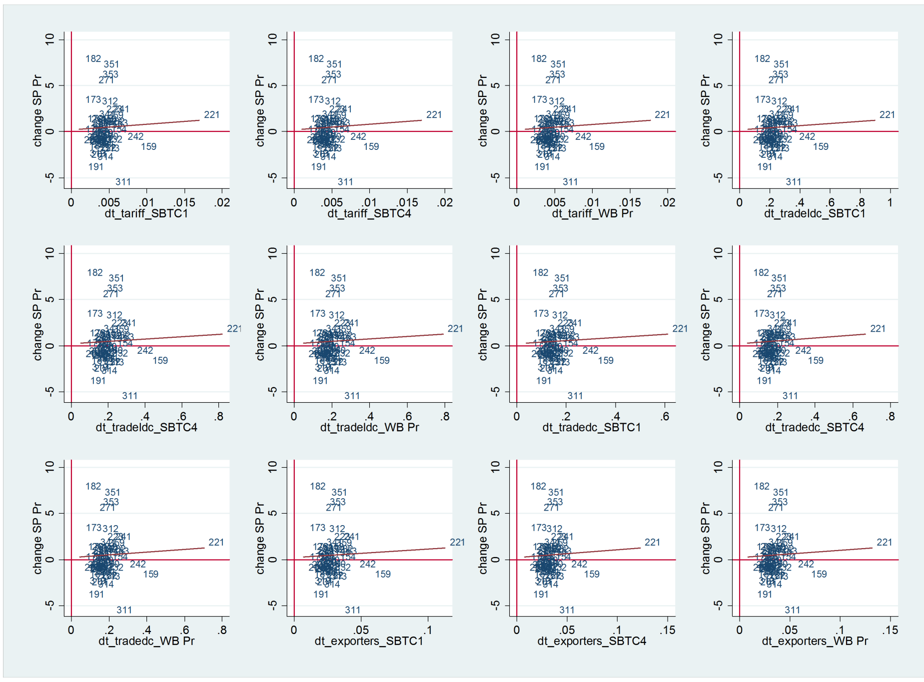
Table A.7: Estimates of Eq. (4) 2000-2012

Dep. Var: Tr Var:	SBTC(2) Exporters	SBTC(5) Exporters	D.wage bill W-S Exporters
Tr Var	0.02020**	2.737	3.652
	(3.280)	(1.185)	(1.517)
Sh-tem	3.031	9.276	10.056
	(1.114)	(0.869)	(0.910)
SI-Perm*Tr Var	-0.01248***	-0.02261*	-0.02320*
	(-3.302)	(-2.036)	(-2.027)
SI-Perm	0.04787***	0.24251***	0.24798***
	(3.658)	(4.580)	(4.528)
Constant	-0.10409**	-0.29288*	-0.33893**
	(-3.073)	(-2.365)	(-2.610)
Obs	230	230	231
RSS	0.033	0.668	0.695

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

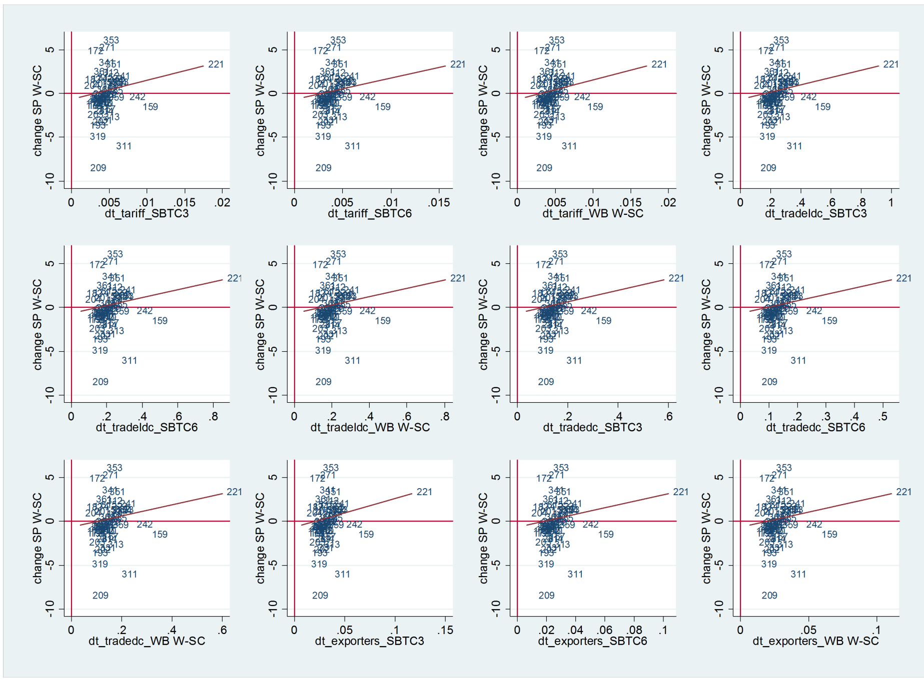
Source: own calculations based on DANE and DIAN data. Arellano-Bond Estimation with robust standard errors. SBTC(1) to SBTC(6) are estimated from models (1) to (6) in Table 5. D: first difference. Notes: t-statistics in brackets, SI: skill intensity, W-S: wages and salaries of permanent workers, Perm: total occupied personnel (except agency in the case of wages), tariffs: tariff reductions between the actual level and the one in 1980, ldc: developing countries, dc: developed countries. Tr Var: trade integration variable, Sh-term: temporary over Pe-te-ag workers.

Figure A.4: Eq. 3. Annual percentage change of skill premia (Pr. workers) and Trade derivatives (dt) 2000-2012



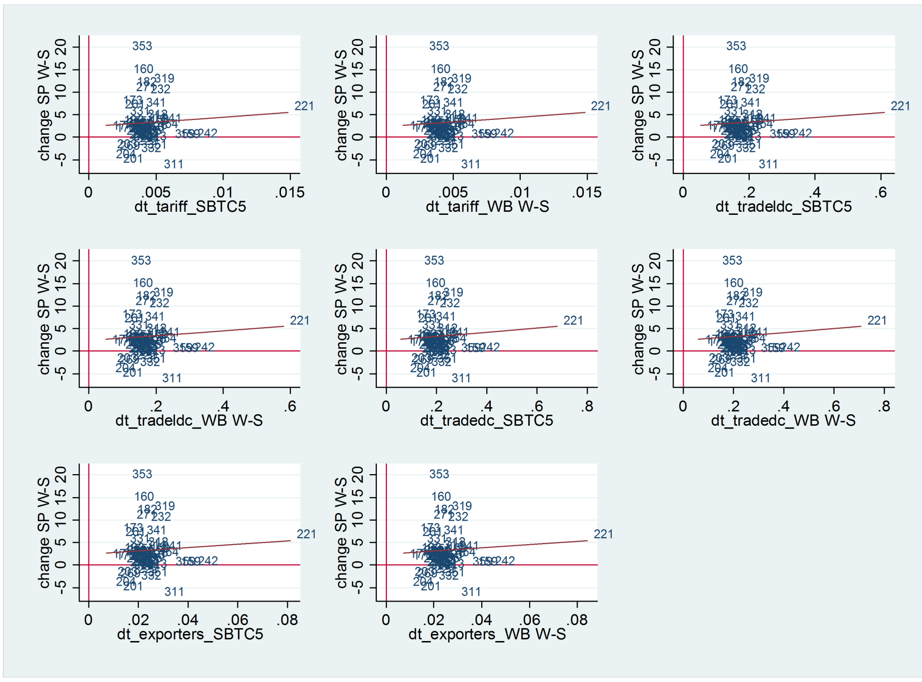
Source: DIAN (Administrative records). Own calculations. Notes: trade derivatives obtained from Eqs. (5) and (8) in the text. Change SP Pr: annual percentage change (during the period 2000-2012) of total occupied personnel (except agency in the case of wages) Skill Premia, ldc: developing countries, dc: developed countries. SBTC1 and SBTC4 correspond to the SBTC measures obtained from Table 2. WB Pr is a SBTC measure: Pr. wage bill variable.

Figure A.5: Eq. 3. Annual percentage change of skill premia (Wages and social security of permanent, temporary and agency workers) and Trade derivatives (dt) 2000-2012



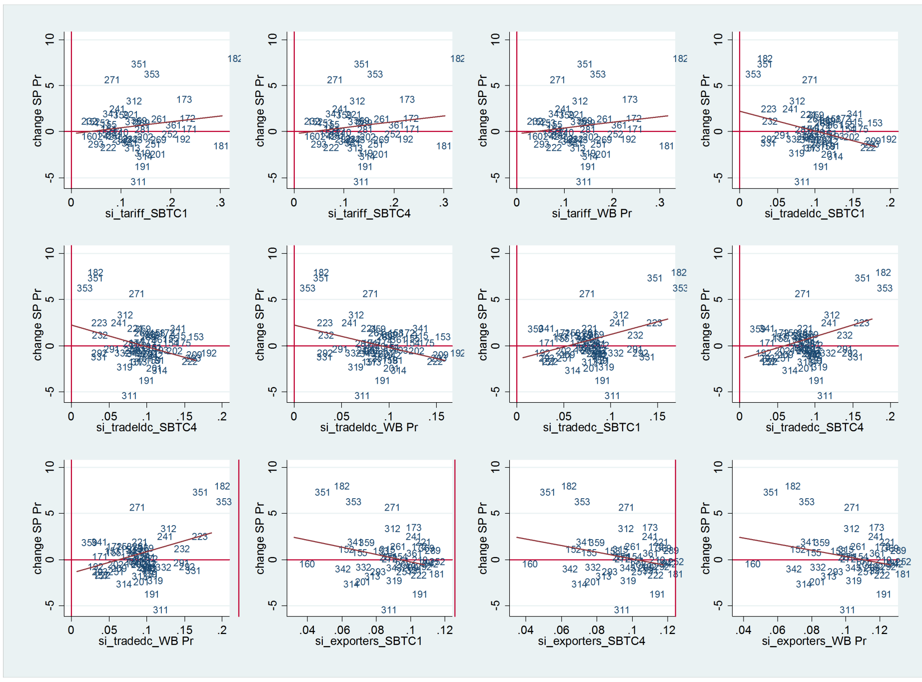
Notes: Trade derivatives obtained from Eqs. (4) and (7) in the text. Change SP W-SC: annual percentage change (during the period 2000-2012) of wages and social security Skill Premia, ldc: developing countries, dc: developed countries. SBTC3 and SBTC6 correspond to the SBTC measures obtained from Table 2. WB W-SC is a SBTC measure: wages and social security wage bill variable.

Figure A.6: Eq. 3. Annual percentage change of skill premia (Wages and salaries of permanent workers) and Trade derivatives (dt) 2000-2012



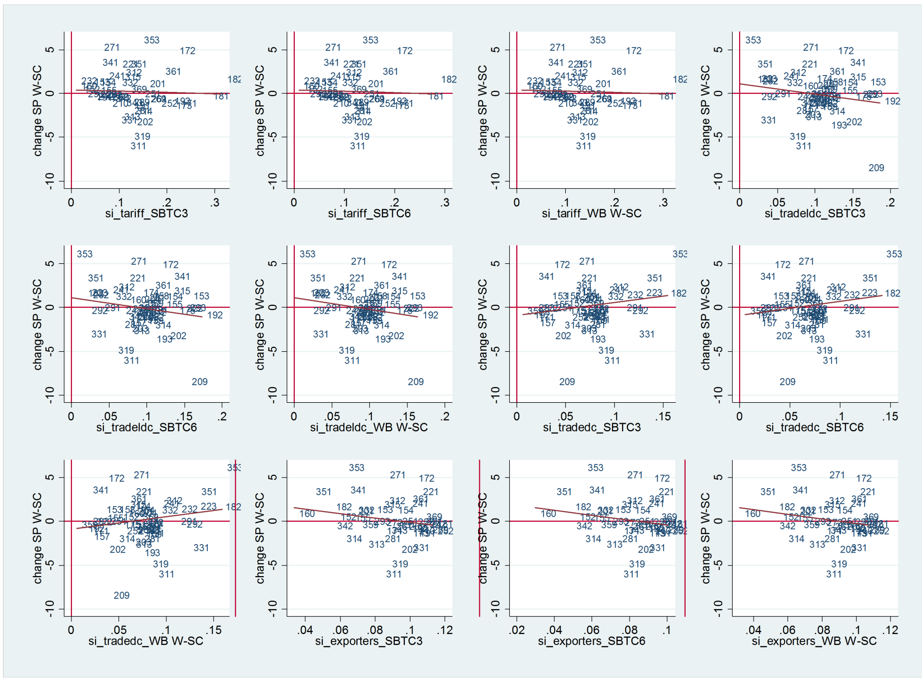
Notes: Trade derivatives obtained from Eqs. (5) and (8) in the text. Change SP W-S: annual percentage change (during the period 2000-2012) of wages and salaries Skill Premia, ldc: developing countries, dc: developed countries. SBTC5 corresponds to the SBTC measure obtained from Table 2. WB W-S is a SBTC measure: wages and salaries wage bill variable.

Figure A.7: Eq. 3. Annual percentage change of skill premia (Pr. workers) and skill intensity derivatives (si) 2000-2012



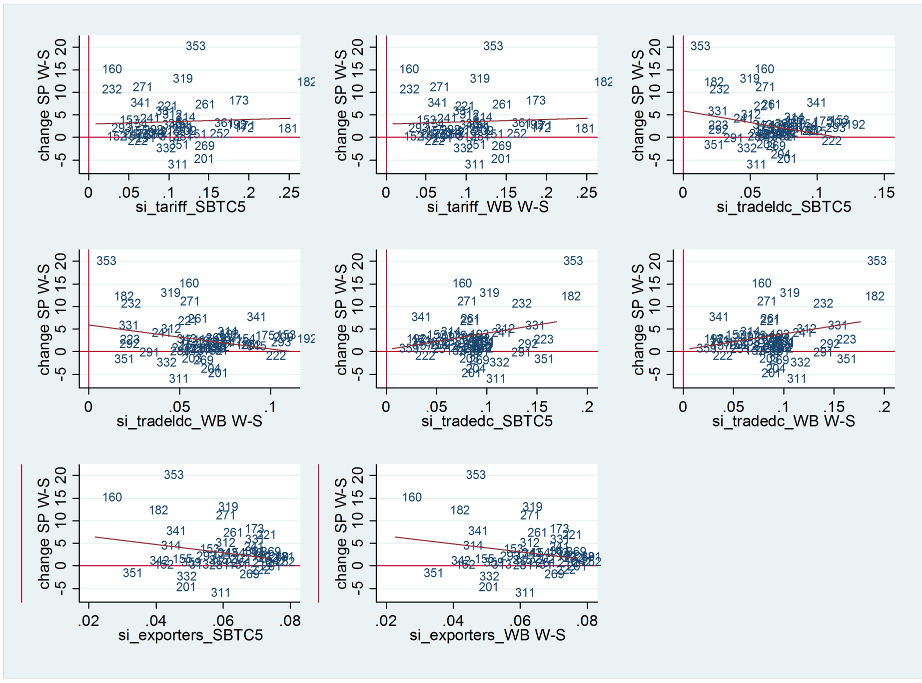
Notes: Skill intensity derivatives obtained from Eqs. (3) and (5) in the text. Change SP Pr: annual percentage change (during the period 2000-2012) of Pr. Skill Premia, ldc: developing countries, dc: developed countries. SBTC1 and SBTC4 correspond to the SBTC measures obtained from Table 2. WB Pr. is a SBTC measure: Pr. wage bill variable.

Figure A.8: Eq. 3. Annual percentage change of skill premia (Wages and social security of permanent, temporary and agency workers) and Skill intensity derivatives (si) 2000-2012



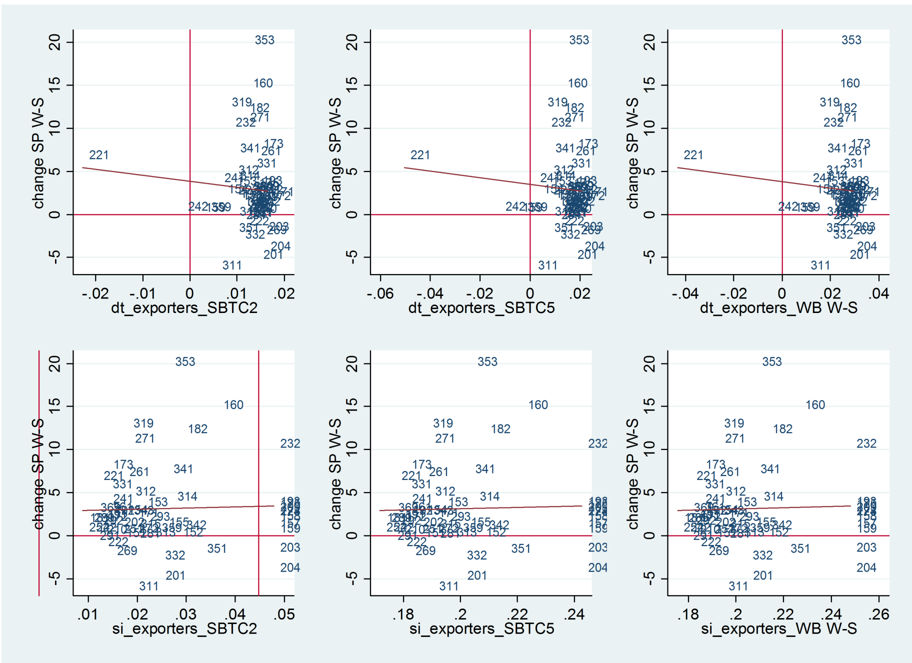
Notes: Skill intensity derivatives obtained from Eqs. (3) and (5) in the text. Change SP W-SC: annual percentage change (during the period 2000-2012) of wages and social security Skill Premia, ldc: developing countries, dc: developed countries. SBTC3 and SBTC6 correspond to the SBTC measures obtained from Table 2. WB W-SC is a SBTC measure: wages and social security wage bill variable.

Figure A.9: Eq. 3. Annual percentage change of skill premia (Wages and salaries of permanent workers) and Skill intensity derivatives (si) 2000-2012



Notes: Skill intensity derivatives obtained from Eqs. (3) and (5) in the text. Change SP W-S: annual percentage change (during the period 2000-2012) of wages and salaries Skill Premia, ldc: developing countries, dc: developed countries. SBTC5 corresponds to the SBTC measure obtained from Table 2. WB W-S is a SBTC measure: wages and salaries wage bill variable.

Figure A.10: Eq. 4. Annual percentage change of skill premia (wages and salaries of permanent workers) and trade (dt) and skill intensity (si) derivatives 2000-2012



Notes: Trade and skill intensity derivatives obtained from Eqs. (4), (5) and (6) in the text. Change SP W-S: annual percentage change (during the period 2000-2012) of wages and salaries Skill Premia. SBTC2 and SBTC5 correspond to the SBTC measures obtained from Table 2. WB W-S is a SBTC measure: wages and salaries wage bill variable.

2

Labor market regulation and international trade: the role of the informal sector

I analyse the relation between international trade and welfare, by segregating the labor market between informal and formal firms in a model of heterogeneous firms. This result comes from introducing a regulatory threshold, according to which firms having less than a certain quantity of workers are defined as informal, otherwise they are formal and should pay additional fixed and marginal labor costs. As a consequence, it is more profitable for the *most productive informal* firms to scale back production to avoid formal labor costs. The numerical solution of the model shows that, after trade openness, a share of the *most productive informal* firms become *less productive informal*, and that the less productive formal firms become *most productive informal*. The welfare in the economy decreases because of higher prices and reduction of available varieties in the economy. Likewise, the comparative static exercise yields evidence that a decrease in the regulatory threshold forces informal firms to become formal; therefore, under full employment conditions, such a policy increases all average wages and raises welfare.

2.1 Introduction

In this article I analyse the effect of trade openness in a theoretical model of international trade with heterogeneous firms, assuming that the government introduces in the economy a regulatory threshold in terms of a firm's size to distinguish formal from informal firms (e.g. a minimum quantity of workers $\bar{l}$). According to Hussmanns [2004] an informal sector enterprise is characterized by being below such a threshold and additionally it is a private unincorporated entity, production is for sale or barter, and it is involved in non-agricultural activities.

In practice, such a regulatory threshold can be expressed in terms of the probability of a firm being monitored by the government, and being forced to have only formal workers. In the theoretical structure I suggest in this article, as in Davies and Paz [2011], that probability is equal to 1 when the firm is above the threshold ($\bar{l}$), and 0 when it is below.

Alternatively, ILO [2016] states that other policies may establish as well, in law or in practice, some labor regulatory thresholds: e.g. minimum hours of work or certain level of wages, in the case of casual jobs, or short-term jobs. Those policies can separate informal from formal workers, as firms are required to pay for the additional labor costs associated with the latter group. As informal workers do not benefit from national labor legislation, informal firms also do not pay income taxation or payroll taxes, social security contributions or specific social protection such as advance notice of dismissal, severance pay, paid annual leave or sick leave. In contrast, formal firms pay additional marginal and fixed labor costs for their workers. Because of the feasibility of the theoretical analysis, I examine the case in which the government sets a threshold level $\bar{l}$ as a minimum quantity of workers, to determine whether the firm is informal, according to its size.

According to Rodriguez and Rodrik [2000], since the late 80s, empirical literature has focused on the relationship between trade policy and growth, finding ambiguous results depending on the internal and external characteristics of the domestic country, including institutional conditions related to the reason why the trade barrier exists, either to reduce market imperfections or because of rent seeking. Indeed, the theory supports the results, as the inclusion of market failures, endogenous technological change, increasing returns to scale as well as the initial factor endowments and technological levels of the country, lead to the results of the typical international trade models. Nevertheless, the authors highlight that, under certain conditions, increases in the growth rate of output is neither a necessary nor a sufficient condition to increase welfare.

International trade models in general associate welfare with the gains of trade. In the Heckscher-Ohlin theory, such gains are related to reallocation of income between the countries involved in trade, as well as to the profits that the exporter sector wins in relation to the importer sector, and with changes in remuneration of the abundant factor versus remuneration of the scarce factor. Any industry can compete successfully in the global market depending on how the domestic country enhances or does not enhance its competitiveness. The results of the model are subject to many assumptions, among them: the countries involved in trade have to be similar in their factor endowments, having the same technological level, and with no trade barriers. In the case of comparative advantages (the Ricardian Model), the gains of trade come from the net profits of producers and consumers obtained by the increase in production, consumption, decrease in prices, and tariff reductions.

Bacchetta et al. [2008] agree with Rodriguez and Rodrik [2000] in the sense that the impact of trade policy on welfare is wider than can be measured by economic growth. For the former, trade policy impacts an individual's welfare in three ways: a) the consumption effect on prices of domestic goods, b) the income effect on a household's income, related to wages, sales of products and employment opportunities, and c) the revenues effect on government revenues and indirectly on households through transfers.

Unlike the classic trade models as mentioned above, the model with heterogeneous firms and monopolistic competition (Melitz [2003]) proposes a welfare definition that functions based on love for varieties, prices of domestic goods and national income (including wages and production). Thus, introducing the regulation threshold ($\bar{l}$) in the model, I evaluate another trade policy effect on welfare, specifically on employment opportunities in the formal or informal sectors, in the framework of heterogeneous technological performance by firm. Indeed, the results contrast with the original model without the labor regulation, where trade policy brings about an improvement in welfare.

The theoretical literature on this topic has not evaluated the effects of these kinds of regulatory thresholds; instead, authors have focused mainly on the formal marginal and fixed costs parameters for firms to decide endogenously whether they are formal or informal (e.g. Becker [2018]). The exception is Davies and Paz [2011] who investigate the firm's decision conditional to the probability of being caught evading taxes, which depends on their productivity level: this probability is zero for the less productive informal firms, and it is one for formal firms. They allow for this probability to be an increasing function of the firm's output, revenues and profits, finding (similarly to this research) a group of informal price-takers. However, these complications of the model prevent them from obtaining analytic solutions. The empirical literature instead is abundant, and has focused on country studies.

Only relatively recently researchers have started to analyse the relation of international trade not only with the informal sector, but also with labor standards and precarious work. The results presented in this paper contribute to analysing and understanding the impacts of different regulations, such as the social and labor provisions incorporated in many Regional and Preferential Trade Agreements, particularly in developing countries.[1] Siroen and Andrade [2016] explain that trade integration is growing rapidly, according to the quantity of Regional and Preferential Trade Agreements signed in recent decades, some of which have incorporated requirements based on the following four main objectives: preventing *social dumping*, minimizing the undesirable effects of free trade on certain workers, promoting universal rights and supporting decent work and sustainable development.[2]

Despite the country's commitment to trade agreements, and ratification of the International Labor Organization conventions, Siroen and Andrade [2016] conclude that "*labor provisions in trade agreements have not played a significant role in improving labor practices*", mainly due to a lack of enforceability. Regardless of the political controversy surrounding raising labor standards or improving working conditions in developing countries, versus disguised protectionism in the developed world, it is necessary to understand economically the possible impacts of those labor policies (e.g. preventing informality) on issues such as welfare, prices, and the survival of firms, in a context of trade integration.

The main results of the paper are obtained by numerical methods. I undertake an exercise of numeric comparative statics to evaluate the effect of the changes in various parameters on the main variables of the model. I find that there exists *informal selection* and export market selection; namely, the less productive formal firms become informal, while the most productive formal firms become exporters. Furthermore, unlike the case

[1]According to ILO [2014], the informal employment level in Latin America and the Caribbean was almost 47% of workers in 2013.

[2]Even though Melitz [2003] provides a better explanation for intra-industry trade between developed countries, yet some effects of openness in the economy are general enough to explain certain stylized facts in developing countries: e.g. market concentrations and exporting self selection. Therefore, this framework, including the regulatory threshold, is useful to study firms' segregation in different development contexts.

with similar models, there is a kind of new loser: the less productive formal firm who becomes an *mpi* firm, and the *mpi* firms who become *lpi* firms. The winners are the most productive exporting firms. Likewise, in the labor market, though there are fewer firms in the economy, workers reallocate towards formal and exporting firms, improving average wages. Lastly, the impact of the trade policy on welfare under these theoretical conditions is negative, due to the exit of some *lpi* firms and the consequent rise in the level of formal and exporting employment, as well as in the price index because there are more workers earning formal wages, and a decrease in varieties.

Regarding the exercise of comparative statics, the following results should be highlighted: first, a reduction in the regulatory threshold forces many informal firms to pay formal costs, reducing the informal sector, whilst the formal and exporting sectors increase, making *mpi* eventually disappear. Under full employment, such a policy raises welfare due to the better wages of an increasing quantity of formal workers and the increasing availability of varieties. Second, higher levels of the formal wage premium (marginal labor costs) moderately decreases welfare. This policy makes informal firms expand, as well as informal workers with low wages, compensating for the rise of formal wages. And third, when the formal fixed cost grows, *lpi* firms rise in number, while *mpi* tend to disappear. However, the higher fixed costs makes formal firms' selection more demanding, which forces them to hire more workers too. As more workers become formal, prices rise significantly, and varieties increase and welfare rises.

The rest of the paper is organized as follows: section 2 presents the empirical and theoretical literature review, section 3 develops the model of heterogeneous firms with informal and formal sectors in a state of autarchy, while the open economy case is presented in section 4. Then in section 5, I show the results of the numerical solution for both equilibrium, in order to undertake next, in section 6, a comparative static exercise, by changing trade and labor policy parameters in the open economy equilibrium. Section 7 provides a concluding statement.

2.2 Literature review

Empirically and theoretically, the relation between international trade and labor markets have been investigated in many contexts. In empirical research, the availability of specific data on the topic has been the main drawback to overcome in analyzing country cases. Hence, in the developing world, Vietnam and Brazil are among the most studied cases. In this section, I present initially some of the most pertinent empirical findings, to discuss, afterward, some relevant theoretical developments to explain this relation.

McCaig and Pavcnik [2013] have found in Vietnam, during the period 1990-2008, that reforms in agriculture, enterprises, and international integration are related to the structural change in the economic development of the country. More specifically, the reforms relate to the rapid growth of employment in the services and manufacturing sectors, as well as the reallocation from household businesses towards the enterprise sector, and from state owned to private domestic and foreign owned firms.

Regarding the international integration, before the foreign trade reforms at the end of the 80s and early 90s, the country was very controlled and closed. Then, the government opened the economy by decreasing tariffs, signing preferential trade agreements, relaxing import and export quotas, eliminating subsidies for exports, simplifying export and import procedures, and performing all these measures with a currency devaluation. These reforms were successful in increasing the aggregate value of trade and its composition, as the percentage of primary product exports decreased from 60% in 1995, to 30% in 2010, in favor of labor intensive manufactures.

McCaig and Pavcnik [2013] explain that, usually, the labor informal sector in developing countries is not only more abundant, but also less productive than the formal sector. Hence, workers' reallocation from informal household businesses or farms, towards the more productive sectors (which export) and formal enterprises within an industry, contributes to increase the aggregate productivity in the country. Likewise, such an effect can be generated by a reduction in trade costs that boost international trade, as illustrated by Melitz [2003].

The same authors, in a recently updated version of the study [McCaig and Pavcnik, forthcoming], find that between 2002 and 2004, a total of 5% of the manufacturing workers reallocate from informal to formal enterprises in Vietnam, and the percentage increases in younger cohorts and in provinces most exposed to international trade, where in turn, urbanization rises. Likewise, they find bigger reductions in household business employment in those industries in which export costs decline more significantly. Workers' welfare in the formal sector is also better, as they are more productive, are paid salary payments, work longer hours and a lower number have multiple jobs.

They also point out that, when measuring the potential aggregate productivity gaps between the formal and informal sectors within manufacturing, it is necessary to consider worker heterogeneity and differences in output-labor elasticities across the two sectors, to avoid overestimating productivity gains, by removing market distortions related to high trade costs.

Dix-Carneiro and Kovak [2017], instead, investigate frictions in workers' reallocation across economic sectors, after the openness policy implemented throughout the 80s and 90s in Brazil, for the period 1986-2010. They find as well that regions in which the tariff decreased the most experienced sustained falls in both formal employment and earnings, with respect to other regions, due to imperfect interregional labor mobility, slow capital adjustment and agglomeration economies. Therefore, they document the increasing effects of liberalization in the long run, for those more affected regions, rather than spatial equalization in local labor market outcomes.

The intuition is that as capital slowly moves away from the harder-hit regions, local labor productivity is affected negatively, as well as the local economic activity, whilst also shaping a negative local labor demand. Dix-Carneiro and Kovak [2017] show evidence of establishment exit, decreasing size, and job destruction in these regions, in favor of agglomeration economics. Thus, trade-induced transitional dynamics matter when explaining the relation with labor markets.

In the same line, Dix-Carneiro and Kovak [2018] deepen the analysis in the more harder-hit regions, allowing for the labor market adjustment margin from tradable to nontradable sectors, finding a more likely worker transition to the latter, located in the low paying service industries. Furthermore, a fraction of the lost tradable jobs goes to non-employment. These results remain in the medium term. However, in that term, there is also evidence of cross-sector integration, in which labor demand decreases even in the nontradable sectors. They also find evidence that trade-displaced workers remain unemployed in the long run, and that the informal sector becomes a cushion for them.

It is worth mentioning Dix-Carneiro et al. [2018], even though this is not a published study, as in a like manner they have developed a structural equilibrium model with heterogeneous firms, which constitutes an important contribution to the literature. They think of the informal sector as compounded by informal workers, who do not have permanent and stable employment with benefits, and informal firms, which do not comply with taxes nor market regulations. Formal firms, in turn, are subject to minimum wages, firing costs, payroll and revenue taxes. This framework is used to study the effects of trade on the labor market and welfare, under burdensome regulations and imperfect enforcement of monitoring, which motivates firms to choose the informal markets, for which, they employ data from Brazil. Moreover, they consider labor market frictions and costs of hiring, which bring about unemployment, as well as the tradable and nontradable sectors.

In the developed world, Prado [2011] finds that for the OECD countries, using a general-equilibrium micro-funded model, with policy reforms related to taxation, enforcement of punishment against informality, as well as other formal sector regulation costs (fixed and red tape costs), can generate welfare gains in the overall economy, on average, of about 1.2% of consumption, or 2.1% when considering alone reductions in regulation. It is demonstrated that countries facing the lower regulation costs exhibit the most benefits, suggesting that the distortion produced in the formal sector should be eliminated, which in turn decreases informality.

Unlike the Brazil and Vietnam studies, the OECD case defines informality as unreported income from production of legal goods and services, thus affecting directly the fiscal budget and informal firms' compliance with labor-market and product-market regulations. Even though Prado [2011] does not analyze the effect of trade, he considers the impact of different institutions on the endogenous choice of a firm to be formal or informal, according to their productivity level, similar to the methodology I am implementing in this article.

The theoretical literature using models with heterogeneous firms and endogenous entry [Melitz, 2003] and exploring different topics within labor markets is numerous, but it is scarce when international trade is incorporated into the analysis. The study by Davies and Paz [2011] is among the most relevant. The author uses this framework to study the effects of tariff reductions versus Value Added Taxes on an informal sector's size and welfare in developing economies. On the one hand it is difficult to collect VAT from informal firms;

thus, higher VAT can be reflected in less formal firms, who become informal to avoid the tax. On the other hand, decreasing tariffs (expanding international trade) can raise fiscal revenues, or welfare, by taxing foreign and domestic firms.

Davies and Paz [2011] define a model of two symmetric countries, producing two goods, a numeraire Y produced under constant returns to scale, which is not taxed and sold under perfect competition, and a differentiated X composed of a continuum of monopolistically competitive firms. Likewise, there is a publicly-provided good G in each country. Firms producing good X choose whether to serve the local or the overseas market (only formal firms), being formal and paying a VAT rate ν, or being informal, not paying VAT and risking being caught, paying taxes and a proportional VAT rate penalty, in the worst of the cases. In terms of risk, the more productive firms are caught with certainty, while the lowest productive firms, in contrast, are not. Therefore, there is a productivity level threshold λ_0 above which the probability of detection is bigger than 0.

The study concludes that tariff cuts reduce informality because of the selection effect, according to which the least competitive firms exit the market when facing foreign competition. In this case, increasing VAT does not necessarily cause a rise in the informal sector, because of the impact of the penalty for evading taxes, which can decrease the output of informal firms, depending on the parameters of the model's simulations. In addition, welfare increases when reducing tariffs and increasing VAT, as soon as the lower prices of imported goods compensate for the losses of the market distortion of the VAT.

Becker [2018] presents another model of heterogeneous firms and endogenous wage dispersion to analyze the impact of trade liberalization on employment, wage inequality, and welfare, taking into account the existence of the informal sector. Due to the selection effect, trade liberalization shrinks informal employment unambiguously, but the impact on total salaried employment, in terms of both wage inequality and welfare, are country-specific.

Indeed, specific country characteristics, as manifested in trade costs, may determine whether the jobs created by growing exporting firms compensate for the fall of the formal sector. This is due to the informalization mechanism of firms after trade liberalization, according to which, the least productive formal firms become informal, shedding formal workers. These changes between the formal and informal sectors and endogenous wage dispersion cause wage inequality in the two sectors, while inequality across all employed workers depends on the allocation of informal and formal workers before the openness.

The effect on the aggregate output is ambiguous and, therefore, so is the effect on the welfare aspect. Albeit exporting firms expand after the openness to trade, the informalization of formal firms and exit of the least productive informal firms, could serve to compensate the aggregate output or even decrease it. Trade liberalization can then affect the level of informal sector participation directly, impacting in turn upon the aggregate output and welfare. Furthermore, Becker [2018] undertakes a simulation exercise to compare the effectiveness of different policies on welfare and on reducing informal employment, finding that liberalizing trade is as effective as contract enforcement, but that the former has stronger impacts than improving access to the formal sector.

In the model, informal firms do not pay extra registration (fixed) costs in the formal sector and they choose not to be formal as a result of a profit maximizing strategy. Becker [2018] studies heterogeneous firms in productivity with labor market frictions such as fair wage preferences and search-and-matching specifications, providing an opportunity to analyze unemployment. The model also incorporates a segment of residual to salaried employment in both the informal and formal sectors, corresponding to self-employed informal entrepreneurs, or subsistence informality, where workers would prefer to have a job in the formal sector instead.

In line with Davies and Paz [2011] and Becker [2018], this article focuses on theoretical analysis of the relation between international trade and the informal/formal sectors, evaluating heterogeneous firms à la Melitz [2003], but including two new contributions. First, in addition to the formal fixed cost, firms self-select into the informal sector accounting for an extra marginal labor cost, expressed as a formal wage premium that does not depend on the worker's effort level. Second, I incorporate a regulatory threshold ($\bar{l}$), the minimum quantity of employees for a firm to be defined as formal, thereby dividing firms between informal and formal. $\bar{l}$ creates a distortion in the labor market, which makes it more profitable for some of the most productive informal firms to not behave as monopolistic competitors. In the next section, I present in detail the model and results of the numerical solution, as well as conclusions of a comparative static exercise.

2.3 The model in a closed economy

2.3.1 Demand

The theoretical framework applied here is similar to Melitz [2003]: preferences of a representative consumer are determined by a continuum of goods indexed by ω and are denoted by a CES utility function, in which ρ represents the elasticity of substitution between any two goods, and Ω represents the mass of available goods:

$$U = \left[\int_{\omega \in \Omega} q(\omega)^{\rho} d\omega \right]^{1/\rho} \tag{2.1}$$

Likewise, consumer behavior is modeled by considering the set of varieties as an aggregate good $Q \equiv U$ associated with an aggregate price, where $\sigma = 1/(1-\rho)$:

$$P = \left[\int_{\omega \in \Omega} p(\omega)^{1-\sigma} d\omega \right]^{1/1-\sigma} \tag{2.2}$$

Optimal consumption and expenditure decisions for individual varieties are defined as:

$$q(\omega) = Q\left[\frac{p(\omega)}{P}\right]^{-\sigma}, \tag{2.3}$$

$$r(\omega) = R\left[\frac{p(\omega)}{P}\right]^{1-\sigma}, \tag{2.4}$$

where $R = PQ = \int_{\omega \in \Omega} r(\omega) d\omega$ is the aggregate expenditure.

2.3.2 Production

All firms have the same fixed cost $f > 0$, but different levels of productivity indexed by $\varphi > 0$. The government sets arbitrarily a quantity of workers $\bar{l}$ (the regulation threshold) above which the firms are defined as formal and required to pay additional labor costs, unlike the informal firms. There are two formal labor costs: a wage premium $1/\eta$ $(0 < \eta < 1)$, coming from social protection or entitlement to certain employment benefits, including advance notice of dismissal, severance pay, or sick leave; and f_f related, for instance, with payroll taxes.

Furthermore, the regulation threshold makes the most productive informal firms increase their profits by scaling back production and hiring up to the threshold number $\bar{l}$ workers, avoiding in this way to be taken as formal, and thus, avoiding having to pay the formal extra costs. Therefore, this kind of firm endogenously chooses to produce as if they were a less productive informal firm, charging the corresponding prices with the respective production level.

This specification results in two kind of informal firms: the less productive informal (*lpi*) between the cutoffs $(\varphi_i^*, \varphi_{mpi}^*)$, and the most productive informal (*mpi*) between the cutoffs $(\varphi_{mpi}^*, \varphi_f^*)$. Where $\varphi_i^* < \varphi_{mpi}^* < \varphi_f^*$, φ_i^* represents the minimum productivity level for an informal firm to access the market, φ_{mpi}^* corresponds to the least productive *mpi* and φ_f^* to the least productive formal firm.[3]

Labor is inelastically supplied at its aggregate level L, while labor demand function is defined as follows:

$$l(\varphi) = f + \frac{q(\varphi)}{\varphi} + f_f h(l - \bar{l}), \tag{2.5}$$

where $h(l - \bar{l})$ is a Heaviside Function:

$$h(l - \bar{l}) = \begin{cases} 0, & \text{if } l \leq \bar{l}, \text{ for informal firms} \\ 1, & \text{if } l > \bar{l}, \text{ for formal firms} \end{cases} \tag{2.6}$$

Informal and formal firms face a residual demand curve with constant elasticity σ, choosing the same profit maximization markup $\sigma/(\sigma - 1) = 1/\rho$. I define wages for every informal firm as w_i and take it as the numéraire, while wages for formal w_f are equal to w_i multiplied by a formal wage premium. The wage function is therefore: $w_{i,f} = 1/(1 - \eta h(l - \bar{l}))$. The pricing rule for the *lpi* (p_{lpi}) and formal (p_f) firms is expressed as follows:

$$p_{lpi,f} = \left(\frac{w_{i,f}}{\rho \varphi} \right) \tag{2.7}$$

[3] Another approach that results in this kind of most informal firm is explored by Davies and Paz [2011], although due to their framework, they do not arrive at the solution for the model.

The *mpi* firms instead, who are looking to not be taken as formal, have to scale back production and adjust their prices to satisfy their residual demand and maximize their profits, hiring up to $\bar{l}$ workers. If they apply the same pricing rule as *lpi* firms, then, their prices would decrease and quantities would increase, according to their productivity level, which in turn would increase the demand for their varieties, making it necessary to hire more than $\bar{l}$ workers, converting them automatically to formal firms, and shrinking significantly their profits as a consequence.

Therefore, *mpi* firms choose the rule of price that equals the production of equation (5), for an informal firm subject to $l(\varphi) = \bar{l}$, and demand of equation (3):

$$p_{mpi} = \left[(\bar{l} - f)\varphi / RP^{\sigma-1}\right]^{-1/\sigma} \tag{2.8}$$

However, as the aggregate price P depends also on p_{mpi}, it is not possible to obtain the numerical solution of the model using such a pricing rule. As an approximation, I suggest assigning to *mpi* firms the following pricing rule:

$$p_{mpi} = \frac{1}{\rho\tilde{\varphi}_{mpi}} \tag{2.9}$$

where

$$\tilde{\varphi}_{mpi} = \left[\frac{1}{G(\varphi_f^*) - G(\varphi_{mpi}^*)} \int_{\varphi_{mpi}^*}^{\varphi_f^*} \varphi^{\sigma-1} g(\varphi) d\varphi\right]^{1/\sigma-1}$$

Equation (9) replicates the price structure for *lpi* firms, except that it considers the average productivity of the *mpi* mass of firms ($\tilde{\varphi}_{mpi}$), defined between the productivity cutoffs for *mpi* (φ_{mpi}^*) and formal (φ_f^*) firms, instead of the simple productivity level φ.

Consistently within the specifications of the model, this pricing rule for *mpi* firms treats them as an aggregate instead of individually. Indeed, even though each firm may experience either an excess demand or excess supply, as well as the possibility of hiring a few less or more workers than $\bar{l}$ (except the one with the average productivity level), the average firm labor demand is $\bar{l}$ and the market clearing condition holds. Likewise, this price does not alter the effects of trade openness on the solution of the model, on the different cutoffs, on the averages and on aggregated variables.

Now, replacing the regulation threshold $\bar{l}$ in eq. (5) yields:

$$\bar{l} = \begin{cases} l_{lpi}(\varphi_{mpi}^*) = f + \dfrac{q_{lpi}(\varphi_{mpi}^*)}{\varphi_{mpi}^*} \\ l_{mpi}(\tilde{\varphi}_{mpi}) = f + \dfrac{q_{mpi}(\tilde{\varphi}_{mpi})}{\tilde{\varphi}_{mpi}} \end{cases} \tag{2.10}$$

Where $q_{lpi}(\varphi) = r_{lpi}(\varphi)/p_i(\varphi)$; $\varphi \in (\varphi_i^*, \varphi_{mpi}^*)$, such that q_{lpi} represents an *lpi* firm's production and r_{lpi} represents their revenues. $q_{mpi}(\tilde{\varphi}_{mpi}) = r_{mpi}(\tilde{\varphi}_{mpi})/p_{mpi}(\tilde{\varphi}_{mpi})$ represents the production of *mpi* firms and r_{mpi} represents *mpi* revenues.

The ratio of any two firms' revenues, in the same group, equals the ratio of their productivity levels, hence:

$$r_{lpi}(\varphi) = \left(\frac{\varphi}{\varphi_i^*}\right)^{\sigma-1} r_{lpi}(\varphi_i^*) \tag{2.11}$$

$$r_{mpi}(\tilde{\varphi}_{mpi}) = \left(\frac{\tilde{\varphi}_{mpi}}{\varphi_{mpi}^*}\right)^{\sigma-1} r_{mpi}(\varphi_{mpi}^*) \tag{2.12}$$

$$r_f(\varphi) = \left(\frac{\varphi}{\varphi_f^*}\right)^{\sigma-1} r_f(\varphi_f^*) \tag{2.13}$$

I can relate now the profit functions for each kind of firm:

$$\pi_{lpi}(\varphi) = \frac{r_{lpi}(\varphi)}{\sigma} - f \tag{2.14}$$

$$\pi_{mpi}(\tilde{\varphi}_{mpi}) = r_{mpi}(\tilde{\varphi}_{mpi}) - \bar{l} \tag{2.15}$$

$$\pi_f(\varphi) = \frac{r_f(\varphi)}{\sigma} - \frac{f_f + f}{1-\eta} \tag{2.16}$$

The distribution of productivity is conditional to the productivity cutoffs:

$$\mu(\varphi) = \begin{cases} \dfrac{g(\varphi)}{G(\varphi_{mpi}^*) - G(\varphi_i^*)}, & \text{if } \varphi_i^* \leq \varphi \leq \varphi_{mpi}^* \text{ } (lpi \text{ firms}) \\ \dfrac{g(\varphi)}{G(\varphi_f^*) - G(\varphi_{mpi}^*)}, & \text{if } \varphi_{mpi}^* \leq \varphi \leq \varphi_f^* \text{ } (mpi \text{ firms}) \\ \dfrac{g(\varphi)}{1 - G(\varphi_f^*)}, & \text{if } \varphi_f^* \leq \varphi \text{ (formal firms)} \\ 0, & \text{if } \varphi < \varphi_i^* \end{cases}$$

Therefore, the average productivity is as follows:

$$\tilde{\varphi}_{lpi} = \left[\frac{1}{G(\varphi_{mpi}^*) - G(\varphi_i^*)} \int_{\varphi_i^*}^{\varphi_{mpi}^*} \varphi^{\sigma-1} g(\varphi) d\varphi\right]^{1/\sigma-1} \tag{2.17}$$

$$\tilde{\varphi}_{mpi} = \left[\frac{1}{G(\varphi_f^*) - G(\varphi_{mpi}^*)} \int_{\varphi_{mpi}^*}^{\varphi_f^*} \varphi^{\sigma-1} g(\varphi) d\varphi\right]^{1/\sigma-1} \tag{2.18}$$

$$\tilde{\varphi}_f = \left[\frac{1}{1 - G(\varphi_f^*)} \int_{\varphi_f^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi\right]^{1/\sigma-1} \tag{2.19}$$

The masses for each kind of firm are defined as follows: less productive informal firms $M_{lpi} = \gamma_{lpi} M$, most productive informal firms $M_{mpi} = \gamma_{mpi} M$, formal $M_f = \gamma_f M$, where $M_a = M_{lpi} + M_{mpi} + M_f$ is the total mass of successful firms in an autarchy. $\gamma_{lpi} = [G(\varphi_{mpi}) - G(\varphi_i^*)]/p_{in}$ corresponds to the ex-ante probability that one successful firm will be an informal *lpi*, $\gamma_{mpi} = [G(\varphi_f^*) - G(\varphi_{mpi})]/p_{in}$ corresponds to the ex-ante probability that one successful firm will be an informal *mpi* and $\gamma_f = [1 - G(\varphi_f^*]/p_{in}$ corresponds to the ex-ante probability that one successful firm will be formal. $p_{in} \equiv 1 - G(\varphi_i^*)$ represents the ex-ante probability of successful entry for any firm.

The weighted average productivity across all firms in the market is represented by $\tilde{\varphi}_a$ (in an autarchy):

$$\tilde{\varphi}_a = \left\{ \frac{1}{M_a} \left[M_{lpi}\tilde{\varphi}_{lpi}^{\sigma-1} + M_{mpi}\tilde{\varphi}_{mpi}^{\sigma-1} + M_f \left[(1-\eta)\tilde{\varphi}_f \right]^{\sigma-1} \right] \right\}^{1/\sigma-1} \tag{2.20}$$

2.3.3 Equilibrium

The zero profit condition for *lpi* firms implies the following expression for revenues:

$$\pi_{lpi}(\varphi_i^*) = 0 \Longleftrightarrow r_{lpi}(\varphi_i^*) = \sigma f \tag{2.21}$$

The average revenues and profits for *lpi* firms are the next:

$$\bar{r}_{lpi} = r_{lpi}(\tilde{\varphi}_{lpi}) = \left[\frac{\tilde{\varphi}_{lpi}(\varphi_i^*)}{\varphi_i^*} \right]^{\sigma-1} r_{lpi}(\varphi_i^*) \tag{2.22}$$

$$\bar{\pi}_{lpi} = \pi_{lpi}(\tilde{\varphi}_{lpi}) = \kappa(\varphi_i^*) f \tag{2.23}$$

Where: $\kappa(\varphi_i^*) = \kappa_{lpi} = \left[\frac{\tilde{\varphi}_{lpi}(\varphi_i^*)}{\varphi_i^*} \right]^{\sigma-1} - 1$

Getting φ_{mpi}^* in terms of φ_i^*. Taking into account that the labor demand of the most productive *lpi* firm should be equal to the labor demand of the least productive *mpi* firm, at the productivity cutoff level (φ_{mpi}^*), so both kind of firms hire up to $\bar{l}$ workers. I express $q_{lpi}(\varphi_{mpi}^*)$ as follows:

$$q_{lpi}(\varphi_{mpi}^*) = \frac{r_{lpi}(\varphi_{mpi}^*)}{p_i} = \left(\frac{\varphi_{mpi}^*}{\varphi_i^*} \right)^{\sigma-1} f(\sigma-1)\varphi \tag{2.24}$$

Then, replacing (23) with the $\bar{l}$ expression, eq. (8), and solving for φ_{mpi}^*, the outcome is:

$$\varphi_{mpi}^* = \left[\frac{\bar{l} - f}{(\sigma-1)f} \right]^{1/\sigma-1} \varphi_i^* \tag{2.25}$$

Proceeding similarly as with the labor demand, at the productivity cutoff level (φ_{mpi}^*), the profits of the most productive *lpi* firm should be equal to the profits of the least productive *mpi* firm:

$$\pi_{lpi}(\varphi_{mpi}^*) = \pi_{mpi}(\varphi_{mpi}^*) \tag{2.26}$$

Therefore,

$$r_{mpi}(\varphi_{mpi}^*) = \pi_{lpi}(\varphi_{mpi}^*) + \bar{l} \tag{2.27}$$

Replacing equation (26) into (11), we obtain the average revenues and profits for *mpi* firms:

$$\bar{r}_{mpi} = r_{mpi}(\tilde{\varphi}_{mpi}) = \left(\frac{\tilde{\varphi}_{mpi}}{\varphi^*_{mpi}}\right)^{\sigma-1} [\pi_{lpi}(\varphi^*_{mpi}) + \bar{l}] \tag{2.28}$$

$$\bar{\pi}_{mpi} = \bar{r}_{mpi} - \bar{l} \tag{2.29}$$

Likewise, at the productivity cutoff (φ^*_f), the profits of the most productive *mpi* firm should be equal to the least productive formal firm. This is because at such a productivity level an *mpi* firm is productive enough to no longer scale back production, and this situation is the no-arbitrage condition:

$$\pi_{mpi}(\varphi^*_f) = \pi_f(\varphi^*_f) \tag{2.30}$$

Therefore, solving for $r_f(\varphi^*_f)$:

$$r_f(\varphi^*_f) = \left[\pi_{mpi}(\varphi^*_f) + \left(\frac{f_f + f}{1-\eta}\right)\right]\sigma \tag{2.31}$$

The average revenues and profits are then:

$$\bar{r}_f = r_f(\tilde{\varphi}_f) = \left(\frac{\tilde{\varphi}_f}{\varphi^*_f}\right)^{\sigma-1} \left[\pi_{mpi}(\varphi^*_f) + \left(\frac{f_f + f}{1-\eta}\right)\right]\sigma \tag{2.32}$$

$$\bar{\pi}_f = \frac{\bar{r}_f}{\sigma} - \left(\frac{f_f + f}{1-\eta}\right) \tag{2.33}$$

I proceed similarly so as to get φ^*_{mpi} to express φ^*_f in terms of φ^*_i, comparing labor demand functions. In this case, at the productivity cutoff level φ^*_f, labor demand for *mpi* firms should be smaller than the formal firms' demand. Indeed, beyond that productivity level, formal firms are so productive that they would require more than $\bar{l}$ workers to maximize their profits. Then, I express q_f as follows:

$$q_f = \frac{r_f}{p_f} = \left(\frac{\varphi}{\varphi^*_f}\right)^{\sigma-1} \left[\pi_{mpi}(\varphi^*_f) + \left(\frac{f_f + f}{1-\eta}\right)\right](\sigma-1)(1-\eta)\varphi \tag{2.34}$$

Replacing eq. (32) into the labor demand for formal firms, eq. (5), and evaluating at $\varphi = \varphi^*_f$, I obtain:

$$l_f(\varphi^*_f) = \left[\pi_{mpi}(\varphi^*_f) + \left(\frac{f_f + f}{1-\eta}\right)\right](\sigma-1)(1-\eta) + (f + f_f) \tag{2.35}$$

As $\bar{l} \leq l_f(\varphi^*_f)$, we can solve for φ^*_f:

$$\varphi^*_f \geq \left[\bar{l}\left(1 + \frac{1}{(\sigma-1)(1-\eta)}\right) - \left(\frac{f_f + f}{1-\eta}\right)\left(1 + \frac{1}{\sigma-1}\right)\right]\left(\frac{\rho\varphi^*_{mpi}}{\bar{l} - f}\right) \tag{2.36}$$

I can now define the average revenues and profits across all domestic firms:

$$\bar{r}_a = \gamma_{lpi} r_{lpi}(\tilde{\varphi}_{lpi}) + \gamma_{mpi} r_{mpi}(\tilde{\varphi}_{mpi}) + \gamma_f r_f(\tilde{\varphi}_f) \tag{2.37}$$

$$\bar{\pi}_a = \gamma_{lpi} \pi_{lpi}(\tilde{\varphi}_{lpi}) + \gamma_{mpi} \pi_{mpi}(\tilde{\varphi}_{mpi}) + \gamma_f \pi_f(\tilde{\varphi}_f) \tag{2.38}$$

Such that $\varphi_i^* < \varphi_{mpi}^* < \varphi_f^*$.

To solve the model, I introduce the free entry condition:

$$\bar{\pi}_a = \frac{\delta f_e}{1 - G(\varphi_i^*)} \tag{2.39}$$

Where δ represents the probability of exiting the market for incumbent firms, and f_e represents the sunk investment cost required for the firms to gain entry.

The Informal Cutoff φ_i^* is obtained by equalizing (37) and (38):

$$[G(\varphi_{mpi}^*) - G(\varphi_i^*)]\tilde{\pi}_{lpi} + [G(\varphi_f^*) - G(\varphi_{mpi}^*)]\tilde{\pi}_{mpi} + [1 - G(\varphi_f^*)]\tilde{\pi}_f = \delta f_e \tag{2.40}$$

With the purpose of illustrating the autarchy equilibrium I summarize (and anticipate) in Figure 1 the results of the numerical solution in section 5. In general, I obtain similar results as observed in Melitz [2003], as the piecewise functions of revenues, profits and labor demand are concave (non-negative curvature), but we can distinguish a significant impact of the regulatory threshold on the informal sector in the whole economy, especially in the *mpi* firms.

The three variables in Figure 1 exhibit constant relationships with respect to the *mpi* firm's productivity, since prices and quantities are constant, corresponding to the average decisions of the group, which explains the jumps in revenue and profit levels. Hence, *mpi* firms scale back production in order to avoid paying the formal labor costs by hiring up to $\bar{l}$ workers.

As expected, there is a change of level in the figure of the labor demand of formal firms. Indeed, any formal firm will hire more than $\bar{l}$ workers to maximize their profits, according to their respective productivity level.

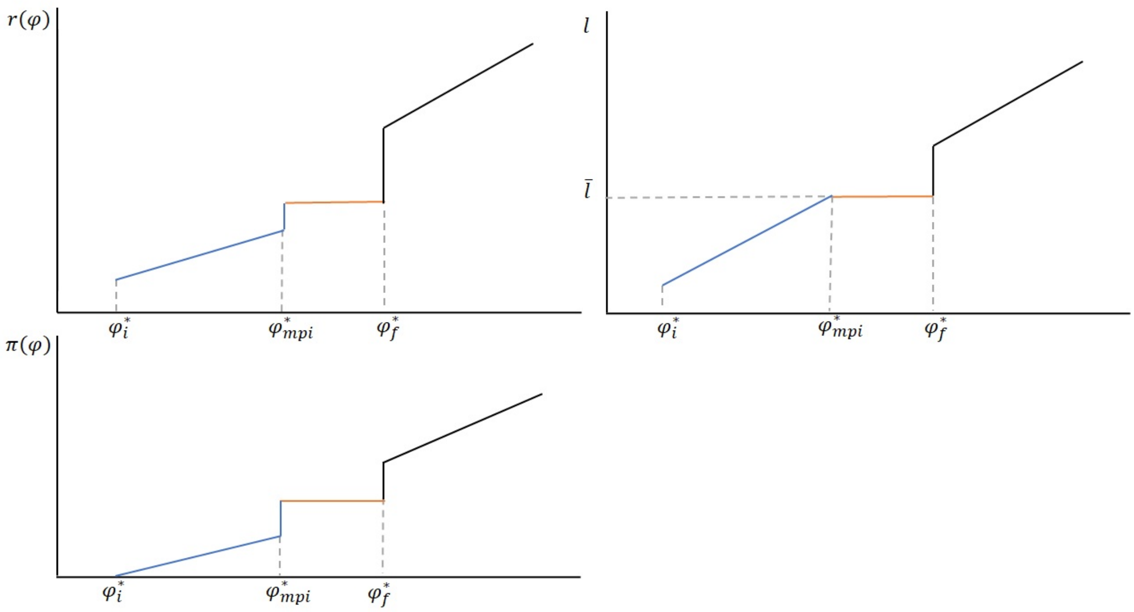


Figure 2.1: Closed economy equilibrium. Revenues, profits and employment. These figures summarize the results of the numerical solution showed in Appendix, Figure A1.

I. **Equilibrium results**

The aggregate stationary equilibrium condition states that the mass of successful entrants (M_{ent}) equals the mass of incumbents who are hit with a bad shock (δ) and exit: $p_{in}M_{ent} = \delta M_a$.

Total payments to labor are defined as $\bar{w}L = \bar{w}(L_p + L_{ent})$, where L_p and L_{ent} denote the aggregate labor used for production and investment, respectively, while $\bar{w} = \gamma_{lpi} + \gamma_{mpi} + \gamma_f(1/(1-\eta))$, denotes the average wage of all kinds of workers.

The market clearing conditions for production and investment workers are: $\bar{w}L_p = R - \Pi$ and $\bar{w}L_{ent} = M_{ent}f_{ent}$, respectively. Thus, $R = \bar{w}L_p + \Pi = \bar{w}L$. Using this expression and the equilibrium mass of incumbent firms ($\bar{\pi} = \delta f_{ent}/[1 - G(\varphi_i^*)]$) I obtain the equilibrium mass of incumbent firms:

$$M_a = \frac{\bar{w}L}{\bar{r}_a} \tag{2.41}$$

Additionally, aggregate labor is composed of the three kinds of firms: $\bar{w}L = \bar{w}(L_{lpi} + L_{mpi} + L_f) = M_{lpi}r_{lpi}(\tilde{\varphi}_{lpi}) + M_{mpi}r_{mpi}(\tilde{\varphi}_{mpi}) + M_f r_f(\tilde{\varphi}_f)$, from which the percentage of each group can be inferred.

Now, using the pricing rules for the three kinds of firms, I obtain the price index for all goods in the economy, as well as the measure of welfare:

$$P = M_a^{1/1-\sigma} p_i(\tilde{\varphi}_a) \tag{2.42}$$

$$\text{Welfare} = \frac{R}{L}P^{-1} = \frac{R}{L}M_a^{1/\sigma-1}\rho\tilde{\varphi}_a \tag{2.43}$$

2.4 Open economy

I reasonably assume that exporting firms are formal;[4] hence, they face the same production costs as any other formal firm, except that they have an additional "iceberg" trade cost $1/\tau$ $(0 < \tau < 1)$ of serving foreign markets. Likewise, they face a fixed export cost f_x to access the international market. f_f is already paid in the domestic market. Henceforth, the sub-index "e" refers to exporting firms and "x" to the open economy variables. The labor demand for exporters is as follows:

$$l_e = f_x + \frac{q(\varphi)}{\varphi\tau} \tag{2.44}$$

The pricing rule equates to:

$$p_e(\varphi) = \frac{1}{(1-\eta)\rho\varphi\tau} = \frac{p_f(\varphi)}{\tau} \tag{2.45}$$

The revenues:

$$r_e(\varphi) = \left(\frac{\varphi}{\varphi_e^*}\right)^{\sigma-1} r_e(\varphi_e^*) \tag{2.46}$$

Where the cutoff φ_e^* denotes the minimum productivity for a formal firm to be exporter.

The profits:

$$\pi_e = \frac{r_e(\varphi)}{\varphi} - \frac{f_x}{1-\eta} \tag{2.47}$$

The quantities:

$$q_e = \frac{r_e}{p_e} = \left(\frac{\varphi}{\varphi_e^*}\right)^{\sigma-1} \left(\frac{f_x}{1-\eta}\right)(\sigma-1)(1-\eta)\tau\varphi \tag{2.48}$$

Exporting firms exhibit combined revenues and profits, as they sell both in the domestic and foreign markets. The parameter "n" denotes the number of trade partners.

$$r_{ex}(\varphi) = r_f(\varphi) + n r_e(\varphi) \tag{2.49}$$

$$\pi_{ex}(\varphi) = \pi_f(\varphi) + n\pi_e(\varphi) \tag{2.50}$$

The distribution of productivity function is represented by the following:

[4] Keen [2008] and Davies and Paz [2011] argue that informal goods are nontradable.

$$\mu_x(\varphi) = \begin{cases} \dfrac{g(\varphi)}{G(\varphi^*_{mpix}) - G(\varphi^*_{ix})}, & \text{if } \varphi^*_{ix} \leq \varphi \leq \varphi^*_{mpix} \\ \dfrac{g(\varphi)}{G(\varphi^*_{fx}) - G(\varphi^*_{mpix})}, & \text{if } \varphi^*_{mpix} \leq \varphi \leq \varphi^*_{fx} \\ \dfrac{g(\varphi)}{1 - G(\varphi^*_{fx})}, & \text{if } \varphi^*_{fx} \leq \varphi \\ \dfrac{g(\varphi)}{1 - G(\varphi^*_{e})}, & \text{if } \varphi^*_{e} \leq \varphi \\ 0, & \text{if } \varphi < \varphi^*_{ix} \end{cases}$$

Therefore, average productivity for the three groups can be defined as before, additionally the exporting firms can be defined as:

$$\tilde{\varphi}_{ix} = \left[\frac{1}{G(\varphi^*_{mpix}) - G(\varphi^*_{ix})} \int_{\varphi^*_{ix}}^{\varphi^*_{mpix}} \varphi^{\sigma-1} g(\varphi) d\varphi \right]^{1/\sigma-1} \tag{2.51}$$

$$\tilde{\varphi}_{iptx} = \left[\frac{1}{G(\varphi^*_{fx}) - G(\varphi^*_{mpix})} \int_{\varphi^*_{mpix}}^{\varphi^*_{fx}} \varphi^{\sigma-1} g(\varphi) d\varphi \right]^{1/\sigma-1} \tag{2.52}$$

$$\tilde{\varphi}_{fx} = \left[\frac{1}{1 - G(\varphi^*_{fx})} \int_{\varphi^*_{fx}}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi \right]^{1/\sigma-1} \tag{2.53}$$

$$\tilde{\varphi}_{e} = \left[\frac{1}{1 - G(\varphi^*_{e})} \int_{\varphi^*_{e}}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi \right]^{1/\sigma-1} \tag{2.54}$$

The equation below $\tilde{\varphi}_{ax}$, represents the weighted productivity average across all firms in the open economy, which can be: formal ($M_{fx} = \gamma_{fx} M_x$), informal *lpi* firms ($M_{lpix} = \gamma_{lpix} M_x$), or *mpi* firms ($M_{mpix} = \gamma_{mpix} M_x$), such that $M_x = M_{lpix} + M_{mpix} + M_{fx}$ represents the total mass of successful domestic firms. The exporting mass of firms is defined as $M_e = \gamma_e M_{fx}$, and $M_t = M_x + nM_e = M_x(1 + n\gamma_e\gamma_{fx})$ denotes the total mass of varieties available in the country.

$$\begin{aligned} \tilde{\varphi}_{ax} = \Bigg\{ \frac{1}{M_t} \Big[& M_{lpix} \tilde{\varphi}^{\sigma-1}_{lpix} + M_{mpix} \tilde{\varphi}^{\sigma-1}_{mpix} + M_{fx} \big[(1-\eta)\tilde{\varphi}_{fx}\big]^{\sigma-1} \\ & + nM_e \big[(1-\eta)\tau\tilde{\varphi}_e\big]^{\sigma-1} \Big] \Bigg\}^{1/\sigma-1} \end{aligned} \tag{2.55}$$

Where $\gamma_{lpix} = \big[G(\varphi^*_{mpix}) - G(\varphi^*_{ix})\big]/p_{inx}$, $\gamma_{mpix} = \big[G(\varphi^*_{fx}) - G(\varphi^*_{mpix})\big]/p_{inx}$, $\gamma_{fx} = \big[1 - G(\varphi^*_{fx})\big]/p_{inx}$ and $\gamma_e = \big[1 - G(\varphi^*_e)\big]/p_{inx}$, and p_{inx} represents the probability of a firm to enter the market, in the open economy.

2.4.1 Equilibrium

The Zero Profit Condition:

$$\pi_e(\varphi_e^*) = 0 \Longleftrightarrow r_e(\varphi_e^*) = \sigma\left(\frac{f_x}{1-\eta}\right) \tag{2.56}$$

The average revenues and profits from export sales and for exporting formal firms:

$$\bar{r}_e = r_e(\tilde{\varphi}_e) = \left[\frac{\tilde{\varphi}(\varphi_e^*)}{\varphi_e^*}\right]^{\sigma-1}\left(\frac{f_x}{1-\eta}\right)\sigma \tag{2.57}$$

$$\bar{r}_{ex} = r_{fx}(\tilde{\varphi}_{fx}) + n\gamma_e r_e(\tilde{\varphi}_e) \tag{2.58}$$

$$\bar{\pi}_e = \pi_e(\tilde{\varphi}_e) = \frac{r_e(\tilde{\varphi}_e)}{\sigma} - \left(\frac{f_x}{1-\eta}\right) \tag{2.59}$$

$$\bar{\pi}_{ex} = \pi_{fx}(\tilde{\varphi}_{fx}) + n\gamma_e \pi_e(\tilde{\varphi}_e) \tag{2.60}$$

The cutoff φ_{iptx}^* determines in the open economy, within informal firms, the group of informal price-taker and informal firms; while φ_{fx}^* separates informal from formal firms. Both cutoffs are found in a similar way as in the closed economy:

$$\varphi_{iptx}^* = \left[\frac{\bar{l}-f}{(\sigma-1)f}\right]^{1/\sigma-1}\varphi_{ix}^* \tag{2.61}$$

$$\varphi_{fx}^* = \left[\bar{l}\left(1+\frac{1}{(\sigma-1)(1-\eta)}\right) - \left(\frac{f_f+f}{1-\eta}\right)\left(1+\frac{1}{\sigma-1}\right)\right]\left(\frac{\rho\varphi_{iptx}^*}{\bar{l}-f}\right) \tag{2.62}$$

φ_e^*, in turn, separates within the formal firms category the ones who export. Expressing φ_e^* in terms of φ_{ix}^*:

$$\frac{r_e(\varphi_e^*)}{r_{ix}(\varphi_{ix}^*)} = \left[\frac{(1-\eta)\tau\varphi_e^*}{\varphi_{ix}^*}\right]^{\sigma-1} = \frac{1}{f}\left(\frac{f_x+f_f}{1-\eta}\right) \tag{2.63}$$

Solving for φ_e^*:

$$\varphi_e^* = \left[\frac{f_x+f_f}{(1-\eta)^\sigma f}\right]^{1/\sigma-1}\frac{\varphi_{ix}^*}{\tau} \tag{2.64}$$

Average revenues and profits across all domestic and exporting firms are defined as follows:

$$\begin{aligned}\bar{r}_x = {} & \gamma_{ix} r_{ix}(\tilde{\varphi}_{ix}) + \gamma_{iptx} r_{iptx}(\tilde{\varphi}_{iptx}) + \gamma_{fx} r_{fx}(\tilde{\varphi}_{fx}) + \\ & \gamma_{fx}[n\gamma_e r_e(\tilde{\varphi}_e)]\end{aligned} \tag{2.65}$$

$$\bar{\pi}_x = \gamma_{if}\pi_{ix}(\tilde{\varphi}_{ix}) + \gamma_{iptx}\pi_{iptx}(\tilde{\varphi}_{iptx}) + \gamma_{fx}\pi_{fx}(\tilde{\varphi}_{fx}) + \gamma_{fx}[n\gamma_e\pi_e(\tilde{\varphi}_e)] \tag{2.66}$$

Such that the cutoff satisfies the following inequalities: $\varphi^*_{ix} < \varphi^*_{iptx} < \varphi^*_{fx} < \varphi^*_e$. Now, retaking the free entry condition FE, eq. (36):

$$\bar{\pi}_x = \frac{\delta f_e}{1 - G(\varphi^*_{ix})}$$

and using it together with the Zero Cutoff Profit Condition, eq. (63), it is possible to solve for φ^*_{ix}:

$$[G(\varphi^*_{iptx}) - G(\varphi^*_{ix})]\tilde{\pi}_{ix} + [G(\varphi^*_{fx}) - G(\varphi^*_{iptx})]\tilde{\pi}_{iptx} + [1 - G(\varphi^*_{fx})]\tilde{\pi}_{fx} + [1 - G(\varphi^*_e)]n\gamma_e\tilde{\pi}_e = \delta f_e \tag{2.67}$$

Aggregate revenues R_x equal the total payments to labor $\bar{w}_x L$. Thus, the mass of incumbent firms M_x is:

$$M_x = \frac{\bar{w}_x L}{\bar{r}_x} \tag{2.68}$$

Where the average wage $\bar{w}_x = \gamma_{ix} + \gamma_{iptx} + \gamma_{fx}(1-\eta) + n\gamma_{fx}\gamma_e(1-\eta)$, and L is decomposed as follows: $\bar{w}_x L = \bar{w}_x\big(L_{ix} + L_{iptx} + L_{fx} + L_{ex}\big) = M_{ix}r_{ix}(\tilde{\varphi}_{ix}) + M_{iptx}r_{iptx}(\tilde{\varphi}_{iptx}) + M_{fx}r_{fx}(\tilde{\varphi}_{fx}) + nM_e r_{ex}(\tilde{\varphi}_e)$.

The price index for the open economy and the welfare measure are derived as follows:

$$P_x = M_t^{1/1-\sigma} p_{ix}(\tilde{\varphi}_{ax}) \tag{2.69}$$

$$\text{Welfare}_x = \frac{R_x}{L} P_x^{-1} = \frac{R_x}{L} M_t^{1/\sigma-1} \rho\tilde{\varphi}_{ax} \tag{2.70}$$

The next sections present the numerical solution and compare the autarchy and open economy equilibrium, to illustrate the results of the specifications in this model. Then, I undertake a numerical comparative static exercise for the open economy, to evaluate the effect of changing divers policy parameters on some variables of interest.

2.5 Numerical solution

As has been showed empirically (e.g. Arkolakis et al. [2008] and Chaney [2008]), in an environment of heterogeneous firms, the Pareto Probability Density Function is very useful in replicating the size and productivity distribution. Consequently, in line with those specifications, I use the same Probability Density Function, with $\alpha = 3$ and $\varphi_m = (\alpha - 1)/\alpha$, where φ_m represents the minimum possible value of φ:

$$f_\Phi(\varphi) = \begin{cases} \dfrac{\alpha\varphi_m^\alpha}{\varphi^{\alpha+1}}, & \text{if } \varphi \geq \varphi_m \\ 0, & \text{if } \varphi < \varphi_m \end{cases}$$

Table (1) shows all the parameters chosen arbitrarily to obtain the numerical solution:

Parameter	Value
η	0.5
f_f	1
f_x	1
τ	0.5
n	50
$\bar{l}$	10
δ	0.025
σ	3
f_e	2
f	1
L	100

Table 2.1: Parameter values of the numerical solution

Calculations of the main variables of the model in the closed and open economies are presented in Table 2, and, figures (A1) and (A2) in the Appendix present the piecewise functions of revenues, profits and labor demand for all kinds of firms, which I summarize in Figure (2) to illustrate the results of Table (2).

Autarchy		Open economy	
φ_i^*	2.538	φ_{ix}^*	2.569
φ_{mpi}	5.384	φ_{mpix}^*	5.450
φ_f^*	5.583	φ_{fx}^*	5.652
		φ_e^*	14.534
$\tilde{\varphi}_a$	4.396	$\tilde{\varphi}_x$	3.705
L_i	39.284	L_{ix}	33.436
L_{mpi}	1.251	L_{mpix}	1.065
L_f	59.465	L_{fx}	50.612
		L_e	14.886
$\bar{r}_a$	12.110	$\bar{r}_x$	14.228
$\bar{\pi}_a$	2.758	$\bar{\pi}_x$	3.346
M_a	9.033	M_x	8.053
M_i	8.087	M_{ix}	7.210
M_{mpi}	0.098	M_{mpix}	0.087
M_f	0.848	M_{fx}	0.756
		M_e	0.004
		M_t	8.262
$\bar{w}$	1.094	$\bar{w}_x$	1.146
P_index	0.114	P_index_x	0.141
$Welfare$	9.635	$Welfare_x$	8.134

Table 2.2: Results of numerical solution

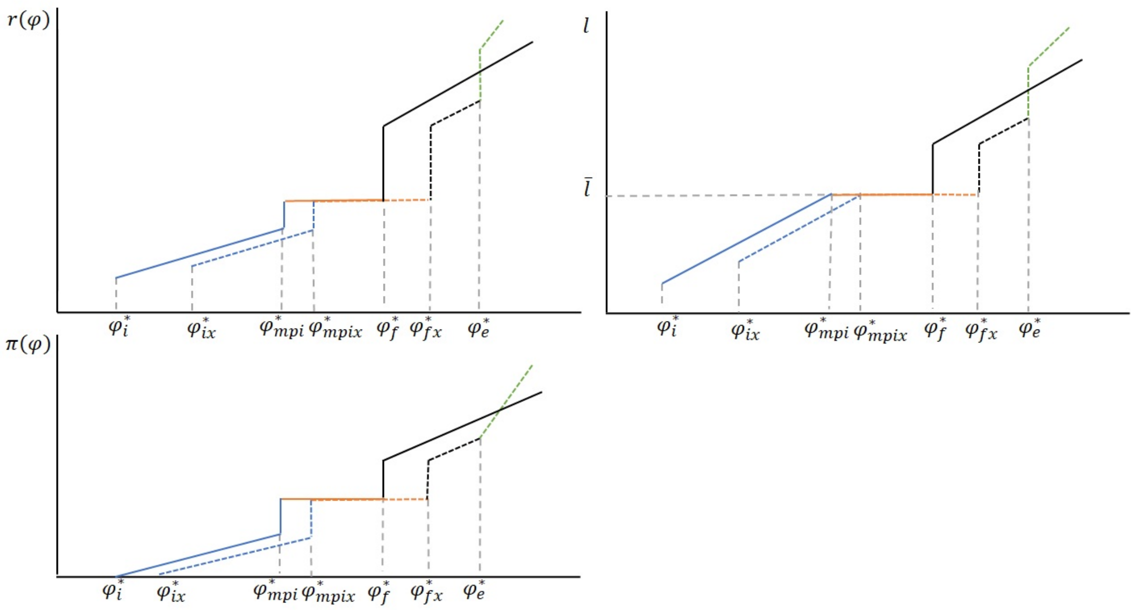


Figure 2.2: Closed and open economy equilibrium. Revenues, profits and employment. Solid lines correspond to the closed economy and dotted lines to the open economy. These figures summarize the results of the numerical solution shown in the Appendix, Figures A1 and A2.

We see in Figure (2) a negative impact of openness for the *lpi* and formal firms in terms of revenues, profits and labor demand, while the three variables remain fixed for the *mpi* firms and increase for the exporting firms, except in the case of the profits for the less productive exporting firms which show a decrease. Hence, in a similar vein to the closed economy results, in the open model *mpi* firms scale back production to avoid the formal labor costs. Another result of this specification occurs in the labor market, where trade integration unambiguously increases the level of formal workers, because of the emergence of exporting firms who hire an important quantity of workers.

Comparing the results in Table (2), I find the (informal) *selection* and *export market selection* effects, according to which $\varphi^*_{ix} > \varphi^*_i$ and $\varphi^*_{fx} > \varphi^*_x$, respectively. Namely, after trade opening, the competition of foreign firms makes the least productive informal firms exit the market, while only the most productive formal firms are able to export. Likewise, there are *mpi* and formal firm selection effects, $\varphi^*_{mpi} < \varphi^*_{mpix}$ and $\varphi^*_f < \varphi^*_{fx}$, bringing about a decrease in the masses of *mpi* and formal firms as well: the least productive formal firms become *mpi*, and the least productive *mpi* become *lpi* firms.

Employees in the *lpi* and *mpi* sectors (L_{ix}, L_{mpix}) decrease, while employment in the exporting sector (L_x) increases. Thus, consistent with the assumption of perfect mobility across sectors, despite the shrink of formal firms in the open economy, workers reallocate into the formal and exporting sectors. However, some workers hired by the least productive formal firms would become informal, as those firms turn *mpi*.

Unlike the results in other trade models with heterogeneous firms, I find an important increase in prices (23.7%), which exceeds the rise of the average wages (4.7%), and thus generates a decrease in welfare after openness, which is reinforced by the decrease of varieties (-8.5%). The higher prices are explained not only in the costly trade but also in the additional fixed and marginal formal costs paid to the new additional formal workers. On the contrary, as the rule of price for *mpi* is defined as constant, and so are quantities, we discard the idea that the down-scale of production shapes a higher price index.

The numerical solution suggests that profits decrease with the openness for *lpi*, *mpi*, the non-exporting formal and the least productive exporting firms. Furthermore, some firms within these groups are worse off: *lpi* firms who exit the market, *mpi* firms who become *lpi*, and formal firms who become *mpi*. The winners are the more productive exporting firms.

2.6 Comparative static exercise

Besides the three policies of trade liberalization analysed in Melitz [2003], τ,f_x and n, I include three labor market regulation policies in this model: $\bar{l}$, η, and f_f. In this exercise I change each of these parameters while keeping the others constant, to see the effects on the cutoffs, market shares, profits, mass of firms, quantity of workers, prices and welfare. The results are shown in the Appendix, Tables (A1) and (A2).

As we can see, higher levels in τ (lower transport costs) and reductions in fixed trade costs f_x, independently, have similar effects: both increase *lpi*, *mpi* and formal cutoffs, while decreasing the exporting cutoffs, as reductions in these two costs result in more concentrated markets around the most productive exporting firms, reallocating workers to this sector, but, at the same time, boosting the most productive formal firms to export.

Consequently, the masses of *lpi*, *mpi* and formal firms fall, as well as the number of workers in those firms. Instead, the mass of exporting firms increases, and thus their worker levels, revenues and profits rise. Welfare increases after changes in the two parameters in different magnitudes. In the case of increases to τ, the positive effects on prices and negative effects on varieties M_t, almost compensate for the increase in formal workers with formal wages, thus we see a moderate increase in welfare. In the case of a decrease in f_X, the impact on prices and varieties is smaller; hence, we see a bigger impact in welfare led by more workers with formal wages. Likewise, having more trade partners n has similar effects as lower transport costs, except that more competition in the domestic market increases the cutoff for exporting firms, reducing them by number.

Regarding the labor market regulation, both tables show that when the government reduces $\bar{l}$ (the regulatory threshold), the *lpi* cutoff rises, forcing the less productive informal firms to leave the market and the most productive to become *mpi*, while the formal cutoff decreases, augmenting formal firms. Likewise, the cutoff for exporting firms increases, concentrating exporting firms in a smaller but very productive group. Accordingly, the mass of *lpi* and *mpi* firms shrinks, even to the extent that the latter tend to disappear, preventing informal firms from taking advantage of the labor market regulation. In a policy of this kind, under full employment, formal workers improve, since the shrink in informal firms in favor of formal firms and exporters reallocates workers towards the most productive firms. Therefore, although the impact on prices is almost null, the welfare increases because there are more workers getting formal wages and more varieties available in the economy.

Now, when the formal wage premium $1/(1-\eta)$ rises (with higher η), formal labor costs increase; hence, informal, formal and exporting cutoffs increase, causing the masses of formal and exporting firms to fall, though the masses of *lpi* and *mpi* tend to increase. Accordingly, informal labor increases while formal labor decreases. The effect on prices has a moderate negative trend, as does the effect on welfare, due mainly to the bigger proportion of informal workers earning informal wages, which compensates for a moderate increase in varieties.

The last regulation parameter is f_f. Unlike η, when the fixed formal cost rises, all cutoffs decrease, increasing the corresponding masses of firms and increasing self-selection in the market. Only the *mpi* mass of firms shrinks, due to the higher costs of being formal that makes them become *lpi* firms and disappear, with only the most productive formal firms remaining in the sector. As exporting becomes more expensive too, many of these firms turn formal. In the labor market, as similarly observed with reductions in $\bar{l}$, workers improve under full employment, as the share of formal employees rises. Nevertheless, the higher fixed cost increases prices and welfare, due mainly to the rise of varieties and more formal workers with better wages.

2.7 Conclusion

In this paper I explore a new definition of informality in the theoretical literature, determined by a regulatory threshold designated by the government according to the size of the firm. In this case, a certain quantity of workers denotes which firms are informal and which formal. Informal firms are divided into two kinds of firms: *lpi*, less productive informal, and *mpi*, the most productive informal, which manipulate their real productivity level to avoid formal cost. Additionally, I incorporate formal fixed and marginal labor costs.

In the autarchy equilibrium, the less productive informal *lpi* firms and the formal firms produce according to their productivity level; therefore, both kind of firms exhibit positive slopes for revenues, labor demand and profits. The most productive informal *mpi* firms instead scale back production to avoid paying additional formal labor costs. To do that, they set a constant rule of price determined by the average productivity of all *mpi* firms, and hence, produce the corresponding constant quantities to that price. Such behaviour allows them not to have excess of demand or excess of supply and not to hire more than $\bar{l}$ workers, as they are pretending to be small firms.

In the open economy equilibrium, I obtain from the numerical solution similar effects as in Melitz [2003]: the *informal selection* and export market selection effects. For this new setup, including informal and formal firms, as well as the labor market regulations, I find formal selection and *mpi* firms selection. Furthermore, there is a reallocation of workers towards formal firms and exporting firms in the labor market. However, unlike the theoretical literature, in this framework welfare decreases, because the better wages earned by more formal workers is counterbalanced and even surpassed by higher prices and less varieties available in the economy. Only the most productive exporting firms are better off than in an autarchy, in terms of profits, whilst *mpi* firms who become *lpi* firms and formal firms who become *mpi* lose.

Regarding the comparative static exercise, the most relevant results derive from evaluation of the three regulation parameters in the labor market: the labor regulatory threshold, the formal wage premium and the formal fixed cost. Changes in parameters related with trade policy have similar effects to the original heterogeneous firms model.

Thus, decreases in the regulatory threshold makes informal firms pay formal costs to stay in the market, reducing the level of informal firms and, under full employment, price-taker firms tend to disappear. Welfare in turn rises, as there are more formal workers earning formal wages. In the case of higher levels of the formal wage premium, welfare moderately decreases, as soon as the mass of formal firms decreases in favor of the informal sector, compensating with a small reduction in prices and higher available varieties. On the other hand, higher formal fixed costs induce *mpi* firms to disappear, while the mass of *lpi*, formal and exporting firms increases, allowing only the most productive to stay in the market. Welfare increases because there are more formal workers and more available varieties, which are not compensated by higher prices.

The next steps to improve the model include the addition in the analysis of labor market distortions, to analyse the effects in the short term, specifically in terms of impacts on unemployment. Certainly, assuming full employment is a strong assumption, specially in the case of developing countries. Moreover, it would be more realistic to allow for informal firms to be assigned an increasing probability of being caught, which should affect output and welfare. Other assumptions can be relaxed; for instance, formal firms could be at the same time informal, as perhaps the strict separation of both sectors is not necessary and can be viewed as less realistic, especially for developed countries.

2.A Appendix chapter 2

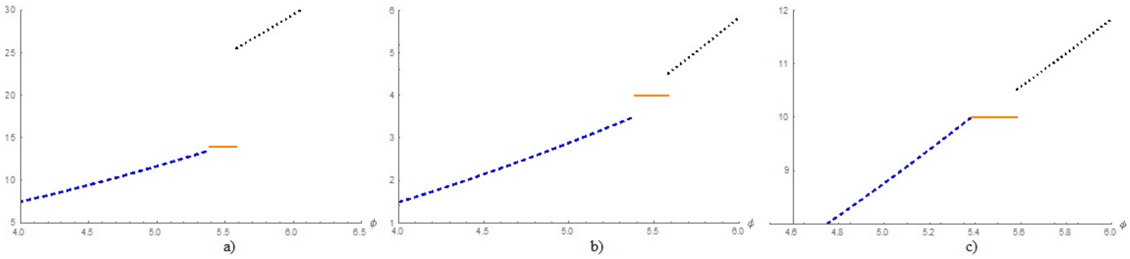


Figure A.1: Equilibrium in closed economy. Dashed lines correspond to the Less Productive Informal firms, solid lines to the Most Productive Informal firms and dotted lines to formal firms. a) Revenues. b) Profits. c) Labor market.

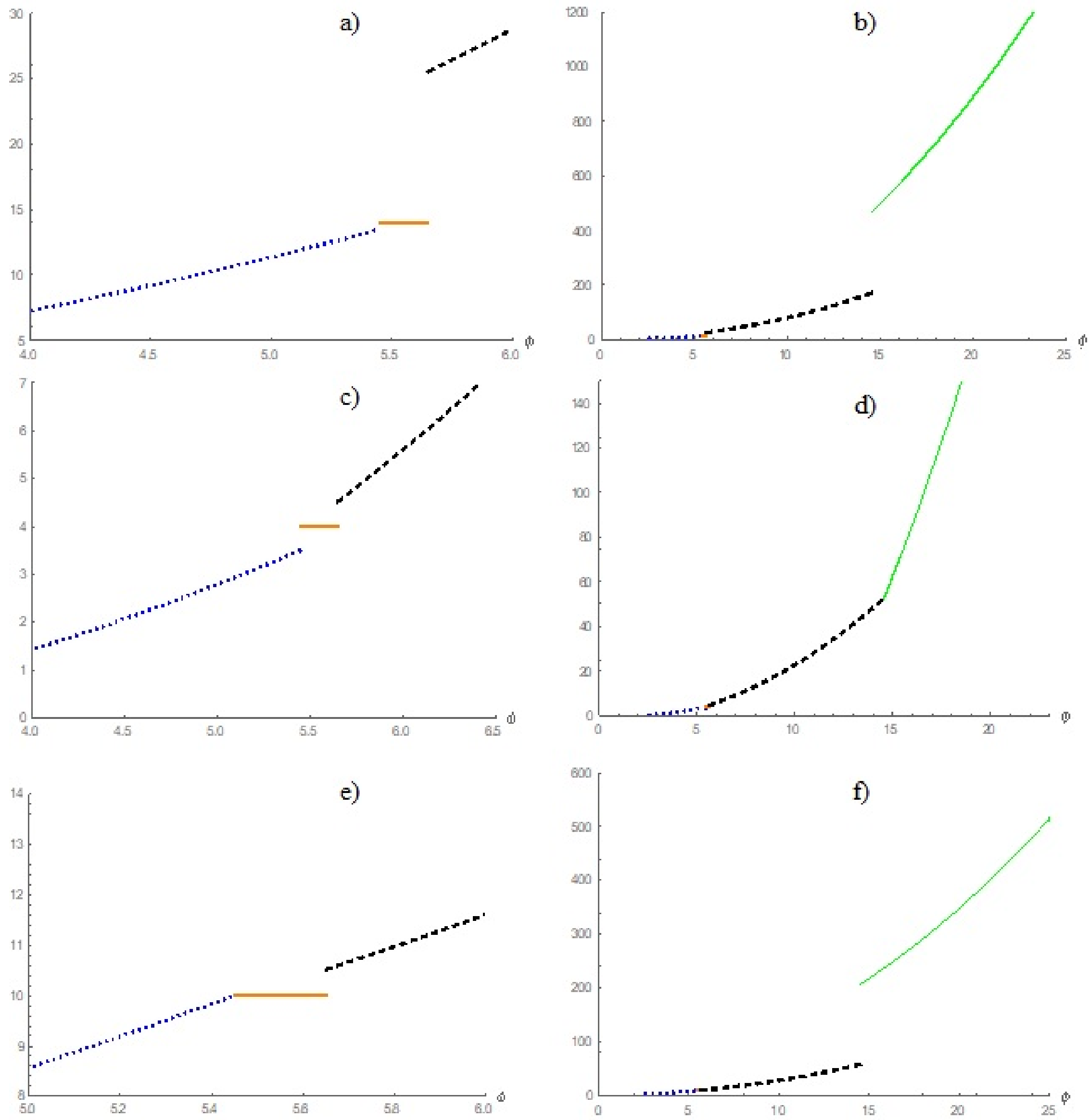


Figure A.2: Equilibrium in open economy. Dotted lines correspond to the Less Productive Informal firms, orange solid lines to the Most Productive Informal firms, dashed lines to formal firms and green solid lines to exporting firms. a) b) Revenues, c) d) Profits, e) f) Labor Market. a) c) e) close up to the Most Productive Informal firms.

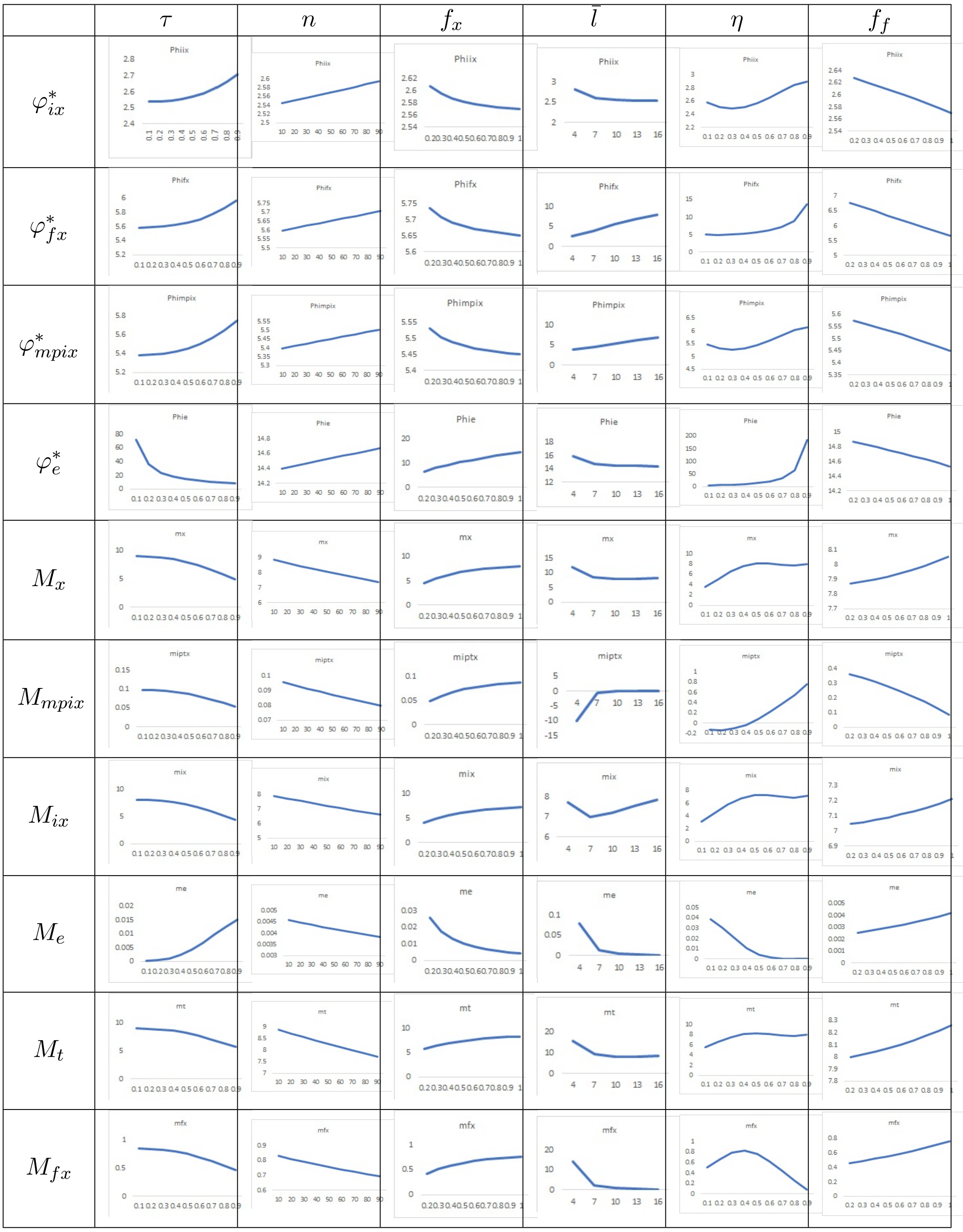


Table A.1: Comparative static results in open economy (a). Continues in Table A2.

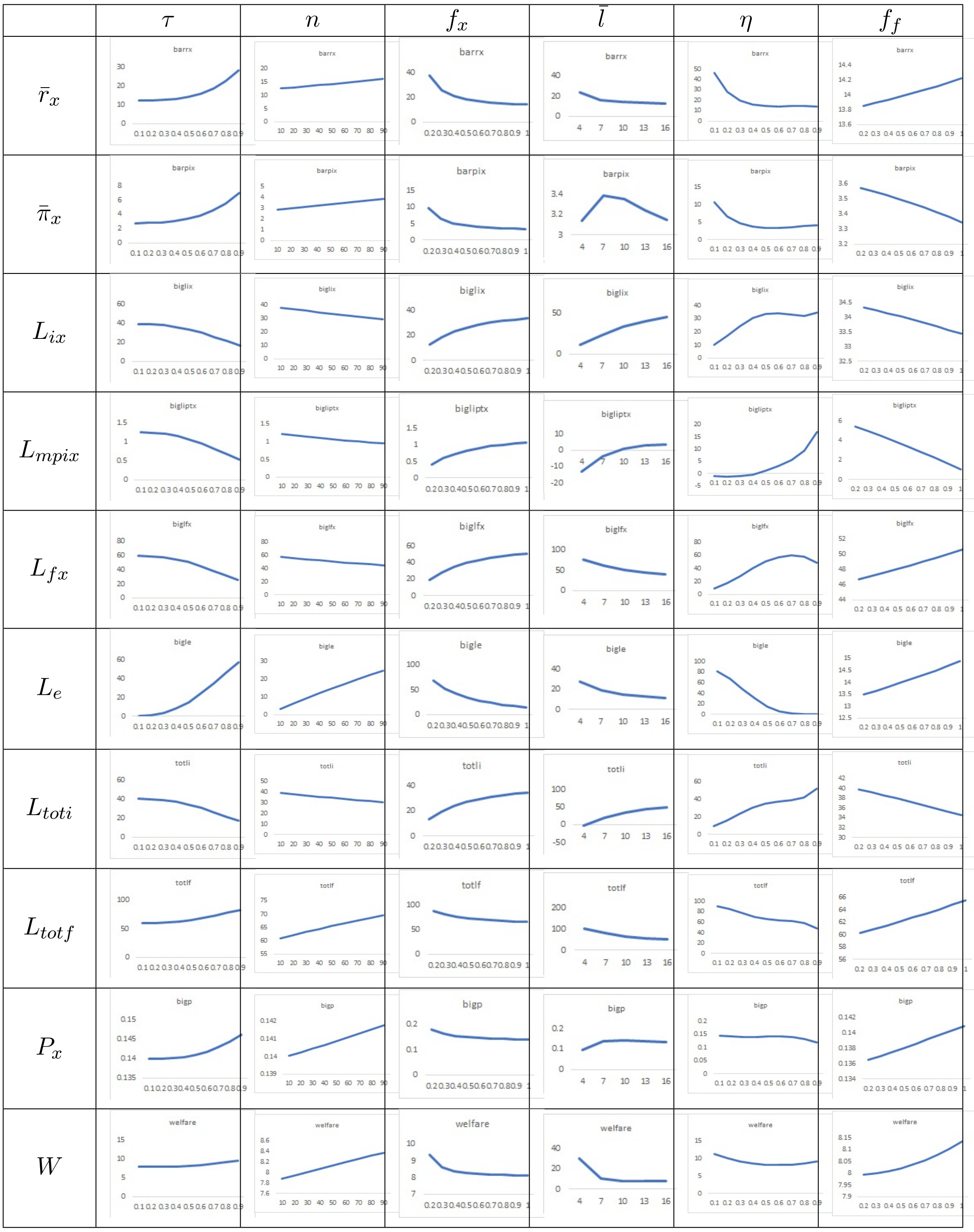


Table A.2: Comparative static results in open economy (b). Continuation from Table A1.

3

The effects of the Dutch disease on the international trade and labor market

I deliver empirical evidence about the impact of the recent oil boom (2003-2015) on aggregate production, trade, employment and informality in developing countries, complementing the recent theoretical analysis on the topic. Using the Difference in Differences methodology, I find that international trade increases, unemployment and informal labor decrease in countries affected by the boom, though the agricultural sector is impacted to a lesser extent. This sector was also worst in terms of employment before the Dutch disease. Against theoretical expectations, production in the services sector decreases, while exports of agriculture and manufacture decline in no boom countries.

3.1 Introduction

I implement an impact evaluation exercise (a Difference in Differences methodology) to test the hypothesis that the Dutch disease that occurred in many countries, between 2003 and 2015, brought about significant outcomes in terms of employment in different economic sectors other than oil and mining, including informal labor, aggregate production and trade of products.

The Dutch disease refers to the relation of the increase in a specific economic sector, with the contraction of others [Corden and Neary, 1982]. For instance, significant growth in the oil and mining sectors could be set against a reduction in the manufacturing and agricultural sectors. The reason why this happens is because exports of the growing sector and the higher revenues of the country they generate, beget an appreciation of the local currency that is reflected in the exchange rate. Therefore, imports become cheaper while exports become more expensive. The existence of the Dutch disease is linked with interaction between higher natural resources revenues, the real exchange rate, and a decline in a lagging sector.

There are two main effects of Dutch disease: the resource movement effect and the spending effect. The first one relates to the movement of the labor force towards the booming sector, and it is also called direct deindustrialization. The second one implies that labor demand in the non-tradable sector rises, for instance in services and construction, while manufacturing and agricultural face indirect deindustrialization. Thus, non-traded prices increase while prices of the booming sector are determined internationally.

Indeed, to illustrate, according to the US Energy Information Administration (see Figure (1)), crude oil WTI prices per barrel went from an average of US$31 in 2003, to a maximum of US$141 in July 2008, while in 2014 the price was still around US$100. This fact is very relevant for the developing world, as an important portion of the main oil producers are developing countries, such as China, Brazil, Mexico, Colombia, Indonesia, Argentina, Egypt, the OPEC countries, alongside others in Africa, Asia and Latin America, who are among the top 30 producers (in 2016). Albeit less dramatic, a similar situation occurred with other mining products, such as gold, coal and nickel. These facts bring about important effects in the real exchange rate and, therefore, in the trade balance and other variables in the labor market and sectoral production.

Regarding the impact evaluation methodology used in this research, Imbens and Wooldridge [2009] present a comprehensive review of the different empirical methodologies to analyse the effects of policy interventions or treatments in different environments. They highlight the fact that the econometric and statistical development in this field make these methods more reliable. Other examples of applying similar methodologies to the international economics field can be found for instance in Slaughter [2001], Campos et al. [2018], Campi and Dueñas [forthcoming] and other references provided in the next section.

In general, most of the theoretical discussion on the Dutch disease excludes the relationship between the resource boom and labor markets. This issue has been studied mainly using General Computable Equilibrium models, as in the case of Arguello et al. [2016], who based their analysis on simulations with Colombian data to explore the relation between the Dutch disease, informality and employment. They use a recursive dynamic computable general equilibrium model to show that the boom sector has important effects on resources reallocation and spending in the economy. Hence, there is a relative drop in no-boom exporting sectors, and most sectors in the economy shrink. Furthermore, they assess the policy impacts of implementing regional funds in 2012 to save royalties produced in the mining sector, finding that it corresponds to a late and insufficient intervention. Indeed, Arguello [2017] states that the policy worsened the effects on informal and formal labor markets after 2013, when the oil boom began to reverse and prices fell sharply.

The novelty in Arguello et al. [2016] is their development of a theoretical model and presentation of evidence on the effect of the oil boom on the informal sector. The intuition of the model is that labor demand of activities related with the oil boom grows faster than the lagged sectors, demanding more skilled workers and capital. The decrease of the lagged sector brings about a lower unskilled labor demand, and the closure of some companies increases the informal sector. However, the Dutch disease effects are reduced as a result of that sector, which is producing mainly non-tradable goods, which also explains the informal sector's growth under the boom.

My intention is therefore to contribute to the literature focusing on the empirical analysis of the relationship between the resource boom and labor markets, by expanding the analysis in Arguello et al. [2016] to include various developing countries affected by the changes in oil prices, which can actually change the conclusions of the research. Specifically, I study the recent oil and mining boom which has not previously been related with formal and informal employment and unemployment at this international scale.

The Difference in Differences analysis on the employment variables yields that the existing negative trend of agricultural employment was deepened during the Dutch disease. That was also the case for the industrial employment prior to the resource boom, but during the phenomenon, employment increased more in the treatment group. In the services sector, the employment presented a positive trend before and after the Dutch disease. Regarding unemployment and informal employment, I find evidence that both variables are smaller in countries with Dutch disease and that the people who benefit the most are those with basic and intermediate education level, and women.

With respect to trade and production variables, the evidence suggests that the resource windfall increases GDP per capita and manufacturing production mainly in countries affected by the Dutch disease, while the effect on the services sector is negative, as is the effect on agricultural production. However, this is the case in both the treatment and control groups. The impact of the treatment on net exports is negative for countries with Dutch disease, despite the decrease in imports. Likewise, exports of agriculture and raw materials, and manufactures, except for high-tech, decrease in the control group.

The next section presents the theoretical and empirical discussion on the relationship between the Dutch disease and different macroeconomic variables. Section 3 explains the Diff in Diff methodology, presents the models to estimate and the results. Section 4 provides a conclusion.

3.2 Literature review

3.2.1 Theoretical discussion

Unlike the pioneering theory of Corden and Neary [1982] designed to explain the economics of the Dutch disease, Krugman [1987] develops a dynamic model in which the comparative advantage evolves over time through a learning-by-doing process instead of the specific characteristics of the country; namely, as there are industry learning curves in each country, the productivity of resources depends on an index of cumulative experience. However, despite differences in assumptions, both studies conclude that the windfall of exportable natural resources brings about permanent loss in other sectors while decreasing welfare in the long run.

To study the case of the Dutch disease, Krugman [1987] introduced into the model a parameter representing a transfer payment from the foreign to the home country, as a proxy of the income earned in the natural resource sector. He finds that for high levels of payments, the rise in the home country's wage will offset the productivity advantage of the country, moving some sectors abroad, and therefore altering the pattern of specialization in the country. Instead, for low levels of payments, the country's higher wage level does not alter the pattern of specialization. Likewise, the duration of the transfer payment determines that in the long run the firms that move abroad remain abroad even when the transfer ends, while if it does not last long enough, the economy will reassert the old pattern of specialization, decreasing wages.

More recently, Jones [2015] revisited the typical international trade theories (the Ricardian, the Heckscher-Ohlin and the Specific Factors models) to conclude that, in order to take into account the effects of economic growth on the country's production pattern, resulting from technological changes or endowment bundle changes, the models can be blended instead of comparing the results across them.

Analysing specifically the Dutch disease, Jones [2015] extends the Specific Factors version using the Heckscher-Ohlin model, by considering a sector consisting of various activities or industries, where capital is sector-specific, instead of industry-specific, while labor is used throughout the economy. Under this structure, when the world prices of a traded commodity (labor-intensive) increase, general wages rise too, with a resulting decline in other industries. On the contrary, if the booming sector is capital intensive, wages decrease and other sectors improve, except for booming sectors that are labor intensive. On the other hand, when the prices that increase are the prices of the non-traded goods, labor-intensive industries in traded commodities contract and capital-intensive sectors expand.

In contrast with the typical Dutch disease models which focus on impacts on the non-resource tradable sector, Oystenstad et al. [2015] extend the model of international trade with heterogeneous firms [Melitz, 2003] to examine the effect of a resource windfall in an economy with two types of labor (low- and high-skill); and Bahar and Santos [2018] discuss the impact on the structure of the non-resource export sector. Likewise, in line with other theories, the authors agree that the windfall resource increases wages in the economy, raising production costs and shrinking the exporting sector.

In particular, Oystenstad et al. [2015] develop a two sector model of a small open economy where one sector corresponds to homogeneous goods and the other sector to heterogeneous firms producing differentiated goods. The windfall is included in the model as an exogenous foreign lump sum assigned to a representative consumer in the economy. As a result, the differentiated sector expands due to a higher demand, while profits and wages increase and new firms at the lower end of the productivity continuum enter the market. Likewise, defining the manufacturing sector as a traded sector and non-manufacturing as a non-traded sector, the authors conclude that the least skilled workers move from the manufacturing towards the expanding sector (non-manufacturing), with only the most skilled remaining in the former. Therefore, welfare will increase because the differentiated sector will offer new varieties in the domestic market.

Bahar and Santos [2018], in turn, focus their analysis in the non-resource export basket, considering a labor-intensive sector and a capital-intensive one, with both industries producing differentiated goods. The increase in wages due to the resource windfall mainly harms the former sector, bringing about a loss in competitiveness of exporting firms and increasing export concentration. This theoretical result is tested by using a panel data of 128 countries and 27 years, with different econometric methodologies, finding a positive relationship between the non-resource export concentration and countries prone to the Dutch disease, as in the case of developing countries. Likewise, even though most of the countries in their database are characterized by high levels of capital-intensive products, they find that when a country has low levels of capital-intensive products in its export basket, a resource windfall may cause more export diversification, while for high levels, the effect of the boom is export concentration.

Other theories relate the Dutch disease with micro-founded models, as in the case of Van der Ploeg and Venables [2013], according to whom the economy reacts to a resource windfall following the Permanent Income Hypothesis; namely, it generates a permanent and immediate rise in consumption. Nevertheless, they recognize and include in the model different constraints on absorptive capacity, focusing on the scarcity of national capital, since much physical capital is sunk and some kinds of capital cannot be obtained on world markets, bringing about increases in prices and in the real exchange rate, thus making new capital dependent on non-traded capital. Therefore, a managing policy for the resource revenues should consider different choices between consumption, domestic investment and foreign asset accumulation, to generate an optimal spending pattern and finally structural change.

In line with macroeconomic models, Hansen and Gross [2018] extend the theory of supply dynamics considering resource exploration, depletion and reserve scarcity in the case of small commodity exporters. To achieve this, the authors include in the model a process of increasing existing reserves through exploration, making it more profitable when commodities' price increases, and endogenizing the supply of reserves. Furthermore, the model predicts appreciation due to the rise of commodities' prices and that transitory price shocks have permanent effects on reserves and on the whole economy. By parameterising the model with and without endogenous reserves, the authors find that endogeneity makes households reduce their consumption to a greater extent to protect themselves against price volatility, decreasing as well their welfare. These results imply that a monetary policy to reduce the effects of commodity price's volatility in the economy is inefficient, as it will also affect non-resource production, exports and consumption. On the contrary, an optimal taxation rule directed towards the resource sector could stabilize consumption, and intersectoral flows of goods and labor, increasing welfare.

3.2.2 Empirical discussion

As in the theoretical literature, empirical literature studying the relationship between the Dutch disease and the formal and informal labor markets is scarce, while research related to the impacts on other macroeconomic variables are more common and focus on case studies, for instance the cases of Bolivia and Indonesia.

Morales and Gómez [2015] and Morales Anaya et al. [2016] analyse for Bolivia the effects on labor markets during the resource windfall (2005-2014) and after, respectively, in the three main exports of the country: gas, minerals and soybean. For the period during the boom, they use data from the Social Accounting Matrix and base the analysis on general equilibrium models, finding positive trends for employment in the formal sector due to an increase in aggregated demand and in consumption, but also in the informal sector, where growth in construction and informal retail sectors led the labor demand. Likewise, other social and macroeconomic variables improved. In contrast, the authors use their estimations to forecast some variables in the economy after the resource boom, from 2015 to 2018, finding decreases in various variables: economic growth, private consumption, employment and informality. They find evidence of a U-shape relationship between imports and informality, suggesting that high levels of imports associated with high levels of economic growth, would mean lower levels of informality and unemployment.

In the Bolivian case, the exporting sector was mainly unskilled labor intensive, while informal labor was around 70% for women and 62% for men in 2012, and informal and formal employment increased with the resource windfall. In contrast, Coxhead and Shrestha [2016] find for Indonesia, using econometric estimations and controlling for individual and district features, that manufacturing and formal employment declined during the resource boom, specially in the skilled-intensive sectors, while informal labor increased mainly in the unskilled-intensive sectors, combined together with stagnation of the real wage and GDP growth. As education is seen as a way to get a formal job in the country, they find as well an impact of the Dutch disease in the school attainments, since the resource boom reduced formal employment.

Other literature has focused on studying strategies to reduce the negative impact of the resource windfall. According to Heeks [1998], a country may propose conscious diversification policies which consider not only large enterprises, but also promote small ones, as they are important tools to increase employment, income generation and distribution, as well as technical innovation. Indeed, the small size of the country and the Dutch disease hinders the development of small firms. Based in a research study conducted from 1995 to 1997, including fieldwork and a survey of enterprises in Brunei, Heeks highlights the main barriers to the firms and suggests a policy to solve some of the issues.

Van Der Hoek [2000], in turn, studies how the Dutch disease of 1970 became the Dutch miracle at the end of the twentieth century. Indeed, the author highlights the relevance of reforms, based on consultancy and tolerance, that make wages more flexible, increase employment, decrease the fiscal budget and reduce the tax burden as well as keeping low inflation levels, all avoiding currency revaluation by maintaining a fixed exchange rate, and thus increasing the balance of payments.

Likewise, some authors have analysed the impact of the Dutch disease on productivity. For instance, Ahrend et al. [2007] compare the Russian case with Ukraine during 2003-2004, explaining that both countries implemented similar reforms during the 1990s, undertaken to help the transition towards democracy and the market system, but the difference in initial natural resources endowments determined lower development progress in Russia with respect to Ukraine. They consider that the key aspect of the issue is the ability of the non-resource-boom sector to maintain competitiveness under a situation of Dutch disease.

They find that the higher terms of trade for Russia actually helped the country to keep its manufacturing sector and protect its employment levels.

In the same way, Djimeu and Omgba [2019], based on a panel of 134 countries between 1965-2010, present evidence that a resource windfall may negatively impact export diversification when a country already had low levels of diversification, before the oil boom, which can be explained by a single export product, an enclave industry or a labor intensive industry. They study three reasons explaining this phenomenon: the interaction between resource dependency and the initial technology gap, the existence of a scarce entrepreneur class, and the ex-ante development of non-resource sectors.

3.3 Methodology and data

I carry out a Difference in Differences methodology, as adopted in Card and Krueger [2000] and Slaughter [2001], to analyse the Dutch disease effect on two sets of variables: labor market, trade and macro variables. The labor market includes employment in the agriculture, industrial and services sector; unemployment disaggregated by education level (advanced, intermediate and basic) and gender; and, the informal sector (firms and workers) and part time employment. The trade and macro variables include GDP per capita; sector production in value added (agriculture, manufacture and services); external and current account balance; and total imports and exports of various kind of goods (high tech, agricultural raw materials, manufactures and Information and Communication Technology (ICT) goods). All these variables are collected from the World Development Indicators database of the World Bank between 1988 and 2017.

Such methodology compares the performance of a treatment group (countries having the Dutch disease) pre and post treatment, with respect to the performance of a control group (countries not experiencing Dutch disease) pre and post treatment. Under certain conditions the control group shows what would have happened to the treatment group if the treatment had not occurred (the treatment effect).

The next two equations express the basic model described by Card and Krueger [2000]:

$$y_{it} = \alpha + \beta d_t + \epsilon_{it} \tag{3.1}$$

Where y_{it} represents any of the outcomes for any country i ($i = 1,\ldots,N$) at time t ($t =$ 0 or 1, before or after the treatment), d_t is equal to 1 if t=1 or 0 if t is equal to 0. Taking the conditional expectations of equation (1): $E(y_{it}|d_t = 1) = \alpha + \beta + E(\epsilon_{it}|d_t = 1) = \alpha + \beta$, when the assumption of conditional independence holds $E(\epsilon_{it}|d_t) = 0$. Likewise, $E(y_{it}|d_t = 0) = \alpha + E(\epsilon_{it}|d_t = 0) = \alpha$. Then, the causal effect of the treatment (the Dutch disease) on the outcome y_{it} is identified by the difference $E(y_{it}|d_t = 1) - E(y_{it}|d_t = 0) = \beta$, which can be obtained either estimating equation (1), or computing the single difference of the change in mean outcomes before and after treatment.

According to Meyer [1994], estimates of equation (1) are valid if the assumption of conditional independence holds, but actually this may not be the case, since estimates may be affected by omitted variables, mismeasurement or trends in outcomes. Such issues can be reduced or eliminated by using a control group to compare with the treatment group as in equation (2). However, to ensure the assumption of conditional independence, the Diff in Diff requires that there are no other omitted interactions between j (in this case $j = 1$ is a label for the treatment group, or $j = 0$ is a label for the control group) and t, which is guaranteed to the extent that *the untreated comparison group is very similar to the treatment group.*

$$y_{it}^{j} = \alpha + \alpha_1 d_t + \alpha^1 d^j + \beta d_t^j + \epsilon_{it}^{j} \tag{3.2}$$

Where d^j is a dummy equal to 1 if $j = 1$ and 0 otherwise, $d_t^j = 1$ if j=1 and $t = 1$ and 0 otherwise. Taking the conditional expectations of equation (2): $E(y_{it}^j|d_t = 1, d^j = 1) = \alpha + \alpha_1 + \alpha^1 + \beta + E(\epsilon_{it}^j|d_t = 1) = \alpha + \alpha_1 + \alpha^1 + \beta$, when the assumption of conditional independence holds $E(\epsilon_{it}^j|d_t) = 0$. Likewise, $E(y_{it}^j|d_t = 0, d^j = 1) = \alpha + \alpha_1 + E(\epsilon_{it}^j|d_t = 1) = \alpha + \alpha_1$. Then, subtracting the conditional expectations $E(y_{it}^j|d_t = 1, d^j = 1) - E(y_{it}^j|d_t = 0, d^j = 1) = \alpha^1 + \beta$, we get α^1 that represents how both groups are affected over time, and β that identifies the causal effect of treatment.

Likewise, following Slaughter [2001], I also extend the Diff in Diff empirical model to analyze the impact of the Dutch disease on the set of employment and other macroeconomic variables represented by y_{rt} during the period t=1 to t=T, and r=0 (pre Dutch disease from t=1 to t=$T/2$) or r=1 (post Dutch disease from t=($T/2$+1) to t=T). As the Dutch disease did not follow the same timetables across the countries, it makes it difficult to set a period t=0 as well as the post-treatment period t=1, as in equations (1) and (2). Hence, the total period is divided in two equal parts. Therefore, I estimate equations (3) and (4):

$$y_{rt} = \alpha_1 + \alpha_2(d_r) + \beta_1(t) + \beta_2(t)(d_r) + \epsilon_{rt} \tag{3.3}$$

Equation (3) describes y_{rt} in function of a dummy d_r equal to 1 if r=1 and 0 otherwise. Taking again the conditional expectations: $E(y_{rt}|d_r = 1) = \alpha_1 + \alpha_2 + \beta_1 + \beta_2 + E(\epsilon_{rt}|d_r = 1) = \alpha_1 + \alpha_2 + \beta_1 + \beta_2$, when the assumption of conditional independence holds $E(\epsilon_{rt}|d_r) = 0$. Likewise, $E(y_{rt}|d_r = 0) = \alpha_1 + \beta_1 + E(\epsilon_{rt}|d_r = 0) = \alpha_1 + \beta_1$. Computing the difference between these conditional expectations we get $\alpha_2 + \beta_2$, where the first parameter represents how the liberalization affects the outcome over time, and the second corresponds to the causal effect of the treatment; namely, it refers to the difference in the outcome during the pre and post Dutch disease periods.

Equation (3), however, does not control for other events than the Dutch disease that occurred during t=$T/2$+1 and t=T, thus, a control group is included in equation (4):

$$\begin{aligned} y_{rt}^j = \alpha_1 + \alpha_2(d_r) + \alpha_3(d^j) + \alpha_4(d_r^j) + \beta_1(t) + \beta_2(t)(d_r) + \\ \beta_3(t)(d^j) + \beta_4(d_r^j) + \epsilon_{rt}^j \end{aligned} \tag{3.4}$$

Where $d^j = 1$ if the country belongs to the Dutch disease group or 0 otherwise, and $d_r^j = 1$ if j=1 and r=1 and 0 otherwise. Taking again the conditional expectations, assuming that conditional independence holds $E(\epsilon_{rt}^j|d_r) = 0$ and proceeding similarly as in equation (2), we obtain the Difference in Differences effect of the Dutch disease on the outcome, for Dutch disease countries with respect to the control group of countries:

Table 3.1: Conditional expectations equation (4)

$E(y_{rt}^j\|d_r = 0, d^j = 0)$	Control group pre-DD period	$\alpha_1 + \beta_1$
$E(y_{rt}^j\|d_r = 1, d^j = 0)$	Control group post-DD period	$\alpha_1 + \alpha_2 + \beta_1 + \beta_2$
$E(y_{rt}^j\|d_r = 0, d^j = 1)$	DD group pre-DD period	$\alpha_1 + \alpha_3 + \beta_1 + \beta_3$
$E(y_{rt}^j\|d_r = 1, d^j = 1)$	DD group post-DD period	$\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 + \beta_1 + \beta_2 + \beta_3 + \beta_4$

Note: DD = Dutch disease.

Computing the difference impact of the treatment within the Dutch disease group $(\beta_2 + \beta_4)$ we get $E(y_{rt}^j|d_r = 1, d^j = 1) - E(y_{rt}^j|d_r = 0, d^j = 1) = \alpha_2 + \alpha_4 + \beta_2 + \beta_4$; while, we get from the difference $E(y_{rt}^j|d_r = 1, d^j = 0) - E(\sigma_{rt}^j|d_r = 0, d^j = 0) = \alpha_2 + \beta_2$, where β_2 represents the treatment effect within the control group; therefore, the Difference in Differences coefficient $\beta_2 + \beta_4 - \beta_2 = \beta_4$ relates the treatment disease effect on the outcome of countries with Dutch disease with respect to countries that do not suffer from the Dutch disease.[1]

Before estimating equations (1) to (4) (in the next subsection), I first define the period during which the Dutch disease occurs, and then define the two groups used in the Diff in Diff. Both definitions are based on the exogenous oil price shock and its length. Figure 1 illustrates the WTI FOB oil prices per barrel between 1986 and 2018 as well as the polynomial trend line grade 4, where we can observe a strong increase according to the well known oil prices boom around the period 2003-2015. In that time, international prices rose by up to 7 times, followed by other mining products such as coal and gold. As this event was not anticipated by the oil exporter countries, they were affected by the so-called Dutch disease in many ways, not only during the boom but also after the period of the boom, where oil prices fell dramatically in just a few years, (nevertheless I focus the research only in periods before and *during* the boom, henceforth the post treatment period). Then, I set the time point $(T/2)$ in 2003, the year in which, approximately, the Dutch disease started, defining the pre treatment period as 1988-2002 and the post treatment period as 2003-2017.

[1] According to Bernal and Peña [2011], even though the inclusion of the control group in equations (2) and (4) solve many problems of inference, still it is possible that the treatment and control groups do not comply with the assumption of parallel trends in the pre treatment period, as soon as in that period other variables than the treatment could affect the trends. To verify this point, it could be useful to include in the model control variables, changing over time, that are not affected by the treatment; therefore, this limitation of the results of the estimates must be taken into account.

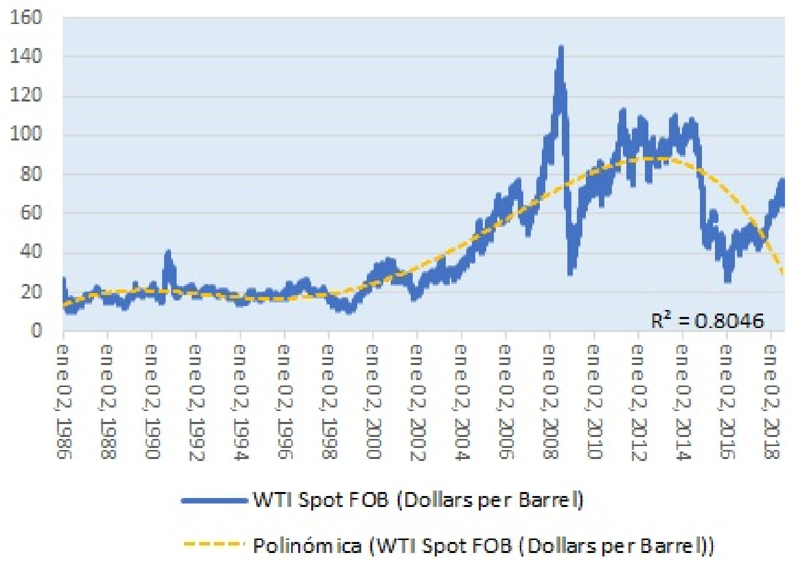


Figure 3.1: Spot Prices for Crude Oil and Petroleum Products and polynomial trend line grade 4. Source: U.S. Energy Information Administration.

On the other hand, to define the treatment and the control groups, I will discuss the issue of selection bias (Bernal and Peña [2011]). Bias occurs when the selection of individuals in the treatment group is not random, but instead some characteristics observed and not observed, can influence its conformation; in that case, some variables can explain the formation of the treatment group as well as the outcome of interest.

In a similar way as in Slaughter [2001],[2] I use relevant macroeconomic characteristics of the countries in the database of the World Bank to separate countries into the two groups, the crude oil exporters who suffered the Dutch disease, and consequently experienced important real exchange rate revaluations (treatment group), and the non-oil-exporters or not significant exporters, with a relatively stable evolution of the exchange rate (control group).

To measure the effects of the Dutch disease on trade and employment variables, during 2003 and 2015, I characterize the symptoms and identify the most affected countries. Hence, according to Arguello et al. [2016], a country experiencing a Dutch disease should be an oil (or other mining products such as coal) producer and exporter, and, as a consequence, it should exhibit revaluation of the local currency during the period.

Table 2 presents the top 50 countries with the higher average Real Effective Exchange Rate annual percentage change, during the period of the oil prices boom. Likewise, the next columns show the ranking of the oil and coal producers. The intersection of countries in this three rankings yields a list of 29 potentially affected countries by the phenomenon: Algeria, Australia, Austria, Brazil, Bulgaria, Canada, Chile, China, Colombia, Croatia, Czech Republic, Georgia, Greece, Hungary, the Islamic Republic of Iran, Italy, Malaysia, New

[2] considers three different ways to define the control group in order to guarantee random selection of the country members, finding similar results for each control group. In order to test random selection in this research, I perform a Logit regression between the treatment variable and the control group, finding no correlation, and thus evidence on random selection.

Zealand, Nigeria, Norway, Pakistan, Philippines, Poland, Romania, Russian Federation, Slovak Republic, Spain, Ukraine and the Bolivarian Republic of Venezuela.

I use in the estimations of the next subsection the available information in the database for 97 countries classified as lower and upper middle income in 2008 (the intermediate year during the Dutch disease period), according to their Growth National Income per capita in US$. Matching the list of the 97 countries with the 29 potentially affected by the Dutch disease, I define a group of 17 treated countries: Algeria, Brazil, Bulgaria, Chile, China, Colombia, Georgia, Islamic Republic of Iran, Malaysia, Nigeria, Pakistan, Philippines, Poland, Romania, Russian Federation, Bolivarian Republic of Venezuela.

3.3.1 Difference in Difference estimations

Tables 3 to 8 present the estimates of equations (3) and (4) to evaluate the effect of the Dutch disease after the period 2003 on different variables related with employment, production and international trade. Equations (1) and (2) are estimated similarly to equations (3) and (4), in the sense that I am not only considering the period t=0 and t=1, for the beginning and end of the treatment, but I am also using the whole period t=0 (1988) to t=T (2017), so I can take advantage of all available data. As the analysis focuses on outcomes of equation (4) and estimates of betas, since the parameters of other specifications are included in (4), and I consider both the control and treatment groups in the latter, I do not present outcomes of equations (1) and (2).

Summarizing the results for estimates of coefficient β_4 (Diff in Diff effect), which corresponds to the variable "Djt_Year" in Tables 3 to 8, we observe initially, for variables related with employment (Tables 3 and 5), evidence that the percentage of agricultural employees decreases in both groups, before the treatment but even more during the treatment (β_1 and β_2 are negative), while the aggregated Diff in Diff effect is not significant. In the service sector $\beta_1 > 0$ shows that the percentage of employees rise for both groups of countries during the pre and post treatment and that there is no significant difference in the Dutch disease effects across the groups $\beta_4 = 0$. The only significant Diff in Diff effect is the percentage of industrial employment ($\beta_4 > 0$), suggesting a positive impact in countries affected by the Dutch disease with respect to the non Dutch disease, though the trend was negative in both groups before the Dutch disease (β_1 and $\beta_1 + \beta_3 < 0$).

Regarding total unemployment, we can see that it decreased particularly in Dutch disease countries ($\beta_4 < 0$) with respect to the non affected by the treatment. Likewise, the biggest decrease was in workers with intermediate education, though workers with basic education were benefited more than men, as were women. This result together with the negative Diff in Diff effect on self employment ($\beta_4 < 0$, Table 8) can be interpreted as the presence of more formal jobs during the Dutch disease in both kind of countries.

Next, Tables 5 to 8 present estimations for variables related with trade and production. As we see, the Diff in Diff effect on GDP per capita indicates that it is positive and higher for countries affected by the Dutch disease ($\beta_4 > 0$, Table 5), and that both groups are

Table 3.2: Country ranking for Δ% Real Effective Exchange Rate, Oil and Coal Production

REER annual percentage change average (2004-2013)	Position	Country	Oil Production Average 1995-2015	Position	Country	Coal Production Average 1995-2015
6,39	1	Saudi Arabia	8.843	1	China	2.696.960
6,23	2	Russia	8.277	2	United States	1.078.574
5,46	3	United States	6.143	3	India	494.241
5,23	4	Iran	3.721	4	Australia	404.592
5,12	5	China	3.619	5	Russia	307.133
5,12	6	Mexico	2.951	6	South Africa	262.845
5,03	7	Venezuela	2.673	7	Indonesia	236.913
4,83	8	Canada	2.496	8	Germany	226.013
4,54	9	United Arab Emirates	2.491	9	Poland	174.502
4,42	10	Norway	2.489	10	Kazakhstan	99.979
4,36	11	Kuwait	2.315	11	Canada	75.989
4,28	12	Nigeria	2.262	12	Turkey	70.907
4,12	13	Iraq	2.213	13	Greece	68.161
3,96	14	United Kingdom	1.745	14	Czech Republic	67.760
3,68	15	Brazil	1.582	15	Ukraine	66.108
3,55	16	Algeria	1.442	16	Colombia	64.518
3,47	17	Libya	1.317	17	Former Serbia and Montenegro	43.185
3,32	18	Angola	1.280	18	Serbia	41.511
3,27	19	Indonesia	1.137	19	Romania	35.156
3,16	20	Kazakhstan	1.116	20	Bulgaria	32.051
1,81	21	Qatar	1.023	21	Vietnam	31.184
3,01	22	Oman	863	22	United Kingdom	29.143
2,94	23	Egypt	712	23	Korea, North	27.400
2,92	24	Colombia	707	24	Thailand	21.020
2,73	25	India	699	25	Spain	18.307
2,73	26	Argentina	695	26	Mexico	14.629
2,60	27	Malaysia	672	27	Mongolia	14.014
2,50	28	Azerbaijan	564	28	Hungary	12.838
2,25	29	Australia	492	29	Kosovo	9.039
2,14	30	Ecuador	464	30	Macedonia	7.921
2,14	31	Syria	387	31	Brazil	6.666
1,98	32	Yemen	316	32	Bosnia and Herzegovina	6.503
1,96	33	Vietnam	305	33	Venezuela	5.393
1,89	34	Denmark	274	34	Slovenia	4.874
1,88	35	Gabon	272	35	New Zealand	4.825
1,47	36	Congo (Brazzaville)	249	36	Philippines	4.220
1,44	37	Sudan	232	37	Zimbabwe	3.975
1,42	38	Equatorial Guinea	226	38	Pakistan	3.940
1,38	39	Turkmenistan	167	39	Uzbekistan	3.565
1,31	40	Thailand	167	40	Korea, South	3.514
1,26	41	Brunei	157	41	Slovakia	3.206
1,08	42	Trinidad and Tobago	114	42	France	2.274
1,00	43	Romania	107	43	Norway	1.850
0,99	44	Italy	98	44	Montenegro	1.789
0,90	45	Peru	86	45	Japan	1.575
0,87	46	Cameroon	84	46	Iran	1.341
0,75	47	Uzbekistan	79	47	Malaysia	1.340
0,70	48	TimorLeste (East Timor)	78	48	Mozambique	1.318
0,61	49	Chad	77	49	Chile	1.143
0,51	50	Tunisia	74	50	Botswana	1.132

Note: Real Effective Exchange Rate index (2010 = 100) is calculated by the International Monetary Fund. It is a measure of the value of a currency against a weighted average of several foreign currencies, divided by a price deflator or index of costs. Source: the World Bank. Petroleum (annual) Production 1000 bbl/d. Coal 1000 ST Production Total Primary Coal. Source: U.S. Energy Information Administration.

benefited. A similar effect is observed in the manufacturing production, where treatment effect on Dutch disease countries with respect to control is positive ($\beta_4 > 0$, Table 7), though unlike the GDP per capita, in this case the impact during the Dutch disease in each group is negative. In the case of the services sector, the treatment effect is negative for the Dutch disease countries with respect to the control group ($\beta_4 < 0$, Table 8), though the effect in each group is positive during the Dutch disease ($\beta_1 + \beta_2$ and $\beta_1 + \beta_2 + \beta_3 + \beta_4$ are > 0). As $\beta_4 = 0$ in Table 7, we can infer that the effect of the Dutch disease in agricultural production is negligible for the treatment group with respect to the control group, and that the impact in each group is negative during the treatment ($\beta_1 + \beta_2$ and $\beta_1 + \beta_2 + \beta_3 + \beta_4$ are < 0).

With respect to the external balance, we observe a Diff in Diff negative effect, indicating that net exports decrease for the treated group with respect to the control ($\beta_4 < 0$, Table 5), which is coherent with the effect on the current account in Table 10. In any case, a more detailed analysis shows that imports decrease more in countries with Dutch disease with respect to the control group ($\beta_4 < 0$, Table 8), while there is no differential effect on exports of agricultural and raw materials, though the effect post treatment by group is negative ($\beta_1 + \beta_2$ and $\beta_1 + \beta_2 + \beta_3 + \beta_4$ are < 0, Table 8). Manufacturing exports decrease more for the Dutch disease countries ($\beta_4 < 0$, Table 6), which together with the higher decrease in imports for treated countries and the increase in manufacturing production, suggests that domestic consumption increases. Likewise, high-tech exports increase more for the treated group with respect to the control ($\beta_4 > 0$, Table 8).

Dep. Var.	(1) Emp Agr (%)	(2) Emp Agr (%)	(3) Emp Ind (%)	(4) Emp Ind (%)	(5) Emp Serv (%)	(6) Emp Serv (%)	(7) UnEmp Tot (%)	(8) UnEmp Tot (%)
Dut_Dis	377.949***	297.473*	-411.132***	-335.269***	33.184	37.802	439.052***	331.326***
	(3.558)	(2.512)	(-6.667)	(-4.880)	(0.361)	(0.369)	(7.401)	(5.026)
Treated		-115.965		273.404*		-157.436		-430.576***
		(-0.533)		(2.167)		(-0.837)		(-3.556)
Djt		411.848		-388.240*		-23.632		551.303***
		(1.538)		(-2.498)		(-0.102)		(3.696)
Year	-0.312***	-0.323***	-0.155***	-0.129***	0.467***	0.452***	0.087***	0.045
	(-7.230)	(-6.713)	(-6.188)	(-4.611)	(12.522)	(10.861)	(3.589)	(1.664)
DD_Year	-0.189***	-0.149*	0.206***	0.168***	-0.016	-0.018	-0.220***	-0.166***
	(-3.568)	(-2.523)	(6.674)	(4.886)	(-0.355)	(-0.362)	(-7.411)	(-5.033)
Trea_Year		0.056		-0.135*		0.079		0.215***
		(0.512)		(-2.135)		(0.840)		(3.543)
Djt_Year		-0.205		0.194*		0.011		-0.276***
		(-1.534)		(2.498)		(0.098)		(-3.703)
Constant	656.268***	678.928***	331.228***	277.804***	-887.496***	-856.732***	-161.732***	-77.596
	(7.609)	(7.062)	(6.616)	(4.981)	(-11.906)	(-10.310)	(-3.358)	(-1.450)
Obs	2349	2349	2349	2349	2349	2349	2349	2349
R2_bwn	0.000	0.012	0.000	0.041	0.000	0.000	0.000	0.013
Chi2	1525.306	1531.347	48.166	58.255	1987.336	1990.466	236.932	257.014
Prob	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

**p<0.05, **p<0.01, ***p<0.001*

Table 3.3: Diff in Diff OLS estimations (1988-2017). Dutch disease effect on employment in agricultural (Emp Agr), industrial sectors (Emp Ind), services sector (Emp Serv) and total unemployment (UnEm Tot). Industry sector consists of mining and quarrying, manufacturing, construction, and public utilities. Independent variables are: Dut_Dis (α_2) equals 1 for the period 2003-2017, Treated (α_3) equals 1 for countries with Dutch disease, and Djt (α_4) equals 1 if Treated equals 1 and Dut_Dis equals 1, Year (β_1) corresponds to the period 1988-2017, DD_Year (β_2) interaction of Dut_Dis and Year, Trea_Year (β_3) interaction of Treated and Year, Djt_Year (β_4) interaction of Djt and Year. t-statistics in brackets.

Dep. Var.	(1) UnEmp adv ed (%)	(2) UnEmp adv ed (%)	(3) UnEmp bas ed (%)	(4) UnEmp bas ed (%)	(5) UnEmp fem (%)	(6) UnEmp fem (%)	(7) UnEmp mal (%)	(8) UnEmp mal (%)
Dut_Dis	972.697**	835.441	1016.939**	426.873	420.092***	278.382**	386.932***	286.104***
	(2.853)	(1.920)	(2.807)	(0.931)	(5.344)	(3.189)	(6.873)	(4.574)
Treated		-412.610		-1740.975*		-483.816**		-428.962***
		(-0.603)		(-2.416)		(-3.018)		(-3.734)
Djt		409.293		1695.225*		725.223***		516.003***
		(0.576)		(2.265)		(3.672)		(3.646)
Year	0.487**	0.418*	0.337	0.037	0.083**	0.035	0.075***	0.033
	(2.948)	(1.975)	(1.919)	(0.165)	(2.583)	(0.998)	(3.292)	(1.315)
DD_Year	-0.487**	-0.418	-0.508**	-0.213	-0.210***	-0.139**	-0.194***	-0.143***
	(-2.854)	(-1.921)	(-2.804)	(-0.927)	(-5.354)	(-3.195)	(-6.884)	(-4.581)
Trea_Year		0.206		0.870*		0.241**		0.214***
		(0.603)		(2.414)		(3.004)		(3.726)
Djt_Year		-0.205		-0.849*		-0.363***		-0.258***
		(-0.577)		(-2.269)		(-3.677)		(-3.654)
Constant	-961.243**	-823.801	-659.977	-60.622	-151.474*	-56.935	-140.354**	-56.534
	(-2.913)	(-1.948)	(-1.882)	(-0.136)	(-2.374)	(-0.803)	(-3.071)	(-1.113)
Obs	662	662	665	665	2349	2349	2349	2349
R2_bwn	0.014	0.003	0.001	0.014	0.000	0.019	0.000	0.005
Chi2	8.783	9.533	19.419	30.037	141.876	164.687	227.677	247.772
Prob	0.032	0.217	0.000	0.000	0.000	0.000	0.000	0.000

**p<0.05, **p<0.01, ***p<0.001*

Table 3.4: Diff in Diff OLS estimations (1988-2017). Dutch disease effect on unemployment with advanced education (UnEmp adv), with basic education (UnEmp bas ed), female (UnEmp fem) and male unemployment (UnEmp mal) employment. Independent variables are: Dut_Dis (α_2) equals 1 for the period 2003-2017, Treated (α_3) equals 1 for countries with Dutch disease, and Djt (α_4) equals 1 if Treated equals 1 and Dut_Dis equals 1, Year (β_1) corresponds to the period 1988-2017, DD_Year (β_2) interaction of Dut_Dis and Year, Trea_Year (β_3) interaction of Treated and Year, Djt_Year (β_4) interaction of Djt and Year. t-statistics in brackets.

Dep. Var.	(1) UnEmp Inted (%)	(2) UnEmp Inted (%)	(3) Employers (%)	(4) Employers (%)	(5) lnGDP pc	(6) lnGDP pc	(7) Ext.Bal (%)	(8) Ext.Bal (%)
Dut_Dis	718.762	-297.546	-61.780	-88.079	-26.651***	-20.822***	285.978	118.966
	(1.739)	(-0.509)	(-1.429)	(-1.830)	(-8.432)	(-5.975)	(1.638)	(0.612)
Treated		-2268.779**		60.234		19.534***		-35.837
		(-2.798)		(0.682)		(3.383)		(-0.115)
Djt		2307.586**		134.586		-32.364***		888.647*
		(2.754)		(1.236)		(-3.997)		(2.031)
Year	0.105	-0.396	-0.025	-0.019	0.013***	0.015***	0.112	0.109
	(0.524)	(-1.382)	(-1.446)	(-0.994)	(11.369)	(11.662)	(1.783)	(1.555)
DD_Year	-0.360	0.149	0.031	0.044	0.013***	0.010***	-0.142	-0.059
	(-1.740)	(0.509)	(1.426)	(1.823)	(8.460)	(5.996)	(-1.632)	(-0.608)
Trea_Year		1.134**		-0.031		-0.010***		0.025
		(2.795)		(-0.691)		(-3.350)		(0.160)
Djt_Year		-1.155**		-0.067		0.016***		-0.443*
		(-2.757)		(-1.227)		(4.007)		(-2.029)
Constant	-193.099	809.694	54.912	43.142	-18.056***	-21.657***	-235.499	-232.457
	(-0.480)	(1.412)	(1.565)	(1.104)	(-7.869)	(-8.517)	(-1.873)	(-1.655)
Obs	642	642	2349	2349	2711	2711	2587	2587
R2_bwn	0.000	0.014	0.000	0.014	0.008	0.025	0.313	0.064
Chi2	66.568	80.311	8.309	19.502	3886.292	3958.964	22.787	44.991
Prob	0.000	0.000	0.040	0.007	0.000	0.000	0.000	0.000

**p<0.05, **p<0.01, ***p<0.001*

Table 3.5: Diff in Diff OLS estimations (1988-2017). Dutch disease effect on unemployment with intermediate education (UnEmp Int ed), self employment jobs (Employers), GDP per capita (lnGDP pc) and external balance (Ext. Bal). Independent variables are: Dut_Dis (α_2) equals 1 for the period 2003-2017, Treated (α_3) equals 1 for countries with Dutch disease, and Djt (α_4) equals 1 if Treated equals 1 and Dut_Dis equals 1, Year (β_1) corresponds to the period 1988-2017, DD_Year (β_2) interaction of Dut_Dis and Year, Trea_Year (β_3) interaction of Treated and Year, Djt_Year (β_4) interaction of Djt and Year. t-statistics in brackets.

Dep. Var.	(1) Self Emp (%)	(2) Self Emp (%)	(3) Manuf (%)	(4) Manuf (%)	(5) ICT Goods Exp (%)	(6) ICT Goods Exp (%)	(7) ICT Goods imports (%)	(8) ICT Goods imports (%)
Dut_Dis	503.018***	364.294***	2231.771***	1923.411***	-161.204	-363.723	302.070	58.824
	(5.197)	(3.387)	(7.782)	(5.924)	(-0.325)	(-0.648)	(0.799)	(0.139)
Treated		-579.128**		-816.264		-636.456		-669.669
		(-2.931)		(-1.604)		(-0.540)		(-0.744)
Djt		709.940**		1392.820*		905.722		1148.548
		(2.917)		(2.008)		(0.764)		(1.271)
Year	-0.105**	-0.161***	0.862***	0.770***	-0.101	-0.174	0.020	-0.052
	(-2.676)	(-3.691)	(8.139)	(6.410)	(-0.412)	(-0.622)	(0.108)	(-0.246)
DD_Year	-0.251***	-0.182***	-1.116***	-0.961***	0.081	0.182	-0.151	-0.029
	(-5.199)	(-3.389)	(-7.789)	(-5.929)	(0.326)	(0.648)	(-0.798)	(-0.139)
Trea_Year		0.287**		0.413		0.321		0.338
		(2.905)		(1.620)		(0.544)		(0.751)
Djt_Year		-0.355**		-0.697*		-0.453		-0.573
		(-2.915)		(-2.010)		(-0.764)		(-1.270)
Constant	255.088**	368.251***	-1682.077***	-1499.970***	206.292	349.600	-33.719	108.844
	(3.246)	(4.216)	(-7.959)	(-6.258)	(0.418)	(0.626)	(-0.090)	(0.259)
Obs	2349	2349	2063	2063	1253	1253	1333	1333
R2_bwn	0.000	0.010	0.009	0.021	0.000	0.058	0.006	0.132
Chi2	616.184	637.549	78.248	84.204	1.301	17.382	64.690	116.591
Prob	0.000	0.000	0.000	0.000	0.729	0.015	0.000	0.000

**p<0.05, **p<0.01, ***p<0.001*

Table 3.6: Diff in Diff OLS estimations (1988-2017). Dutch disease effect on self employed (Self Emp), manufactures exports (Manuf), Information and Communication Technology goods exports (ICT goods) and Information and Communication Technology goods imports (ICT goods imports). Independent variables are: Dut_Dis (α_2) equals 1 for the period 2003-2017, Treated (α_3) equals 1 for countries with Dutch disease, and Djt (α_4) equals 1 if Treated equals 1 and Dut_Dis equals 1, Year (β_1) corresponds to the period 1988-2017, DD_Year (β_2) interaction of Dut_Dis and Year, Trea_Year (β_3) interaction of Treated and Year, Djt_Year (β_4) interaction of Djt and Year. t-statistics in brackets.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. Var.	Part Time	Part Time	Cur Acc Bal	Cur Acc Bal	Agr (%)	Agr (%)	Manuf (%)	Manuf (%)
Dut_Dis	-294.432	-223.068	345.504*	155.157	-500.796***	-486.175***	29.410	83.323
	(-0.550)	(-0.321)	(2.301)	(0.932)	(-7.467)	(-6.490)	(0.507)	(1.327)
Treated		21.309		-370.800		144.155		640.928***
		(0.020)		(-1.344)		(1.197)		(5.721)
Djt		219.804		1011.902**		-60.190		-378.449*
		(0.200)		(2.651)		(-0.358)		(-2.499)
Year	-0.076	-0.008	0.055	0.018	-0.400***	-0.385***	-0.175***	-0.123***
	(-0.287)	(-0.024)	(0.993)	(0.296)	(-16.476)	(-14.117)	(-8.284)	(-5.375)
DD_Year	0.147	0.112	-0.172*	-0.077	0.249***	0.242***	-0.015	-0.042
	(0.550)	(0.322)	(-2.295)	(-0.929)	(7.446)	(6.471)	(-0.507)	(-1.330)
Trea_Year		-0.011		0.188		-0.072		-0.318***
		(-0.020)		(1.360)		(-1.201)		(-5.662)
Djt_Year		-0.110		-0.504**		0.030		0.190*
		(-0.201)		(-2.645)		(0.359)		(2.506)
Constant	167.157	31.446	-113.027	-41.066	814.317***	783.006***	364.183***	257.959***
	(0.316)	(0.046)	(-1.032)	(-0.337)	(16.787)	(14.395)	(8.616)	(5.657)
Obs	496	496	2419	2419	2589	2589	2452	2452
R2_bwn	0.003	0.058	0.001	0.038	0.133	0.134	0.045	0.126
Chi2	4.859	12.474	7.061	23.753	1623.724	1627.954	582.208	688.272
Prob	0.182	0.086	0.070	0.001	0.000	0.000	0.000	0.000

**p<0.05, **p<0.01, ***p<0.001*

**p<0.05, **p<0.01, ***p<0.001*

Table 3.7: Diff in Diff OLS estimations (1988-2017). Dutch disease effect on part time employment (Part Time), current account balance (Cur Acc), agriculture (Agr) and manufacturing value added (Manuf). Independent variables are: Dut_Dis (α_2) equals 1 for the period 2003-2017, Treated (α_3) equals 1 for countries with Dutch disease, and Djt (α_4) equals 1 if Treated equals 1 and Dut_Dis equals 1, Year (β_1) corresponds to the period 1988-2017, DD_Year (β_2) interaction of Dut_Dis and Year, Trea_Year (β_3) interaction of Treated and Year, Djt_Year (β_4) interaction of Djt and Year. t-statistics in brackets.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. Var.	Services	Services	High Tech	High Tech	Imports (%)	Imports (%)	Agr raw	Agr raw
Dut_Dis	423.839***	211.411	-1.789e+11	3.900e+11	285.978	118.966	-403.930***	-393.384***
	(3.834)	(1.713)	(-0.256)	(0.497)	(1.638)	(0.612)	(-5.271)	(-4.534)
Treated		-1132.722***		-1.498e+12		-35.837		61.266
		(-5.861)		(-1.230)		(-0.115)		(0.453)
Djt		899.410***		-3.439e+12*		888.647*		-39.714
		(3.383)		(-2.213)		(2.031)		(-0.215)
Year	0.460***	0.329***	5.820e+08*	2.926e+08	0.112	0.109	-0.223***	-0.216***
	(11.281)	(7.201)	(2.083)	(0.921)	(1.783)	(1.555)	(-7.919)	(-6.763)
DD_Year	-0.212***	-0.106	39428299.104	-1.951e+08	-0.142	-0.059	0.202***	0.196***
	(-3.846)	(-1.720)	(0.257)	(-0.497)	(-1.632)	(-0.608)	(5.265)	(4.526)
Trea_Year		0.566***		7.518e+08		0.025		-0.032
		(5.841)		(1.232)		(0.160)		(-0.469)
Djt_Year		-0.450***		1.719e+09*		-0.443*		0.020
		(-3.392)		(2.215)		(-2.029)		(0.220)
Constant	-866.882***	-605.573***	-1.163e+12*	-5.845e+11	-235.499	-232.457	450.755***	436.873***
	(-10.664)	(-6.641)	(-2.084)	(-0.921)	(-1.873)	(-1.655)	(8.009)	(6.849)
Obs	2153	2153	1716	1716	2587	2587	2051	2051
R2_bwn	0.050	0.059	0.010	0.080	0.001	0.055	0.036	0.041
Chi2	391.842	454.611	51.078	164.829	22.787	44.991	218.911	223.329
Prob	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

**p<0.05, **p<0.01, ***p<0.001*

**p<0.05, **p<0.01, ***p<0.001*

Table 3.8: Diff in Diff OLS estimations (1988-2017). Dutch disease effect on services value added (Services), high technology exports (High tech), imports of goods and services (Imports) and agricultural row materials exports (Agr raw mat). Independent variables are: Dut_Dis (α_2) equals 1 for the period 2003-2017, Treated (α_3) equals 1 for countries with Dutch disease, and Djt (α_4) equals 1 if Treated equals 1 and Dut_Dis equals 1, Year (β_1) corresponds to the period 1988-2017, DD_Year (β_2) interaction of Dut_Dis and Year, Trea_Year (β_3) interaction of Treated and Year, Djt_Year (β_4) interaction of Djt and Year. t-statistics in brackets.

3.4 Conclusion

I adopt a Difference in Differences methodology to analyze the effects of the boom, due to a sharp increase in international prices of oil and other mining sectors, that is referred to as the Dutch disease. Then, I study the impacts of this phenomenon on employment and other macroeconomic variables. To perform the analysis, I set the Dutch disease period during 2003-2017 (the treatment), and the pre-treatment period 1988-2002, and according to the behaviour of the real exchange rate and the world ranking of natural resource exports, I classify into the treated group 17 lower and middle income countries affected by the Dutch disease, while the control group is defined by the rest of the lower and middle income countries (80) according to the World Bank data.

Following the Diff in Diff methodology suggested by Card and Krueger [2000] and Slaughter [2001], I find that the treatment and control groups already had a negative trend on employment in the agriculture sector, before the Dutch disease, but that this trend was strengthened during the Dutch disease, while both groups presented a positive trend of employment in the services sector before and during the treatment. In the case of industrial employment, the evidence suggests that there was a negative trend before the treatment in both groups, but after the boom, the employment in the sector increased more in the Dutch disease countries. Likewise, the treatment effect on unemployment for Dutch disease countries is more negative than for the control group, benefiting mainly intermediate and basic education workers, and women, while self employment tends to decrease more as well in treated countries.

In the case of production, I find evidence of a higher positive effect of the resource windfall on the GDP per capita levels and manufacture production for the treatment group, with respect to the countries not affected by the Dutch disease. On the contrary, the impact of the treatment on services sector production is more negative for Dutch disease countries, while the treatment effect is not significant on agricultural production. Likewise, the effect of the Dutch disease was more negative on net exports and the current account of treated countries with respect to the control group. Indeed, there is evidence of a negative differential effect on imports in the treated group, while exports of agricultural and raw materials decrease in both groups. Manufacturing exports decrease more as well in the Dutch disease countries. Only high-tech exports benefit more the treatment group.

In terms of ongoing research, based on the current project I suggest some additional measures to improve the analysis and the robustness of results in different ways, as well as to extend the scope of the questions. Firstly, considering that international oil prices returned to the levels before the boom, at around 2016, the effects of more than 10 years of the resource boom could remain in many economic variables, and may have affected the outcomes of new Free Trade Agreements entered into force around those dates. For instance the FTA cases of Peru-USA and Colombia-USA are interesting examples, where the different outcomes in economic performance can be explained in part by the resource windfall. Indeed, depending on the length of the phenomenon and the particular characteristics of the country, negative consequences can be observed after the Dutch disease.

Secondly, to provide robustness checks on the results, I can try different placebo methodologies, for instance choosing randomly different treatment groups among the whole countries or setting different treatment periods. Estimations within the "similar" middle income countries can also be evaluated. This exercise would make it possible to verify whether the estimates achieved are random or due to the "real" treatment and control group.

Thirdly, other econometric specifications can be tested to verify the assumption of parallel trends. For exemple, the Dutch disease Dummy variable can be interacted with GDP to see the relevance of the income of the country in the results, thus analysing different impacts on developing and developed countries. In addition, other variables explaining the outcome, but not affected by the treatment and changing over time, can be considered as controls, such as country population, exports diversification levels or educational attainments. Likewise, as a test of robustness, equations 1 and 2 could be estimated only for the two periods t=0 and t=1 (as in Card and Krueger [2000]), to compare the results with our expanded model. Some misleading results could be explained by the size of some countries within the treatment group, as the case of China, whose characteristics may bias the estimates.

General conclusion

The objective of the thesis is studying and contributing to the literature with empirical and theoretical evidence about the relationship between international trade and labor markets. To do that, the thesis is composed of three interconnected chapters: the first one delivers empirical evidence for the Colombian manufacturing sectors on the relationship between the trade integration and sector skill intensity variables, with the skill premia, during the period 2000-2012. I bring forward different measures of Skill-Biased Technical Change (SBTC), and considering wages and social security benefits, I estimate the bias generated by the sector skill intensity, and compare it with the sector-specific bias, arising from the interaction between the skill intensity and four measures of international trade. As the openness and the labor flexibility reforms occurred almost simultaneously around the 1990s, I control for the share of temporary workers in each manufacturing subsector. I find evidence that, together, skill intensity and international trade bring about more SBTC, causing more wage inequality in many sectors. However, such an effect is counterbalanced by a negative impact: the increasing use of temporary workers on the skill premia.

The Colombian manufacturing sector experienced important changes since the openness policy introduced in 1990 and during the deepening of the policy with new bilateral trade agreements signed after 2000. I estimate the skill bias wage gap in this second phase of the opening policy, finding that in sectors with relatively more skilled workers, between 2000-2012, the real average wage gap is around 17%-20% higher than in less skill-intensive sectors. Indeed, during the 2000s, 87.5% of the manufacturing sectors increase international trade with developed countries, while only 8.3% increase trade with developing countries.

Likewise, formalization of agency workers in 1990 and the introduction of labor costs flexibilization to hire direct temporary workers resulted in a decrease in the real average wage after the 2000s, in which the increasing trade with developed countries would force firms to rise the share of temporary workers to increase competitiveness and survive in the market. This policy has had negative effects on the SBTC, decreasing, in turn, wage inequality between skilled and unskilled workers, and counterbalancing the positive effect of interaction between sector skill intensity and trade integration.

The magnitude of the impact of sector skill intensity on SBTC decreases when interacting with tariffs reduction across the sectors, or exporting firms, while it barely changes when interacting with international trade with developed and developing countries. Likewise, most of the sector bias of SBTC is positive, either after changes in trade integration or the sector skill intensity, which corresponds to positive changes on wage inequality in many manufacturing sectors. Nevertheless, I highlight some negative correlations between the sector-specific bias and changes of skill premia; for instance, trade with developing countries, and quantity of exporters by sector, tend to shape less wage inequality when the sector skill intensity increases.

The estimates presented in this chapter can be refined in different ways, in terms of the measure of SBTC, which has been controversial because of endogeneity. For future research, it remains the empirical explanation in terms of providing the evidence of negative skill premia changes and positive sector-specific bias, which could be related to technological heterogeneity across manufacturing sectors.

The second chapter uses a theoretical model of heterogeneous firms, considering a segregated labor market between informal and formal firms, to analyze the relationship between international trade and welfare. The segregation, in this case, is a result of the introduction in the market of a regulatory threshold, according to which, firms having less than a certain quantity of workers are defined as informal, otherwise, they are formal and should pay additional fixed and marginal labor costs. This threshold creates endogenously a situation where it is more profitable for the most productive informal firms scaling back production to avoid formal labor costs. The numerical solution of the model shows that after trade openness, a share of the most productive informal firms becomes less productive and that the less productive formal firms become informal. The welfare in the economy decreases because of the higher prices and the reduction of available varieties in the economy. Likewise, the comparative static exercise yields evidence that a decrease in the regulatory threshold forces informal firms to become formal; therefore, under full employment conditions, such a policy increases average wages and raises welfare.

In the autarchy equilibrium, the less productive informal *lpi* firms and the formal firms produce according to their productivity level; therefore, both kind of firms exhibit positive slopes for revenues, labor demand and profits. The most productive informal *mpi* firms instead scale back production to avoid paying additional formal labor costs. To do that, they set a constant rule of price determined by the average productivity of all *mpi* firms, and hence, produce the corresponding constant quantities to that price. Such behaviour allows them not to have excess of demand or excess of supply and not to hire more than $\bar{l}$ workers, as they are pretending to be small firms.

In the open economy equilibrium, I obtain from the numerical solution similar effects as in Melitz [2003]: the informal selection and export market selection effects. For this new setup, including informal and formal firms, as well as the labor market regulations, I find formal selection and mpi firms selection. Furthermore, there is a reallocation of workers towards formal firms and exporting firms in the labor market. However, unlike the theoretical literature, in this framework welfare decreases, because the better wages earned by more formal workers is counterbalanced and even surpassed by higher prices and less varieties available in the economy. In terms of profits, only the most productive exporting firms are better off than in an autarchy, whilst mpi firms who become lpi firms and formal firms who become mpi lose.

Regarding the comparative static exercise, the most relevant results derive from evaluation of the three regulation parameters in the labor market: the labor regulatory threshold, the formal wage premium and the formal fixed cost. Changes in parameters related with trade policy have similar effects as Melitz 2003. Thus, decreases in the regulatory threshold makes informal firms pay formal costs to stay in the market, reducing the level of informal firms and, under full employment, price-taker firms tend to disappear. Welfare in turn rises, as there are more formal workers earning formal wages. In the case of higher levels of the formal wage premium, welfare moderately decreases, as soon as the mass of formal firms decreases in favor of the informal sector, compensating with a small reduction in prices and higher available varieties. On the other hand, higher formal fixed costs induce mpi firms to disappear, while the mass of lpi, formal and exporting firms increases, allowing only the most productive to stay in the market. Welfare increases because there are more formal workers and more available varieties, which are not compensated by higher prices.

The next steps to improve the model include the addition in the analysis of labor market distortions, to analyze the effects in the short term, specifically in terms of impacts on unemployment. Certainly, assuming full employment is a strong assumption, especially in the case of developing countries. Moreover, it would be more realistic to allow for informal firms to be assigned an increasing probability of being caught, which should affect output and welfare. Other assumptions can be relaxed; for instance, formal firms could be at the same time informal, as perhaps the strict separation of both sectors is not necessary and can be viewed as less realistic, especially for developed countries.

The third chapter delivers empirical evidence about the impact of the recent oil boom, on aggregate production, trade, employment, and informality, contributing to complete the recent theoretical analysis on the topic. Using the Diff in Diff methodology, I find that international trade flow increases in countries affected by the boom, though agriculture in a lower magnitude. This sector was even worse in terms of employment before the Dutch disease. Likewise, unemployment and informal labor are lower in those countries. Against the theory, production in the services sector decreases, while exports of agriculture and manufacture move down in no boom countries.

Following the Diff in Diff methodology suggested by Card and Krueger [2000] and Slaughter [2001], I find that the treatment and control groups had a negative trend on employment in the agriculture sector, before the Dutch disease, but that this trend was strengthen during the Dutch disease, while both groups presented a positive trend of employment in the services sector before and during the treatment. In the case of industrial employment, the evidence suggests that there was a negative trend before the treatment in both groups, but after the boom, the employment in the sector increased more in the Dutch disease countries. Likewise, the treatment effect on unemployment for Dutch disease countries is more negative than for the control group, benefiting mainly intermediate and basic education workers, and women, while self-employment tend to decrease more as well in treated countries.

In the case of production, I find evidence of a higher positive effect of the resource windfall on the GDP per capita levels and manufacture production, for the treatment group with respect to the countries not affected by the Dutch disease. On the contrary, the impact of the treatment on services sector production is more negative for Dutch disease countries, while the treatment effect is not significant on agriculture production. Likewise, the effect of the Dutch disease was more negative on net exports and the current account of treated countries with respect to the control group. Indeed, there is evidence of a negative differential effect on imports in the treated group, while exports of agricultural and raw materials decrease in both groups. Manufacturing exports decrease more as well in the Dutch disease countries. Only high-tech exports benefit more the treatment group.

Accordingly to this on working research, I suggest a list of things to do in order to improve the analysis and the robustness of results in different ways, as well as to extend the scope of the questions. Firstly, considering that international oil prices return to the levels before the boom, around 2016, the effects of more than 10 years of the resource boom could remain in many economic variables, and may have affected the outcomes of new Free Treade Agreements entered into force around those dates. For instance the cases FTA Peru-USA and Colombia-USA are interesting examples, where the different outcomes in economic performance can be explained in part by the resource windfall. Indeed, depending on the length of the phenomenon and the particular characteristics of the country, negative consequences can be observed after the Dutch disease.

Secondly, to provide robustness checks on the results, I can try different placebo methodologies, for instance choosing randomly a different treatment groups among the whole countries or setting different treatment periods. Estimations within similar middle income countries can also be evaluated. This exercise would allow to verify whether the estimates I get are random or due the real treatment and control group.

Thirdly, other econometric specifications can be tested to verify the assumption of parallel trends. For exemple, the Dutch disease Dummy variable can be interacted with GDP to see the relevance of the income of the country in the results, thus analysing different impacts on developing and developed countries. In addition, other variables explaining the outcome but not affected by the treatment and changing over time, can be considered as controls, such as country population, exports diversification levels or educational attainments.

Likewise, as a test of robustness, equations 1 and 2 could be estimated only for the two periods t=0 and t=1 (as in Card and Krueger [2000]), to compare the results with our expanded model. Some misleading results could be explained by the size of some countries within the treatment group, as the case of China, whose characteristics may bias estimates.

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