Trade and Labor Market Institutions: A Tale of Two Liberalizations

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Abstract

In this paper I study how labor market institutions at the time of a trade reform determine the post-reform dynamics of unemployment. I first document that for a large group of developing countries (1) unemployment increases on average following a trade reform, (2) there are significant cross-country differences in unemployment response, and (3) cross-country variation in the labor market institutions in place at the time of the reform can account for the observed unemployment changes. I interpret this evidence through the lens of a model of international trade, featuring heterogeneous firms, endogenous industry dynamics, search and matching frictions in the labor market and duality between formal and informal employment. I estimate the model to match the pre-liberalization firm dynamics in Colombia and Mexico, two countries that differed by the labor regulations in place at the time of trade liberalization, and I characterize numerically the full transition path towards the new steady state. I show that the dynamic response of unemployment to a reduction in trade costs is non-linear across different combinations of labor market institutions in place at the time of the reform. Consistent with the cross-country evidence, the response is stronger and more persistent when the firing costs are lower and the statutory minimum wage and unemployment benefits are larger. On average, these three institutions together account for up to 58 percent of the increase in unemployment in the case of Mexico, and up to 32 percent in the case of Colombia.

Keywords: Trade Reform, Labor Market Institutions, Unemployment, Transition
JEL Classification: E24, F12, F16, L11

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1 Introduction

Over the past 40 years, most developing countries have embarked on programs of trade liberalization.[1] Despite the well-known benefits of product market integration, a large literature has documented that trade reforms can also create adverse effects on labor markets, and a key concern has been the higher unemployment that often follows.[2] Countries, however, differ significantly in how they fare with respect to unemployment after trade reform.[3]

In this paper I study whether labor market institutions in place at the time of a trade liberalization are responsible for the post-reform dynamics of unemployment. Labor institutions in place at the eve of a trade reform vary greatly among countries.[4] Some countries adopt free-trade policies with flexible labor market institutions, while others do so with more rigid ones. Is the unemployment response to a reduction in trade costs stronger when the labor market is more flexible? Are labor market regulations a burden for trade adjustment? If so, why? What are the main channels? To address these questions, I develop and estimate a structural model of firm dynamics with a rich institutional environment, and I show that regulations in the labor market are key determinants of the transitional dynamics after a trade liberalization episode.

To illustrate how labor market institutions shape the response to a trade opening, I provide aggregate evidence from an event study analysis. In particular, I track the dynamics of unemployment rate within a panel of 40 developing countries who experienced a trade reform in the last 30 years. On average, the unemployment rate increases shortly after a trade liberalization and it stays higher within 15 years of the reform. Employment protection legislation (EPL, henceforth), minimum wage regulation and unemployment insurance (UI, henceforth) in place at the time of a trade reform induce heterogeneous responses of unemployment to a fall in trade costs, and the cross-country variation in these three labor market institutions can account for the observed unemployment responses. This evidence suggests that the institutional features of local labor markets need to be considered in order to understand the adjustments triggered by product market integration.

To interpret this result and quantify the causal effects of regulations in the labor market, I develop a two-sector structural equilibrium model of a small open economy with endogenous firm dynamics and a dual labor market. I discipline the model using firm level data from the Colombian and the Mexican manufacturing sector and I solve for the full transition path that results from lowering variable trade costs towards the new steady state. I show that

[1] See Rodrik (1993) for a comprehensive overview of the trade policy reforms in developing countries.

[2] For a summary about the adjustment costs of trade in developing countries, consequence and policy recommendation, see Hoekman and Porto (2010).

[3] On the effect of trade openness on unemployment in developing countries, see, for instance, Revenga (1997) for the case of Mexico, Currie and Harrison (1997) for Morocco, Goldberg and Pavcnik (2004) for Colombia, Kpodar (2007), Nicita (2008) for Madagascar, Balat and Porto (2007) for Zambia, Hasan et al. (2012) for India and Menezes-Filho and Muendler (2011), Dix-Carneiro (2014) and Dix-Carneiro and Kovak (2017) for Brazil.

[4] See Freeman (2010) for a discussion about differences in labor market institutions across countries.

the response of unemployment after a trade reform is consistent with the empirical evidence: a counter-factual exercise indicates that the labor market institutions at the time of trade opening can explain up to 58 (32) percent of the increase in unemployment after a trade reform in Mexico (Colombia).

The model combines endogenous firm dynamics with costly employment adjustment and search and matching frictions in the labor market in a standard trade environment. The economy consists of a non-tradable sector, populated by unit measure of firms producing homogeneous service goods, and by a continuum of heterogeneous firms operating in a tradable sector, producing differentiated industrial goods and engaging in international trade. Unlike most of the works in the trade literature, the focus of this paper is on the transitional dynamics triggered by a reduction in trade costs, within a framework characterized by a rich institutional setting and by a dual labor market.

Industrial firms enter and exit the industry, driven by profit considerations and exogenous bankruptcy shocks, and they expand and shrink their size, subject to idiosyncratic productivity shocks. They must comply with minimum wage, are subject to firing costs as well as payroll taxes. On the other hand, the imperfect enforcement of regulations gives incentives to informal employment. To hire formal workers, firms are subject to search and matching frictions and convex adjustment costs, which prevent immediate adjustment in response to a shock, and leads to unemployment. From the worker side, formal employment comply with three major labor market institutions: (1) firing restrictions, modeled as a tax on employment reductions; (2) a statutory minimum wage, modeled as a legal minimum contribution each employer is forced to provide to employees; (3) unemployment insurance, modeled as a government lump-sum payment accruing to workers who separate from their employers, and financed with taxes on firms payroll. Informal employment is introduced in the model along the intensive margin: formally registered firms hire informal workers in a frictionless labor market, fire them without being subject to any restriction (e.g. firing costs), and can illegally evades labor market regulations (e.g. minimum wages or payroll taxes).[5]

A reduction in trade costs has two major effects in the model. First, it induces greater competition in the product market. Access to foreign markets becomes cheaper and domestic consumers substitute home-produced varieties with foreign varieties. Import penetration reduces the revenues of low-productivity, domestic firms which are forced to lower wages and, depending on productivity level and stage of life-cycle, to adjust their workforce downward and, eventually, exit. Second, a drop in trade costs gives incentives for exporters to increase the share of products sold in the foreign market and for high-productivity non-exporting firms to serve the foreign market. The revenue premium from exporting increases, and exporting firms start rising their wage and expanding their size.

[5] Ulyssea (2013) shows that the intensive margin in Brazil accounts for a large fraction of total informal employment. Similarly, Kumler et al. (2015) empirically analyze wage underreporting in Mexico and show that it is substantial.

In this framework, the labor market regulations in place determine the direction and the magnitude of employment adjustment after a trade shock, with implications for job volatility, worker reallocation, unemployment rate and informality. On the one hand, employment protection exerts a *stabilization effect* after trade openings, by increasing hoarding of formal labor, reducing employment volatility and ensuring workers against unemployment risk driven by greater product market competition. On the other hand minimum wage and unemployment benefits induce an *amplification effect*, increasing the cost of labor, and making the domestic firms respond to foreign competition with larger worker displacement. Furthermore, greater wage and employment rigidity induce firms to shift from formal to informal employment during transition, as a solution to cope with expected loss in revenues induced by foreign competition.

In a quantitative exercise I focus on the trade reforms of Colombia and Mexico. These two countries constitute two relevant case studies for several reasons. First, between the end of the 1980's and the beginning of the 1990's, both Colombia and Mexico went through a massive series of external economic liberalizations, and witnessed an unprecedented expansion of the imports of goods and services within ten years after the implementation of the reform.[6] Second, Colombia and Mexico opened up to trade under very different labor market institutions. In paritucular, Colombia massively cut firing costs while Mexico kept a rigid labor market. At the time of trade reform, firms contributions for worker dismissal in Colombia were roughly equivalent to one average real monthly wage, less than one third of the value reported for Mexico. Furthermore, Colombia kept very high minimum wage, Mexico did the opposite. At the time of liberalization, the average statutory minimum wage was more than half of the average market wage in Colombia, and no more than one third in Mexico.

In order to discipline the model, I exploit firm-level data for the manufacturing sectors of both countries during the pre-reform years: the key parameters are estimated using the method of simulated moments, so that the model replicates firm dynamics, distribution of formal employment and export dynamics observed in the Mexican and Colombian economies. I use these estimates to study a general equilibrium transition paths in response to a trade liberalization reforms.

As a first exercise, I implement a once-and-for-all reduction of both tariffs and non-tariff barriers (NTB, henceforth), and I solve for the full transition path towards the new steady state, while keeping the regulations in the labor market equal to the observed. The predictions of the model are consistent with the differences in the dynamic response between Colombia and Mexico: the model predicts a larger increase of unemployment rate in the Colombian economy, jointly with a larger reduction in the employment share of manufacturing, and a larger increase in the informality rate.

As a second exercise, I quantify the role played by each institutions. To do so, I first

[6]In Colombia, the imports share of GDP increased by around 39 percent, going from 13.81 to 19.17. In Mexico the figure went from 10.98 to 17.89, with an increase of 64 percent. Source: World Development Indicator Database, https://data.worldbank.org.

implement a reform in the labor market with a once-and-for-all change in one of the institutions in place. I then open to trade with a reduction of both tariffs and NTB, and I compare the average response of unemployment to the case without labor reform. The main result is that on average, unemployment reacts more strongly the less stringent the employment protection legislation, the stricter the minimum wage policy, and the larger the coverage of unemployment insurance. This pattern resembles the cross-country evidence of the event study of liberalization.

The model generate a rich dynamics towards the new steady state. The transition following a trade reform may take a long time, depending on the magnitude and the speed of employment adjustment. As in Kambourov (2009), regulations in the labor market are key determinants of magnitude and the speed of employment adjustment after a trade reform. First, low-productivity incumbents react on impact. High firing costs hamper job destruction, low minimum wage or low unemployment insurance foster greater wage cuts. Greater job destruction contributes to increase unemployment, particularly in the short run. Second, high-productivity firms expand slowly. Search and matching frictions and convex adjustment costs prevent exporting firms to jump immediately to the new optimal size, with the effect of keeping, at the aggregate level, unemployment duration of displaced workers higher along the transition path. It follows that, as in Bellon (2016), unemployment and employment share of manufacturing overshoot in the short-run. Third, expanding firms recruit formal workers at a faster pace the less strict the EPL: lower firing costs increase the firms marginal surplus from hiring formal workers by reducing the expected costs of shedding them in the future. Fourth, lower minimum wage and lower UI induce temporary survive of low-productivity incumbents, thereby reducing firm selection. At the aggregate level, lower selection slows down the adjustment process, with the effect of crowding out higher-productivity entrants, hence depressing average firm growth in the tradable sector. Finally, as in Itskhoki and Helpman (2015), the share of exporters increases on impact but may undershoot the long-run value, since high-productivity firms gradually attain their optimal size.

The remainder of the paper is structured as follows. I first outlines the relation of this paper with the existing literature. Section 2 discusses cross-country evidence on the effect of trade liberalization on unemployment rate and highlight the role of labor market institutions. Section 3 outlines the structural model, defines a notion of equilibrium along the transition path from autarcky to openness, and lays out the mechanisms of the labor markets. Section 4 describes the trade reforms of Colombia and Mexico and the different institutional backgrounds in place. Section 5 explains the estimation strategy. Section 6 explores the quantitative implication of the model and numerically characterize the transitional dynamics after a trade reform under the different labor market policies. Section 7 concludes. The Appendix contains technical details on the model, description of the data used, further empirical evidence and quantitative results.

1.1 Review of related literature

This papers relates to a number of literature. First, it contributes to the recent literature that studies the joint effects of labor market frictions and trade reforms. To this extent, this paper is close to Helpman and Itskhoki (2010), Helpman et al. (2010) and Felbermayr et al. (2016) who focus on the long-run impact of globalization and labor market rigidities on job volatility, unemployment rate and the distribution of wages.[7] Within this literature, Fajgelbaum (2016) embeds job-to-job transition into a trade environment to study how search frictions impede exporting firms to grow in response to reduction in trade costs. Cosar et al. (2016) estimate a structural steady-state model using Colombian firm-level data to quantify the contribution of trade and labor market reforms on the observed increase in wage inequality and job volatility. Unlike these papers, I focus on the consequences of labor market institutions for transitional dynamics in a framework where firms costly adjust employment and switch between formal and informal employees as a response to a fall in trade costs. I quantitatively characterize the differential impact of trade reforms on unemployment rate along the entire transition path between different steady states, through ongoing productivity shocks, endogenous firm entry and exit, and endogenous job creation and destruction.

Models with transitional dynamics have primarily focused on two main key dimensions: the reallocation of workers with different levels of human capital across sectors, and reallocation of heterogeneous jobs between firms within the same sector, in frameworks with labor market frictions. Papers like Cosar (2013) and Dix-Carneiro (2014) belong to the first group: they develop models where workers slowly accumulate sector-specific human capital, and can costly switch between sectors, to study the distributional response to a trade shock.[8] This paper instead belongs to the literature that focuses on the role of employment adjustments, preventing firms to instantaneously adjust to changes in the product market. To this extent, it is close to Itskhoki and Helpman (2015) who use a two-country two-sector model to study how jobs and workers reallocate along the entire transition path after a change in trade costs, and to Bellon (2016) who develops a model of directed search in the labor market and costly firms′ screening of workers to micro-found the dynamic response of inequality to a trade liberalization. Both models yield comparable prediction about unemployment: they both show that falling trade costs can generate a short-run increase in unemployment. Unlike these papers, my model links the response of unemployment to the regulations in place at the time of a trade reform, a feature they both abstract from, generating in comparison much richer responses of firms to the lowering of variable trade costs.

[7] Empirical papers on this subject include, among the others, Amiti and Cameron (2012) and Helpman et al. (2017).

[8] Empirical evidence has shown instead that most of the workers and job reallocation after a trade liberalization occurs within sector. Wacziarg and Wallack (2004) use 25 episodes of trade liberalization to provide evidence of weak intersectoral labor movements after a trade reforms. Haltiwanger et al. (2004) document the association between job turnover and openness in Latin America. Bernanrd et al. (2003) estimates substantial effect of a trade liberalization on intersectoral job turnover using the US Census of Manufacturing.

This paper speaks eventually about the effects of labor market institutions on unemployment. To this regard, this paper can be viewed as complementary of Bentolila and Bertola (1990), Hopenhayn and Rogerson (1993), and, among all, to Alvarez and Veracierto (2000), who explore to which extent differences in labor market policies, such as minimum wages, firing restrictions, unemployment insurance, and unions, can generate differences in labor-market performance and aggregate efficiency. Extensive studies have focused on the effects of regulations on labor market performance of low and middle-income countries, exploiting for instance, the waves of reforms that have characterized many Latin American and Caribbean (LAC) countries during the 1980's and the 1990's.[9] This paper extends the analysis by studying the effect of labor market institutions on the labor market performance of an economy subject to large structural shock, that is, a trade liberalization. On this matter, this paper is close to Veracierto (2008), who studies the effect of firing costs on an economy that is subject to business cycle technological shocks, and to Anderton et al. (2015) and di Mauro and Ronchi (2016) who analyze the effects of labor market institutions on firms adjustment to the great recession. The focus of this paper is on trade reforms, which, as opposed to a business cycle shock, induce asymmetric responses between high-productivity firms - which benefit from larger demand from foreign markets - and low-productivity firms - which lose from larger import penetration. Kambourov (2009) uses a general equilibrium model of international trade to study the effect of firing costs on the speed of inter-sectoral reallocation of workers after a trade shock. Instead, I focus on the intra-sectoral reallocation of labor triggered by a fall in trade costs, and the potential increase in unemployment during transition. Dix-Carneiro and Kovak (2017) and McCaig and Pavcnik (2014) document that shifts into or out of non-employment and informal employment constitute important margins of labor market adjustment to trade. To this purpose, my model incorporates search and matching frictions in the labor market and informal employment: both feature allow me to study how a reduction in trade costs generates unemployment in a setting where labor market institutions are not perfectly enforceable and informality serves as a buffer for firms against the increased competition.

Finally, this model contributes to the recent theoretical labor-search literature that incorporate a notion of firm size, including Elsby and Michaels (2013), Acemoglu and Hawkins (2014), and Kaas and Kircher (2015), and speaks more generally about the interaction between labor market and product market regulations, giving particular emphases on the consequences of increased import competition on firm and employment dynamics, and to this regard it is closed to Koeniger and Prat (2007), Felbermayr and Prat (2011) and Felbermayr et al. (2011).

[9]For a comprehensive review of the literature, with particular focus on the effect of EPL and minimum wages policies on employment, turnover rates and wage distribution between demographic groups, see Heckman and Pages (2004). For a discussion about labor market institutions and unemployment in continental European economies, see Nickell and Layard (1999).

2 Aggregate Evidence

Between the mid-70s and the mid-90s, various developing countries liberalized their trading regimes, dismantling trade barriers and lowering import tariffs.[10] This wave of trade reforms was particularly intense in Latin American and the Caribbean (LAC, henceforth) countries, where, as a result of unilateral trade opening policies, the regional average tariffs on imports fell from 45% to 13% and non-tariff restrictions and permits went to cover from 34% of total imports to no more than 11%.[11] As a consequence, trade flows significantly expanded, increasing import penetration of intermediate inputs and final manufactured goods and exposing these countries to foreign competition.[12]

In this section, I focus on a subset of countries who embraced a process of trade liberalization during the last 40 years and I report aggregate evidence on the response of the unemployment rate to a liberalization episode. In particular, I track the dynamics of unemployment within each country before and after the trade reform and I relate it to the degree of employment protection, minimum wages and unemployment insurance observed at the time of trade liberalization.

The event study I conduct mainly draws from four data sources. To identify periods of trade openness, I use the liberalization dates reported by Wacziarg and Welch (2003), which are based on those developed by Sachs and Warner (1995), and I construct a country-specific dummy variable taking value one in each period afterward this date. To capture the strength of different labor market institutions, I rely on the data provided by the Fondazione Rodolfo de Benedetti (FRdb-IMF labor institutions database v.1).[13] In particular, I use the ratio between the statutory minimum wage in place and the average market wage as a proxy for the minimum wage legislation, while I use the average number of months of advance notice in case of dismissal plus the average compensation for dismissal over different seniority horizon to identify differences in employment protection regulation. Finally, to measure the unemployment benefit legislation I use the average gross replacement rates within one year of dismissal, weighted by the total benefit coverage. The series for unemployment rate are constructed using data from ILO-Stat database, while information on population, nominal and real GDP, import and exports, employment, rate of inflation and exchange rate are taken from the World Development Indicators (henceforth the WDI) provided by the World Bank merged with the Penn World

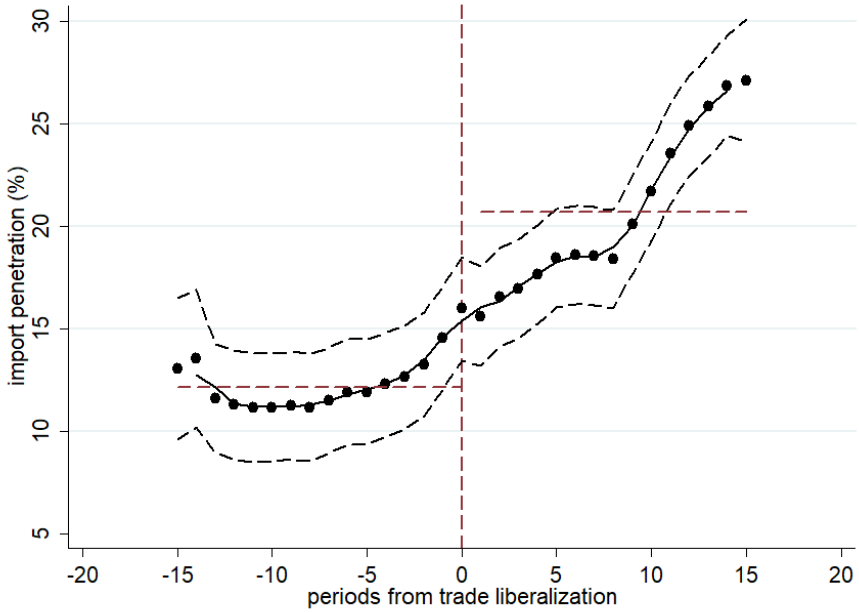
[10] Wacziarg and Wallack (2004) report that more than 70% of the countries in the world were open up to international trade by the end of the 1990s, a share representing almost 50% of the world population.

[11] Data on trade barriers are taken from the IADB, Integration and Trade Division, and are reported in Lora (1997). For the same period, Haltiwanger et al. (2004) document a marked reduction in the standard deviation of average 2-digit sector tariffs in all countries of the region.

[12] From 1985, total imports of goods and services (over GDP) in LAC countries increased at a annual rate of 2.5%. Further evidence on trade openness and drop in tariffs are available at the WITS dataset from the World Bank. See http://wits.worldbank.org.

[13] The FRdb-IMF labor institutions database collects information on minimum wages, unemployment benefits and employment protection legislation around the world. It covers a set of 91 countries and a time span from 1980 to 2005. Source: http://www.frdb.org/page/data/categoria/international-data

Figure 1: **Import dynamics**



Note: Import penetration is construct as total imports divided by GDP minus net export. Each dot is the OLS estimate of year fixed effects in a regression with the dependent variable and year dummy variables. The continuous lines are three-years moving averages of the year fixed effects. The dashed lines are 95 percent confidence intervals constructed using robust standard errors. Source: ILO-stat, WBI and author's calculations.

Table version 9.0.[14]

Overall, I gather data for 40 countries, spanning on average 30 years around their respective timing of liberalization, and covering 6 main regions (7 countries in East-Europe, 15 in the LAC region, 8 in Africa and 10 in Middle- and South-Asia). Appendix A reports definition, source and summary statistics of the data.

The liberalization dates capture the average expansion in imports flows observed across countries in the last 40 years and the average timing it occurred.[15] Figures 1 reports the unconditional cross-sectional average import penetration, for each period around the date of reform, within a time-window of 30 years. First, the share of imported goods in domestic output after a liberalization episode is on average almost as twice as large than before (21 versus 12 percent). Second, the import flows fluctuates around the pre-reform average and take off roughly at the time indicated by the liberalization date, reaching almost 30 percent after 15 years from the reform.

[14]For a detailed description of the data and the data sources, see Appendix A.

[15]Harrison and Hanson (1999) have criticized the ability of the liberalization dates to correctly capture trade openness. Though the empirical analysis I conduct might suffer from well-established limitations (see Rodriguez and Rodrik (2000) for a critique) and should only be viewed as suggestive, the liberalization indicators do capture the dynamics of trade flows fairly well. I will try to address various limitations as a part of the robustness checks. See Appendix A.

Table 1: **Trade Liberalization and Unemployment**

	unemp_{it}			
VARIABLES	(1.1)	(1.2)	(1.3)	(1.4)
Liberalization dummy				
$\mathbf{1}_{\{t \geq t_i^*\}}$	2.019	1.706	1.620	1.685
	[0.847]**	[0.768]**	[0.707]**	[0.717]**
R-squared	0.088	0.148	0.538	0.607
Observations	1004	1004	1004	998
Country FE	yes	yes	yes	yes
Year FE	no	yes	yes	yes
Country trend	no	no	yes	yes
Controls	no	no	no	yes

Note: unemp_{it} refers to the unemployment rate in country i at time t. $\mathbf{1}_{\{t \geq t_i^*\}}$ is a country-specific dummy variable taking value one in each period after the trade liberalization, t_i^*. Controls include population growth, real GDP per capita and its square, real GDP per capita growth, employment growth, investment share of GDP, the rate of price inflation on household consumption goods and the market exchange rate of the national currency w.r.t the US dollar. Robust standard errors are clustered at country level (in parenthesis). Source: ILO-stat, WBI, Penn-Table 9.0 and author's calculations.
**** p<0.01, ** p<0.05, * p<0.1.*

2.1 Trade reform and unemployment

The first hypothesis I investigate in this paper is whether unemployment rate has been relatively higher after a trade reform. Figure 2-a reports the unconditional cross-sectional average unemployment rate, each period around the date of liberalization. After a trade opening, the unemployment rate increases about two percentage points (from 6 to 8 percent of the active labor force). To provide more detailed evidence, I estimate the following cross-country equation,

$$\text{unemp}_{it} = \alpha \mathbf{1}_{\{t \geq t_i^*\}} + \gamma_t + \upsilon_i + \eta_i (t - t_i^*) + \delta X_{it} + \epsilon_{it} \tag{1}$$

where unemp_{it} is the unemployment rate for country i at time t, υ_i is a dummy variable for country i, meant to capture country-specific averages, γ_t is a dummy variable for year t, included to filter out year-specific fixed effects, and η_i are country-specific time trends, capturing country differences in long-run movements of unemp_{it}. The variable $\mathbf{1}_{\{t \geq t_i^*\}}$ is a country-specific indicator taking value one at any year t from the date of liberalization, t_i^*, forward, and it is meant to isolate permanent shifts in the average value of unemp_{it} occurred after the trade reform. Finally, X_{it} is a vector of controls, including population growth, real GDP per capita and its square, real GDP per capita growth, employment growth, investment share of GDP, the rate of price inflation on household consumption goods and the market exchange rate of the national currency w.r.t the US dollar. If the average response of unemployment to a trade reform were positive, then the estimates for α should be significantly greater than zero.

Table 2: **Labor Market Institutions**

	Min/Mean wage	EPL AN	EPL SP	UI benefits	UI coverage
Average	0.37	1.14	4.86	15.63	17.22
St. Dev.	0.18	0.77	4.35	21.52	27.16
LAC	0.39	1.07	7.35	6.04	5.45
East Europe	0.36	1.44	3.09	19.95	18.05
Asia	0.43	0.92	3.91	11.35	20.10
Africa	0.24	1.16	2.71	16.62	8.05

Note: The minimum wage is expressed as share of the average yearly wage. AN refers to the months of advance notice, SP refers to level of severance payment: both are expressed as a multiple of average real monthly wage. UI benefits refers to the average gross replacement ratio after one year of dismissal, UI coverage refers to the share of unemployed workers entitled to benefits after dismissal: both are expressed in percentage. Source: FRdB Labor Institution v.1 database and authors' calculation.

Table 1 displays the estimates for the impact of trade shocks on unemployment rate. In particular, I report the OLS estimates of α, together with robust standard errors, clustered at country level (in brackets), for a number of possible and alternative specifications of equation (1). The estimates suggest a non-negligible increase in unemployment rate in the aftermath of a trade reform: the coefficient α is always positive and statistically significant at 5% percent level. Conditional on the full set of observables, the unemployment rate is roughly 1.7 percentage point higher after a trade liberalization.[16]

2.2 Trade reform and labor market institutions

Trade liberalizations were not followed by labor market reforms.[17] At the time of trade opening, the extent of labor market rigidity varies considerably across countries, most of the local labor markets were highly regulated and with limited active labor market policies.[18] Table 2 reproduces this evidence for the countries in the sample.

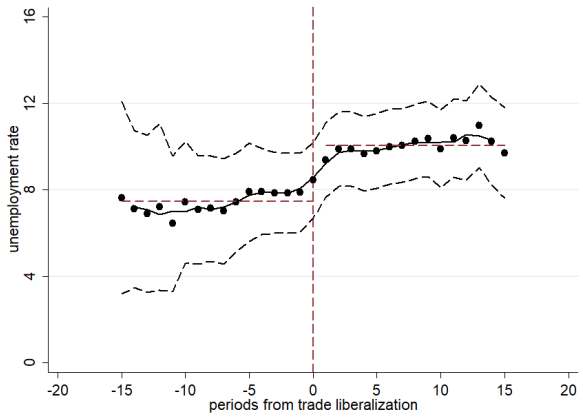
[16]The liberalization dates used in the main specification are based on what Wacziarg and Welch (2003) labeled as,*de-jure* criteria on trade regulations, e.g. tariffs on imports and other non-tariffs barriers, the existence monopolies, the discrepancy between official and black market exchange rate and the presence of a socialist regime. Alternative dates, based on *de-facto* criteria (5+ percent growth in the share of trade merchandise in GDP between two consecutive periods) have been proposed in the literature. In Appendix A I explore the robustness of the main results to the choice of liberalization date.

[17]In a report prepared by the World Bank for Latin America and the Caribbean, Burki and Perry (1997) write that "labor market reform is the area of structural reform where the least progress has been made in the region". In the same spirit, the IADB (1997) concludes: "labor code reforms have been few and not very deep," adding that "current labor legislation may have hindered the re-absorption of workers who were displaced during the reform process". See Forteza and Rama (2006) for a summary.

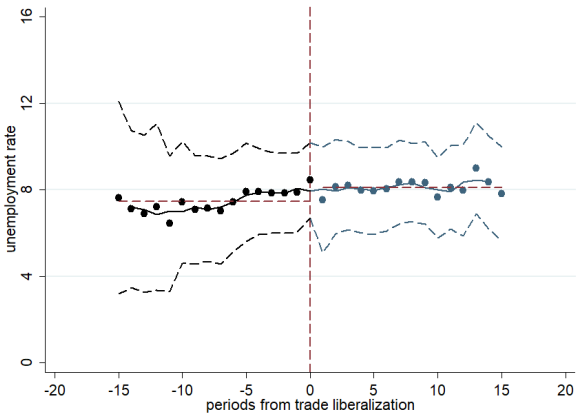
[18]Freeman (2007) documents large cross-country differences in labor institutions for a spectrum of developing countries, with particular focus on government regulations, as dismissal costs, social security and minimum wage policies. See Heckman and Pages (2004) for a description of the labor market institutions in place in LAC countries, the nature of the reforms implemented, and the link with trade liberalization.

Figure 2: **Unemployment Dynamics**

(a) Unconditional



(b) Controlling for labor market institutions



Note: Each dot is the OLS estimate of year fixed effects in a regression with the dependent variable and year dummy variables. The continuous lines are three-years moving averages of the year fixed effects. The dashed lines are 95 percent confidence intervals constructed using robust standard errors. Source: ILO-stat, WBI and author's calculations.

The second hypothesis I investigate in this paper is whether the institutional features of the local labor markets determined the response of unemployment to a trade shock. That is, can the dynamics of unemployment documented in section 2.2 be explained by the labor market institutions in place at time of reform? Figure 2-b reports the unweighted cross-sectional average for the unemployment rate, each period around the date of trade liberalization, after filtering out the effect of minimum wage, employment protection and unemployment benefits. Conditional on the legislation in place, the is no significant difference in the unemployment rate before and after trade openings anymore, suggesting that the labor market institutions can account for a large share of cross-country variation in unemployment during free trade.

To confirm this fact, I extend the specification used in Kambourov (2009) and I estimate the following cross-country equation,

$$\text{unemp}_{it} = \alpha \mathbf{1}_{\{t \geq t_i^*\}} + \beta \mathbf{1}_{\{t \geq t_i^*\}} \text{z}_i + \gamma_t + \upsilon_i + \eta_i (t - t_i^*) + \delta X_{it} + \epsilon_{it} \tag{2}$$

where the interaction terms $\mathbf{1}_{\{t \geq t_i^*\}} \text{z}_i$, are included to estimate cross-country differences in unemployment rate in periods of post-liberalization that are systematically associated to the degree of a particular labor market institutions, z_i, meaning unemployment insurance, minimum wage and employment protection.

Table 3 reports the estimates of equation (2) for a number of different specifications. Labor market institutions explain the variation in unemployment rate observed after a trade reforms: the coefficient α looses significance once the interaction terms are included. The p-value for the F-test of a joint positive effect of UI, minimum wage and EPL suggests that cross-sectional

Table 3: **Trade Liberalization and Labor Market Institutions**

			unemp_{it}		
VARIABLES	(2.1)	(2.2)	(2.3)	(2.4)	(2.5)
Liberalization dummy					
$\mathbf{1}_{\{t \geq t_i^*\}}$	1.048	-1.010	3.176	0.428	0.211
	[0.910]	[1.332]	[1.093]***	[1.546]	[1.837]
Liberalization dummy × UI					
$\mathbf{1}_{\{t \geq t_i^*\}} \text{ub}_i$	0.283			0.197	0.232
	[0.115]**			[0.0573]***	[0.120]*
Liberalization dummy × Minimum wage					
$\mathbf{1}_{\{t \geq t_i^*\}} \underline{\text{w}}_i$		6.291		5.373	5.446
		[3.342]*		[2.856]*	[2.386]**
Liberalization dummy × EPL					
$\mathbf{1}_{\{t \geq t_i^*\}} \text{epl}_i$			-0.110	-0.118	-0.102
			[0.0480]**	[0.0586]*	[0.0550]*
Observations	907	901	972	784	784
R-squared	0.570	0.595	0.584	0.601	0.632
Country FE	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes
Country trend	yes	yes	yes	yes	yes
Controls	no	no	no	no	yes
F-test p-value	n.a.	n.a.	n.a.	0.987	0.996

Note: unemp_{it} refers to the unemployment rate in country i at time t. $\mathbf{1}_{\{t \geq t_i^*\}}$ is a country-specific dummy variable taking value one in each period after the trade liberalization, t_i^*. $\text{epl}_i, \text{ub}_i$ and $\underline{w}_i$ refers to employment legislation, unemployment benefits and minimum wage regulation in place at the time of liberalization. Controls include population growth, real GDP per capita and its square, real GDP per capita growth, employment growth, investment share of GDP, the rate of price inflation on household consumption goods and the market exchange rate of the national currency w.r.t the US dollar. The p-value refers to the F-test for joint significance of labor market institutions, i.e. $H_0 : \mathbf{1}_{\{t \geq t_i^*\}} + \mathbf{1}_{\{t \geq t_i^*\}} ub_i + \mathbf{1}_{\{t \geq t_i^*\}} \underline{w}_i + \mathbf{1}_{\{t \geq t_i^*\}} epl_i > 0$. Robust standard errors are clustered at country level (in parenthesis). Source: ILO-stat, WBI, Penn-Table 9.0 and author's calculations.
**** p<0.01, ** p<0.05, * p<0.1.*

variation in labor market institutions significantly capture the differences in unemployment response to a trade liberalization across countries. Moreover, the estimates from the specification with full set of controls (column 5 in Table 3) predict the following dynamics. The unemployment rate would be 0.545 percentage points higher under free trade with a 10 percentage points larger minimum wage share of the market wage at the time of opening up to trade. Using the same estimates, countries with a 1 percent larger unemployment benefit coverage are likely to experience on average an increase in unemployment rate of 0.232 percentage points higher under free trade. And finally, one month more in the average firing costs would predict a 0.102 percentage points lower unemployment rate in the aftermath of a trade reform.

The event study in this section indicates that labor market institutions are key to understand the dynamics of unemployment post-trade liberalization. The analysis suggests three main facts. First, a trade reform is followed by a positive and significant average response of unemployment. Second, the dynamics of unemployment is tightly linked to the labor market

institutions in place at the time of liberalization. Third, the unemployment response is higher the lower the costs of dismissing workers and the larger the minimum wage and the unemployment insurance in place. However, these results should not be viewed as causal evidence of the effect of labor market institutions yet. In particular, country-specific unobserved heterogeneity in the labor market, or other possible sources of endogeneity, cannot be fully ruled out as drivers of the observed results.

In the next section I propose a structural model of firm dynamics operating in a dual labor market and engaging in international trade that allows me to study the interaction of trade reform and labor market frictions and to disentangle the role of each labor market institutions from the effect of other characteristics.

3 The model

In this section I build on the work of Cosar et al. (2016) and I extend their framework to a non-stationary setting with a dual labor market. Time is discrete and indexed by t. The dependence of time is made explicit to highlight non-stationarity in the model. I consider a small open economy populated by three types of agents: a unitary measure of workers-consumers, an endogenous measure of firms operating in a tradable industrial sector and a fixed measure of firms producing a non-tradable service goods.[19] Workers are homogeneous, risk neutral and live hand-to-mouth: they derive their utility from consumption and no savings technology is available to them. They can be employed in the industrial sector, either formally or informally, employed in the service sectors, or they can be unemployed. Firms in the non-tradable sector are homogeneous and operate in a perfectly competitive market under constant return to scale in production. Firms in the tradable sector are heterogeneous: they produce a differentiated industrial variety and operate under monopolistic competition in the product market. The labor market for industrial job is dual: industrial firms employ formal workers, subject to search and matching frictions and convex adjustment costs, and informal workers, through a competitive market. Informality is introduced by means of a one-period-lasting job, available to workers who do not search for formal jobs.

3.1 Consumption

Workers derive utility from the consumption of a homogeneous, non-tradable service good, s_t, and from the consumption of a CES composite of tradable, industrial differentiated varieties, c_t, defined as

$$c_t = \left(\int_0^{N_t} c_t(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{3}$$

[19] The small open economy assumption ensures foreign conditions do not react to changes in the home-policies.

where N_t is a measure of tradable varieties, ω, available at time t, inclusive of imported goods, $N_{f,t}$, and domestically-produced products, $N_{h,t}$, whereas $\sigma > 1$ is the elasticity of substitution across tradable varieties. Services and industrial goods are combined by means of a Cobb-Douglas function,

$$\mathcal{U}_t = c_t^{\gamma} s_t^{1-\gamma}, \tag{4}$$

where $\gamma \in (0, 1)$ is the fraction of expenditure on the composite tradable sector good.

3.2 Prices

Denote by $p_{s,t}$ the price of a unit of non-tradable service good, by $p_t(\omega)$ the home-price of a domestically-produced variety ω and by $p_t(\omega^*)$ the home-price of an imported variety ω^* at time t. An ideal home price index for the aggregate industrial good, P_t, can written as

$$P_t = \left(P_{h,t}^{1-\sigma} + (\tau_{c,t}\tau_{a,t}k_t P_{f,t})^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{5}$$

where

$$P_{h,t} = \left(\int_{N_{f,t}}^{N_t} p_t(\omega)^{1-\sigma} d\omega \right)^{\frac{1}{1-\sigma}} \tag{6}$$

is the home price index for goods domestically-produced while $P_{f,t}$ is the FOB price index for imported goods, exogenous to the home-economy, and defined as

$$P_{f,t} = \left(\int_{0}^{N_{f,t}} p_t(\omega^*)^{1-\sigma} d\omega^* \right)^{\frac{1}{1-\sigma}} \tag{7}$$

The home price index for imported goods is then subject to iceberg trade costs, $\tau_{c,t} > 1$, and ad-valorem tariff rate, $\tau_{a,t} > 1$, and it is converted to home-currency using the equilibrium exchange rate, k_t. Since the exchange rate adjusts in general equilibrium to clear the trade balance, we can normalize the foreign price index. Therefore, I set $P_{f,t} = 1$. Finally, let the foreign price of domestic good exported abroad be $p_t^*(\omega)$, denominated in foreign currency. An ideal foreign market price index for exported goods, denominated in foreign currency, is defined as

$$P_{h,t}^* = \left(\int_{N_{f,t}}^{N_t} \mathbf{1}_t^x(\omega) p_t^*(\omega)^{1-\sigma} d\omega \right)^{\frac{1}{1-\sigma}} \tag{8}$$

where $\mathbf{1}_t^x(\omega)$ is an indicator function that equals one if variety ω is exported, zero otherwise.

3.3 Production

Firms in the non-tradable sector are homogeneous: they all produce the same non-tradable service good using labor only.[20] Unemployed workers sustain themselves by home-producing $b < 1$ units of service goods. The total production of service sector is then equal to

$$s_t = L_{s,t} + bL_{u,t} \tag{9}$$

where $L_{s,t}$ is labor employed in service sector whereas $L_{u,t}$ is the measure of unemployed workers. Firms in the industrial sectors are heterogeneous. Each of them produces a unique product, ω, and is subject to an idiosyncratic productivity shock, z, which follows an AR(1) process,

$$z_{t+1} = \rho_z z_t + \sigma_z \epsilon_{z,t} \tag{10}$$

where $\rho_z \in (0,1)$, $\epsilon_{z,t} \sim N(0,1)$ and $\sigma_z > 0$ is the standard deviation of the productivity innovation. To produce, firms combine labor, ℓ_t, and final goods used as intermediates, m_t, through a Cobb-Douglas production technology,

$$q_t(\omega) = z_t m_t^{1-\alpha} \ell_t^{\alpha} \tag{11}$$

where $\alpha \in (0,1]$ is the employment elasticity of output, m_t aggregates differentiated varieties used as intermediates,

$$m_t = \left(\int_0^{N_t} m_t(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{12}$$

while ℓ_t is a Cobb-Douglas composite of formally-hired labor, $\ell_{f,t}$, and informally-hired labor, $\ell_{i,t}$, defined as

$$\ell_t = \ell_{f,t}^{\alpha_f} \ell_{i,t}^{1-\alpha_f} \tag{13}$$

with $\alpha_f \in (0,1]$ is the formal employment elasticity of total labor.[21]

3.4 Labor Market

Workers can obtain a job in the service sector with certainty: the service sector labor market is frictionless. If they choose to get a job in the services, they earn a wage $w_{s,t}$. In what follows, without loss of generality, I choose the wage in the services to be the numeraire of the economy. Therefore, I set $w_{s,t} = 1$, $\forall t$.

The industrial sector labor market is dual and segmented into formal and informal. Workers

[20] Since firms in this sector are homogenous in terms of productivity and produce a unique homogenous good, the analysis does not change if they are allowed to hire one or multiple workers, as long as they remain price takers. See for instance, Helpman and Itskhoki (2010).

[21] The Cobb-Douglas aggregate of formal and informal labor can be understood as a particular case of a more general production technology, involving a unitary measure of different tasks, α_f of which can only be accomplished by formal employees, for the limit case of unitary elasticity of substitution between tasks.

can either get an informal job with certainty, ensuring a wage $w_{i,t}$, or they can look for a formal job subject to search and matching frictions. Hiring workers informally is immediate and costless. To hire workers formally, industrial firms need to post vacancies. Workers search for formal jobs randomly. Each period, the aggregate measure of new *formal matches* depends on the measure of workers seeking a formal job, U_t, and the measure of vacancies posted, v_t, and it is governed by the following constant-returns-to-scale matching function:[22]

$$m_t(v_t, U_t) = \frac{v_t U_t}{(v_t^\theta + U_t^\theta)^{\frac{1}{\theta}}} \tag{14}$$

where $\theta > 0$ governs the elasticity of new matches to the measure of searching workers. This matching function implies a probability of filling a formal vacancy for firms, ϕ_t, equal to:

$$\phi_t = \frac{m_t(v_t, U_t)}{v_t} = \frac{U_t}{(v_t^\theta + U_t^\theta)^{\frac{1}{\theta}}} \tag{15}$$

and probability of finding a formal job for workers, $\widetilde{\phi}_t$, equal to:

$$\widetilde{\phi}_t = \frac{m_t(v_t, U_t)}{U_t} = \frac{v_t}{(v_t^\theta + U_t^\theta)^{\frac{1}{\theta}}} = (1 - \phi_t^\theta)^{\frac{1}{\theta}} \tag{16}$$

As in Bertola and Caballero (1994), workers who get matched with an industrial firm enter a bargaining stage to determined the wage rate, $w_{f,t}$, which will be function of the characteristics of the firm they will work for. Workers who fail to get matched end up being unemployed. At the end of the matching process, the population is split into workers formally and informally employed in the industrial sector, $L_{f,t}$ and $L_{i,t}$, workers employed in the services, $L_{s,t}$ and unemployed workers, $L_{u,t}$.

3.5 Revenues

Service goods are sold in a perfectly competitive market. Perfect competition and constant return to scale in production makes the price charged for unit of service good be equal to the marginal cost, implying, in equilibrium, zero profits and the equality between price and wage, $p_{s,t} = w_{s,t} = 1$.

The industrial sector is modeled following Krugman (1980). Differentiated industrial goods are sold in monopolistically competitive and internationally segmented markets and are purchased by consumers as final consumption good and by firm as intermediate inputs. As I show in Appendix B, the total domestic demand for any domestic variety $\omega \in (N_{f,t}, N_t]$ at time t can be written as

$$q_t(\omega) = D_{h,t} p_t(\omega)^{-\sigma} \tag{17}$$

[22]This functional form for the matching function has been introduced first in den Haan and Watson (2000) and used in Cosar (2013), Fajgelbaum (2016) and Cosar et al. (2016).

where $D_{h,t}$ denotes the aggregate size of the domestic market and it is constant across all domestic varieties. Similarly, the total domestic demand for any imported variety $\omega^* \in [0, N_{f,t}]$ reads as

$$q_t(\omega^*) = D_{h,t}[\tau_{a,t}\tau_{c,t}k_t p_t(\omega^*)]^{-\sigma} \tag{18}$$

whereas the total foreign demand for any domestic variety $\omega \in (N_{f,t}, N_t]$ exported abroad is equal to

$$q_t(\omega) = D_{f,t}p_t^*(\omega)^{-\sigma} \tag{19}$$

where $D_{f,t}$ denotes the aggregate size of the foreign market, expressed in units of foreign currency and assumed to be exogenous to the home country and constant across all exported varieties. Given the demand functions (17) and (19), the gross revenue function of non-exporting domestic firms can be written as

$$G_{h,t}(\omega) = D_{h,t}^{\frac{1}{\sigma}} q(\omega)^{\frac{\sigma-1}{\sigma}} \tag{20}$$

whereas the gross revenues of an exporting domestic firms are equal to

$$G_{f,t}(\omega) = [D_{h,t} + k_t^{\sigma}\tau_{c,t}^{-(\sigma-1)}D_{f,t}]^{\frac{1}{\sigma}} q(\omega)^{\frac{\sigma-1}{\sigma}} = D_{h,t}^{\frac{1}{\sigma}}[1 + d_{f,t}]^{\frac{1}{\sigma}} q(\omega)^{\frac{\sigma-1}{\sigma}} \tag{21}$$

where $d_{f,t}$ is the *revenue premium from exporting*, defined as the ratio between the foreign market capacity and the domestic revenues,

$$d_{f,t} = k_t^{\sigma}\tau_{c,t}^{-(\sigma-1)}\frac{D_{f,t}}{D_{h,t}} > 0 \tag{22}$$

In both cases, because of the CES structure, monopolistic competition leads to downward sloping demand and decreasing marginal revenue functions, since consumers′ marginal utility from a particular variety declines with firms′ supply.

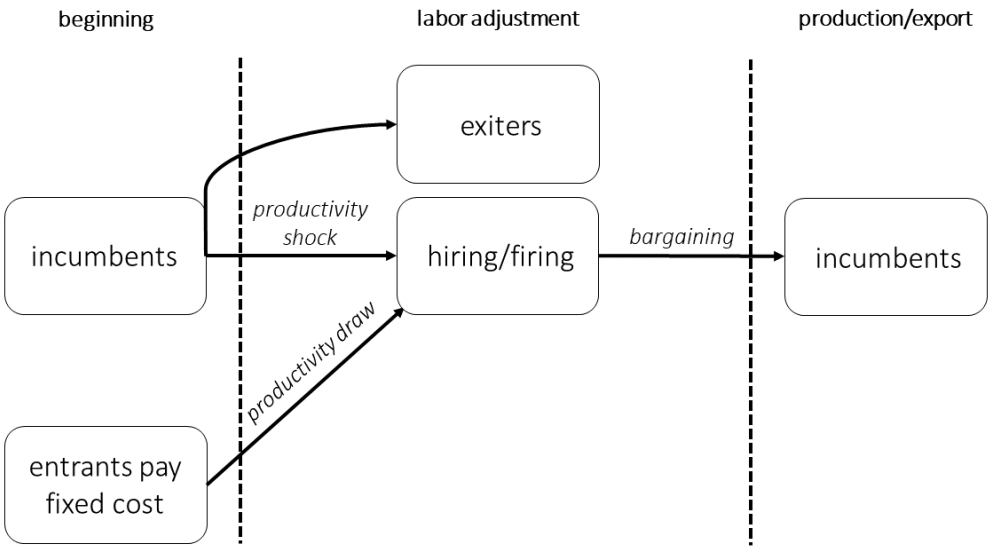
3.6 Industrial firms′ problem

At the beginning of a period t, incumbent firms decide whether to keep operating or not. Conditional on operating, they observe a new productivity level, z', and enter the interim stage of the period with an inherited stock of formal employees, ℓ_f. Thereafter, they choose the optimal employment scale, purchase intermediates and determine export participation. In the final stage of the period, production takes place and wages are paid.

3.6.1 Export decision

Each period t, incumbent firms decide whether to sell their product abroad or not. Participation in the export market is a static decision. Following Melitz (2003), I assume that the industrial producers bear a fixed cost of exporting c_x, in terms of service homogeneous good. Given

Figure 3: **Firm dynamics**



output levels $q(\omega)$, firms choose to export so to maximize their current gross sales revenues, i.e.

$$G_t(q(\omega)) = \max\{G_{h,t}(q(\omega)), G_{f,t}(q(\omega)) - c_x\} \tag{23}$$

where $G_{h,t}(q(\omega))$ and $G_{f,t}(q(\omega))$ are defined in equations (20) and (21). A for policy export participation, $\mathbf{1}_t^x$ is an indicator function defined as follows:

$$\mathbf{1}_t^x = \begin{cases} 1 & \text{if} \quad G_{f,t}(q(\omega)) - c_x > G_{h,t}(q(\omega)) \\ 0, & \text{otherwise} \end{cases} \tag{24}$$

Using equations (20) and (21) the total gross revenues can be written as a function of the export participation policy, policy (24),

$$G_t(q(\omega)) = D_{h,t}^{\frac{1}{\sigma}}[1 + \mathbf{1}_t^x d_{f,t}]^{\frac{1}{\sigma}} q(\omega)^{\frac{\sigma-1}{\sigma}} - c_x \mathbf{1}_t^x \tag{25}$$

3.6.2 Intermediate inputs

Intermediate inputs are purchased to maximize net revenues. Substituting equations (11) and (13) into (25) to express gross revenues in terms of current period productivity, z, and employment values, ℓ_f and ℓ_i, the net revenue function reads as follows,

$$R_t(z, \ell_f, \ell_i) = \max_m \quad G_t(zm^{1-\alpha}(\ell_f^{\alpha_f}\ell_i^{1-\alpha_f})^{\alpha}) - P_t m \tag{26}$$

3.6.3 Employment

Conditional on the new realization of the productivity shock, z', each incumbent firm decides whether to hire or fire formal employees and chooses how many informal workers to employ in the current period. The value of a firm entering the interim stage with ℓ_f formal employees is thus equal to

$$\tilde{V}_t(z', \ell_f) = \max_{\{\ell'_f, \ell'_i\}} \quad \pi_t(z', \ell_f, \ell'_f, \ell'_i) - c_o + V_{t+1}(z', \ell'_f) \tag{27}$$

where $\pi_t(z', \ell_f, \ell'_f, \ell'_i)$ denotes current gross profits at time t, defined as

$$\pi_t(z', \ell_f, \ell'_f, \ell'_i) = R_t(z', \ell'_f, \ell'_i) - w_{i,t}\ell'_i - (1 + \tau_{w,t}) \max\{\underline{w}_t, w_{f,t}(z', \ell'_f, \ell'_i)\}\ell'_f - C_t(\ell_f, \ell'_f) \tag{28}$$

c_o is a per-period fixed cost of operation, and $V_{t+1}(z', \ell'_f)$ is the firm continuation value at the beginning of time $t + 1$.

Formal and informal employment differ by four main features. First, the informal wage, $w_{i,t}$ is competitively determined in the labor market, thus is taken as given by the employers, whereas the wage paid to formal employees, $w_{f,t}(z', \ell'_f, \ell'_i)$, depends on the stocks of both formal and informal employees in firm′s hand. This is the case because (1) the wage of formal employees is negotiated through the *intra-firm bargaining* protocol proposed by Stole and Zwiebel (1996), (2) the marginal revenue is *decreasing* in formal labor, and (3) the revenue function is *supermodular* in formal and informal employees.[23] Second, the wage of formal employees is subject to a the legal constraint imposed by the statutory minimum wage in force, $\underline{w}_t$. Third, employers are subject to a tax on payroll of formal employees, $\tau_{w,t} \geq 0$, collected by the government and rebated back to consumers, while they can evade it on informal workers. Finally, the scale of informal employment can be immediately and costlessly adjusted in each period whereas changes in formal employment are subject to adjustment costs, $C_t(\ell_f, \ell'_f)$, expressed in terms of service goods, and described by the following function,

$$C_t(\ell_f, \ell'_f) = \begin{cases} C_t^h(\ell_f, \ell'_f) = \frac{c_h}{\lambda_1}\left(\frac{\ell'_f - \ell_f}{\phi_t \ell_f^{\lambda_2}}\right)^{\lambda_1}, & \text{if} \quad \ell'_f > \ell_f \\ C_t^f(\ell_f, \ell'_f) = c_{f,t}(\ell_f - \ell'_f), & \text{if} \quad \ell'_f < \ell_f \\ 0, & \text{otherwise} \end{cases} \tag{29}$$

The hiring cost profile is endogenously time-varying, as it depends on the job filling rate, ϕ_t along the transition path, and it is function of three main parameters, i.e. c_h, governing the overall cost of adjustment, $\lambda_1 > 0$ governing the convexity of the cost with respect to the size of formal employment adjustment, and $\lambda_2 > 0$ governing the relative cost faced by small and

[23] See section 3.8 for a description of the wage bargaining protocol.

large employers.[24] On the other hand, the firing costs are described by a single parameters, $c_{f,t}$, which is assumed to be constant, unless subject to an exogenous reform. Finally, I assume that firing costs are collected by the government and are rebated back to consumers, while the adjustment costs of hiring are incurred in terms of service good.

3.6.4 Entry and exit

At the beginning of period t, incumbent firms choose between keep operating or not: they compare the expected value of entering the interim stage with ℓ_f formal workers in hand against the outside option of closing down.[25] The ex-ante value of a firm with initial productivity z and formal employment, ℓ_f is thus equal to

$$V_t(z, \ell_f) = \max \left\{ 0, \frac{1-\delta}{1+r_t} \mathbf{E}_{z'|z} \tilde{V}_t(z', \ell_f) \right\} \tag{30}$$

where $\delta > 0$ is a fixed exogenous probability of firm death and r_t is a rate of discount, assumed to be exogenous to the home-country.

Each period, a large pool of potential firms decide whether to enter the industry and start a new business: they compare the expected value of operating, evaluated at the ergodic productivity distribution of the productivity shock, with the sunk cost of creating a new firm, $c_e \phi_t^{-\lambda_1}$, inclusive of capital fixed costs and initial hiring costs. With a positive measure of entrant firms in equilibrium, $N_{e,t} \geq 0$, a free entry condition must hold:

$$V_t^e = \int_{z \in \mathcal{Z}} \tilde{V}_t(z, 1) \psi_e(z) dz \leq c_e \phi_t^{-\lambda_1}, \quad \text{with equality if} \quad N_{e,t} > 0 \tag{31}$$

where $\psi_e(z)$ is a time-invariant ergodic distribution of productivity shock.

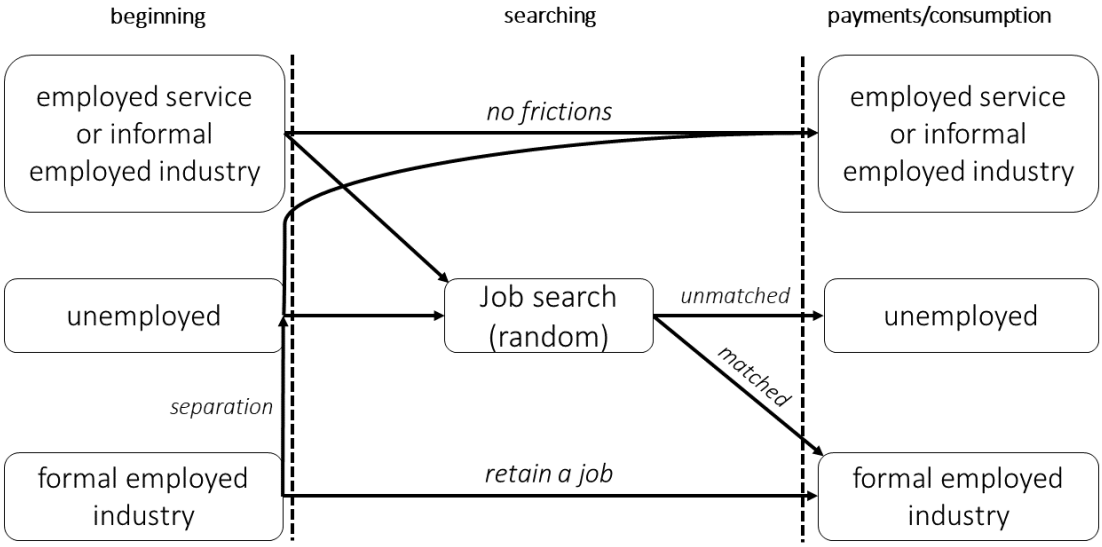
3.7 Workers′ problem

In this section I turn to describe the problems of the workers. Consider a worker who is not formally employed in the industrial sector. At the beginning of period t, this worker has three different options: to work in the service sector, be informally hired in the industrial sector, or to search for a formal job in the industrial sector. Call J_t^o, J_t^s, J_t^i and J_t^u, the value of being not-employed in the industrial sector at the beginning of period t, the value of working in the service sector, the value of being informally employed in the industrial sector and the value of searching for a formal job in the industrial sector, respectively. The value of being not-employed

[24] Yashiv (2000) provides empirical evidence in favor of convex vacancy hiring costs. Other papers that include convexity adjustment costs in net employment include Nilsen et al. (2007) and Cooper et al. (2007).

[25] Notice that bankruptcy can be an attractive option for firms because (1) it allows to save on wage bills (plus taxes) of formal and informal employees, (2) it allows to save on fixed costs of operation and (3) it allows to save on firing costs in case of dismissal of formal employees.

Figure 4: **Worker dynamics**



in the industry at the beginning of period t reads as follows:

$$J_t^o = \frac{1}{1+r_t} \max\{J_t^s, J_t^i, J_t^u\} \tag{32}$$

where the value of being employed in the services, J_t^s, is equal to

$$J_t^s = 1 + J_{t+1}^o, \tag{33}$$

while the value of being informally employed in the industrial sector, J_t^i, can be written as

$$J_t^i = w_{i,t} + J_{t+1}^o, \tag{34}$$

Finally, the value of searching for a formal job in the industry, J_t^u is equal to

$$J_t^u = \widetilde{\phi}_t \mathbf{E} J_t^{e,h} + (1 - \widetilde{\phi}_t)[b + b_t^u + J_{t+1}^o] \tag{35}$$

where b denotes home production, $b_t^u \geq 0$ is a value for the unemployment benefit, while $\mathbf{E}J_t^{e,h}$ is the expected value of a formal match with a firm operating in the industrial sector for a worker searching for a formal job, which depends on the distribution of hiring firms, through the vacancies they post, and on the value of the formal jobs they offer, through the wage they pay,

$$\mathbf{E}J_t^{e,h} = \int_{z' \in \mathcal{Z}} \int_{\ell_f \in \mathcal{L}} [\max\{\underline{w}_t, w_{f,t}(z', \ell'_f, \ell'_i)\} + J_{t+1}^e(z', \ell'_f)] g_t(z', \ell_f) dz' d\ell_f \tag{36}$$

In equation (36), $J^e_{t+1}(z', \ell'_f)$ stands for the continuation value of a worker formally employed in the industrial sector at beginning of period $t+1$ while $g_t(z', \ell_f)$ is the distribution of formal vacancies posted in the interim stage of the period by hiring firms with productivity z' and ℓ_f formal employees.[26] By construction, the wages of *every* hiring firm are such that unemployed workers will always accept a formal job offer whenever contacted, regardless the nature of the hiring firm.

Under risk neutrality, the supply of workers searching for a formal employment in the industrial sector depends on their expected income outside the sector, i.e., their outside options. Because workers are free to direct their search to any type of job, in any equilibrium with both sectors in operation and strictly positive measure of informal employees in the industrial sector, workers must be indifferent between J^s_t, J^i_t and J^u_t, so that $J^s_t = J^i_t = J^u_t$, $\forall t$.[27] Using equations (33) and (34), it follows that workers in the services and informal employees in the industry ensures the same wage payment, $w_{it} = 1$, $\forall t$.[28] Moreover, using condition (32), it must be that J^s_t, J^i_t, and J^u_t are all equal to

$$J^o_t = \frac{1}{1+r_t}[1 + J^o_{t+1}] \tag{37}$$

The equalization between value of searching for a formal job the industrial sector and the outside values works through the adjustment in the matching rates, $\tilde{\phi}_t$, whereas the equalization between the value of an informal job in the industry and the value of working in the services works though the adjustment in the equilibrium wage for informal employees, w_{it}. First, suppose $J^u_t > J^s_t$ or $J^u_t > J^i_t$. If so, all job seekers would direct their search towards formal jobs. As more and more workers apply, the contact rate with a hiring firm decreases up to the point where the value of searching for formal jobs is as profitable as the values of the outside options. The opposite, i.e. an increase in the contact rate, would happen if $J^u_t < J^s_t$ or $J^u_t < J^i_t$. Suppose now that $J^u_t = J^i_t > J^s_t$. Job seekers not looking for formal jobs would direct their search towards informal jobs. As more and more workers are hired informally in the industry, the wage rate decreases up to the point where informal employment is as profitable as working in the services. The opposite, i.e. an increase in informal wage, would happen if $J^u_t = J^s_t > J^i_t$.

Consider now the problem of a worker who is formally employed in the industrial sector at the beginning of period t. This worker can separate from his job either because the firm decides to exit the industry, or because, after observing the new productivity level, the firm wants to contract her scale. In this case, the worker joins the pool of searchers and enjoy a value equal to J^o_t. On the other hand, if a worker keeps her job in the industrial sector, she will receive a

[26] In equation (36) it is acknowledged that both ℓ'_f and ℓ'_i are functions of the state variables (z', ℓ_f), over which the expectation is taken.

[27] As in Helpman et al. (2010), this feature of the model makes the equilibrium job finding rate decreasing in workers' income outside formal industrial jobs. This mechanism trace back at least to the Harris and Todaro (1970) model. See Cosar et al. (2016) for a discussion.

[28] Notice that the same result would arise in a framework where informal employees are able to retain their job for more than one period, as long as the informality is modeled by means of a frictionless labor market.

new wage payment, $w_{f,t}(z', \ell'_f, \ell'_i) \geq \underline{w}$, conditional on the realization of the productivity shock and will start the next period employed. Industrial formal workers do not have the option of searching on-the-job.[29] Moreover, informal workers cannot switch to a formal job within the same employer without searching first. Denote by $p_t^o(z, \ell_f)$ the probability for a worker of being dismissed because of firm exit, and by $p_t^f(z', \ell_f)$, the probability for a worker of being fired by a contracting firm. Therefore, the value of being employed at the beginning of period t is equal to

$$J_t^e(z, \ell_f) = p_t^o(z, \ell_f) J_t^u + (1 - p_t^o(z, \ell_f)) \mathbf{E}_{z'|z} \max \left\{ J_t^u, J_t^c(z', \ell_f) \right\} \tag{38}$$

where $J_t^c(z', \ell_f)$ is the value of continuing to work for the same employer, equal to

$$J_t^c(z', \ell_f) = p_t^f(z', \ell_f) J_t^u + \frac{(1 - p_t^f(z', \ell_f))}{1 + r_t} [\max\{\underline{w}_t, w_{f,t}(z', \ell'_f, \ell'_i)\} + J_{t+1}^e(z', \ell'_f)] \tag{39}$$

Notice that hiring and firing policies determine the probability of retaining a job in the future, impacting value and the stability of being formally employed for a given employer.

3.8 Wage Determination

Wages for formal employees are determined using the Stole and Zwiebel (1996) bargaining solution, which generalizes the standard Nash bargaining solution to a setting when marginal returns are diminishing. At the time of bargaining the labor market is already closed and the costs of posting vacancies are sunk. Upon matching, firms and workers meet and bargain simultaneously and on a one-to-one basis. Failing to reach an agreement would imply a loss for firms (who cannot recover back the costs of posting vacancies and cannot contact other workers in the current period to replace the existing ones) and for workers (who would instead become unemployed in the current period). This generates a surplus to split between firms and workers. At the time of determining wages, firms marginal surplus is equal to:

$$\Pi_t^{\text{firm}}(z', \ell'_f, \ell'_i) = \frac{\partial R_t(z', \ell'_f, \ell'_i)}{\partial \ell'_f} - (1 + \tau_{w,t}) \frac{\partial w_{f,t}(z', \ell'_f, \ell'_i) \ell'_f}{\partial \ell'_f} + \frac{\partial V_{t+1}(z', \ell'_f)}{\partial \ell'_f} \tag{40}$$

while worker marginal surplus equal the difference between the interim value of being formally employed and the outside option at the time of bargaining, given by the home-production:

$$\Pi_t^{\text{worker}}(z', \ell'_f, \ell'_i) = w_{f,t}(z', \ell'_f, \ell'_i) + J_{t+1}^e(z', \ell'_f) - (b + b_t^u + J_{t+1}^o) \tag{41}$$

[29] Workers could at any moment leave their job and join the pool of job seekers. However, since in the model all the employers have to ensure at least the value of searching for a formal job to their employees, no workers have incentive to quit.

The Nash bargaining problem consists of maximizing the joint surplus subject to the participation constraints, ensuring a non-negative surplus accruing to the worker,

$$\max_{w_{f,t}} \quad \left(\Pi_t^{\text{firm}}(z', \ell'_f, \ell'_i)\right)^{1-\beta} \left(\Pi_t^{\text{worker}}(z', \ell'_f, \ell'_i)\right)^{\beta}$$
$$\text{s.t.} \quad \Pi_t^{\text{worker}}(z', \ell'_f, \ell'_i) \geq 0, \quad \textit{(participation constraints)}$$

where $\beta \in (0, 1)$ is the worker bargaining power in the wage negotiation.

Consider now a firm currently hiring formal workers. Formal workers generate positive rents at a hiring firm, making the wage solution of the bargaining problem be implicitly determined by the following Nash sharing rule:

$$\beta \Pi_t^{\text{firm}}(z', \ell'_f, \ell'_i) = (1-\beta)\Pi_t^{\text{worker}}(z', \ell'_f, \ell'_i) \tag{42}$$

Substituting expressions (40) and (41) into (42), and assuming that the surplus continuation values are split the same way as current surpluses,[30] one obtains a first-order partial differential equation in wage, whose solution is a wage function for formal workers at a hiring firm:

$$w_{f,t}^{\text{h}}(z', \ell'_f, \ell'_i) = \frac{(1-\beta)}{1+\beta\tau_{w,t}}(b + b_t^u) + \frac{\beta}{1-\beta+\alpha_f\beta\Lambda(1+\tau_{w,t})}\frac{\partial R_t(z', \ell'_f, \ell'_i)}{\partial \ell_f} \tag{43}$$

where $\Lambda = \frac{\alpha(\sigma-1)}{\sigma-(1-\alpha)(\sigma-1)} > 0$. Equation (43) has a straightforward interpretation: workers at a hiring firm obtain a share of their marginal revenues, and the share increases (1) the larger the bargaining power of worker, (2) the lower the production elasticity of formal labor and (3) the lower payroll tax.

Consider instead a firm firing formal workers. In this case, the existing matches do not generate anymore positive rents, making the worker participation constraint of the problem be binding. Therefore, the unique wage solution of the bargaining problem between a worker and a firing firm is the one ensuring the participation constraint is satisfied:

$$\Pi_t^{\text{worker}}(z', \ell'_f, \ell'_i) = 0 \tag{44}$$

which implies the following wage for formal workers at a firing firm,

$$w_{f,t}^{\text{f}}(z', \ell'_f) = b + b_t^u + J_{t+1}^o - J_{t+1}^e(z', \ell'_f) \tag{45}$$

Notice that this bargaining protocol generated dispersion of wage of formal workers also across firing firms, since workers who continue to be employed enjoy the continuation value $J_{t+1}^e(z', \ell'_f)$.

[30] Same assumption is made, among the others, in Bertola and Garibaldi (2001) and Cosar et al. (2016).

3.9 Import and Export

Given the domestic demand for foreign variety ω^* in equation (18), the value of aggregate imports expressed in unit of local currency, and before tariffs on import are imposed, is equal to

$$\int_0^{N_{f,t}} D_{h,t}[\tau_{a,t}\tau_{c,t}k_t p_t(\omega^*)]^{1-\sigma} d\omega^* = D_{h,t}(\tau_{c,t}\tau_{a,t}k_t)^{1-\sigma} \tag{46}$$

where the equivalence comes from the definition of price index for imported varieties, given in equation (7). Taking tariffs into account, the domestic demand for foreign currency equals

$$\frac{D_{h,t}}{\tau_{a,t}}(\tau_{c,t}\tau_{a,t}k_t)^{1-\sigma} = D_{h,t}\tau_{a,t}^{-\sigma}(\tau_{c,t}k_t)^{1-\sigma} \tag{47}$$

Given the foreign foreign demand for domestic variety ω in equation (19), the value of aggregate exports, expressed in domestic currency, is equal to

$$\frac{k_t}{\tau_{c,t}} \int_{N_{f,t}}^{N_t} \mathbf{1}_t^x(\omega) D_{f,t} p_t^*(\omega)^{1-\sigma} d\omega = \frac{k_t}{\tau_{c,t}} D_{f,t} P_{h,t}^{*1-\sigma} \tag{48}$$

where the equivalence comes from the definition of price index for domestic varieties exported abroad, given in equation (8).

3.10 Government

Government revenues are collected from two different sources, namely tariffs on imports

$$D_{h,t}\tau_{a,t}^{-\sigma}(\tau_{c,t}k_t)^{1-\sigma}(\tau_{a,t}-1) \tag{49}$$

firing costs,

$$c_{f,t} \int_{z\in\mathcal{Z}} \int_{\ell_f\in\mathcal{L}} \mathbf{1}_t^f(z',\ell_f)(\ell_f - \ell_f')\tilde{\psi}_t(z',\ell_f) dz' d\ell_f \tag{50}$$

and taxes on firms' formal payroll,

$$\tau_{w,t} \int_{z\in\mathcal{Z}} \int_{\ell_f\in\mathcal{L}} w_{f,t}(z',\ell_f',\ell_i')\psi_t(z',\ell_f') dz' d\ell_f' = \tau_{w,t} N_{h,t} \overline{w}_{f,t} \tag{51}$$

where $\overline{w}_{f,t}$ is the average wage paid in the economy to formal workers. Revenues are returned to unemployed worker in form of unemployment benefit and, what left, to each worker in the form of lump-sum transfers.

3.11 Recursive Competitive Equilibrium

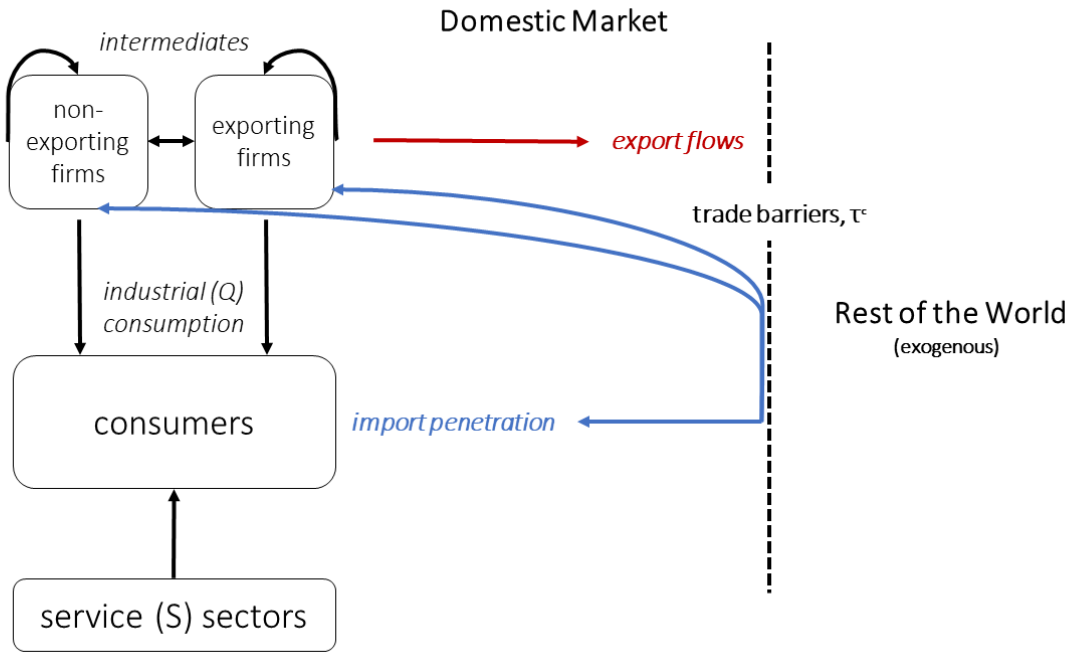
The following six conditions characterize a Recursive Competitive Equilibrium for this economy. First, incumbent firms in the industrial sector choose formal and informal employment to

solve the problem in equation (27) and take exit decision according to equations (30), whereas new firms enter the industry till condition (31) holds with equality. Second, the probability distributions of firms over the state space at the end and the interim stage of the period are consistent with the Markov processes on idiosyncratic productivity, the policy functions for employment, entry and exit, and the productivity draws upon entry. Third, formal wages solve the bargaining problem between workers and the firm, as in equations (42) in the case of hiring firms and as in (44) in the case of firing firms. Fourth, workers optimally choose the sector in which they are working or seeking work, so that the equilibrium value of searching for a formal job in the industrial sector is equal to the value of working in the service sector and to the value of an informal job in the industrial sector. Fifth, the labor markets clear, that is, (1) the measure of formal and informal workers who are employed in the industrial sector match the measure of formal and informal active jobs, (2) the sum of employment levels across sectors and the number of unemployed workers must be equal to the total labor force, normalized to one, and (3) the vacancy filling rate and the job finding rate are consistent with the measures of worker searching for formal job in the interim state and the measure of vacancy posted by firms. Sixth, the market for service clears, and both trade and government budget are balanced. Government′s revenues come from tariffs on imports, firing costs and taxes of firms formal payroll, which used to finance unemployment benefits and eventually lump-sum transferred to consumers. Aggregate income is given by the sum total labor income (industrial and service sector wage payments plus value of home production), aggregate profits and government transfers, while aggregate expenditure in non-tradable services is divided between final good expenditure - given by a share $1-\gamma$ of total income - and intermediate good expenditure, given by the sum of labor adjustment costs, operating costs, exporting costs and initial costs of set-up for firms. In Appendix B, I provide with a detailed discussion of the equilibrium conditions.

3.11.1 Stationary Recursive Competitive Equilibrium

A Stationary Recursive Competitive Equilibrium is a Recursive Competitive Equilibrium where (1) value functions and policy functions are time-invariant; (2) the probability distributions of firms over the state space replicate themselves through the Markov processes on idiosyncratic productivity, the policy functions and the productivity draws upon entry, (3) the exit rate is constant and the measure of exiting firms resembles that of entrants; (4) the vacancy filling rate for firm and the probability of finding jobs for workers are time-invariant; (5) the number of workers flowing into industrial formal jobs matches the number of industrial formal jobs that are destroyed; (6) the measure of workers in the services, the measures of formal and informal industrial workers, aggregate price indexes, aggregate income, profits and wages, interest rate and exchange rate are constant over time.

Figure 5: **Flows of goods**



3.12 Mechanisms

Trade openness and unemployment - The evolution of the unemployment rate after a trade reform is tightly linked to the employment adjustments of firms and to the reallocation of workers across employers. A reduction in trade costs boosts cross-border flows of goods for intermediate and final consumption (Figure 5). Lowering trade barriers produces two opposing forces. On the one hand, it increases *import penetration* of foreign varieties in the domestic market and reduces revenues in small, low-productive, non-exporting firms, who respond, on impact, by displacing workers or by adjusting wages downward. On the other hand, free trade magnifies the value of participating in the foreign market: large, high-productive firms can benefit from higher revenues by increasing their *export flows* and respond to lower trade costs by expanding their size. However, because of search frictions in the labor market and convexity in the hiring costs, exporting firms grow slowly, making reallocation of workers toward larger and higher productive employers sluggish. Moreover, since the hiring costs per worker vary with size, the rate at which firms adjust formal employment and wages in response to shocks depends upon their size. After the initial response, labor market dynamics is governed by larger firms. Along the transition towards the new steady state, low-productivity firms become less responsive to shocks, employment is reallocated towards larger and more-stable firms and job turnover is triggered by the larger revenue steepness of old and new exporting firms. Labor market institutions enter the picture distorting the adjustments in labor demand after a trade shock, with effects on employment volatility, workers turnover and, ultimately, the unemployment rate.

Effect of firing costs - In partial equilibrium, higher firing costs make firms employment less volatile by discouraging labor adjustments to fluctuations in revenues. As in Bertola and Caballero (1994), larger EPL increases the cost of downsizing after a bad productivity shock, hampering labor mobility and increasing labor hoarding, thus keeping alive unproductive matches that would otherwise disappear. In general equilibrium, the opposite effect arises. Larger EPL increases the future costs of hiring, both directly, by rising the expected costs of dismissing workers, as in Hopenhayn and Rogerson (1993), and indirectly, by modifying the firms probability of filling vacancies. Firms react by posting less vacancies, generating a positive pressure on unemployment. Accordingly, the effect of firing costs on unemployment is ambiguous.

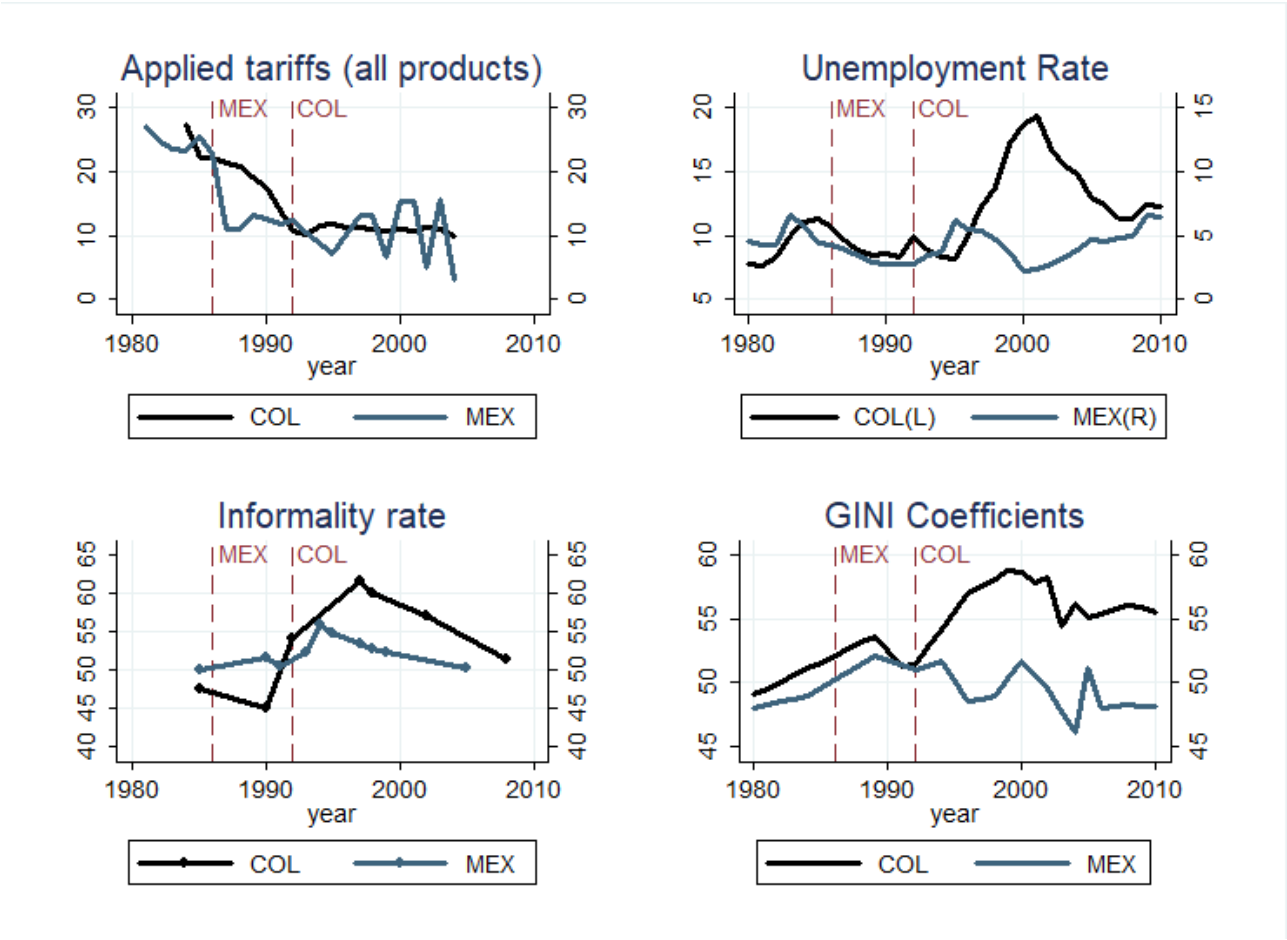
Effect of minimum wage - Higher statutory minimum wage magnifies the downward adjustment of employment in response to a negative productivity shock, leading to larger formal job displacement. In the aftermath of trade reform, a high minimum wage is likely to hurt small, low-productivity firm relatively more, since the constraint on wage is relatively more likely to binding. On the other hand, a higher minimum wage induces a selection mechanism, by shifting the productivity/size threshold for operating in the industry rightward. As the economy approaches the new steady state, only high-productivity firms survive, inducing a new distribution for the marginal revenue product of labor which in turn feeds back into the distribution of wages, the distribution of new vacancy for formal jobs and the job filling rate, confounding the net effect of a high minimum wage on unemployment rate.

Effect of unemployment benefits - The unemployment insurance have less ambiguous effect on unemployment. Other things equal, larger benefits increases the cost of formal labor, by rising the outside option available to workers (equation 43). A larger cost of labor induces firms to shed workers in formal jobs and to shift from formal to informal employment, triggering an increase in labor market tightness and a reduction in the the job finding rate. Furthermore, by shifting the wage distribution in formal jobs rightward, larger unemployment benefits increase the value of formal employment in the industrial sector. In order for the no-arbitrage conditions between sectors to hold, this effect has to be offset by a further reduction in the job finding probability. Finally, as in Hagedorn and Manovskii (2008), the unemployment insurance plays a central role in determining the elasticity of unemployment to changes in aggregate domestic and foreign expenditure: by reducing the match surplus, larger workers outside options make employers more sensitive to shocks to revenues, leading to larger employment adjustments as a response.

4 The cases of Colombia and Mexico

To explore the mechanisms proposed above, I compare the cases of Colombia and Mexico. Between the end of the 1980′s and the beginning of the 1990′s, both Colombia and Mexico went

Figure 6: **Mexico VS Colombia**



Note: This figures report the evolution of average tariffs on imports, unemployment rate, informality rate and income inequality (GINI coefficient on income) before and after the trade liberalization for Colombia and Mexico.

through a massive series of trade and investment reforms. As part of the *Apertura* (opening) plan, from 1985 to 1994 Colombia gradually liberalized its trading regime by reducing the tariff levels and virtually eliminating all the non-tariff barriers to trade, a process that culminated in the drastic reductions of 1990-91. In this decade, the average tariff across all industry declined from 21 to about 11 percent (Goldberg and Pavcnik, 2004), with a drop from 50 to 13 in the only manufacturing sector. As for protection through non-tariff barriers, the average coverage ratio went from 72.2 percent in 1986 to 10.3 percent in 1992 (Attanasio et al., 2004). Throughout the 1990s, further trade reforms were implemented, including bilateral trade agreements with other Latin American countries in 1993-94.

During the second half of the ′80s, after more than a decades of pursuing an import-substitution industrialization strategy, Mexico initiated a radical liberalization of its external sector as well. In 1984, Mexico pursued a policy of privatization and liberalization in order to attract foreign direct investment (Henry, 1999). In 1985, a program of stabilization and structural adjustment was implemented, including trade liberalization. After signing the Gen-

Table 4: **Pre- and post-reforms conditions**

	COLOMBIA		MEXICO	
	Pre	**Post**	**Pre**	**Post**
Trade barriers				
Tariffs (%)	21.1	11.0	23.0	12.5
NTB (%)	73.2	10.3	92.2	13.4
Export dynamics				
Share exporting firms	0.119	0.301	0.216	0.359
Export revenue share	0.134	0.225	0.212	0.267
Unemployment/Informality				
Unemployment rate	0.098	0.129	0.049	0.041
Informality rate	0.463	0.567	0.504	0.525
Job turnover rate	0.165	0.226	0.168	0.181
Income Inequality				
GINI	50.04	56.01	48.97	49.50
$90^{th}/10^{th}$ ratio	3.44	4.23	3.27	3.27
Labor market institutions				
Firing costs	0.50	0.083	0.27	
Minimum wage	0.54		0.33	
Unemployment benefits	0		0	

Note: "Pre" and "Post" refer to pre- and post-liberalization periods as defined by Sachs and Warner (1995). Firing costs and minimum wages are expressed as multiple of the average yearly real wage (source: FRdB Database). The unemployment benefits refer to the coverage rate (source: FRdB Database). The unemployment rate is from the ILO-stat database. The informality rate for Colombia is constructed using the National Household Survey Program (Encuesta Nacional de Hogares, ENH) while the informality rate for Mexico is constructed using the Mexican Employment Survey (Encuesta Nacional de Empleo Urbano, ENEU).

eral Agreement on Tariffs and Trade (GATT) in 1985, official prices for imports were entirely abolished. Import licensing requirements were scaled back to about a quarter of their previous levels - the domestic production value covered by import licensing went from 92.2 percent in 1985 to less than 20 percent by 1989 - while the production-weighted tariff averages fell from 23 per cent in 1986 (Dornbusch and Werner, 1994) to 12.5 per cent in 1989 (Puyana, 2010). Eventually, with the entry into force of the North America Free Trade Agreement (NAFTA) in 1994, almost 70 per cent of U.S. imports from Mexico and 50 per cent of U.S. exports to Mexico received duty-free treatment, the average Mexican tariff rate dropped from 12 percent in 1993 to 1.3 percent in 2001 and the U.S. tariffs on imports from Mexico fell from around 2 percent to 0.2 per cent (Kose et al., 2004).

The trade openings in Colombia was followed by different patterns of unemployment, informality and income inequality compared to Mexico. Panel B in Figure 6 report the evolution of the unemployment rate in both countries from 1980 to 2010. The stock of jobless workers dramatically increased in Colombia, going from an average of roughly 10 percent before 1992

to almost 20 per cent in 1998. As opposed to Colombia, Mexican unemployment only slightly increased along this period, experiencing a single upward spike in 1995 during the Mexican "peso crisis", and reverting back afterwards. As for unemployment, Colombia experienced a significant surge in the rate of informal employment, an increase in formal job turnover and a rise in income inequality, measured by the Gini coefficient, after 1992 (see panel E in Figure 6).[31] In contrast, inequality did not increase in Mexico (it slightly decreased after 2000) and informal employment mirrored the evolution of the unemployment rate.[32]

The labor market institutions in place at the time of trade liberalization were very different between Colombia and Mexico. Table 4 reports the values of firing costs, minimum wage and unemployment insurance observed in both countries before and after the year of reform. On the one hand, Colombia massively cut dismissal costs at the beginning of the 90s, while Mexico kept a rigid labor market. At the time of trade reform, Colombian employers were required to deposit a contribution equal to 8 percent of the yearly real annual wage (corresponding to roughly one month) into a savings fund, eventually accessible to workers in the event of separation, whereas in Mexico the severance payment legislation, defined under Labor Law Article 165, prescribed an obligation of 90 days (roughly three months) of minimum daily salary for each year of service.[33] Moreover, the advance notice for termination of indefinite contracts in Colombia was set to 15 days a year whereas in Mexico it was kept to one month (Heckman and Pages, 2000), and the compensation for dismissal due to economic reasons for one-year tenure workers was reduced to 45 days, one third than what observed in Mexico.[34] On the other hand, the minimum wage legislation in Colombia was much stricter than Mexico. At the beginnings of the 1990s, the average statutory minimum wage in Colombia amounted to roughly 50 percent of the average market wage, versus 34 percent in Mexico.[35] For the same period, Bell (1997) reports values for the minimum wage of white and blue collar workers in Mexican manufacturing sector, amounting, respectively, to 22 and 42 percent of their average wage in 1984. The same figures reported for Colombia amount to 39 percent for high-skill workers, 52 percent for low-skill workers, and 73 percent for apprentice workers in 1987.[36] Notice that, in both countries,

[31] Informality rate refers to the share of wage and salary workers without social security benefits plus the share of workers in firms with less than five employees.

[32] This evidence on inequality is reinforced when I compare the income share held by the households at the lowest 10 per cent of the income distribution over the shares held by the richest 10 per cent across countries. See Table 4.

[33] Source: Kugler (1999) for Colombia and Grandolini and Cerda (1998) - based on information provided by the Instituto Mexicano de Seguridad Social (IMSS)- for Mexico.

[34] Source: Kambourov (2009) and IADB Report (1997) based on information from Ministries of Labour.

[35] Source: ILO-stat. When the figures are missing, I construct them converting the annual nominal minimum wage reported by the ILO-stat into real minimum wage (at 2005 constant prices) using the PPP conversion factor, and then dividing them by the average real wage observed in the same year.

[36] Bell (1997) documents a divergent trend in the real value of the legally imposed minimum wage in Mexico and Colombia in the 1980s, leading by 1990 to a level equal to just 13% of the average unskilled manufacturing wage in Mexico and roughly 53% of the average unskilled wage in Colombia. As explained in Maloney and Mendez (2004), the difference between these two patterns can be partly explained by the wage indexation to past inflation (*salario minimo movil*), imposed by the Constitution in Colombia and not present in Mexico.

Table 5: **Calibration**

Panel A: External Parameters

Description	Symbol	COLOMBIA Value	MEXICO Value	Source
Discount rate (%)	r	10.63	6.46	IFS (2017) / Riaño (2011)
Service share (%)	$1-\gamma$	52.4	49.9	ECLAC-CEPAL
Service wage (2012 USD)	w_s	3165.67	5680.13	author's calculation
Elasticity varieties	σ	6.43		Baier and Bergstrand (2001)
Matching elasticity	θ	1.84		Fajgelbaum (2016)
Bargaining power	β	0.5		standard
Intermediate elasticity	$1-\alpha$	0.657	0.751	material expenditure share
Exporter revenue premium	d_f	1.135	1.271	export-sales ratio

Panel B: Policy Parameters

Description	Symbol	COLOMBIA Value	MEXICO Value	Source
Tariffs	τ_a-1	0.21	0.23	Goldberg and Pavcnik (2004) / Dornbush and Werner (1994)
Iceberg costs	τ_c-1	1.52		Anderson and van Wincoop (2001)
Payroll taxes	τ_w	0.16	0.18	Ayala (2013) / Kumler et al. (2015)
Firing costs/mean wage	$c_f/\overline{w}$	0.50	0.27	FRdB-IMF
Minimum/mean wage	$\underline{w}/\overline{w}$	0.54	0.33	FRdB-IMF / Bell (1997)
Unemployment benefit	b^u	0		FRdB-IMF

Note: This table reports the list of parameters either directly calibrated into the model or taken from the literature.

at the time of trade openings no unemployment insurance system was in place (FRdB-IMF, 2018).

5 Bringing the model to the data

Assuming that both economies were in steady state before the trade reform, I fit the model respectively to the periods 1981-1990 for Colombia and 1984-1986 for Mexico, as to replicate the pre-liberalization behavior of these two economies. The model is set to fit the distribution of formal employment in the autarckic steady-state, together with the size distribution of plants, export dynamics and plant turnover.

5.1 Parametrization

A number of parameters are taken from outside the model. Panel A in Table 5 describes them and their source. I fix a time period in the model equal to one year and population is normalized to one. I set the discount rate, r, to be consistent with an observed average real borrowing rates of 6.46% in Mexico, as in Riaño (2009), and 10.63% in Colombia (IFS, 2017). I use information from the ECLAC-CEPAL database to compute the average share of service sector value added out of GDP during the sample periods, and I set $1-\gamma$ equal to 0.499 for Mexico and 0.524 for Colombia. The elasticity of substitution between varieties, σ, is taken

from Baier and Bergstrand (2001), who estimate a value equal to 6.43. Following Fajgelbaum (2016), I fix the parameter governing the elasticity of matching function, θ, equal to 1.84, and I set the worker bargaining power, β equal to one half in both countries. As a numeraire of these economies, I calculate the average annual service sector wage (or equivalently, the price of the service good), to be equal to $w_s = \$3165.67$ in 2012 US dollars for Colombia and to $w_s = \$5680.13$ in 2012 US dollars for Mexico during the reference period.[37]

The remaining parameters matching moment from the data are the revenue elasticity of material, $1-\alpha$, and the exporter revenue premium, $d_{f,t}$, which is treated as exogenous in the estimation algorithm, and assumed to fixed in the autarkic steady state. To calibrate α and $d_{f,t}$, I match the average share of total material expenditure out of total sales, which in the model is equal to

$$(1-\alpha)\frac{\sigma-1}{\sigma}$$

and the average share of output exported abroad out of total output, which in the model is equal to

$$1-\frac{1}{(1+d_f)^{\sigma}}$$

Using the calibrated values of σ, I find values for α equal to 0.343 in Colombia and to 0.241 in Mexico and values for d_f equal to 0.134 in Colombia and to 0.212 in Mexico.[38] Finally, I choose the *policy* parameters, i.e. the tariffs on imports, τ_a, the firing costs, c_f, the minimum wage, $\underline{w}$, and unemployment benefit, b^u, to be consistent with the values observed in both countries before the reforms (see panel B in Table 5). I take the payroll taxes for Colombia from Ayala (2013), who reports a value equal to 16% for the period 1980-1990, while for Mexico, I set the value equal to 18%, as documented by Kumler et al. (2015) for the same time period. Finally, I set the iceberg costs, τ_c to 1.52, as in Anderson and Van Wincoop (2001).

5.2 Estimation

This leaves a vector of 11 further *structural* parameters, $\vartheta = \{c_o, c_x, c_e, c_h, \lambda_1, \lambda_2, \rho_z, \sigma_z, \alpha_f, \delta, b\}$, plus the size of the domestic market, D_h, which is endogenously determined as an equilibrium outcome. These parameters are estimated using the method of simulated moments.[39] In the specific, let $\overline{m}(\vartheta)$ be a vector of $g \geq \dim[\vartheta]$ moment conditions, defined as

$$\overline{m}(\vartheta) = \overline{m} - m(\vartheta)$$

[37] See the Appendix for details on the source and the construction of the external parameters.

[38] These values are obtained using the Colombian Annual Manufacturer Survey for the period 1981-1990, and from the Mexican Annual Industrial Survey for the period 1984-1986. See the section on estimation for a description of the data.

[39] See, for instance, McFadden (1989), Pakes and Pollard (1989) and Gourieroux and Monfort (1996)

where $\overline{m}$ is a vector of sample statistics while $m(\vartheta)$ is a vector of simulation-based statistics. The estimator, $\hat{\vartheta}$ can be defined as the argument that minimize the following objective function,

$$\hat{\vartheta} = arg \min_{\vartheta \in \Theta} \quad \overline{m}(\vartheta)' \hat{\Sigma} \overline{m}(\vartheta) \tag{52}$$

where $\hat{\Sigma}$ is a $g \times g$ symmetric positive definite matrix. To implement this estimation, for a given guess of the parameter vector, ϑ_0, I solve the dynamic programming problem in the pre-reform stationary equilibrium, and I find the relevant policy functions for firms and workers. I use these policy functions to simulate the behavior of large pool of plants and workers over a large number of periods, I discard the first T periods to mitigate the effect of the initial conditions, and use the remaining observations to compute the same moments, $m(\vartheta_0)$, as those constructed from the data. I then search over the parameter space, Θ, and update the initial guess until the vector of moments generated by simulating the model is close enough to the vector of statistics obtained from the data. In the estimation algorithm, I choose $\hat{\Sigma}$ to be a bootstrapped estimate for the inverse of the variance-covariance matrix of the moment conditions, $[var(\overline{m})]^{-1}$. In order to deal with non-smoothness of the objective function and avoid local minima, I use a genetic algorithm to search over the parametric space and solve the optimization problem in equation (52).[40]

To construct the relevant moment conditions, I use information on Colombian manufacturing plants collected in the Annual Manufacturer Survey (*Encuesta Anual Manifacturera* - EAM) and provided by the Colombian National Statistics Department (DANE) while, for Mexico, I rely on the Annual Industrial Survey (*Encuesta Industrial Anual*, EIA) produced by the National Institute of Statistics, Geography and Information (INEGI), which contains information on Mexican manufacturing firms.[41] [42] Both data have annual frequency, and provide with standard information on revenues, number of formally registered employees and their remuneration, export decision, material and other inputs usage, for a number of consecutive periods.

5.2.1 Moment Selection and Identification

Table 6 reports the list of aggregate moments constructed from the data and used in the estimation algorithm. For both countries, I employ 20 moments, divided in three main groups. The first set of moments consists of means, variances and first-order auto-covariances for the log of employment, $\ln[l]$ and the log of gross revenues $\ln[g]$ (expressed, in both countries, in

[40] Genetic algorithm is global stochastic search method based on a natural selection process that mimics biological evolution. Is is usually employed to solve optimization problems in which the objective function is discontinuous, non-differentiable, stochastic, or highly nonlinear. See Malhotra et al. (2011)

[41] The Colombian Annual Manufacturer Survey has been used, among the others, by Roberts and Tybout (1996) and Cosar et al. (2016). After cleaning, the dataset covers 152,580 plant-year observations for employers with more than 10 employees over the sample period, 1981-1990.

[42] The Mexican Annual Industrial Survey appears, among the others, in Tybout and Westbrook (1995) and Riaño (2009). After cleaning, it covers 9,657 firm-year observations over the sample periods, 1984-1986.

Table 6: **Moment Selections**

	COLOMBIA		MEXICO	
Moments	**Data**	**Model**	**Data**	**Model**
Firm-level moments				
$\mathbf{E}[\ln l]$	3.619	3.720	3.303	3.243
$\text{var}[\ln l]$	1.134	1.426	1.497	1.366
$\text{cov}[\ln l, \ln l_{-1}]$	1.218	1.348	1.403	1.358
$\mathbf{E}[\ln g]$	5.430	4.746	4.559	4.405
$\text{var}[\ln g]$	1.674	1.713	1.746	1.880
$\text{cov}[\ln g, \ln g_{-1}]$	1.543	1.859	2.136	2.473
$\mathbf{E}[\mathbf{1}^x]$	11.89	10.87	21.56	22.16
Log-employment distribution				
20^{th} perctile	2.676	2.851	1.946	2.259
40^{th} perctile	3.178	3.343	2.944	2.831
60^{th} perctile	3.720	3.907	3.761	3.404
80^{th} perctile	4.450	4.563	4.625	4.027
Firm size distribution				
1-49 employees	70.81	69.55	82.66	82.18
50-99 employees	14.01	15.72	9.18	9.34
100-199 employees	7.90	9.26	4.55	5.47
200-499 employees	5.21	4.74	2.30	2.96
Aggregate moments				
Exit rate	12.04	13.27	11.01	13.06
Job turnover rate	16.54	13.80	16.08	15.76
Average wage	19.87	18.70	3.02	2.74
Labor share	45.01	45.26	34.10	36.88
Vacancy rate	2.27	2.34	1.51	1.40

Note: This table reports selected data-based and model-implied moment statistics used in the estimation.

terms of thousands of 1977 LCU) and the mean for the export decision, $\mathbf{1}^x$, an indicator taking value one anytime a plant reports positive exports, zero otherwise.[43] The second group of moments includes the quintiles of the log employment distribution and the firm distribution across selected size bins, while the last set of moments include aggregate statistics such as the firm exit rate, the job turnover rate, the average wage, the payment compensation share of

[43]For the case of the export indicator, the variance, $var[\mathbf{1}^x]$ is dropped from the list of moments because of redundancy, while the first-order auto-covariance, $cov[\mathbf{1}^x, \mathbf{1}^x_{-1}]$ is not included because information on exports in the Mexican dataset is not available during the first two years of the sample, hence it cannot be constructed.

revenues and the vacancy rate.[44]

In what follows, I discuss how these statistics will help identify the parameters in ϑ. Even though the model does not admit any closed-form map from a particular parameter to a specific moment, still each moment carries information about the underlying structural parameters. The average firm exit rate will discipline the magnitude of the fixed cost of operating a firm, c_o, as larger fixed costs will force a larger share of businesses to shut down, while the share of exporting firms will identify the costs of exporting, c_x, since lower fixed costs will induce a larger number firms to sell their product in the foreign markets.

As in Hopenhayn (1992), the cost of starting a business, c_e, will be such that the free entry condition is satisfied with a strictly positive mass of firms entering each period. Vacancy rate and job turnover rate will be informative of the overall cost of hiring, c_h, and the exogenous firm hazard rate, δ: lower hiring costs will shrink the optimal inaction region for employment, inducing firms to post more vacancy on average, while larger hazard rate will increase the measure of job destroyed and, because of stationarity, reallocated to new employers. The moments describing the distribution of log employment will discipline the revenue elasticity of formal employment, α_f, the persistency and volatility of firm productivity, ρ_z and σ_z, whereas the firm-size distribution will identify the parameters governing the convexity of the adjustment costs, λ_1 and the relative stability of large versus small firms, λ_2. Finally, the average log revenues, the average wage and the labor compensation share will pin down the size of the domestic aggregate expenditure, D_h and the workers outside option b, since each of these parameters determine the magnitude of rents accruing to firms and workers, through the definition of firm and worker surplus and solution of the bargaining problem.

5.2.2 Point estimates and model fit

Table 7 reports the point-wise estimates for ϑ, together with the standard errors, constructed using the formula for the asymptotic variance-covariance matrix,

$$\text{var-cov}(\vartheta) = (D'\hat{\Sigma}D)^{-1}(D'\hat{\Sigma})\hat{\Omega}(\hat{\Sigma}D)(D'\hat{\Sigma}D)^{-1} \tag{53}$$

where $\hat{\Sigma}$ is the weighting matrix used in the estimation, D is the Jacobian matrix for the vector of moment conditions, with dimension $\dim[\vartheta] \times g$, and generic entry in position (i, j) equal to $D_{ij} = \partial\overline{m}_i(\vartheta)/\partial\vartheta_j$, whereas $\hat{\Omega}$ is a bootstrapped estimate for variance-covariance matrix of the moment conditions, $\Omega = \mathbf{E}[\overline{m}(\vartheta)\overline{m}(\vartheta)']$, with dimension $g \times g$.

The model is able to replicate the Colombian and the Mexican plant-level data fairly well, with an average absolute deviation between data-based and model-based moments equal, re-

[44] While I observe entry and exit of plants for Colombia, the same does not happen for Mexico. To circumvent this problem, I follow Riaño (2009) and I use information from the "Job Flows in Latin America" dataset, a database constructed by the Inter-American Development Bank using administrative records collected by the Mexican Social Security Institute (Institudo Mexicano del Seguro Social, IMSS). From this dataset, I obtain the average firm exit rate and the job turnover rate used in the estimation.

Table 7: **Estimates from Method of Simulated Moments**

		COLOMBIA	MEXICO
Description	**Symbol**	**Value**	**Value**
Fixed cost of operating	c_o	**7.812**	**7.717**
		[0.058]	[0.413]
Fixed cost of exporting	c_x	**101.20**	**64.36**
		[0.744]	[4.184]
Cost of entry ($= V^e$)	c_e	**33.06**	**44.18**
		[0.409]	[3.215]
Constant, hiring costs	c_h	**0.293**	**0.423**
		[0.009]	[0.008]
Convexity, hiring costs	λ_1	**3.513**	**2.720**
		[0.045]	[0.066]
Scale effect, hiring costs	λ_2	**0.215**	**0.124**
		[0.003]	[0.012]
Productivity persistency	ρ_z	**0.965**	**0.957**
		[0.000]	[0.002]
Innovation volatility	σ_z	**0.144**	**0.143**
		[0.000]	[0.001]
Elasticity, formal employment	α_f	**0.763**	**0.788**
		[0.000]	[0.000]
Exogenous firm exit	δ	**0.025**	**0.013**
		[0.000]	[0.002]
Home production	b	**0.523**	**0.475**
		[0.004]	[0.013]
Objective Function, deviation		**0.095**	**0.093**

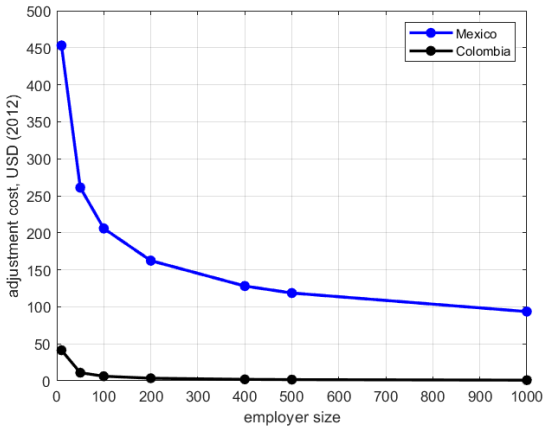
Note: This table reports the estimates for the structural parameters estimates using MSM, $\vartheta = \{c_o, c_x, c_e, c_h, \lambda_1, \lambda_2, \rho_z, \sigma_z, \alpha_f, \delta, b\}$, together with the respective standard errors (in parenthesis).

spectively, to 9.5 and 9.3 percent. Moreover, since the sample moments are constructed using a large sample of plants, their sample variability is limited and the parameters are estimated with fine accuracy: the standard error are in general two order of magnitudes smaller than the point estimates, making each parameters statistically different than zero. On the other hand, larger sample variability in the Mexican survey due to the smaller number of firm-year observations in the dataset reflects into a sensibly larger estimation uncertainty compared to the Colombia estimates.

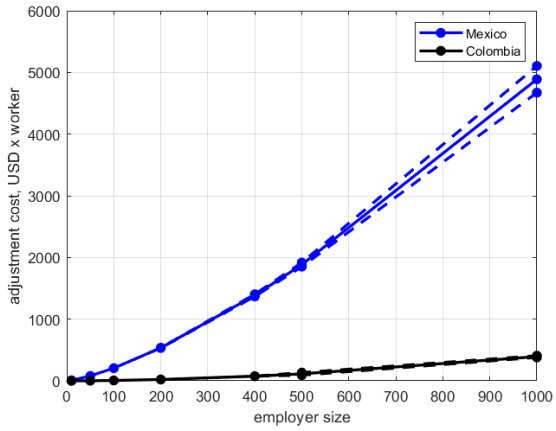
The model is able to match the firm size distribution and the log-employment distribution in each countries, and it correctly captures the share of exporters, the average wage, the labor share and the vacancy rate. However, it underestimates the magnitude of firm revenues for Colombia and it predicts slightly larger employer exit rates in both countries. Expressed in 2012 price level, the estimation predicts a per-period annual fixed cost of operating equal to

Figure 7: **Hiring costs profile, by firm size**

(a) single worker



(b) one percent of workforce, per worker



Note: This figure reports the hiring cost profile for a single formal worker (panel a) and for a one percent increase of the total formal workforce (panel b) as a function of current number of formal employees. Standard errors are constructed using the delta method.

7.812 x 3, 165.67 USD= 24, 730.21 USD in Colombia and to 7.714 x 5, 680.13 USD = 43, 816.52 USD in Mexico; a per-period fixed cost of exporting equal to 101.20 x 3, 165.67 USD=320, 365.80 USD in Colombia and to 64.36 x 5, 680.13 USD =365, 573.17 USD in Mexico; and a sunk cost of setting up a business equal to 33.06 x 3, 165.67 USD = 104, 657.05 USD in Colombia and to 44.18 x 5, 680.13 USD = 250, 948.14 USD in Mexico. The estimation also predicts a value of home production, b, around half of the income per capita in both countries. Unemployed workers in Colombia in fact are able to ensure around 52 percent of the average wage in the service sector, corresponding to 1.655.65 USD, whereas the return from home production in Mexico accounts for 48 percent of the average service wage, amounting to 2.698, 06 USD. Expressed in income per-capita term, these values are equivalent to 49 and 42 percent, respectively. On the other hand, relative to the minimum wage in place, home production is roughly 15 percent larger in Mexico, whereas it is 31 percent lower in Colombia.

The estimates for the parameters of the vacancy cost functions imply a significantly larger and but less convex hiring costs in Mexico than Colombia. Panel A of Figure 7 displays the estimates for the cost of hiring a single worker as a function of the current workforce of the plant. While for a firm of ten employees this cost is estimated to be 450 USD higher in Mexico than Colombia, for very large enterprises the difference drops to 50 USD. In panel B, I report the per-worker cost faced by a plant expanding its workforce by one percent, as a function of the original workforce. The cost profile is much larger in Mexico, where it amounts to 5000 USD per worker in a firm with a thousand formal employees, compared to Mexico, where the same figure is less than 1000 USD. Since the estimates for the mean reversion and volatility of the productivity process, ρ_z and σ_z, are not statistically different between the two countries,

Table 8: **Aggregate Implications**

	COLOMBIA		MEXICO	
	Model	**Data**	**Model**	**Data**
Relative market size to ROW	0.006	0.009	0.022	0.019
Employment share, manufacturing	0.381	0.355	0.283	0.260
Unemployment rate	0.075	0.098	0.043	0.049
Informality share	0.177	0.463	0.289	0.504

Note: The manufacturing share of employment is taken from Attanasio et al (2005) for Colombia (source: National Household Survey - Encuesta Nacional de Hogares, ENH) and from Fairris and Levine (2004) for Mexico (source: National Survey of Household Income and Expenditure - Encuesta Nacional de Ingresos y Gastos de los Hogares, ENIGH)

the differences in the adjustment cost will play a dominant role in shaping the employment dynamics in response to a productivity innovation. Finally, the estimation suggests that a share between 85 (Colombia) and 90 (Mexico) percent of the model-implied exit rate can be attributed to adverse productivity shocks, while the remaining due to factors exogenous to the model and captured by the estimates of δ.

5.3 Additional statistics

In this section I discuss a number of additional aggregate implications and cross-sectional facts the model is able to generate without being part of the targets in the estimation. Because of firms heterogeneity and search and matching frictions in the labor market, the model can reproduce wage dispersion observed in the data, where differences in wage payments across employers are linked to differences in size, idiosyncratic productivity and export status. Because of the convexity in the employment adjustment costs, the model is able to replicate the patterns of job growth that declines over employer size and the greater stability observed in larger firms. Moreover, the model generates enough vacancy posting to correctly reproduce the observed manufacturing share of employment and enough job turnover to induce a rate of equilibrium unemployment which is aligned with the data.

Aggregate implications

Table 8 reports a series of aggregate statistics. The model slightly overestimate the share of employment in the manufacturing while it is able to reproduce the difference in the unemployment rate observed between Colombia and Mexico. On the other hand, the model under-estimate the share of workers informally employed. This is not surprising, since the model abstract from informality in the service sector. However, a back of the envelope calculation implies that an informality rate of 69 percent in the Colombian service sector and of 62 percent in the Mexican service sector would reconcile the simulated industrial informality rate with pre-reform

Table 9: **Exporters shares and wage premia**

	COLOMBIA		MEXICO	
	Model	**Data**	**Model**	**Data**
Exporters shares				
Revenue share of exporters	0.634	0.521	0.834	0.860
Employment share of exporters	0.441	0.360	0.699	0.631
Exporters wage-premium: $\ln w_{it} = \beta_1 \mathbf{1}^x_{it} + \epsilon_{it}$				
β_1	0.646	0.416	0.499	0.314
	[0.002]***	[0.005]***	[0.001]***	[0.023]***
R^2	0.270	0.088	0.502	0.025
Size-wage relationship: $\ln w_{it} = \beta_1 \log l_{it} + \epsilon_{it}$				
β_1	0.051	0.215	0.088	0.114
	[0.001]***	[0.001]***	[0.000]***	[0.000]***
R^2	0.034	0.283	0.213	0.090

*Note: For Colombia, both regressions are run using 152,580 observations. For Mexico using 9,657 observations. Standard errors are bootstrapped over 3000 repetitions with replacement. *** p<0.01, ** p<0.05, * p<0.1*

conditions. Finally, the model generates predictions for the size of the aggregate domestic expenditure in tradable goods relative to the demand from the rest of the world, $\frac{D_h}{k^\sigma D_f}$. A plausible empirical counterpart to this measure is the average real GDP in Colombia relative to the sum of its trade partners′s GDP during the pre-reform period.[45] I find a value of 0.009 for Colombia and 0.019 for Mexico, remarkably close to the model prediction.

Role of Exporters

In the data, a large share of aggregate firm revenues and aggregate employment in the manufacturing sector is concentrated on exporting firms. Exporting firms account for one third (Colombia) and two third (Mexico) of the total aggregate employment in manufacturing, and one half (Colombia) and four fifth (Mexico) of the economy-wise employers revenues. Table 9 reports the aggregate employment share and the aggregate revenue share for exporters obtained using simulated data, and compare them to the observed values. The model is able to reproduce and match the degree of concentration in both countries.

Cross-sectional implication for wages

Export-Wage premium. Exporters pay higher wages. Bernard et al. (1995) estimate a value for the unconditional export wage premium roughly equal to 20 percent, and values between

[45] To compute this ratio we use data from the WBI tables of the World Bank.

Table 10: **Wage Dispersion**

	COLOMBIA		MEXICO	
	Model	**Data**	**Model**	**Data**
Firms				
St.Dev. log wage	0.369	0.461	0.484	0.456
Max-Mean log wage	2.755	8.261	2.167	5.457
Workers				
St.Dev. log wage	0.624	0.800	0.652	0.930

Note: The standard deviation of worker-level log wage is taken from Attanasio, Goldberg, and Pavcnik (2004) for Colombia (Source: Colombian National Household Survey - DANE) and from Cortez (2001) for Mexico (Source: Mexican Household Income and Expenditure Survey - INEGI)

7 percent and 11 percent after controlling for plant specific characteristics.[46] To shed light on the relationship between firm-level wages and export status, I run the following firm-level regression,

$$\ln w_{it} = \beta_1 \mathbf{1}_{it}^x + \epsilon_{it}$$

where β_1 denotes the wage premium paid by exporting firms. I estimate this equation using simulated data and I compare the estimates with the actual data. Table 9 reports the results. The model generates a wage premia for exporting firms of the same order of those observed in the data, though the magnitude is slightly over-predicted. The tendency to overstate exporter premia reflects the fact that in this model the only source of heterogeneity comes from idiosyncratic productivity and size, making all firms above a certain productivity threshold be exporters.

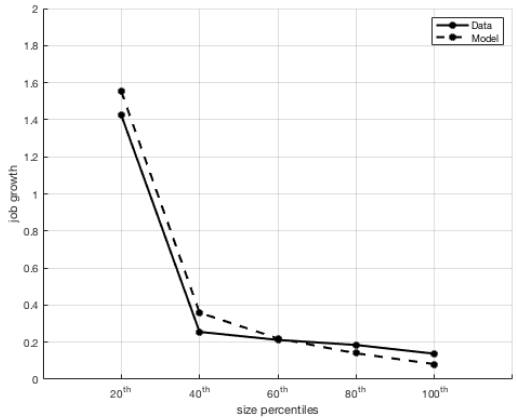
Employer Size-Wage Effect. Brown and Medoff (1989) noted that workers employed in larger firms are often paid higher wages. Inspection of the wage equation (43) for hiring firms reveals there are two forces at play: on the one hand, the diminishing marginal product of labor in the model predicts a negative correlation between wages and employer size; on the other hand, larger employers will be those with higher idiosyncratic productivity z, and those participating in the foreign market, hence earning a revenue premium. The implications of the model for the employer size-wage effect depend on which of these forces dominates. To test if the model can also replicate the positive employer size-wage effect, I follow Schaal (2012) and I estimate the following firm-level regression,

$$\ln w_{it} = \beta_1 \ln l_{it} + \epsilon_{it}$$

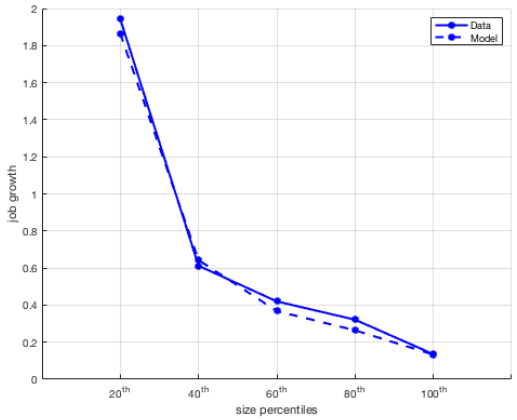
[46] These values refers to a cross-section of US manufacturing plants for the period 1967-1986.

Figure 8: **Job growth by firm size**

(a) COLOMBIA



(b) MEXICO



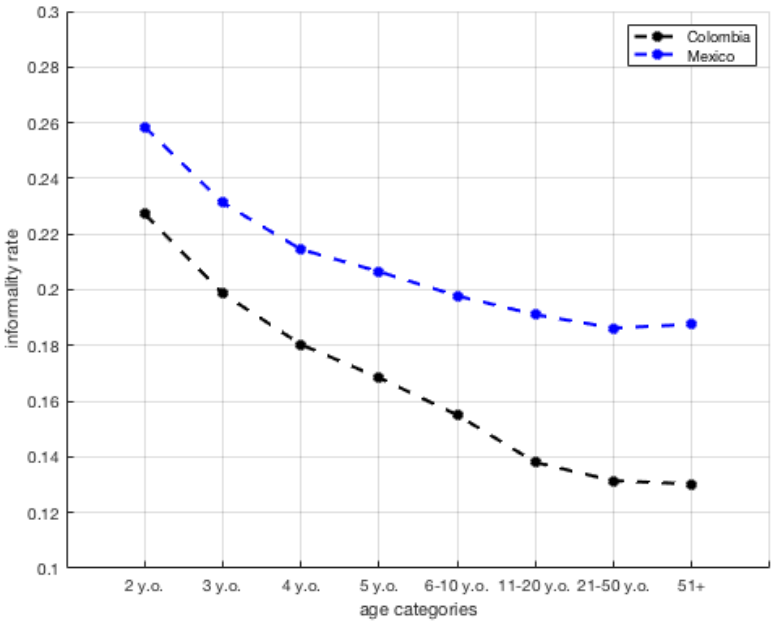
where β_1 denotes the wage elasticity of employer size. Notice that two major forces will be at play: on the one hand, decreasing marginal return from labor will induce a declining wage as the employer size increases. On the other hand, larger employers will be those with higher idiosyncratic productivity and a better likelihood of being exporters. The implication of the model for the wage-size relation depends on which force dominates the other. Table 9 reports the OLS estimates for the wage elasticity of size. The model generates a positive and significant wage elasticity of employer size, of magnitudes ranging between 5.1 percent for Colombia and 8.8 percent for Mexico, and in line with what we observe in the data.

Wage Dispersion. To analyze the degree of wage dispersion that the model can generate, I consider the cross-plant standard deviation of log average wages, the max-mean firm-level wage ratio, and the standard deviation of worker-level log wages. A simulated version of model predicts a standard deviation of firm-level log wages equal to 0.369 for Colombia against the observed 0.461, and equal to 0.484 for Mexico against the observed 0.456. Overall, the model is able to match the observed standard deviation of firm-level wage in Colombia (Mexico), and can account for slightly more than one third of the mean-max wage ratio in both countries. On the other hand, the model under-predicts the unconditional dispersion of worker-level log wages, consistent with other search models that do not incorporate on-the-job search (Hornstein et al., 2011), or with firm-level models that abstracts from workers heterogeneity, which typically accounts for around a third of the empirical wage dispersion (Mortensen, 2005).

Cross-sectional implication for employment

Formal employment growth distribution. The model speaks also about firm stability over size and differential job growth. In Figure 8, I report the actual and the simulated rates of job

Figure 9: **Informality by firm age**

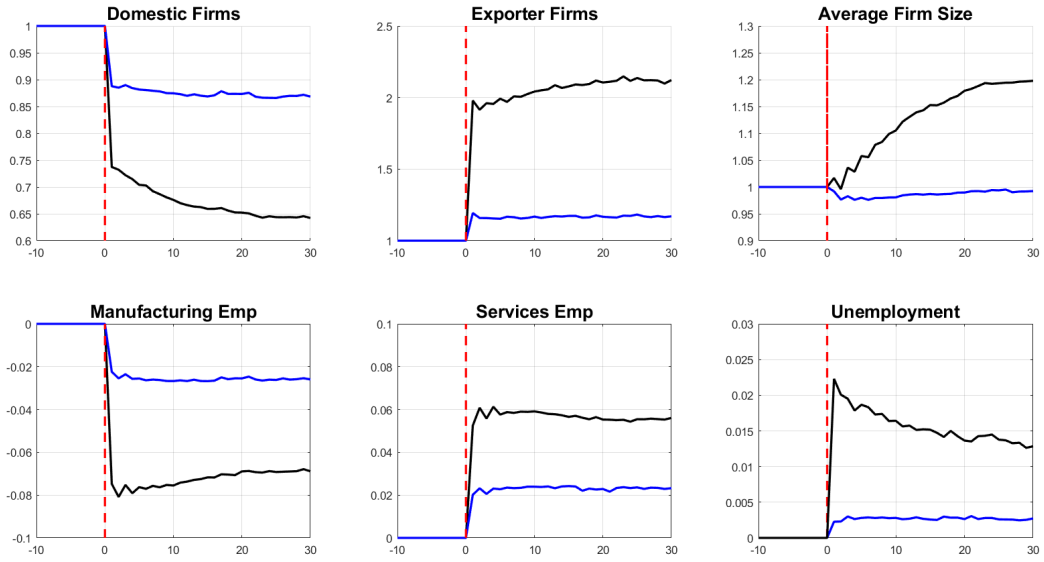


growth ranked by size quintiles, for both Colombia and Mexico.[47] The model also does a remarkable job of reproducing the decline of job growth rates across employer size quintiles, and matches remarkably well the magnitudes observed in both countries. The convexity of the adjustment costs, λ_1, implies that those firms that would like to adjust employment by a greater amount (i.e. large firms) find it increasingly costly to post vacancies. Thus, the pace at which they hire slows down and job growth is reduced. This effect is in turn reinforced by a positive scale effect, λ_2, which makes the cost of expanding the workforce increasing in firm size.

Informality rate. Empirically, the average within-firm informality rate declines with firm age. Ulyssea (2016) uses administrative data on the universe of Brazilian formal firms and workers collected by the Ministry of Labor to report evidence on firms′ informality rate, and he documents an average decline of informality along the intensive margin of 10% in first ten years of cohort′s age, going from 48 to 38 percent. The model is able to replicate this finding. Figure 9 reports the average within-firm share of informal employment for different age categories. In both countries, this rate drops as firms age old: on average within-firm informality declines by around 6 percent in the first ten years of age.

[47]The growth rate is constructed using only the sample of expanding firms. This is the case because, in the model, the linearity of the firing costs makes only the upward adjustment of employment be function of the current employer size.

Figure 10: **Transitional dynamics**



Note: This figure displays the transitional dynamics following a trade liberalization in Colombia (black line) and Mexico (blue line).

6 Trade reforms

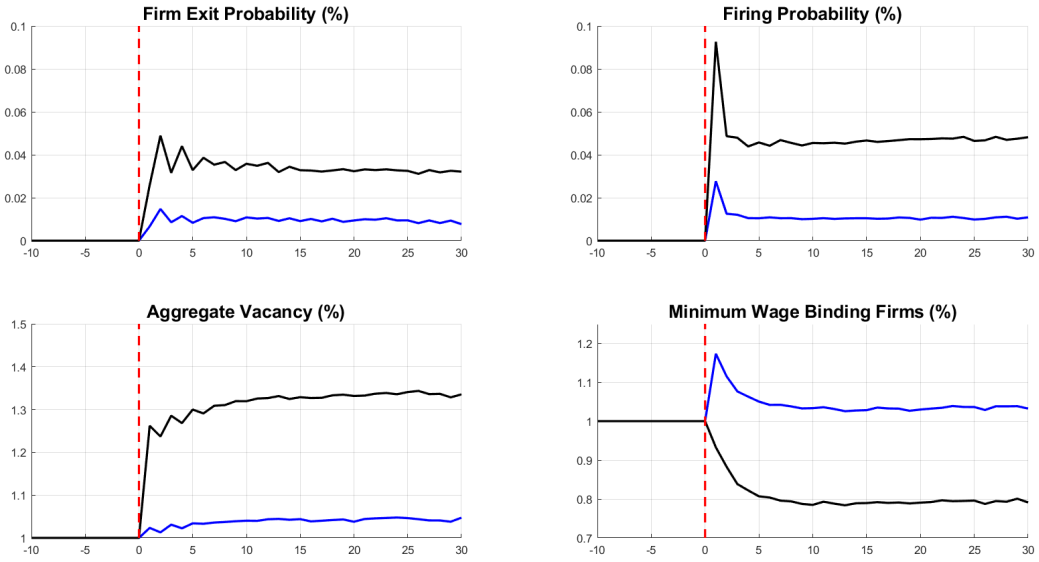
In this section I use the model to explore the quantitative implications of a trade liberalization. The goal of this exercise is to determine (1) the ability of the model to replicate the dynamics response of unemployment, sectoral employment and job volatility to a drop in trade costs, and (2) the ability of the model to capture the differences in aggregate dynamics between Colombia and Mexico.

Starting from an autarkic stationary equilibrium, I shock the economy with a once-and-for-all reduction of trade barriers, causing a proportional increase in the value of foreign absorption. The magnitude of the drop in tariffs is chosen so to mimic the the reduction observed after the trade liberalization, while the drop in iceberg costs is modeled to match the increase in the aggregate revenue share of exports (Table 4). Therefore, I track unemployment rate and other aggregates along the transition to the new steady state. Along the transition path, I keep the interest rate fixed at the autarkic level, $r_t = r_0, \forall t \geq 1$.[48]

Figure 10 reports the transitional dynamics for the measure of domestic firms in the tradable sector, the measure of exporters, the average firm size (reported in terms of formal employees), the employment shares across sectors and the unemployment rate, after an unexpected and

[48]This assumption bears implications for the dynamics of firms and workers. Having the same interest rate along the transition path implies a constant value of searching for a formal job in the tradable sector in each period after the shock. As long as trade openness triggers an increase in the value of formal employment in the manufacturing sector, the equilibrium no-arbitrage condition requires a drop (rise) in the job finding (filling) rate, with implications for the firm vacancy posting decisions of firms and the unemployment rate.

Figure 11: **Firm adjustments**



Note: This figure displays the margins of adjustments along the transition path following a trade liberalization in Colombia (black line) and Mexico (blue line).

permanent fall in trade costs in Colombia (black line) and Mexico (blue line).

First, a fall in trade costs reduces the number of domestic firms and the impact response undershoots the long-run values. The share of exporters increases in impact in both countries, and expand further along the transition in Colombia. Second, employment is driven out of the tradable sector, which shrinks on impact in both countries. This drop overshoot the long-run value in Colombia, where exporters slowly expand along the transition. As a consequence, the average size of a tradable firm grow by twenty percent the pre-reform value. Finally, the model-based dynamics of the unemployment rate closely resembles the observed dynamics in Colombia and Mexico. The model predicts that unemployment rate increases by more than two percentage points in Colombia, whereas it marginally responds in Mexico.

To explore the mechanisms behind the impulse response and the role played by the labor market institutions, Figure 11 reports the evolution in the firing probabilities, due to either firm closing or individual dismissal, the average measure of vacancy posted in the economy and the share of firms paying the minimum wage along the transition towards the new steady state.

First, a fall in trade costs triggers large employment adjustment. Firing probability and firm exit rate rise on impact in both countries, and stays high in the long run. Second, low employment protection and high minimum wage amplify this margin of adjustments in Colombia, where the workers probability of being fired rise on impact four times more as in Mexico. At the same time, vacancy posting grows substantially more in Colombia, because of lower hiring costs and greater firm selection. Third, higher employment protection and lower minimum wage

Table 11: **Role of minimum wage**

	COLOMBIA				MEXICO			
	$\underline{w} = 0.54$ (baseline)	$\underline{w} = 0.33$ (counter)	diff	%	$\underline{w} = 0.33$ (baseline)	$\underline{w} = 0.54$ (counter)	diff	%
L_u	1.99	1.35	-0.64	-32.16	0.24	0.36	0.12	47.90
L_s	5.75	8.47	2.72	47.10	2.36	1.17	-1.19	-50.49
$L_f + L_i$	-7.74	-9.82	-2.08	-26.87	-2.61	-1.53	1.07	41.22

Note: This table reports the model-based average response to a trade shock of unemployment rate (L_u) under the observed (actual) and the counterfactual minimum wage policy.

Table 12: **Role of EPL**

	COLOMBIA				MEXICO			
	$c_f = 0.083$ (baseline)	$c_f = 0.50$ (counter)	diff	%	$c_f = 0.27$ (baseline)	$c_f = 0.083$ (counter)	diff	%
L_u	1.99	1.79	-0.20	-10.01	0.24	0.35	0.11	46.71
L_s	5.75	5.47	-0.28	-4.93	2.36	2.48	0.12	5.04
$L_f + L_i$	-7.74	-7.25	0.49	6.33	-2.61	-2.82	-0.22	-8.38

Note: This table reports the model-based average response to a trade shock of unemployment rate (L_u) under the observed (actual) and the counterfactual EPL.

Table 13: **Role of unemployment benefits**

	COLOMBIA				MEXICO			
	$b^u = 0$ (baseline)	$b^u = 0.1b$ (counter)	diff	%	$b^u = 0$ (baseline)	$b^u = 0.1b$ (counter)	diff	%
L_u	1.99	2.25	+0.25	13.07	0.24	0.38	0.14	58.33
L_s	5.75	4.85	-0.90	-15.65	2.36	2.21	-0.15	-6.36
$L_f + L_i$	-7.74	-7.10	0.64	8.27	-2.61	-2.59	0.02	0.77

Note: This table reports the model-based average response to a trade shock of unemployment rate (L_u) under the observed (actual) and the counterfactual unemployment benefits.

trigger large wage cuts instead of employment adjustments. The share of employers paying the minimum wage increases by fifteen percent in Mexico, whereas it drops in Colombia.

6.1 The role of labor market institutions

To isolate the contribution of each labor market institutions, I conduct the following experiment. For a chosen set of policies, I compute the new steady-state unemployment rate and the sectoral employment keeping the trade costs unchanged. Therefore, I shock the economy with trade liberalization, and I obtain the transitional dynamics for L_u, L_s, and $L_f + L_i$. The goal of the experiment is to determine to which extent the labor market institutions in place at the time of a trade liberalization affect the dynamics of unemployment afterward.

Tables 11, 12 and 13 report the the average response of unemployment rate and sectorial em-

Table 14: **Response of informal employment**

COLOMBIA	baseline	trade reform	trade reform + policies		
c_f (firing cost)	0.50	0.50	0.083	0.50	0.50
$\underline{w}$ (minimum wage)	0.54	0.54	0.54	0.33	0.54
b^u (unemployment benefit)	0	0	0	0	$0.1b$
Informality rate	0.179	0.201	0.199	0.154	0.201
%	-	+12.01	+10.89	-13.91	+12.35

MEXICO	baseline	trade reform	trade reform + policies		
c_f (firing cost)	0.27	0.27	0.083	0.27	0.27
$\underline{w}$ (minimum wage)	0.33	0.33	0.33	0.54	0.33
b^u (unemployment benefit)	0	0	0	0	$0.1b$
Informality rate	0.347	0.356	0.355	0.370	0.372
%	-	+2.42	+2.30	+6.51	+7.25

Note:

ployment along the transition from autarky to openness for different combinations of minimum wage, employment protection and unemployment benefits.

In both countries, the dynamics of unemployment is non-linear to the initial conditions: the average response is larger the lower the EPL and the higher minimum wage and benefits. Everything else fixed, the labor market institutions account between 10 and 32 percent of the average increase in unemployment rate after a trade reform in Colombia, and between 46 and 58 percent of the same figure in Mexico.

6.2 Informal employment

Finally, I explore the effects of a trade liberalization on the rate of informality in the industrial employment. Table 14 reports the model-implied informality rate, constructed as the share of informal workers in the industrial sector, after a trade reform, for different combination of labor market institutions. After a reduction in trade costs, manufacturing firms shifts their employment towards informal workers. However, the informality rate after reform increases by less under flexible labor market institutions, i.e. the lower EPL, the lower minimum wage and unemployment benefits.

7 Conclusion

In this paper I investigate the hypothesis that the institutional features of the local labor markets determine the response to a trade liberalization. In particular, I use a structural model to characterize the dynamics of unemployment at the eve of a trade reform implemented under

different labor market institutions. I calibrate the model to replicate the pre-liberalization firm dynamics in Colombia and Mexico, and I solve the for the full transition path after a trade reform. I show that the labor market institutions at the time of a trade shock determine the magnitude and the speed of how firms adjust employment in response to changes in product markets, causing higher unemployment rate the lower EPL and the higher minimum wage legislation and UI. The nature of adjustment to a trade shock bears significant implications for the magnitude of the gains from trade and how the gains are spread across the population. This analysis could be extended along several dimensions. In particular, introducing ex-ante workers heterogeneity would allow the model to speak about the effect of trade liberalization on the unemployment rate across different skill-groups of workers, and about the role of labor market institutions in sorting workers between formal and informal employment, and between tradable and non-tradable sectors. Moreover, the model could be expanded with more articulated service sector, to better characterize economy-wide patterns of unemployment. I leave this analysis for future research.

References

Acemoglu, D. and Hawkins, W. B. (2014). Search with multi-worker firms. *Theoretical Economics*, 9(3):583–628.

Alvarez, F. and Veracierto, M. (2000). Labor&market policies in an equilibrium search model, in nber macroeconomics annual. *Cambridge and London: MIT Press*, pages 265–304.

Amiti, M. and Cameron, L. (2012). Trade liberalization and the wage skill premium: Evidence from indonesia. *Journal of International Economics*, 87(2):277–287.

Anderson, J. E. and Van Wincoop, E. (2001). Borders, trade and welfare. Technical report, National Bureau of Economic Research.

Anderton, R., Jarvis, V., Szörfi, B., Périnet, M., Petroulas, P., Bonthuis, B., Beck Nelleman, P., Conefrey, T., Soosaar, O., Nicolitsas, D., et al. (2015). Comparisons and contrasts of the impact of the crisis on euro area labour markets.

Attanasio, O., Goldberg, P. K., and Pavcnik, N. (2004). Trade reforms and wage inequality in colombia. *Journal of Development Economics*, 74(2):331–366.

Ayala, S. A. (2013). Payroll taxes and labor demand in colombia. *Universitat Autonoma de Barcelona*, unpublished manuscript.

Baier, S. L. and Bergstrand, J. H. (2001). The growth of world trade: tariffs, transport costs, and income similarity. *Journal of International Economics*, 53(1):1–27.

Balat, J. F. and Porto, G. G. (2007). Globalization and complementary policies: Poverty impacts on rural zambia. In *Globalization and Poverty*, pages 373–416. University of Chicago Press.

Bell, L. A. (1997). The impact of minimum wages in mexico and colombia. *Journal of Labor Economics*, 15(3):102–135.

Bellon, M. (2016). Trade liberalization and inequality: a dynamic model with firm and worker heterogeneity. *Columbia University*, unpublished manuscript.

Bentolila, S. and Bertola, G. (1990). Firing costs and labour demand: How bad is eurosclerosis?. *The Review of Economic Studies*, 57(3):381–402.

Bernanrd, A., Eaton, J., Jensen, J. B., and Kortum, S. (2003). Plants and productivity in international trade. *American Economic Review*, 93(4):1268–1290.

Bernard, A. B., Jensen, J. B., and Lawrence, R. Z. (1995). Exporters, jobs, and wages in us manufacturing: 1976-1987. *Brookings papers on economic activity. Microeconomics*, 1995:67–119.

Bertola, G. and Caballero, R. J. (1994). Cross-sectional efficiency and labour hoarding in a matching model of unemployment. *Review of Economic Studies*, 61(3):435–456.

Bertola, G. and Garibaldi, P. (2001). Wages and the size of firms in dynamic matching models. *Review of Economic Dynamics*, 4(2):335–368.

Brown, C. and Medoff, J. (1989). The employer size-wage effect. *Journal of political Economy*, 97(5):1027–1059.

Burki, S. J. and Perry, G. E. (1997). *The long march: a reform agenda for Latin America and the Caribbean in the next decade*. The World Bank.

Cooper, R., Haltiwanger, J., and Willis, J. L. (2007). Search frictions: Matching aggregate and establishment observations. *Journal of Monetary Economics*, 54:56–78.

Cosar, K. (2013). Adjusting to trade liberalization: Reallocation and labor market policies. *University of Virginia*, unpublished manuscript.

Cosar, K., Guner, N., and Tybout, J. (2016). Firm dynamics, job turnover, and wage distributions in an open economy. *American Economic Review*, 106(3):625–663.

Currie, J. and Harrison, A. (1997). Sharing the costs: the impact of trade reform on capital and labor in morocco. *Journal of Labor Economics*, 15(S3):S44–S71.

den Haan, Wouter J., G. R. and Watson, J. (2000). Job destruction and the propagation of shocks. *American Economic Review*, 90(3):482–498.

di Mauro, F. and Ronchi, M. (2016). 5 centralisation of wage bargaining and firms' adjustment to the great recession: a micro-based analysis. *Measuring competitiveness in Europe: resource allocation, granularity and trade*, page 74.

Dix-Carneiro, R. (2014). Trade liberalization and labor market dynamics. *Econometrica*, 82(3):825–885.

Dix-Carneiro, R. and Kovak, B. K. (2017). Margins of labor market adjustment to trade. Technical report, National Bureau of Economic Research.

Dornbusch, R. and Werner, A. (1994). Mexico: Stabilization, reform and no growth. *Brooking Papers on Economic Activity*, 1.

Elsby, M. W. L. and Michaels, R. (2013). Marginal jobs, heterogeneous firms, and unemployment flows. *American Economic Journal: Macroeconomics*, 5(1):1–48.

Fajgelbaum, P. (2016). Labor market frictions, firm growth, and international trade. *NBER Working Paper*, 19492.

Felbermayr, G., Impullitti, G., and Prat, J. (2016). Firm dynamics and residual inequality in open economies. *IZA Discussion Paper*, 7960.

Felbermayr, G. and Prat, J. (2011). Product market regulation, firm selection and unemployment. *Journal of the European Economic Association*, 9:278–317.

Felbermayr, G., Prat, J., and Schmerer, H.-J. (2011). Globalization and labor market outcomes: Wage bargaining, search frictions, and firm heterogeneity. *Journal of Economic Theory*, 146(1):39–73.

Forteza, A. and Rama, M. (2006). Labor market 'rigidity'and the success of economic reforms across more than 100 countries. *The Journal of Policy Reform*, 9(1):75–105.

FRdB-IMF (2018). Labour institutions database (1980-2005). available at http://www.frdb.org.

Freeman, R. B. (2007). Labor market institutions around the world. Technical report, National Bureau of Economic Research.

Freeman, R. B. (2010). Labor regulations, unions, and social protection in developing countries: market distortions or efficient institutions? In *Handbook of development economics*, volume 5, pages 4657–4702. Elsevier.

Goldberg, P. K. and Pavcnik, N. (2004). Trade reforms and wage inequality in colombia. *Journal of Development Economics*, 74(2):331–366.

Gourieroux and Monfort (1996). Simulation-based econometric methods. *Oxford, UK: Oxford University Press*.

Grandolini, G. and Cerda, L. (1998). The 1997 mexican pension reform: genesis and design features. *Financial Markets and Pension Reform Project, Policy Research Working Paper*, 1733.

Hagedorn, M. and Manovskii, I. (2008). The cyclical behavior of equilibrium unemployment and vacancies revisited. *American Economic Review*, 98(4):1692–1706.

Haltiwanger, J., Kugler, A., Kugler, M., Micco, A., and Pages, C. (2004). Effects of tariffs and real exchange rates on job reallocation: Evidence from latin america. *Journal of Policy Reform*, 7(4):191–208.

Harris, J. R. and Todaro, M. P. (1970). Migration, unemployment, and development: A two-sector analysis. *American Economic Review*, 60(1):126–142.

Harrison, A. and Hanson, G. (1999). Who gains from trade reform? some remaining puzzles1. *Journal of development Economics*, 59(1):125–154.

Hasan, R., Mitra, D., Ranjan, P., and Ahsan, R. N. (2012). Trade liberalization and unemployment: Theory and evidence from india. *Journal of Development Economics*, 97(2):269–280.

Heckman, J. and Pages, C. (2000). The cost of job security regulation: Evidence from latin american labor markets. *NBER working paper*, 7773.

Heckman, J. and Pages, C. (2004). Law and employment: Lessons from latin america and the caribbean. *NBER working paper*, 10129.

Helpman, E. and Itskhoki, O. (2010). Labor market rigidities, trade and unemployment. *Review of Economic Studies*, 77(3):1100–1137.

Helpman, E., Itskhoki, O., Muendler, M.-A., and Redding, S. J. (2017). Trade and inequality: From theory to estimation. *The Review of Economic Studies*, 84(1):357–405.

Helpman, E., Itskhoki, O., and Redding, S. (2010). Inequality and unemployment in a global economy. *Econometrica*, 78(4):1239–1283.

Hoekman, B. and Porto, G. (2010). Trade adjustment costs in developing countries: Impacts, determinants and policy responses. *Trade Adjustment Costs in Developing Countries: Impacts, Determinants and*, page 1.

Hopenhayn, H. (1992). Entry, exit, and firm dynamics in long run equilibrium. *Econometrica*, 60(5):1127–1150.

Hopenhayn, H. and Rogerson, R. (1993). Job turnover and policy evaluation: A general equilibrium analysis. *Journal of Political Economy*, 101(5):915–938.

Hornstein, A., Krusell, P., and Violante, G. L. (2011). Frictional wage dispersion in search models: A quantitative assessment. *American Economic Review*, 101(7):2873–98.

IADB (1997). *Latin America after a decade of reforms: economic and social progress: 1997 report*. Inter-American Development Bank.

Itskhoki, O. and Helpman, E. (2015). Trade liberalization and labor market dynamics with heterogeneous firms. *Princeton Papers*.

Kaas, L. and Kircher, P. (2015). Efficient firm dynamics in a frictional labor market. *American Economic Review*, 105(10):3030–60.

Kambourov, G. (2009). Labor market regulations and the sectoral reallocation of workers: The case of trade reforms. *Review of Economic Studies*, 76(4):1321–1358.

Koeniger, W. and Prat, J. (2007). Employment protection, product market regulation and firm selection. *The Economic Journal*, 117:302–332.

Kose, A., Meredith, G. M., and Towe, C. M. (2004). How has nafta affected the mexican economy? review and evidence. *IMF working paper*, 59.

Kpodar, K. (2007). *Why has unemployment in Algeria been higher than in MENA and transition countries*. Number 7-210. International Monetary Fund.

Krugman, P. (1980). Scale economies, product differentiation, and the pattern of trade. *The American Economic Review*, 70(5):950–959.

Kugler, A. D. (1999). The impact of firing costs on turnover and unemployment: Evidence from the colombian labour market reform. *International Tax and Public Finance*, 6(3):389–410.

Kumler, T., Verhoogen, E., and Frias, J. A. (2015). Enlisting employees in improving payroll-tax compliance: Evidence from mexico. *NBER Working Paper*, (19385).

Lora, E. (1997). A decade of structural reforms in latin america: What has been reformed and how to measure it. *IADB Working Paper*, 348.

Malhotra, R., Singh, N., and Singh, Y. (2011). Genetic algorithms: Concepts, design for optimization of process controllers. *Computer and Information Science*, 4(2):39.

Maloney, W. and Mendez, J. (2004). Measuring the impact of minimum wages. evidence from latin america. *NBER working paper*, 9800.

McCaig, B. and Pavcnik, N. (2014). Export markets and labor allocation in a low-income country. Technical report, National Bureau of Economic Research.

McFadden, D. (1989). A method of simulated moments for estimation of discrete response models without numerical integration. *Econometrica*, 57(5):995–1026.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71(6):1695–1725.

Menezes-Filho, N. A. and Muendler, M.-A. (2011). Labor reallocation in response to trade reform. Technical report, National Bureau of Economic Research.

Mortensen, D. T. (2005). *Wage dispersion: why are similar workers paid differently?* MIT press.

Nicita, A. (2008). Who benefits from export-led growth? evidence from madagascar's textile and apparel industry. *Journal of African Economies*, 17(3):465–489.

Nickell, S. and Layard, R. (1999). Chapter 46 labor market institutions and economic performance. *Handbook of Labor Economics*, 3:3029–3084.

Nilsen, Ø. A., Salvanes, K. G., and Schiantarelli, F. (2007). Employment changes, the structure of adjustment costs, and plant size. *European Economic Review*, 51(3):577–598.

Pakes, A. and Pollard, D. (1989). Simulation and the asymptotics of optimization estimators. *Econometrica*, 57(5):1027–1057.

Puyana, A. (2010). The impact of trade liberalization and the global economic crisis on the productive sectors, employment and incomes in mexico. *Issue Paper*, 15.

Revenga, A. (1997). Employment and wage effects of trade liberalization: the case of mexican manufacturing. *Journal of labor Economics*, 15(S3):S20–S43.

Riaño, A. (2009). Trade, technology adoption and the rise of the skill premium in mexico. *University of Nottingham*, unpublished manuscript.

Roberts, M. J. and Tybout, J. R. (1996). Industrial evolution in developing countries: Micro patterns of turnover, productivity, and market structure.

Rodriguez, F. and Rodrik, D. (2000). Trade policy and economic growth: a skeptic's guide to the cross-national evidence. *NBER macroeconomics annual*, 15:261–325.

Rodrik, D. (1993). Trade and industrial policy reform in developing countries: a review of recent theory and evidence. Technical report, National Bureau of Economic Research.

Sachs, J. D. and Warner, A. (1995). Economic reform and the process of global integration. *Brookings Papers on Economic Activity*, 26(1):1–118.

Schaal, E. (2012). Uncertainty, productivity and unemployment in the great recession. *Federal Reserve Bank of Minneapolis*, mimeo.

Stole, L. A. and Zwiebel, J. (1996). Intra-firm bargaining under non binding contracts. *The Review of Economic Studies*, 63(3):375–410.

Tybout, J. R. and Westbrook, M. D. (1995). Trade liberalization and the dimensions of efficiency change in mexican manufacturing industries. *Journal of International Economics*, 39(1-2):53–78.

Ulyssea, G. (2013). Firms, informality and welfare. *Chicago: University of Chicago*.

Ulyssea, G. (2016). Formal and informal firm dynamics. In *PET 16-Rio*.

Veracierto, M. (2008). Firing costs and business cycle fluctuations. *International Econoomic Review*, 49(1):1–39.

Wacziarg, R. and Wallack, J. S. (2004). Trade liberalization and intersectoral labor movements. *Journal of International Economics*, 64(2):411–439.

Wacziarg, R. and Welch, K. H. (2003). Trade liberalization and growth: New evidence. *NBER Working Paper*, 10152.

Yashiv, E. (2000). The determinants of equilibrium unemployment. *American Economic Review*, 90(5):1297–1322.

Appendix A. Details on Aggregate Evidence

A.1. Data Source and Definitions

The cross-country empirical evidence is based on 40 countries, for a period spanning between 30 and 40 years around the respective date of trade liberalization. In the specific, the countries covered are Albania (1970-2010), Argentina (1970-2010), Azerbaijan (1980-2010), Bangladesh (1980-2010), Republic of Bolivia (1970-2006), Brazil (1970-2010), Burkina Faso (1980-2010), Chile (1960-1996), Colombia (1970-2010), Cote d′Ivoire (1980-2010), Dominican Republic (1970-2010), Ecuador (1970-2010), Egypt (1980-2019), El Salvador (1970-2009), Ethiopia (1980-2010), Georgia (1980-2010), Hungary (1980-2010), India (1980-2007), Israel (1970-2005), Jamaica (1973-2009), Kyrgyzstan (1980-2010), Latvia (1990-2010), Lithuania (1980-2010), Madagascar (1980-2010), Mexico (1970-2006), Mozambique (1980-2010), New Zealand (1970-2007), Nicaragua (1970-2010), Pakistan (1980-2010), Paraguay (1970-2009), Peru′ (1970-2010), Philippines (1970-2008), Poland (1980-2010), Romania (1985-2010), South Africa (1970-2010), Republic of Tanzania: Mainland (1980-2009), Tunisia (1970-2009), Turkey (1970-2009), Uruguay (1970-2010) and the Bolivarian Republic of Venezuela (1974-2010). [49]

Trade Liberalizations: The liberalization dates are taken from Wacziarg and Welch (2003) and are based on Sachs and Warner (1995) criteria. Sachs and Warner classify an economy as open starting from the first year from which the following five characteristics are continuously met:

1. Average nominal tariff rates (TAR) below 40%;
2. Non-tariff barriers (NTB) covering less than 40% of trade;
3. A black market exchange rate (BMP) depreciated by less than 20% relative to the official exchange rate;
4. Absence of monopoly (XMB) on major exports;
5. No socialist economic system (SOC), as defined by Kornai (1992), is in place.[50]

[49] Data on trade liberalization and unemployment is also available for Croatia (1984-2010), Honduras (1970-2010), Malta (1983-2010), Serbia (1990-2014) and Tajikistan (1990-2010). However, since I do not have information on labor market institutions for these countries, I drop them from the sample. The inclusion of these observations in the first regression does not alter any of the results presented.

[50] A full description of these five variables is provided in the Sachs and Warner (1995).

Sachs and Warner (1995) selected the these five criteria to cover various types of trade restrictions. Tariffs and NTBs (like for instance, import quotas) increase directly or indirectly (through import substitution) the effective FOB price paid for importing foreign goods. A black market premium on the exchange rate can have effects equivalent to a formal trade restriction: if exporters purchase foreign inputs using foreign currency obtained on the black market, but remit their foreign exchange receipts from exports to the government at the official exchange rate, the black market premium acts as a trade restriction. The state monopoly on exports is included among the trade restriction, since it acts as an alternative form of export subsidy and finally the socialist regime dummy variable accounts for the trade-limiting aspects of centrally-planned economies. However, the threshold values set in the first three criteria are arbitrary. See Appendix 1 in Wacziarg and Welch (2003) for further details on the data used to construct these five indicators. They provide with liberalization dates for 141 countries for which they have enough information. From 1960, the great majority of the countries in the sample experienced a unique episode of trade liberalization and subsequent period of prolonged openness. Within the sample of countries used in this paper, only Bolivia, Ecuador and Jamaica went through a period of temporary liberalization, i.e. a period of full trade opening followed by subsequent failure on one or more of the five criteria listed above. For these countries, the date of reform is taken to be that at which the openness criteria are met without subsequent reversal, thus ignoring the initial episode of openness.

Labor Market Institutions: Measures of labor market institutions are taken from the Fondazione R. de Benedetti (FrdB) Labor Instituion v.1 database. In the paper, I focus on three specific institutions, namely minimum wage, unemployment benefit and employment protection legislation.

- The minimum wage regulation is identified using the ratio of statutory minimum wage to mean wage. Reported data correspond to the values in effect on July 1st of each year, unless otherwise specified. In countries were several minimum wages were in place, varying by sector or by location, a simple average minimum wage was constructed. Non-statutory minimum wage arrangements in place, like wage grids, or minimum wage determined by collective agreements are excluded.

- The unemployment benefits legislation is proxied by country-specific measure of unemployment insurance, constructed by multiplying the average gross replacement rate over 1 year after dismissal and unemployment benefits coverage, so to capture both extensive and intensive margin of the legislation. The gross replacement ratio is defined as levels of statutory entitlements over the average wage, after the first year of unemployment, while the unemployment benefit coverage is constructed as the ratio of the number of UI benefit recipients to the number of unemployed.

- The employment protection legislation is measured by sum of the average advance notice periods and the average severance payments, measured after 9 months, 4 and 20 years, and expressed in months. The data are collected and reported for workers with regular contracts of unspecified duration after any trial period, for the case of fair dismissals caused by personal grounds or individual redundancy (economic reason) at the initiative of the employer, and averaged out across different types of workers (high and low skilled, white and blue collars, when differently specified).

Unemployment Rates: Series for unemployment rate are constructed using data from ILO-Stat database, except for Chile, for which I used data from Caputo and Saravia (2014). ILO-Stat defines unemployed a person of working age (from 15 to 64 y.o.) who was (i) without work during the reference period, i.e. was not in paid employment or self-employment, (ii) currently available for work, meaning available for paid employment or self-employment during the reference period, and (iii) seeking work, i.e. had taken specific steps in a specified recent period to seek paid employment or self-employment. For purposes of international comparability, ILO-Stat defines the period of job search as the preceding four weeks, though the definition might vary from country to country. Therefore, the unemployment rate is calculated as the number of persons who are unemployed during the reference period given as a percent of the total number of employed and unemployed persons (i.e., the labour force) in the same reference period.

Controls: Series for GDP, GDP deflator, imports, exports and total population are taken from the World Development Indicator (WDI) Database of the World Bank. For the case of Poland and Paraguay, they are integrated with estimates from the International Financial Statistics (IFS) Database. GDP series are nominal and expressed in current USD price level. Nominal GDP measures the total output of goods and services for final use occurring within the domestic territory of a given country, regardless of the allocation to domestic and foreign claims. Total population refers to all residents regardless of legal status or citizenship. Nominal measures are converted into real values using the associated GDP deflator and expressed at constant 2005 USD price level. The import penetration is constructed by dividing total imports by GDP minus of net exports. Series for employment, rate of inflation and exchange rate are taken from the Penn Table Dataset v.9.0. Total employment refers to the number of persons engaged in production. Inflation rate is constructed as the growth rate of price level for household consumption goods (with price level of USA GDP in 2011 normalized to 1). Finally, the exchange rate refers the market value of national currency per USD.

A.2. Descriptive Statistics

In this section I report descriptive statistics for the sample of countries analysed. In particular, for each country I report the liberalization date constructed using Sachs and Warner

Table 15: **DESCRIPTIVE STATISTICS**

COUNTRY	LIBERALIZATION		UNEMPLOYMENT		IMPORT PENETRATION		MINIMUM		
	(DE-JURE)	(DE-FACTO)	PRE	POST	PRE	POST	WAGE	EPL	UI
Average	-	-	7.73	10.22	12.96	20.96	0.37	6.01	5.33
St.Dev.	-	-	5.42	5.26	10.43	13.68	0.18	4.47	9.16
Median	-	-	6.10	9.20	9.73	17.36	0.34	4.75	0
ALB	1992	1992	5.53	16.63	3.54	16.15	0.61	2.33	8.39
ARG	1991	1992	4.35	13.55	7.19	8.58	0.28	4.67	1.31
AZE	1995	1995	4.90	7.42	5.45	15.51	0.00	4.17	3.31
BFA	1998	1998	2.60	2.87	6.77	11.55	0.57	1.32	0.00
BGD	1996	1997	2.16	3.86	4.42	9.41	0.58	9.83	0.00
BOL	1986	1986	8.67	8.26	15.22	13.66	n.a.	11.12	0.00
BRA	1991	1991	3.34	8.07	6.35	8.61	0.16	11.75	9.23
CHL	1976	1979	6.65	11.83	9.91	12.42	0.37	4.00	3.40
CIV	1994	1994	9.16	9.21	15.72	20.66	0.74	4.20	0.00
COL	1992	1993	9.18	13.25	5.24	9.22	0.52	1.01	0.00
DOM	1992	2003	19.70	16.53	24.73	15.63	0.54	6.54	0.00
ECU	1991	1999	6.41	9.50	11.43	14.08	0.61	n.a.	0.00
EGY	1995	2000	7.72	9.59	10.09	8.11	0.20	0.36	n.a.
ETH	1996	1996	4.85	6.07	5.94	10.13	0.05	4.02	0.00
GEO	1996	1997	12.02	12.67	2.31	15.16	0.28	2.50	5.22
HUN	1990	1990	0.28	7.53	15.24	32.65	0.42	3.07	37.20
IND	1994	1995	3.95	4.07	3.73	5.20	0.68	5.00	n.a
ISR	1985	1985	5.08	8.73	26.38	30.19	0.48	8.82	7.01
JAM	1989	1992	23.93	15.37	26.90	33.94	0.32	6.17	0.00
KGZ	1994	1995	1.35	7.66	0.92	12.68	0.19	1.17	8.25
LTU	1993	1993	10.13	14.01	14.60	36.68	0.30	4.75	4.09
LVA	1996	1996	6.01	12.82	14.72	33.51	0.32	2.00	8.18
MDG	1996	1997	2.92	3.81	9.08	18.50	0.14	2.44	0.00
MEX	1986	1986	4.93	3.84	4.95	13.77	0.31	8.33	0.00
MOZ	1995	1995	24.06	23.54	29.54	25.98	0.24	16.00	0.00
NIC	1991	1995	12.95	11.30	7.82	19.25	0.36	4.33	0.00
NZL	1987	1989	3.35	7.46	23.02	25.44	0.44	0.44	25.56
PAK	2001	2001	4.55	7.17	6.32	7.57	0.61	6.56	0.00
PER	1991	1992	6.68	8.54	7.98	11.53	0.21	11.22	0.00
PHL	1988	1989	6.15	9.75	11.16	15.60	0.48	7.25	0.00
POL	1990	1990	6.30	14.53	9.03	15.62	0.32	3.67	23.22
PRY	1989	1989	5.99	8.19	13.17	18.27	0.49	4.17	0.00
ROU	1992	1992	3.66	8.24	5.93	16.85	0.48	0.75	15.31
SLV	1989	1990	7.65	7.77	31.29	59.81	0.70	8.39	0.00
TUN	1989	1989	14.31	15.88	22.42	21.03	0.24	2.63	n.a
TUR	1989	1994	10.62	8.06	4.83	10.56	0.00	9.92	0.00
TZA	1995	1995	3.85	3.40	5.99	9.82	n.a	4.94	0.00
URY	1990	2000	11.14	11.76	10.00	14.90	0.34	8.00	3.57
VEN	1996	1996	8.83	11.94	12.84	17.16	0.29	5.17	n.a
ZAF	1991	1995	14.35	23.81	11.65	13.40	0.00	0.67	23.22

Note: "Pre" and "Post" refer to pre- and post-liberalization periods as defined by Sachs and Warner (1995). Source: The liberalization dates are from Sachs and Warner (1995) and Wacziarg and Weich (2003); the unemployment rate is from ILO-stat; the import penetration rate is constructed using data on imports, exports and GDP from the Penn Table Dataset v.9.0; information on the labor market institutions is from FRdB Labor Institution v.1 database.

(1995)′s criteria, the average unemployment rate and the average import penetration rate before and after the trade reform occurs, and the labor market institutions in place at the time of trade reform. After a trade reform was implemented, the import penetration increase on average by 8 percentage points (from 12.96 to 20.96) while the unemployment rate increased

on average by about 2.5 percentage points (from 7.73 to 10.22 percent). At the time of a trade reforms, the cross-country average minimum wage in place wage slightly more than one third (37%) of the average real monthly wage, the average firing costs was slightly less than the equivalent of one year and half salary (16.2 real monthly wages), while slightly more than five percent (5.33%) of the labor force without a job was covered by unemployment insurance.

A.3. Robustness and further aggregate evidence

In what follows I report a set of robustness checks and further aggregate evidence on the relation between trade regimes, labor market institutions and unemployment. The main results always go through: (1) unemployment is significantly higher after a trade reform, (2) labor market institutions can explain the cross-country variation in unemployment after a trade liberalization, (3) the marginal effect of a trade reform on unemployment is significantly higher the greater the statutory minimum wage, the greater the unemployment insurance and the lower the costs of worker dismissal in place at the time of openings.

Different sub-samples. The first robustness is about sample selection. In particular, I split the sample into LAC and non-LAC countries, and estimate the following equation,

$$\text{unemp}_{it} = \alpha \mathbf{1}_{\{t \geq t_i^*\}} + \gamma_t + \upsilon_i + \eta_i (t - t_i^*) + \delta X_{it} + \epsilon_{it} \tag{54}$$

separately for the two sub-sample. Table 16 reports the OLS coefficients. Robust standard errors, clustered at country level, are reported in parenthesis.

Table 16: **Robustness check 1 - Sub-samples**

VARIABLES	(1.1)	unemp$_{it}$ (1.2)	(1.3)
		LAC countries	
Liberalization Dummy			
$\mathbf{1}_{\{t \geq t_i^*\}}$	3.382	2.914	3.344
	[1.519]**	[1.508]*	[1.410]**
Observation	466	466	463
R-squared	0.163	0.561	0.672
		non-LAC countries	
Liberalization Dummy			
$\mathbf{1}_{\{t \geq t_i^*\}}$	2.154	2.002	1.184
	[0.789]**	[0.691]***	[0.523]**
Observation	0.423	0.594	0.677
R-squared	538	538	535
Country FE	yes	yes	yes
Year FE	yes	yes	yes
Country trend	no	yes	yes
Controls	no	no	yes

Note: unemp$_{it}$ refers to the unemployment rate in country i at time t. $\mathbf{1}_{\{t \geq t_i^*\}}$ is a country-specific dummy variable taking value one in each period after the trade liberalization. Controls include population growth, real GDP per capita and its square, real GDP per capita growth, employment growth, investment share of GDP, the rate of price inflation on household consumption goods and the market exchange rate of the national currency w.r.t the US dollar. Robust standard errors are clustered at country level (in parenthesis). Source: ILO-stat, WBI, Penn-Table 9.0 and author′s calculations.
**** p<0.01, ** p<0.05, * p<0.1.*

Table 17: **Robustness check 2 - De-jure liberalization**

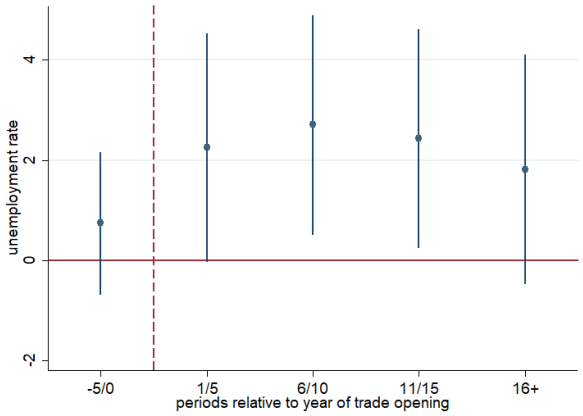
		unemp_{it}	
VARIABLES	(1.1)	(1.2)	(1.3)
		Full-sample	
De-facto Liberalization			
$\mathbf{1}_{\{t \geq t_i^*\}}$	1.969	2.134	1.833
	[0.623]***	[0.615]***	[0.600]***
Observation	0.165	0.541	0.620
R-squared	1004	1004	998
		LAC countries	
De-facto Liberalization			
$\mathbf{1}_{\{t \geq t_i^*\}}$	1.907	2.192	2.370
	[0.982]*	[1.047]*	[0.945]**
Observation	0.143	0.556	0.663
R-squared	466	466	463
		non-LAC countries	
De-facto Liberalization			
$\mathbf{1}_{\{t \geq t_i^*\}}$	2.433	2.344	1.497
	[0.793]***	[0.726]***	[0.505]***
Observation	0.434	0.606	0.683
R-squared	538	538	535
Country FE	yes	yes	yes
Year FE	yes	yes	yes
Country trend	no	yes	yes
Controls	no	no	yes

*Note: unemp_{it} refers to the unemployment rate in country i at time t. $\mathbf{1}_{\{t \geq t_i^*\}}$ is a country-specific dummy variable taking value one in each period after the **de-facto** trade liberalization. Controls include population growth, real GDP per capita and its square, real GDP per capita growth, employment growth, investment share of GDP, the rate of price inflation on household consumption goods and the market exchange rate of the national currency w.r.t the US dollar. Robust standard errors are clustered at country level (in parenthesis). Source: ILO-stat, WBI, Penn-Table 9.0 and author's calculations. *** p<0.01, ** p<0.05, * p<0.1.*

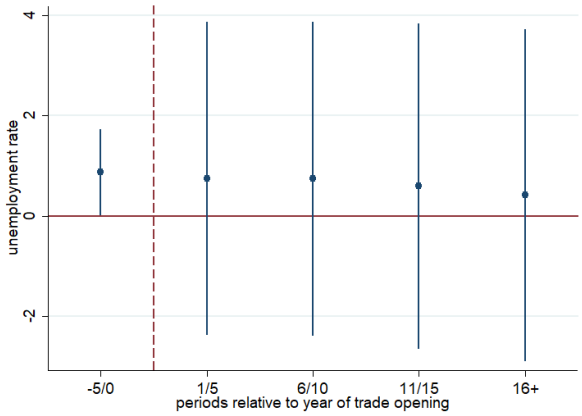
De-facto vs de-jure liberalization. The second robustness is about the date of trade reform. Following Wacziarg and Weich (2003), I construct a *de-facto* liberalization date, which combines the five criteria used in Sachs and Warner (1995) together with a sixth indicator, taking value one from the first year a country experience a five percent growth in trade openness (measured by the sum of total exports and imports over GDP), onward. Table 17 displays the OLS estimates of equation (54) using instead this new indicator, for the full sample and two sub-samples. Robust standard errors, clustered at country level, are reported in parenthesis.

Figure 12: **Lead and lagged effect of trade reform**

(a) Baseline



(b) Controlling for labor market institutions



Note: This figure report the OLS estimates of lead and lagged effects of a trade reform on the unemployment rate for the baseline case (equation 55) and after controlling for labor market institutions (equation 56).

Dynamic response. Here I complement the main analysis by looking at the dynamic response of unemployment to a trade reform. To do so, I first estimate a dynamic version of equation (54), i.e.

$$\text{unemp}_{it} = \sum_{j\in\{-5,0,5,10,15\}} \alpha_j \mathbf{1}_{\{t\in(t_i^*+j,t_i^*+j+5]\}} + \gamma_t + \upsilon_i + \eta_i(t-t_i^*) + \delta X_{it} + \epsilon_{it} \qquad (55)$$

where t_i^* denotes the liberalization date of country i, whereas $\mathbf{1}_{\{t\in(t_i^*+j,t_i^*+j+5]\}}$ is a dummy variable that takes value one if for any period t between t_i^*+j and t_i^*+j+5. I fit five of these dummies into equation (55), covering any periods $t\in(t_i^*-5,t_i^*+20]$, and I set the time spanning between t_i^*-20 and t_i^*-5 as a baseline group. Second, I estimate a further dynamic version of equation (54), i.e.

$$\text{unemp}_{it} = \sum_{j\in\{-5,0,5,10,15\}} \alpha_j \mathbf{1}_{\{t\in(t_i^*+j,t_i^*+j+5]\}} + \beta \mathbf{1}_{\{t\geq t_i^*\}} z_i + \gamma_t + \upsilon_i + \eta_i(t-t_i^*) + \delta X_{it} + \epsilon_{it} \qquad (56)$$

where the interaction terms $\mathbf{1}_{\{t\geq t_i^*\}} z_i$ are now included to capture cross-country differences in unemployment rate in periods of post-liberalization systematically associated to labor market institutions, z_i. Figure **??** displays the time-varying marginal effects of a trade reform estimated in equation (55) and (56). In the baseline case, the coefficient on the trade reform leads is not statistically different than zero, showing little anticipatory response within each country about to adopt a trade liberalization. From the year of adoption onward, the unemployment rate increases substantially by more than two percentage points, reaching its peak between six and ten years after the reform, and declining afterwards. Once controlling for the cross-country

variation in minimum wage, epl and unemployment benefits at the time of the trade reform, no significant effect on unemployment rate is detected anymore.

Appendix B. Details on the Model

B.1. Demand Functions and Firm Revenues

In this section I characterize the demand functions for each variety ω, the revenue functions of domestic firms and the revenue premium of domestic exporting firms. Given the CES structure, the inverse demand for a domestic variety ω at time t from a worker i with income I_i and from a firm j with gross revenues G_j is equal, respectively, to

$$q_{i,t}(\omega) = \gamma \left(\frac{p_t(\omega)}{P_t} \right)^{-\sigma} \frac{I_{i,t}}{P_t}$$

and

$$q_{j,t}(\omega) = (1-\alpha)\frac{\sigma-1}{\sigma} \left(\frac{p_t(\omega)}{P_t} \right)^{-\sigma} \frac{G_{j,t}}{P_t}$$

Combining demands and aggregating across workers and firms, we get,

$$\begin{aligned} q_t(\omega) &= \int_0^1 q_{i,t}(\omega)di + \int_0^{N_{h,t}} q_{j,t}(\omega)dj \\ &\implies q_t(\omega) = p_t(\omega)^{-\sigma} D_{h,t} \end{aligned} \tag{57}$$

where

$$D_{h,t} = P_t^{\sigma-1} \left[\gamma \int_0^1 I_{i,t}di + (1-\alpha)\frac{\sigma-1}{\sigma} \int_0^{N_{h,t}} G_{j,t}dj \right]$$

denotes the aggregate domestic expenditures. Similarly, the domestic inverse demand for a foreign variety ω^*, read

$$q_{i,t}(\omega^*) = \gamma \left(\frac{\tau_{a,t}\tau_{c,t}k_t p_t(\omega^*)}{P_t} \right)^{-\sigma} \frac{I_{i,t}}{P_t}$$

and

$$q_{j,t}(\omega^*) = (1-\alpha)\frac{\sigma-1}{\sigma} \left(\frac{\tau_{a,t}\tau_{c,t}k_t p_t(\omega^*)}{P_t} \right)^{-\sigma} \frac{G_{j,t}}{P_t}$$

which implies

$$q_t(\omega^*) = \int_0^1 q_{i,t}(\omega^*)di + \int_0^{N_{h,t}} q_{j,t}(\omega^*)dj$$
$$\implies q_t(\omega^*) = [\tau_{a,t}\tau_{c,t}k_t p_t(\omega^*)]^{-\sigma} D_{h,t} \tag{58}$$

Finally, the foreign demand for domestically produced good ω is given by

$$q_t^*(\omega) = p_t^*(\omega)^{-\sigma} D_{f,t} \tag{59}$$

where $p_t^*(n)$ is the price of domestic variety ω in the foreign market while $D_{f,t}$ denotes the aggregate expenditures abroad denominated in foreign currency, net of any effects of foreign commercial policies, and treated as exogenous parameter.

Consider the problem of a domestic firm that produces q_t units of output which are sold in the home market. The gross revenues of this firm at time t are equal to

$$G_{h,t}(\omega) = p_t(\omega)q_t(\omega) \tag{60}$$

From the inverse demand in equation (57) we can solve for the price of variety ω charged in the home market, $p_t(\omega)$, i.e.

$$p_t(\omega) = \left(\frac{q_t(\omega)}{D_{h,t}}\right)^{-\frac{1}{\sigma}}$$

Substituting $p_t(n)$ into equation (60), we obtain the revenues of non-exporting domestic firms,

$$G_{h,t}(\omega) = D_{h,t}^{\frac{1}{\sigma}} q_t(\omega)^{\frac{\sigma-1}{\sigma}} \tag{61}$$

Consider now the problem of a firm located in the home country that produces q_t units of output which are then shipped to the foreign market in addition to the home market. The choice variables for the firm are the fraction is the fraction χ_t of total output allocated to either markets. Because of iceberg trade costs, $\tau_{c,t}$, only $\frac{1}{\tau_{c,t}}\chi_t q_t$ units are exported to the foreign market, where the quantity $\frac{\tau_{c,t}-1}{\tau_{c,t}}\chi_t q_t$ is lost in shipping the good abroad. The gross revenues of this firm at time t are equal to

$$G_{f,t}(\omega) = \max_{\chi_t} \quad p_t(\omega)(1-\chi_t)q_t(\omega) + k_t p_t^*(\omega)\frac{\chi_t q_t(\omega)}{\tau_{c,t}} \tag{62}$$

From the inverse demand in equation (59) we can solve for the price of variety ω charged in

the foreign market, $p_t^*(\omega)$, i.e.

$$p_t^*(\omega) = \left(\frac{q_t(\omega)}{D_{f,t}}\right)^{-\frac{1}{\sigma}}$$

Substituting $p_t(\omega)$ and $p_t^*(\omega)$ into equation (62), we obtain the revenues of exporting domestic firms,

$$G_{f,t}(\omega) = \max_{\chi_t} \quad q_t(\omega)^{\frac{\sigma-1}{\sigma}} \left[(1-\chi_t)^{\frac{\sigma-1}{\sigma}} D_{h,t}^{\frac{1}{\sigma}} + k_t \left(\frac{\chi_t}{\tau_{c,t}}\right)^{\frac{\sigma-1}{\sigma}} D_{f,t}^{\frac{1}{\sigma}}\right] \tag{63}$$

The optimal output share allocated to the foreign market is the maximizer of the problem in equation (63), and it reads as

$$\chi_t = \frac{k_t^\sigma D_{f,t} \tau_{c,t}^{1-\sigma}}{D_{h,t} + k_t^\sigma D_{f,t} \tau_{c,t}^{1-\sigma}} \tag{64}$$

Substituting χ_t into equation (63), we can write the revenue function as follows,

$$G_{f,t}(\omega) = q_t(\omega)^{\frac{\sigma-1}{\sigma}} \left[D_{h,t} + k^\sigma \tau_{c,t}^{-(\sigma-1)} D_{f,t}\right]^{\frac{1}{\sigma}} = q_t(\omega)^{\frac{\sigma-1}{\sigma}} D_{h,t}^{\frac{1}{\sigma}} [1 + d_{f,t}]^{\frac{1}{\sigma}} \tag{65}$$

where $d_{f,t}$ is the revenue premium from exporting, equal to

$$d_{f,t} = k_t^\sigma \tau_{c,t}^{-(\sigma-1)} \frac{D_{f,t}}{D_{h,t}} \tag{66}$$

Finally, combining equations (64) and (63), I can write the optimal share of output allocated to the foreign market as

$$\chi_t = 1 - [1 + d_{f,t}]^{-\sigma} \tag{67}$$

B.2. Intermediate expenditure

Intermediate inputs are chosen every period so to maximize the net revenue function. This implies the following optimization problem for a generic firm,

$$R_t(z, \ell_f, \ell_i) = \max_m \quad G_t(q(z, m, \ell_f, \ell_i)) - P_t m \tag{68}$$

where $G_t(q(z, m, \ell_f, \ell_i))$ denotes the gross revenue function,

$$G_t(q(z, m, \ell_f, \ell_i)) = D_{h,t}^{\frac{1}{\sigma}}[1 + \mathbf{1}_t^x d_{f,t}]^{\frac{1}{\sigma}} q(z, m, \ell_f, \ell_i)^{\frac{\sigma-1}{\sigma}} - c_x \mathbf{1}_t^x \tag{69}$$

whereas $q(z, m, \ell_f, \ell_i)$ is the production function,

$$q(z, m, \ell_f, \ell_i) = z m^{1-\alpha} (\ell_f^{\alpha_f} \ell_i^{1-\alpha_f})^{\alpha} \tag{70}$$

Material expenditure satisfies the following first order condition,

$$P_t m_t = (1-\alpha)\frac{(\sigma-1)}{\sigma} G_t(q(z, m, \ell_f, \ell_i))$$

Solving for m_t and substituting into equation (68), yields the following expression for the net revenue function,

$$R_t(z, \ell_f, \ell_i) = \Delta_t(z, \ell_f, \ell_i)(z(\ell_f^{\alpha_f} \ell_i^{1-\alpha_f})^{\alpha})^{\frac{\sigma-1}{\sigma-(1-\alpha)(\sigma-1)}} \tag{71}$$

where $\Delta_t(z, \ell_f, \ell_i)$ is equal to

$$\Delta_t(z, \ell_f, \ell_i) = \frac{1 - (1-\alpha)^{\frac{(\sigma-1)}{\sigma}}}{\left((1-\alpha)^{\frac{(\sigma-1)}{\sigma}}\right)^{1-\frac{\sigma}{\sigma-(1-\alpha)(\sigma-1)}}} \left[\frac{D_{h,t} + \mathbf{1}_t^x(z, \ell_f, \ell_i) k^{\sigma} \tau_{c,t}^{-(\sigma-1)} D_{f,t}}{P_t^{-(1-\alpha)(\sigma-1)}}\right]^{\frac{1}{\sigma-(1-\alpha)(\sigma-1)}} \tag{72}$$

B.3. Firms optimal policies

Informal Employment Policy. Optimal informal labor demand is implicitly determined as the solution of the following order condition

$$\frac{\partial R_t(z', \ell_f^*, \ell_i')}{\partial \ell_i'} = w_{i,t} + \frac{\partial w_{f,t}(z', \ell_f^*, \ell_i')}{\partial \ell_i'} \ell_f^*$$

evaluated at the optimal level formal employment, $\ell_f' = \ell_f^*$. At the optimum, marginal revenues generated by an extra informal worker equates the marginal costs, equal to the wage rate paid to informal workers, $w_{i,t}$ plus an extra term capturing the intra-firm marginal effect of informal labor on the wage of formal employees, $\frac{\partial w_{f,t}(z', \ell_f^*, \ell_i')}{\partial \ell_i'} \ell_f'$. Notice that, since the the wage of informal workers, $w_{i,t}$, is competitively determined in the labor market, no intra-firm effect of informal labor on the wage of informal employees is present, i.e. $\frac{\partial w_{i,t}}{\partial \ell_i'} = 0$

Formal Employment Policy. Standard optimization arguments lead to the two following first order conditions for hires and separation of formal workers in any active firm in

period t:

$$\frac{\partial \pi_t(z', \ell_f, \ell'_f, \ell_i^*)}{\partial \ell'_f} + \frac{\partial V_{t+1}(z', \ell'_f)}{\partial \ell'_f} = 0$$

$$\implies \frac{\partial R_t(z', \ell'_f, \ell_i^*)}{\partial \ell'_f} + \frac{\partial V_{t+1}(z', \ell'_f)}{\partial \ell'_f} = \frac{\partial w_{f,t}(z', \ell'_f, \ell_i^*)\ell'_f}{\partial \ell'_f} + \mathbf{1}_t^h(z', \ell_f)\frac{\partial C_t^+(\ell_f, \ell'_f)}{\partial \ell'_f} - \mathbf{1}_t^f(z', \ell_f)c_{f,t}$$

where $\mathbf{1}_t^h(z', \ell_f)$ and $\mathbf{1}_t^f(z', \ell_f)$ are two indicator functions taking value one if the firm is, respectively, hiring and firing and zero otherwise, $\frac{\partial R_t(z', \ell'_f, \ell_i^*)}{\partial \ell'_f}$ denotes marginal revenues, evaluated at the optimal level of informal employment, $\ell'_i = \ell_i^*$, and $\frac{\partial V_{t+1}(z', \ell'_f)}{\partial \ell'_f}$ captures the marginal effect of current employment decisions on the continuation value of the firm. This equation has a straightforward interpretation: firm will expand or contract up to the point where current and future marginal benefits from resizing is equal to the relative marginal costs, captured by the marginal effect on wage payments, $\left(\frac{\partial w_t(z', \ell'_f, \ell_i^*)\ell'_f}{\partial \ell'_f}\right)$ plus the marginal costs of hiring new workers, $\left(\frac{\partial C_t^+(\ell_f, \ell'_f)}{\partial \ell'_f}\right)$ or firing some of them ($c_{f,t}$). As in Cooper et al. (2007) and Elsby and Michaels (2013), the presence of adjustment costs make the optimal employment decisions of the firm be characterized by two reservation thresholds, $z^H(\ell_f)$ and $z^F(\ell_f)$, which are defined by the following two equations:

$$\frac{\partial R_t(z^H(\ell_f), \ell'_f, \ell_i^*)}{\partial \ell'_f} - \frac{\partial w_{f,t}(z^H(\ell_f), \ell'_f, \ell_i^*)\ell'_f}{\partial \ell'_f} + \frac{\partial V_{t+1}(z^H(\ell_f), \ell'_f)}{\partial \ell'_f} = \frac{\partial C_t^+(\ell_f, \ell'_f)}{\partial \ell'_f}$$

$$\frac{\partial R_t(z^F(\ell_f), \ell'_f, \ell_i^*)}{\partial \ell'_f} - \frac{\partial w_{f,t}(z^F(\ell_f), \ell'_f, \ell_i^*)\ell'_f}{\partial \ell'_f} + \frac{\partial V_{t+1}(z^F(\ell_f), \ell'_f)}{\partial \ell'_f} = -c_{f,t}$$

The derivative of the continuation value of the marginal worker can be written as

$$\frac{\partial V_{t+1}(z', \ell'_f)}{\partial \ell'_f} = \frac{1-\delta}{1+r_{t+1}}\mathbf{1}_{t+1}^o(z', \ell'_f)\left(\frac{\partial \mathbf{E}_{z''|z'} \max_{\{\ell''_f, \ell''_i\}}[\pi_{t+1}(z'', \ell'_f, \ell''_f, \ell''_i) + V_{t+1}(z'', \ell''_f)]}{\partial \ell'_f}\right)$$

which, by the envelope theorem, reads as

$$\frac{\partial V_{t+1}(z',\ell'_f)}{\partial \ell'_f} = \frac{1-\delta}{1+r_{t+1}}\mathbf{1}^o_{t+1}(z',\ell'_f)\mathbf{E}_{z''|z'}\mathbf{1}^h_{t+1}(z'',\ell'_f)\frac{\partial C^+_{t+1}(\ell'_f,\ell''_f)}{\partial \ell'_f}$$
$$-\frac{1-\delta}{1+r_{t+1}}\mathbf{1}^o_{t+1}(z',\ell'_f)\mathbf{E}_{z''|z'}\mathbf{1}^f_{t+1}(z'',\ell'_f)c_{f,t+1}$$
$$+\frac{1-\delta}{1+r_{t+1}}\mathbf{1}^o_{t+1}(z',\ell'_f)\mathbf{E}_{z''|z'}(1-\mathbf{1}^h_{t+1}(z'',\ell'_f))(1-\mathbf{1}^f_{t+1}(z'',\ell'_f))\left[\frac{\partial \pi_{t+1}(z'',\ell'_f,\ell''_f,\ell^{**}_i)}{\partial \ell'_f}+\frac{\partial V_{t+2}(z'',\ell'_f)}{\partial \ell'_f}\right]$$

or equivalently

$$\frac{\partial V_{t+1}(z',\ell'_f)}{\partial \ell'_f} = \begin{cases} -\frac{(1-\delta)}{1+r_{t+1}}\mathbf{1}^o_{t+1}(z',\ell'_f)c_{f,t+1}, & \text{if} \quad z' < z^F(\ell_f) \\ \frac{(1-\delta)}{1+r_{t+1}}\mathbf{1}^o_{t+1}(z',\ell'_f)\mathbf{E}_{z''|z}\left[\frac{\partial \pi_{t+1}(z'',\ell'_f,\ell''_f,\ell^{**}_i)}{\partial \ell'_f}+\frac{\partial V_{t+2}(z'',\ell''_f)}{\partial \ell'_f}\right], & \text{if} \quad z' \in [z^H(\ell_f), z^H(\ell_f)] \\ \frac{(1-\delta)}{1+r_{t+1}}\mathbf{1}^o_{t+1}(z',\ell'_f)\frac{\partial C^+_{t+1}(\ell'_f,\ell''_f)}{\partial \ell'_f}, & \text{if} \quad z' > z^H(\ell_f) \end{cases}$$

Consider an incumbent firm entering the period with ℓ_f formal employees, receiving an idiosyncratic productivity shock z'. The optimal level of formal employment in the current period, $L_{f,t}(z',\ell_f)$, is thus characterized by the following policy function,

$$L_{f,t}(z',\ell_f) = \begin{cases} \ell^F_f(z') = \ell_f(z^F(\ell_f),\ell_f), & \text{if} \quad z' < z^F(\ell_f) \\ \ell_f, & \text{if} \quad z' \in [z^F(\ell_f), z^H(\ell_f)] \\ \ell^H_f(z') = \ell_f(z^H(\ell_f),\ell_f), & \text{if} \quad z' > z^H(\ell_f) \end{cases}$$

where $\ell^F_f(z')$ and $\ell^H_f(z')$ refer to the optimal level of formal employment consistent with the optimality conditions,

$$\frac{\partial R_t(z',\ell'_f,\ell^*_i)}{\partial \ell'_f}\,|_{\ell'_f=\ell^H_f} - \frac{\partial w_t(z',\ell'_f,\ell^*_i)\ell'_f}{\partial \ell'_f}|_{\ell'_f=\ell^H_f} + \frac{\partial V_{t+1}(z',\ell'_f)}{\partial \ell'_f}|_{\ell'_f=\ell^H_f} = \frac{\partial C^+_t(\ell_f,\ell'_f)}{\partial \ell'_f}|_{\ell'_f=\ell^H_f} \quad (73)$$

$$\frac{\partial R_t(z',\ell'_f,\ell^*_i)}{\partial \ell'_f}|_{\ell'_f=\ell^F_f} - \frac{\partial w_t(z',\ell'_f,\ell^*_i)\ell'_f}{\partial \ell'_f}|_{l'=l^F} + \frac{\partial V_{t+1}(z',l')}{\partial l'}|_{l'=l^F} = -c_{f,t} \quad (74)$$

Therefore, if the idiosyncratic productivity z' is below the reservation threshold, $z^F(\ell_f)$, the firm will fire workers, pushing up the marginal benefits from employment till it is equal to marginal cost of dismissal. The opposite will happen if z' is above the reservation threshold, $z^H(\ell_f)$: the firm will hire workers, driving down the marginal return from employment till it is equal to the marginal cost of hiring. On the other hand, if z' lied between the two thresholds, the firm will be inactive, and will set current formal employment level equal to the previous one.

Export Policy. Each period t, incumbent firms decide whether to sell their product abroad or not. Export is a static decision, it entails the payment of a fixed costs, c_x, and grant a revenue premium, $d_{f,t}$. The presence of a fixed cost of exporting makes the optimal export participation decision, $\mathbf{1}_t^x(z', \ell_f)$ be characterized by a threshold productivity level, $z^x(\ell_f)$, which is implicitly defined as a solution the following equation,

$$G_{h,t}(z^x(\ell_f), \ell'_f(z^x(\ell_f), \ell_f), \ell'_i(z^x(\ell_f), \ell_f)) = G_{x,t}(z^x(\ell_f), \ell'_f(z^x(\ell_f), \ell_f), \ell'_i(z^x(\ell_f), \ell_f)) - c_x$$

so that

$$\mathbf{1}_t^x(z', \ell_f) = \begin{cases} 1, & \text{if} \quad z' \geq z^x(\ell_f) \\ 0, & \text{otherwise} \end{cases}$$

Exit Policy. At the beginning of each period t, firms who did not exit the industry for exogenous reasons decide whether to continue to operate or not. The presence of a fixed cost of operation, c^o, together with the autocorrelation of the idiosyncratic productivity process, makes the optimal exit decision be characterized by a threshold productivity level, $z^O(\ell_f)$, which is defined by the following equation

$$\mathbf{E}_{z'|z^O(\ell_f)} \left[\max_{\{\ell'_f, \ell'_i\}} \left(\pi_t(z', \ell_f, \ell'_f, \ell'_i) - c_o + V_{t+1}(z', \ell'_f) \right) \right] = 0$$

or, equivalently,

$$\mathbf{E}_{z'|z^O(\ell_f)} \left[\max_{\{\ell'_f, \ell'_i\}} \left(R_t(z', \ell'_f, \ell'_i) - w_{i,t}\ell'_i - w_{f,t}(z', \ell'_f, \ell'_i)\ell'_f - C_t(\ell_f, \ell'_f) + V_{t+1}(z', \ell'_f) \right) \right] = c^o$$

Consider a firm entering the period with l employees and receiving an idiosyncratic productivity shock z'. The optimal exit strategy, $\mathbf{1}_t^o(z, l)$, is thus characterized by the following policy function:

$$\mathbf{1}_t^o(z, \ell_f) = \begin{cases} 1, & \text{if} \quad z \geq z^O(\ell_f) \\ 0, & \text{otherwise} \end{cases}$$

B.4. Wage Determination

Wages of formal employees are determined using the Stole and Zwiebel (1996) bargaining solution, which generalizes the standard Nash bargaining solution to a setting when marginal

returns are diminishing. Firms and workers meet and bargain simultaneously and on a one-to-one basis. Each worker is treated marginally by the firm. Failing to reach an agreement would imply a loss for the firm (who cannot recover back the costs of posting vacancies and cannot contact other workers in the current period to replace the existing ones) and for workers (who would remain unemployed in the current period). This generates a surplus to split between firms and workers. Consider a firm hiring formal workers. A solution for the wage paid to formal employees is implicitly defined by the following sharing rule,

$$\beta \Pi_t^{\text{firm}}(z', \ell'_f, \ell'_i) = (1-\beta)\Pi_t^{\text{worker}}(z', \ell'_f, \ell'_i) \tag{75}$$

where $\Pi_t^{\text{firm}}(z', \ell'_f, \ell'_i)$ is the firm marginal surplus, defined as,

$$\Pi_t^{\text{firm}}(z', \ell'_f, \ell'_i) = \frac{\partial R_t(z', \ell'_f, \ell'_i)}{\partial \ell'_f} - (1+\tau_{w,t})\frac{\partial w_{f,t}(z', \ell'_f, \ell'_i)\ell'_f}{\partial \ell'_f} + \frac{\partial V_{t+1}(z', \ell'_f)}{\partial \ell'_f} \tag{76}$$

while $\Pi_t^{\text{worker}}(z', \ell'_f, \ell'_i)$ is the worker marginal surplus equal to

$$\Pi_t^{\text{worker}}(z', \ell'_f, \ell'_i) = w_{f,t}(z', \ell'_f, \ell'_i) + J^e_{t+1}(z', \ell'_f) - (b + b^u + J^o_{t+1}) \tag{77}$$

Substituting the surplus functions into the sharing rule, and assuming the continuation values are split using the same sharing rule, one obtains the following first-order partial differential equation,

$$w_{f,t}(z', \ell'_f, \ell'_i) = \frac{(1-\beta)}{1+\tau_w\beta}(b+b^u) + \frac{\beta}{1+\tau_w\beta}\left(\frac{\partial R_t(z', \ell'_f, \ell'_i)}{\partial \ell'_f} - (1+\tau_w)\frac{\partial w_{f,t}(z', \ell'_f, \ell'_i)}{\partial \ell'_f}\ell'_f\right) \tag{78}$$

To solve this equation, I follow Cahuc et al (2007, Appendix B.2). Re-arranging the differential equation, we get

$$\frac{\partial w_{f,t}(z', \ell'_f, \ell'_i)}{\partial \ell'_f} + \frac{w_{f,t}(z', \ell'_f, \ell'_i)}{\tilde{\beta}(1+\tau_w)\ell'_f} - \left[\frac{\partial R_t(z', \ell'_f, \ell'_i)}{\partial \ell'_f} - \frac{(1-\beta)}{1+\tau_w\beta}(b+b^u)\right]\frac{1}{(1+\tau_w)\ell'_f} = 0 \tag{79}$$

where $\tilde{\beta} = \frac{\beta}{1-\beta\tau_w}$. Suppressing for easy of notation the dependence from z' and ℓ'_i, equation (79) can be re-written in the following form:

$$\frac{\partial y(\ell'_f)}{\partial \ell'_f} + p(\ell'_f)y(\ell'_f) + q(\ell'_f) = 0 \tag{80}$$

where

$$\begin{aligned} y(\ell'_f) &= w_{f,t}(z', \ell'_f, \ell'_i) \\ p(\ell'_f) &= \frac{1}{\tilde{\beta}(1+\tau_w)\ell'_f} \\ q(\ell'_f) &= -\left[\frac{\partial R_t(z', \ell'_f, \ell'_i)}{\partial \ell'_f} - \frac{(1-\beta)}{1+\tau_w\beta}(b+b^u)\right]\frac{1}{(1+\tau_w)\ell'_f} \end{aligned} \tag{81}$$

Plugging the expressions in (82) into the solution of (80), one can express wages as

$$w_{f,t}(z', \ell'_f, \ell'_i) = \frac{1}{1+\tau_w}(\ell'_f)^{-\frac{1}{\tilde{\beta}(1+\tau_w)}} \int_0^{\ell'_f} x^{\frac{1-\tilde{\beta}(1+\tau_w)}{\tilde{\beta}(1+\tau_w)}} \frac{\partial R_t(z', x, \ell'_i)}{\partial x} dx \tag{82}$$

Substituting the definition of marginal revenue function into (80) and integrating over formal employment yields the wage expression in the text

$$w_{f,t}(z', \ell'_f, \ell'_i) = \frac{(1-\beta)}{1+\beta\tau_{w,t}}(b+b^u) + \frac{\beta}{1-\beta+\alpha_f\beta\Lambda(1+\tau_{w,t})}\frac{\partial R_t(z', \ell'_f, \ell'_i)}{\partial \ell_f} \tag{83}$$

with $\Lambda = \frac{\alpha(\sigma-1)}{\sigma-(1-\alpha)(\sigma-1)} > 0$. Notice that equation (83) generalizes the solution obtained in Cosar et al. (2016) for the case where firms payroll is subject to tax rate $\tau_w \geq 0$.

B.5. Recursive Competitive Equilibrium

Given aggregate foreign expenditure denominated in foreign currency, $\{D_{f,t}\}_{t=0}^{\infty}$, a sequence of iceberg costs and tariffs on imports, $\{\tau_{c,t}, \tau_{a,t}\}_{t=0}^{\infty}$, a sequence of labor market policies, $\{c_{f,t}, \underline{w}_t, b_t^u, \tau_{w,t}\}_{t=0}^{\infty}$, a path for the interest rate $\{r_t\}_{t=0}^{\infty}$, initial mass of operating firms $N_{h,-1}$, initial probability distributions of firms over the state space (z, ℓ_f) at the end and at the interim stage of the period, $\{\psi_{-1}(z, \ell_f), \widetilde{\psi}_{-1}(z, \ell_f)\}$, a transition density function of the Markov process for productivity shock z, $\Omega(z'|z)$ and its ergodic distribution, $\psi_e(z)$, a Recursive Competitive Equilibrium for this economy is characterized by a list of value functions for incumbent and potential entrant firms, $\{V_t(z, \ell_f), V_t^e\}_{t=0}^{\infty}$, and value functions for workers, $\{J_t^o, J_t^s, J_t^i, J_t^u, J_t^e(z, \ell_f), J_t^c(z', \ell_f)\}_{t=0}^{\infty}$, a list of policy functions for incumbent firms, $\{L_{f,t}(z', \ell_f), L_{i,t}(z', \ell_f), \mathbf{1}_t^o(z', \ell_f), \mathbf{1}_t^h(z', \ell_f), \mathbf{1}_t^f(z', \ell_f), \mathbf{1}_t^x(z', \ell_f)\}_{t=0}^{\infty}$, a list of measures for incumbent and entrant firms $\{N_{h,t}, N_{e,t}\}_{t=0}^{\infty}$, a list of aggregate domestic price indexes and aggregate domestic demand for the industrial composite good $\{D_{h,t}, P_t\}_{t=0}^{\infty}$, a stream of aggregate income $\{I_t\}_{t=0}^{\infty}$ and exchange rates $\{k_t\}_{t=0}^{\infty}$, a list of measures for workers employed in the service sector, informal and formal workers in the industrial sector, workers searching for formal jobs in the industrial sector and unemployed workers, $\{L_{s,t}, L_{i,t}, L_{f,t}, U_t, L_{u,t}\}_{t=0}^{\infty}$, a list of vacancy filling rates, job finding rates and probabilities of being fired, $\{\phi_t, \widetilde{\phi}_t, p_t^o(z, \ell_f), p_t^f(z', \ell_f)\}_{t=0}^{\infty}$, a stream of wage schedules for formal workers at hiring and firing firms, $\{w_{f,t}^{\mathrm{h}}(z, \ell_f), w_{f,t}^{\mathrm{f}}(z, \ell_f)\}_{t=0}^{\infty}$, and

for informal workers, $\{w_{i,t}\}_{t=0}^{\infty}$, and a list of probability distributions of firms over the state space (z, ℓ_f) at the end and at the interim states of the period, $\{\psi_t(z', \ell_f), \widetilde{\psi}_t(z', \ell'_f)\}_{t=0}^{\infty}$ such that the following conditions are met:

1. the policy functions $\{L_{f,t}(z', \ell_f), L_{i,t}(z', \ell_f), \mathbf{1}_t^o(z', \ell_f), \mathbf{1}_t^h(z', \ell_f), \mathbf{1}_t^f(z', \ell_f), \mathbf{1}_t^x(z', \ell_f)\}_{t=0}^{\infty}$ solve the problem of the incumbent firms in the industrial sector and $V_t(z, l)$ attains its maximum $\forall t = 0, 1, ...$

2. there is a positive mass of entrant firms in the industrial sector, $N_{e,t} > 0$, in every period t, and V_t^e attains its maximum $\forall t = 0, 1, ...$

3. no-arbitrage conditions holds,

$$J_t^o = J_t^i = J_t^u = J_t^s \quad \forall t = 0, 1, ..., \tag{84}$$

since workers are free to choose between working in the service sector, being informally hired or searching for formal job in the industrial sector;

4. the probabilities that a formal worker is fired, $p_t^o(z, \ell_f)$ and $p_t^f(z', \ell_f)$, are consistent with firm exit policy function, employment policy function and optimal hiring and firing decisions, i.e.

$$p_t^o(z, \ell_f) = \delta + (1 - \delta)(1 - \mathbf{1}_t^o(z, \ell_f)) \qquad p_t^f(z', \ell_f) = \mathbf{1}_t^f(z', \ell_f)\left(\frac{\ell_f - L_{f,t}(z', \ell_f)}{\ell_f}\right) \tag{85}$$

5. the probability distributions of firms over the state space (z, ℓ_f) at the end and the interim stage of the period, $\{\psi_t(z', \ell'_f), \widetilde{\psi}_t(z', \ell_f)\}_{t=0}^{\infty}$, evolve according to the following laws of motion:

$$\widetilde{\psi}_t(z', \ell_f) = \begin{cases} (1 - \delta) \int_{z \in \mathcal{Z}} \Omega(z'|z) \psi_{t-1}(z, \ell_f) \mathbf{1}_t^o(z, \ell_f) dz, & \text{if} \quad \ell_f \neq 1 \\ \frac{N_{e,t}}{N_{h,t-1}} \psi_e(z') + (1 - \delta) \int_{z \in \mathcal{Z}} \Omega(z'|z) \psi_{t-1}(z, \ell_f) \mathbf{1}_t^o(z, \ell_f) dz, & \text{if} \quad \ell_f = 1 \end{cases} \tag{86}$$

where $\frac{N_{e,t}}{N_{h,t-1}}$ is the ratio of firms entering in period t over the total mass of firm active at time $t - 1$, and

$$\psi_t(z\prime, \ell'_f) = \frac{\int_{\ell_f \in \mathcal{L}} \widetilde{\psi}_t(z', \ell_f) \mathbf{1}_{L_{f,t}(z', \ell_f) = \ell'_f} d\ell_f}{\int_{\ell_f \in \mathcal{L}} \int_{z'' \in \mathcal{Z}} \widetilde{\psi}_t(z'', \ell_f) \mathbf{1}_{L_{f,t}(z'', \ell_f) = \ell'_f} dz'' d\ell_f} \tag{87}$$

where $\mathbf{1}_{L_{f,t}(z', \ell_f) = \ell'_f} = 1$ if $L_{f,t}(z', \ell_f) = \ell'_f$, 0 otherwise;

6. firms enter the economy up to the point where the free entry condition holds with equality,

$V_t^e = c_e \phi_t^{-\lambda_1}$ and the total mass of firms evolve according the following law of motion:

$$N_{h,t} = (1-\delta)(1-\mu_t^{exit})N_{h,t-1} + N_{e,t} \tag{88}$$

where μ_t^{exit} is the fraction of firms exiting at time t, determined by the end-of period distribution at time $t-1$ and the exit policy function at time t:

$$\mu_t^{exit} = \int_{\ell_f \in \mathcal{L}} \int_{z \in \mathcal{Z}} [1 - \mathbf{1}_t^o(z, \ell_f)] \psi_{t-1}(z, \ell_f) dz d\ell_f \tag{89}$$

7. the wage of informal employees is consistent with the no-arbitrage conditions (84), which implies $w_{i,t} = 1$, whereas the wage of formal employees, $w_{f,t}(z', \ell'_f, \ell'_i)$ is consistent with the bargaining protocols given in equations (42) and (44) for hiring and firing firms;

8. the labor markets clear, i.e.

   - the measure of formal workers who are employed at time t in the industrial sector, $L_{f,t}$, matches the measure of active formal industrial jobs:

$$L_{f,t} = N_{h,t} \int_{\ell_f \in \mathcal{L}} \int_{z' \in \mathcal{Z}} L_{f,t}(z', \ell_f) \widetilde{\psi}_t(z', \ell_f) dz' d\ell_f \tag{90}$$

   - the measure of informal workers who are hired at time t in the industrial sector, $L_{i,t}$, matches the measure of active informal industrial jobs:

$$L_{i,t} = N_{h,t} \int_{\ell_f \in \mathcal{L}} \int_{z' \in \mathcal{Z}} L_{i,t}(z', \ell_f) \widetilde{\psi}_t(z', \ell_f) dz' d\ell_f \tag{91}$$

   - the measure of workers who are unemployed at the end of the period, $L_{u,t}$, evolves according to the following low of motion:

$$L_{u,t} = (1 - \widetilde{\phi}_t) U_t \tag{92}$$

   where $U_t = \tilde{U}_t + L_{u,t-1}$ and

$$\begin{aligned} \tilde{U}_t = \delta N_{h,t-1} \int_{\ell_f \in \mathcal{L}} \int_{z \in \mathcal{Z}} \ell_f \psi_{t-1}(z, \ell_f) dz d\ell_f + \\ (1-\delta) N_{h,t-1} \int_{\ell_f \in \mathcal{L}} \int_{z \in \mathcal{Z}} (1 - \mathbf{1}_{t-1}^o(z, \ell_f)) \ell_f \psi_{t-1}(z, \ell_f) dz d\ell_f + \\ N_{h,t} \int_{\ell_f \in \mathcal{L}} \int_{z \in \mathcal{Z}} \mathbf{1}_t^f(z', \ell_f) [\ell_f - L_{f,t}(z', \ell_f)] \widetilde{\psi}_t(z', \ell_f) dz' d\ell_f \end{aligned} \tag{93}$$

   - workers who have jobs in one of the sectors and unsuccessful industrial job seekers must sum up to total population, i.e. $L_{f,t} + L_{i,t} + L_{s,t} + L_{u,t} = 1 \quad \forall t = 0, 1, ...$

- the vacancy filling rate, ϕ_t, and the job finding rate, $\widetilde{\phi}_t$, are consistent are consistently determined by the measures of worker searching for formal jobs in the interim state, U_t, and the measure of vacancy posted by firms,

$$v_t = N_{h,t} \int_{\ell_f \in \mathcal{L}} \int_{z' \in \mathbf{Z}} \mathbf{1}_t^h(z', \ell_f) \left(\frac{L_{f,t}(z', \ell_f) - \ell_f}{\phi_t} \right) \widetilde{\psi}_t(z', \ell_f) dz' d\ell_f \tag{94}$$

9. the market for service clears, i.e. total supply of services, equal to the sum of home and market production, $bL_{u,t} + Ls_{s,t}$, matches the total demand of services, which sums intermediate and final demand.

$$bL_{u,t} + L_{s,t} = \underbrace{N_{h,t}[\overline{c} + c_o + \mu_x c_x] + N_{e,t} c_e}_{\text{intermediate demand}} + \underbrace{(1-\gamma) I_t}_{\text{final demand}} \tag{95}$$

The intermediate demand sums firms demand for services used to pay fixed operating costs, exporting costs, initial costs of set-up for firms and labor adjustment costs (hiring costs), defined as

$$\overline{c} = N_{h,t} \int_{z' \in \mathcal{Z}} \int_{\ell_f \in \mathcal{L}} \mathbf{1}_t^h(z', \ell_f) C_t^h(\ell_f, L_{f,t}(z', \ell_f)) \tilde{\psi}_t(z', \ell_f) dz' d\ell_f \tag{96}$$

The final demand is equal to a share $(1-\gamma)$ of total income, I_t, which is composed by total labor income (industrial and service sector wage payments plus value of home production) aggregate profits in the industrial sector distributed to worker-consumers who own the firms and government transfers

$$\begin{aligned} I_t = \underbrace{[b + b_t^u] L_{u,t} + L_{s,t} + w_{i,t} L_{i,t} + \overline{w}_{f,t} N_{h,t}}_{\text{labor income}} + \underbrace{T_t}_{\text{lump-sum transfer}} + \\ \underbrace{N_{h,t} \int_{z' \in \mathcal{Z}} \int_{\ell_f \in \mathcal{L}} [\pi_t(z', \ell_f, L_{f,t}(z', \ell_f), L_{i,t}(z', \ell_f)) - c_o)] \tilde{\psi}_t(z', \ell_f) dz' d\ell_f - N_{e,t} c_e}_{\text{aggregate profits}} \end{aligned} \tag{97}$$

10. trade is balanced, i.e. every period t the exchange rate k_t adjusts so that total domestic expenditures on imported varieties (expressed in domestic currency) equals total export revenues,

$$D_{h,t} \tau_{a,t}^{-\sigma} (\tau_{c,t} k_t)^{1-\sigma} = k_t D_{f,t} \tau_{c,t}^{-1} \tag{98}$$

11. government budget is balanced, i.e. unemployment benefits plus lump-sum rebates matches

revenues collected from firing costs, tariffs and payroll taxes

$$T_t + b_t^u L_{u,t} = \underbrace{\tau_w \overline{w}_{f,t} N_{h,t}}_{\text{payroll tax revenues}} + \underbrace{c_{f,t} \int_{z\in\mathcal{Z}} \int_{\ell_f \in \mathcal{L}} \mathbf{1}_t^f(z', \ell_f)(\ell_f - L_{f,t}(z', \ell_f))\tilde{\psi}_t(z', \ell_f) dz' d\ell_f}_{\text{firing cost revenues}} + \underbrace{D_{h,t}\tau_{a,t}^{-\sigma}(\tau_{c,t}k_t)^{1-\sigma}(\tau_{a,t} - 1)}_{\text{tariff revenue}} \tag{99}$$

B.6. Stationary Recursive Competitive Equilibrium

A Stationary Recursive Competitive Equilibrium is a Recursive Competitive Equilibrium where

1. value functions and policy functions are time-invariant;
2. the probability distributions of firms over the state space (z, ℓ_f) at the end and the interim stage of the period, $\psi(z, \ell_f)$ and $\widetilde{\psi}(z, \ell_f)$ are time-invariant, i.e. they replicate themselves through the Markov processes on z, the policy functions and the productivity draws upon entry;
3. the measure of active firms in the industrial sector is time-invariant, the exit rate is constant and the measure of exiting firms resembles that of entrants,

$$N_e = \mu^{exit} N_h$$

4. the vacancy filling rate for firm and the probability of finding formal jobs for workers are time-invariant;
5. the number of workers flowing into industrial formal jobs matches the number of industrial formal jobs that are destroyed,

$$\begin{aligned}\widetilde{\phi} U = \delta N_h \int_{\ell_f \in \mathcal{L}} \int_{z\in\mathcal{Z}} \ell_f \psi(z, \ell_f) dz d\ell_f + \\ (1-\delta) N_h \int_{\ell_f \in \mathcal{L}} \int_{z\in\mathcal{Z}} (1 - \mathbf{1}^o(z, \ell_f)) \ell_f \psi(z, \ell_f) dz d\ell_f + \\ N_h \int_{\ell_f \in \mathcal{L}} \int_{z'\in\mathcal{Z}} \mathbf{1}^f(z', \ell_f)[\ell_f - L_f(z', \ell_f)] \widetilde{\psi}(z', \ell_f) dz' d\ell_f\end{aligned}$$

6. the measures over workers over services, informal employment and formal employment are constant over time

7. aggregate price indexes, aggregate income and profits, wages, interest rate and exchange rate are constant over time

B.7. Numerical Solution Algorithm

To characterize the dynamics of this economy outside the stationary equilibria, I assume the following timing. At time $t = 0$ the economy is in a stationary equilibrium with limited openness to trade. At $t = 1$ a trade reform is implemented. Workers cannot forecast the date of the reform, which takes the form of unexpected shock. I assume by the time $T > 1$ the transition towards the new steady state is complete. In the quantitative exercise (based on yearly time periods) I will impose $T = 50$. From period T onward, the economy converges to a new stationary equilibrium with a larger trade exposure. The trade shock consists of an exogenous and unexpected once-and-for-all increase in the revenue premium from exporting, $d_{f,t}, \forall t \geq 1$, led by either a drop in the iceberg costs, $\tau_{c,t}$ or by a drop the tariffs on imports, $\tau_{a,t}$, or both. Let $\{c_{f,t}, \underline{w}_t, b_t^u\}_{t=0}^T$ be an exogenous sequence of labor market policies. To solve for the full transition I assume the interest rate is exogenous and does not react to changes in home-policies, i.e. $r_t = r$, $\forall t = 0, 1, ...T$. The numerical strategy I adopt is therefore the following.

1. I first solve for the initial and the final stationary equilibria. (See Appendix 4 in Cosar, Guner and Tybout (2016)). To do so, I discretize the state space using a log-spaced grid of 300 points for employment in formal jobs, ℓ_f and a grid of 50 equally-distanced points for productivity, z. Once solved, I store equilibrium allocations and prices. In particular, I store:

    - the stationary probability distributions of firms over the state space (z, ℓ_f) at the end and the interim stage of the initial equilibrium, $\psi_0(z, \ell_f), \widetilde{\psi}_0(z, \ell_f)$, and the final equilibrium $\psi_T(z, \ell_f), \widetilde{\psi}_T(z, \ell_f)$
    - the initial mass of operative firms, $N_{h,0}$
    - the final steady-state value functions for the firms, $V_T(z, \ell_f)$, and the final steady-state value of being employed in a formal industrial job at the beginning of period T for the workers, $J_T^e(z, \ell_f)$
    - the initial and the final steady-state values for the equilibrium taxes on formal payroll, $\tau_{w,0}$ and $\tau_{w,T}$

2. I impose a path of foreign expenditure of domestic products, $d_{f,t}, \forall t = 1 : T - 1$, so to match the observed the revenue premium of exporters

3. I guess a path along the periods $t = 1 : T - 1$ for the following variables:

- probability of filling a vacancy, $\{\phi_t\}_{t=1}^{T-1}$, which determines a sequence of workers probability of finding a formal job, $\{\widetilde{\phi}_t\}_{t=1}^{T-1}$, through equation 16
- domestic sales, $\{D_{h,t}\}_{t=1}^{T-1}$
- wages of formal workers at hiring and firing firms, $\{w^{\text{h}}_{f,t}(z,\ell_f,\ell_i), w^{\text{f}}_{f,t}(z,\ell_f)\}_{t=1}^{T-1}$
- firm entry rate, $\{N_{e,t}\}_{t=1}^{T-1}$
- taxes on formal payroll, $\{\tau'_{w,t}\}_{t=1}^{T-1}$
  (only if $b^u_t > 0$, otherwise I fix $\tau_{w,t} = \tau_{w,0}$, $\forall t = 0, 1, ...$)

I will update these guesses until convergence so to be consistent with a number of equilibrium conditions. In the specific, along the transition path:

- guesses for domestic sales, $\{D_{h,t}\}_{t=1}^{T-1}$, are updated until convergence *period by period backward*, so to ensure that the firm entry condition holds at any t
- guesses for wages, $\{\{w^{\text{h}}_{f,t}(z,\ell_f,\ell_i), w^{\text{f}}_{f,t}(z,\ell_f)\}_{t=1}^{T-1}\}_{t=1}^{T-1}$, are updated until convergence *period by period backward*, using the closed form solutions available
- guesses for firm entry rates, $\{N_{e,t}\}_{t=1}^{T-1}$, are updated until convergence *period by period forward*, so to ensure that supply and demand are equal in the service sector at any period t
- guesses for the probability of filling a vacancy, $\{\phi_t\}_{t=1}^{T-1}$, are updated *after simulating forward*, to ensure equilibrium in the labor market of the industrial sector in any period t. New guesses are used to solve the problem backward again, until convergence.
- guesses for taxes on payroll, $\tau_{w,t}$, are updated *after simulating forward*, to ensure that unemployment benefits is fully self-financed and the government budget balances every period

4. Given the steady state value function at time T for the firm and the guesses of the above variables, I solve recursively the problem of the firm at time $T-1$:

$$V_{T-1}(z,\ell_f) = \max\left\{0, \frac{1-\delta}{1+r}\mathbf{E}_{z'|z}\max_{\{\ell'_f,\ell'_i\}}[\pi_{T-1}(z',\ell_f,\ell'_f,\ell'_i) - c_o + V_T(z',\ell'_f)]\right\}$$

where:

$$\pi_{T-1}(z',l,l') = R_{T-1}(z',\ell'_f,\ell'_i) - w_{i,T-1}\ell'_i - (1+\tau_{w,T-1})w^{\text{h}}_{f,T-1}(z',\ell'_f,\ell'_i)\ell'_f - C^h_{T-1}(\ell_f,\ell'_f)$$

if $\ell'_f > \ell_f$, or

$$R_{T-1}(z',\ell'_f,\ell'_i) - w_{i,T-1}\ell'_i - (1+\tau_{w,T-1})w^{\text{f}}_{f,T-1}(z',\ell'_f)\ell'_f - c_{f,T-1}(\ell_f - \ell'_f)$$

if $\ell'_f \leq \ell_f$. I store firms value function at time $T-1$, $V_{T-1}(z, \ell_f)$ and the associated policy functions for formal employment, $\ell'_f = L'_{f,T-1}(z, \ell_f)$, informal employment, $\ell'_i = L'_{i,T-1}(z, \ell_f)$, the optimal exit decision, $\mathbf{1}^o_{T-1}(z, \ell_f)$ and exporting decision, $\mathbf{1}^x_{T-1}(z', \ell'_f, \ell'_i)$.

5. Using the solution of the firm problem, I compute the expected value of entry at time $T-1$:

$$V^e_{T-1} = \int_{z \in \mathcal{Z}} \max_{\{\ell'_f, \ell'_i\}} [\pi_{T-1}(z, 1, \ell'_f, \ell'_i) - c_o + V_T(z, \ell'_f)] \psi_e(z) dz$$

where $\psi_e(z)$ is the ergodic distribution of productivity z, constant over time. To obtain domestic sales arising in equilibrium, I compare V^e_{T-1} with the cost of entry, $c_e \phi_t^{-\lambda_1}$. If $V^e_{T-1} > c_e \phi_t^{-\lambda_1}$, I decrease domestic sales $D_{h,T-1}$, otherwise I increase them. Therefore, I repeat this until convergence and I store the converged value, $D^*_{h,T-1}$

6. Using the final steady state value of being employed, $J^e_T(z', \ell'_f)$, and exploiting the equilibrium condition $J^u_t = J^s_t = J^i_t = J^o_t = 1/r \quad \forall t = 0, 1, ...T$, I update the wages for firing firms so to ensure formal workers with are indifferent between leaving and keeping their job, i.e. such that the interim value of leaving employment to search for a different job and the interim value of a match are equal:

$$w^{\mathrm{f}}_{f,T-1}(z', \ell'_f) = b + b^u_t + J^o_T - J^e_T(z', \ell'_f)$$

Thus I repeat this until convergence and I store the converged value for the firing wage, $w^{\mathrm{f}*}_{f,T-1}(z', \ell'_f)$.

7. Using the guesses for ϕ_{T-1} and the converged values for $D^*_{h,T-1}$ and $w^{\mathrm{f}*}_{f,T-1}(z', \ell'_f)$, I update wages for hiring firms using the closed form solution of the bargaining problem:

$$w^{\mathrm{h}}_{f,t}(z', \ell'_f, \ell'_i) = \frac{(1-\beta)}{1+\beta\tau_{w,t}}(b + b^u_t) + \frac{\beta}{1-\beta+\alpha_f\beta\Lambda(1+\tau_{w,t})} \frac{\partial R_t(z', \ell'_f, \ell'_i)}{\partial \ell'_f}$$

where $\Lambda = \frac{\alpha(\sigma-1)}{\sigma-(1-\alpha)(\sigma-1)}$. Thus I repeat until convergence and I store the converged value for the hiring wage, $w^{\mathrm{h}*}_{f,t}(z', \ell'_f, \ell'_i)$. I construct the final wage bill imposing a legal minimum wage, $\underline{w}_t$.

8. Given the final steady state value function for workers and guesses for the above variables, I solve recursively the problem of the workers. I use the final steady state value of being employed for the worker, $J^e_T(z', \ell'_f)$, and the converged value for wages of hiring firms, $w^{\mathrm{h}*}_{f,T-1}(z', L'_{f,T-1}(z, \ell_f), L'_{i,T-1}(z, \ell_f))$ to compute the interim value of being formally employed in a hiring firms:

$$J^{e,h}_{T-1}(z', \ell_f) = w^{\mathrm{h}*}_{f,T-1}(z', L'_{f,T-1}(z, \ell_f), L'_{i,T-1}(z, \ell_f)) + J^e_T(z', L'_{f,T-1}(z, \ell_f))$$

9. Using the firms policy functions obtained above, and the wage scheduled constructed above, I compute the workers value of being employed at the beginning of period $T-1$:

$$J^e_{T-1}(z,\ell_f) = \frac{1}{1+r}\Bigg((\delta + (1-\delta)(1-\mathbf{1}^o_{T-1}(z,\ell_f))J^u_{T-1} + ... \\ ... \quad (1-\delta)\mathbf{1}^o_{T-1}(z,\ell_f)\mathbf{E}_{z'|z}\max\left\{J^u_{T-1}, J^c_{T-1}(z',\ell_f)\right\}\Bigg)$$

and I store it.

10. Therefore I solve *backward* for all the periods $t = T-1, ..., 1$ along the transition path, e.g. I repeat steps 3-8 for all the periods backward. Using the policy functions obtained before and the guesses for the mass of entrants, $\{N_{e,t}\}_{t=1}^{T-1}$, I simulate the economy for T periods *forward*, using $\psi_0(z,\ell_f), \widetilde{\psi}_0(z,\ell_f)$ as initial distributions for the end and the interim states.

11. I update guesses for the mass of entrants, $N_{e,t}$ as follow:

- given $\psi_{t-1}(z,\ell_f), \widetilde{\psi}_{t-1}(z,\ell_f)$, the policy function for exit, $\mathbf{1}^o_t(z,\ell_f)$, the guessed mass of entrants, $N_{e,t}$, and the total mass of firms at time $t-1$, $N_{h,t-1}$, I compute $\psi_t(z,\ell_f), \widetilde{\psi}_t(z,\ell_f)$, the probability distributions over (z,ℓ_f) at the end and interim stage in period t.
- I use the guess for ϕ_t to compute formal vacancies at time t:

$$v_t(z',\ell_f) = \mathbf{1}^h_t(z',\ell_f)\frac{(L_{f,t}(z',\ell_f) - \ell_f)}{\phi_t}$$

- I use $\widetilde{\psi}_t(z,\ell_f)$ to compute the average number of vacancies $\bar{v}_t$, the average formal employment $\bar{\ell}_{f_t}$ and the average informal employment, $\bar{\ell}_{it}$ in period t:

$$\bar{v}_t = \int_{\ell_f\in\mathcal{L}}\int_{z'\in\mathcal{Z}} v_t(z',\ell_f)\widetilde{\psi}_t(z',\ell_f)dz'd\ell_f$$
$$\bar{\ell}_{ft} = \int_{\ell_f\in\mathcal{L}}\int_{z'\in\mathcal{Z}} L_{f,t}(z',\ell_f)\widetilde{\psi}_t(z',\ell_f)dz'd\ell_f$$
$$\bar{\ell}_{it} = \int_{\ell_f\in\mathcal{L}}\int_{z'\in\mathcal{Z}} L_{i,t}(z',\ell_f)\widetilde{\psi}_t(z',\ell_f)dz'd\ell_f$$

- Using $\psi_t(z,\ell_f)$ and the exit policy function, $\mathbf{1}^o_t(z,\ell_f)$, I compute the exit rate at time t, μ^{exit}_t, using equation (89).
- Given the initial guess for the measure of entrant firm, $N_{e,t}$, the exit rate, μ^{exit}_t, and the previous period mass of firms, $N_{h,t-1}$, I compute the mass of operative firms at time t using equation (88).

- Given the initial guess for the measure of entrant firm, $N_{e,t}$, the mass of operative firms, $N_{e,t}$, and the guess for the job finding probability, $\widetilde{\psi}_t(z, \ell_f)$, I compute the distribution of vacancies in the interim stage, $g_t(z', \ell_f)$.
- Given $g_t(z', \ell_f)$, I use $J^e_{h,t}(z', \ell_f)$ to compute the expected value of a match in the interim stage, $\mathbf{E}_t J^e_{h,t}(z', \ell_f)$.
- Given $N_{h,t}, N_{e,t}, \bar{v}_t$, the guess for ϕ_t and $v^e_t = 1/\phi_t$ (equilibrium vacancies posted by entrant firms), I compute the unique measure of workers searching for a formal job in the industrial sector at time t, U_t from the following equation:

$$\phi_t = \frac{U_t}{[(N_{h,t}\bar{v}_t + N_{e,t}v^e_t)^\theta + U^\theta_t]^{\frac{1}{\theta}}}$$

- given U_t and $\widetilde{\phi}_t$, I compute the mass of unemployed workers who fail to find a job in the industrial sector, $L_{u,t} = (1 - \widetilde{\phi}_t)U_t$
- given $\bar{\ell}_{f_t}$ and $\bar{\ell}_{it}$, I compute the mass of workers who are employed in the service sector, $L_{s,t} = 1 - L_{u,t} - L_{i,t} - L_{f,t}$, where $L_{f,t} = \bar{\ell}_{f_t} N_{h,t}$ and $L_{i,t} = \bar{\ell}_{it} N_{h,t}$
- with $N_{h,t}, N_{e,t}, L_{u,t}, L_{s,t}$ and $L_{i,t}$ I compute aggregate income I_t at time t, and I check if supply and demand are equal in the service sector. If not, I update the initial guess for $N_{e,t}$.
- I iterate until convergence and I store the converged value for entry rate, $N^*_{e,t}$.
- Finally, I compute J^u_t through the following formula:

$$J^u_t = \widetilde{\phi}_t \mathbf{E} J^e_{h,t} + (1 - \widetilde{\phi}_t)\left(b + b^u_t + \frac{1}{r}\right)$$

  If $J^u_t > 1/r_t$, I assign a lower value to new guess of the probability of filling a vacancy at time t, otherwise, I increase it. Thus I store the new path of guesses, $\{\phi_t\}^{T-1}_{t=1}$.
- I update $\tau_{w,t}$ such that

$$\tau'_{w,t} N_{h,t} \overline{w}_{f,t} = b^u_t L_{u,t}$$

12. I use the new path of guesses for $\{\phi_t\}^{T-1}_{t=1}$ and $\{\tau_{w,t}\}^{T-1}_{t=1}$ to solve again the recursive problem backward and I iterate until convergence.

13. Once convergence is achieved, I compute the aggregate export revenues using the firm policy functions and the equilibrium firm distribution and I use the equilibrium condition in the foreign market to back up the unique sequence of exchange rates, $\{k_t\}^{T-1}_{t=1}$ that ensures trade balance (total exports equal to total imports), for an exogenous values for the iceberg costs and the tariffs.

Appendix C. Details on Estimation

C.1. External Parameters

In the calibration exercise, a number of parameters are taken from external sources. Among those, the discount rate, r, the service share in output, γ and the average wage in the service sector used as numeraire, w_s are constructed as follows.

Interest Rate. The interest rate for Mexico is taken from Riaño (2011). It corresponds to the average real interest rate for the period 1982-2006 based *Certificados de la Tesoreria de la Federazione a 28 dias*, CETES bonds. The interest rate for Colombia is taken from the IFS dataset and it corresponds to real average lending rate, defined as the bank rate net of inflation that usually meets the short- and medium-term financing needs of the private sector, for the period 1986-2010. Ruhl and Willis (2017) report similar value, equal to 10.9% for the period 1980-2005.

Service Share. For both countries, the service share in output is taken from national accounts information available at http://estadisticas.cepal.org/cepalstat.

Average Service Wage. The average wage in the service sector is constructed as follow. I first construct an estimate for the average manufacturing wage of both countries in the pre-liberalization period. For Colombia, I take the nominal weekly wage in the manufacturing sector for the period 1984-1990 reported in Attanasio, Goldberg and Pavcnik (2002) and express it in annual term (assuming 48 working weeks a year). I convert this value from national currency (pesos) into USD using the observed exchange rate (available at FRED dataset), and express it in real terms (2012 constant price) using the producer price index for all commodities (available at FRED). For Mexico, I take the nominal daily wage in the manufacturing sector for 1982 reported in Boltvinik (2000), "Nada que festejar", published in Jornada, available at http://www.jornada.unam.mx/2000/05/05/boltvinik.html and express it in annual term (assuming 264 working days a year). I convert this value from national currency (pesos) into USD using the exchange rate reported in Tailor (1995), "Peso's Plummeting Past", available at http://timothytaylor.net/1995/031695.htm and express it in real terms (2012 constant price) using the producer price index for all commodities (available at FRED). Finally, I convert the average real wage in the manufacturing sector into average real wage in the service sector using a ratio between the two equal to 1.20:1 in Colombia (Cosar, Guner and Tybout, 2016) and to 1.03:1 (Marcouiller, Ruiz de Castilla and Woodruff, 1997) in Mexico.

C.2. Data Description

The Colombian data is obtained from the Annual Manufactuer Survey (*Encuesta Anual Manufacturera*, EAM) run by the National Administrative Department of Statistics (*Departamento Administrativo Nacional de Estadistica*, DANE) and covers the universe of manufacturing plants with more than 10 employees, along the period 1981-1991. The Mexican data is obtained from the Annual Industrial Survey (*Encuesta Industrial Anual*, EIA) run by the Mexican National Institute of Statistics, Geography and Information (*Institudo Nacional de Estadistica, Geografia e Informacion*, INEGI), and covers a sample of 3200 firms for the period 1984-1987. Although the Mexican data reports firm-level data, I use the term "plant" to describe a unit of observation. In both data, firms are required to report the number of formal employees, which is used as measure of size in the estimation. The data provide with further information about annual domestic and foreign sales, employment compensation (inclusive of salaries and other benefits), and cost of material and other intermediate inputs. Total sales is constructed by summing domestic and foreign sales plus the change in inventories. Nominal variables are cleaned and deflated as in Roberts and Tybout (1996).[51] Each firm-year observation is classified as exporter if the firm exports a positive share of their output. For Mexico, information on exports is available starting from 1986, and entry and exit of firms cannot be observed.

C.3. Estimation Algorithm

To estimate the model, I assume the economy is in the autarkic steady state. Thereafter, I can drop the time index, t. During the estimation, I treat the aggregate domestic expenditure, D_h, as a parameter to estimate. This is not the case when I compute the equilibrium of the model (see section on solution algorithm), in which case D_h is endogenously determined by the free entry condition. Moreover, since no unemployment benefits were available in either countries during the '80s, b^u is set equal to zero, and the payroll tax, τ_w, is kept equal to the observed value (see Table 5 in the main text). This is not the case when I compute the equilibrium under the counterfactual scenario of a positive benefit, $b^u > 0$, in which case τ_w is endogenously determined to balance the government budget constraint. Given these assumptions, the estimation algorithm goes as follow.

1. I propose a guess for the following parameters: $\vartheta_0 = \{c_o^0, c_x^0, c_h^0, \lambda_1^0, \lambda_2^0, \rho_z^0, \sigma_z^0, \alpha_f^0, \delta^0, b^0, D_h^0\}$. Notice that no guess for the entry cost, c_e, is proposed.

2. Given the guess, I solve for the equilibrium. To do so,

[51] See the section "Appendix: Data Preparation" in Clerides, Lach and Tybout (1998) for a comprehensive description of the data cleaning.

2.1. I guess a value for job finding probability in the formal labor market, ϕ.

i. I guess the wage schedule for formal workers, $w_f(z, \ell_f, \ell_i)$.

A. I solve the dynamic problem of the firms, given by equation (27) of the main text. I store value functions and policy functions.

B. I compute the firm entry value, V^e using equation (31) in the main text, and I set the entry cost, $c_e = V^e$.

C. If $c_e < 0$, I discard the initial parameter guess, and I go back to step 1.

ii. If $c_e > 0$, I update the wage equation. To do so, I first solve the dynamic problem the workers, given by equation (38) in the main text and I store the value functions and policy functions. Therefore, I use workers value function, firms policy functions and the solution to the bargaining problem given in equations (43) and (43) in the main text to construct a new wage schedule. I go back to step 2.1.i.A. till convergence. I store the wage function.

2.2. If convergence is achieved, I update the job filling probability. To do so, I construct the stationary probability distributions of firms over the state space (z, ℓ_f) at the end and the interim stage of the period, $\psi(z', \ell_f)$, and $\psi(z', \ell'_f)$. I use them to construct the distribution of vacancies for formal jobs at interim stage of the period, $g(z', \ell_f)$, and, in turn, to compute the expected value of being employed in the formal industrial sector, $\mathbf{E}J^{e,h}$ (equation 36 in the main text) and the value of searching for a formal job, J^u (equation 35 in the main text). Therefore, I use the no-arbitrage condition between sectors to obtain a new guess for ϕ, as in step 11 of the solution algorithm. I go back to step 2.1.i. till convergence. I store the job filling rate.

3. Once convergence is achieved and an equilibrium for the economy is found, I use the equilibrium policy functions, wage schedule and job filling rate to simulate a large pool of firms for a large number of periods. I discard the first T periods of the simulation to remove the dependence from the initial conditions, and I use the remaining periods to construct the vector of firm-level simulated moments, $m(\vartheta_0)$, listed in Table 6 in the main text.

4. I use simulated moments, $m(\vartheta_0)$ and the respective sample statistics $\overline{m}$, to evaluate the fit of the model under the initial guess. To do so, I compute the objective function in equation (52) at ϑ_0, i.e. $\overline{m}(\vartheta_0)'\hat{\Sigma}\overline{m}(\vartheta_0)$, where $\overline{m}(\vartheta_0) = m(\vartheta_0) - \overline{m}$, whereas $\hat{\Sigma}$ is a bootstrapped estimate for the inverse of the variance-covariance matrix of the moment conditions, $[var(\overline{m})]^{-1}$. I store $\overline{m}(\vartheta_0)'\hat{\Sigma}\overline{m}(\vartheta_0)$ and I go back to step 1.

I search and selected new guesses over the parametric space Θ using a genetic algorithm.

Appendix D. Additional tables and figures

Table 18 reports a list of additional statistics for the autarkic steady state under the baseline estimation.

Table 18: **Additional statistics**

		COLOMBIA	**MEXICO**
Variables	Symbols	Value	Value
Industrial price	P_t	5.6265	3.5299
Exchange rate	k_t	2.4244	1.7378
Searchers, industry	U_t	0.0899	0.0569
Job filling rate, industry	ϕ_t	0.9684	0.9578
Job finding rate , industry	$\tilde{\phi}_t$	0.2117	0.2469
Market tightness	v_t/U_t	0.2186	0.2578
Domestic firms	$N_{h,t}$	0.0050	0.0051
Domestic expenditure	$D_{h,t}$	4946.5	424.39
Income x capita	I_t	1.0670	1.1603
Profit/Income	Π_t/I_t	0.2192	0.1337

Note: This table reports a list of endogenous outcomes predicted by the model in the initial steady-state.