Labor Market Regulations and the Sectoral Reallocation of Workers: The Case of Trade Reforms*

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July 9, 2008.

Abstract

In this paper I highlight the importance of incorporating the institutional features of local labor markets into the analysis of trade reforms. A trade reform is often deemed beneficial because the elimination of trade barriers allows labor to reallocate toward those sectors in the economy in which the country has a comparative advantage. The amount and speed of the reallocation, however, and the post-reform behavior of output, productivity and welfare, will depend on how regulated the labor market is. First, I document that high firing costs slow down the intersectoral reallocation of labor after a trade reform. Second, in order to isolate the effect of firing costs on labor reallocation, output, and welfare after a trade reform, I build a dynamic general equilibrium model. I find that if a country does not liberalize its labor market at the outset of its trade reform, the intersectoral reallocation of workers will be 30% slower and as much as 30% of the gains in real output and labor productivity in the years following the trade reform will be lost. From a policy standpoint, the message is that while trade reforms are desirable they need to be complemented by labor market reforms in order to be fully successful.

JEL Classification: E24, F16, J24, J65, O54.

Keywords: Firing costs, sectoral labor reallocation, trade reforms, human capital.

*I am grateful to Andrés Erosa, Berthold Herrendorf, Tim Kehoe, Igor Livshits, Jim MacGee, Iourii Manovskii, Miana Plesca, Ed Prescott, Diego Restuccia, Richard Rogerson, Gustavo Ventura, Marcelo Veracierto, Gianluca Violante, two anonymous referees, and the editor (Kjetil Storesletten) for helpful discussions and suggestions. I have also benefited from comments by seminar participants at the 2003 CEA Meeting, the 2004 SED Meeting, Arizona State, Bank of Canada, Guelph, Montreal, Queen's, Toronto, Victoria, and Western Ontario. All errors are mine.

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1 Introduction

A large literature has studied the effects of trade reforms on output, productivity, and welfare. In this paper I argue that in order to fully understand the effects of trade reforms we need to incorporate the institutional features of local labor markets into our analysis. A trade reform is often deemed beneficial because the elimination of trade barriers allows labor to reallocate toward those sectors in the economy in which the country has a comparative advantage and thus increase output, productivity, and welfare. The amount and speed of the reallocation, however, will depend on the particular characteristics of the labor market − a flexible labor market will facilitate the required reallocation of labor while a highly regulated labor market will slow it down. Studying the relationship between trade reforms and labor market regulations is a particularly relevant question in view of the fact that most of the recent trade reforms were implemented in highly regulated labor markets.[1]

This paper makes two significant contributions to our understanding of the effect of labor market regulations on the effectiveness of trade reforms. First, I document that in the presence of regulated labor markets with high firing costs the intersectoral reallocation of labor after a trade reform is slowed down. The empirical analysis shows that countries that liberalize trade in a rigid labor market environment − such as Mexico − face a prolonged period of labor reallocation across sectors. Countries which liberalize trade in a flexible labor market environment, however, − such as Chile − experience a quick and substantial reallocation of labor across sectors. Second, in order to isolate and quantify the effect of labor market regulations on the intersectoral reallocation of labor, output, and welfare after a trade reform, I build a dynamic general equilibrium model. I find that if a country does not liberalize its labor market at the outset of its trade reform, then the intersectoral reallocation of workers will be significantly slower, and a substantial fraction of the gains in real output and labor productivity in the years following the trade reform will be lost. From a policy standpoint, these results imply that while trade reforms are desirable they

[1] For instance, various Latin American countries implemented trade reforms in the late 1980s and early 1990s. As Heckman and Pagés (2000) document, firing costs in Latin America are extremely high. Further, the IADB (1997) and Lora (1997) construct an index of structural reforms in Latin America and argue that while in the period from 1985 to 1995 the Latin American countries implemented significant trade reforms, the labor markets remained highly regulated and virtually unchanged.

need to be complemented by labor market reforms in order to be fully successful.

I build a dynamic general equilibrium sectoral model of a small open economy with sector-specific human capital, firing costs, and tariffs. The model economy consists of a continuum of sectors each producing a good that is part of a composite consumption good. These sectors are heterogeneous with respect to their productivity − those which are more productive attract workers from other sectors and are net exporters in the economy while the sectors which are less productive are net importers. In addition to these purely technological differences, sectors also differ with respect to their tariff protection. Policy makers usually implement import substitution policies, in an attempt to protect the less productive sectors in an economy, by imposing tariffs on similar foreign goods. As a result, they create a protected and an unprotected group of sectors in the economy. In order to capture this sectoral heterogeneity in terms of tariff protection, I separate all sectors in the economy into two groups, referred to as clusters, and model the sectors in one of the clusters as being on average less productive and with a higher tariff protection than the sectors in the other cluster. In addition, all sectors face uncertainty as they experience idiosyncratic productivity shocks every period. I model firing costs as a tax that firms have to pay whenever they decrease their employment level. In this case, the existence of uncertainty is necessary in order to capture the effect of firing costs not only on firms' firing decisions but also on their hiring decisions. Workers accumulate human capital by working in a given sector. Human capital is, however, sector-specific and is lost upon a sectoral switch. Modeling human capital explicitly is necessitated by the fact that even in the absence of any labor market regulations the sectoral reallocation of labor could be slow after trade reforms if workers have accumulated significant levels of human capital in their sectors.[2]

In the main analysis in the paper, I calibrate the model to Chile. In the early 1970s Chile was a closed economy with high tariffs and high firing costs. In 1974, Chile implemented a far-reaching trade reform accompanied by a labor market reform which drastically reduced

[2]Albuquerque and Rebelo (2000) build a model of industrial inertia in order to study the observed persistence in a country's industrial configuration after trade reforms. Their paper differs from this one in two important dimensions. First, they focus and base their argument on irreversible capital investment rather than the features of the labor market. Second, their approach is theoretical and provides qualitative results while this paper quantitatively studies the importance of labor market regulations.

the level of firing costs in the country. I carry out a quantitative analysis which studies the behavior of the economy under two scenarios. First, I perform an experiment in which both tariffs and firing costs are eliminated. Second, a trade reform is implemented by eliminating tariffs but the high firing costs are kept in place. In both cases I solve for the full transition path toward the new steady state. I find that if Chile did not liberalize its labor market at the outset of its trade reform, then the intersectoral reallocation of workers would have been 30% slower and as much as 30% of the gains in real output and labor productivity in the years following the trade reform would have been lost.

I also use the model to study the effect of labor market regulations on the performance of the Mexican economy after its trade reform in 1986. Mexico's trade and labor market distortions were quantitatively different from those in Chile, its trade reform was more gradual, and Mexico implemented a trade reform without liberalizing the labor market. The model analysis, which incorporates all of these specific to the Mexican liberalization episode features, isolates the extent to which firing costs, rather than any of the other features, led to a smaller post-reform intersectoral reallocation of workers in Mexico. The analysis shows that the observed reallocation of workers would have been substantially higher if Mexico had eliminated the labor market restrictions at the outset of its trade reform. Furthermore, the foregone benefits of not liberalizing the labor market are quantitatively substantial − in terms of the present discounted value of real output and real output per worker Mexico lost 30% and 39% of the benefits from its trade liberalization reform.

Firing costs impede gains from trade in two significant ways. First, firms do not fire the optimal amount of workers because of the high firing costs. Second, the existence of firing costs makes firms cautious in hiring new workers since in the event of a bad productivity shock in the future, a decision to adjust their labor force would involve paying firing costs. If firing costs are eliminated at the beginning of the trade reform, then output, employment, and productivity will decline for a short period of time as a large number of workers reallocate toward the more productive sectors, and in the process destroy the experience they accumulated in their old sectors. Output, employment, and productivity, however, will pick up quickly as more and more workers successfully reallocate and build their human capital in the new sectors of employment. In the presence of firing costs, on the other hand, the effects of a trade reform will be different. While output, employment, and productivity may not decline significantly, the economy will nevertheless stagnate for a long period of time. First, not enough workers will reallocate toward the new sectors that have a comparative advantage after the trade reform has been implemented. Second, even though some of the workers will preserve their human capital by staying in their old sectors, they will miss the opportunity of building human capital in the new more productive sectors.

This paper also contributes to the literature on firing costs by studying and quantifying the effects of firing costs on the performance of an economy that undergoes a significant structural change − a trade reform in this particular case. The main focus in the literature so far has been on understanding the effect of firing costs on the performance of the US and European labor markets, and the extent to which firing costs can account for the observed large differences in unemployment rates and durations. Empirical work on the OECD countries by Lazear (1990) and Di Tella and MacCulloch (2005) shows that higher firing costs increase employment durations and unemployment durations, decrease employment and labor force participation, and have an ambiguous effect on unemployment. Heckman and Pagés (2000), who use a cross-country time-series data on firing costs in the OECD countries and countries in Latin America and the Caribbean, report similar findings. Models by Bentolila and Bertola (1990), Hopenhayn and Rogerson (1993), and Alvarez and Veracierto (1999) provide theoretical frameworks for studying and explaining the observed effects of firing costs. This paper, however, is a first attempt at analyzing the effects of firing costs on the performance of an economy that is subject to a large structural shock.[3]

The remainder of the paper is organized as follows. Section 2 documents the empirical facts motivating this paper. I describe the model and define its equilibrium in Sections 3 and 4, respectively. The calibration of the model to the Chilean trade reform, the results, and the sensitivity analysis are presented in Sections 5 and 6. The calibration of the model to the Mexican trade reform is presented in Section 7 while Section 8 concludes.

[3] Veracierto (2008) studies the effect of firing costs on an economy which is subjected to business cycle technological shocks.

2 Empirical Facts

This section presents the empirical background of the paper. First, I show that numerous countries have implemented trade reforms in the presence of rigid labor markets. Second, I document that the sectoral reallocation of labor after a trade reform is much faster in the absence of labor market regulations.

2.1 Trade Liberalization

Between 1986 and 1995 most Latin American countries implemented far-reaching trade reforms. The 1997 Inter-American Development Bank (IADB) Report notes that the average tariffs declined from 42% in 1986 to 14% in 1995, the average tariff dispersion declined from 24% down to 5%, and maximum tariffs were lowered from an average of 84% to 41%. In addition, nontariff restrictions which affected 38% of imports in the pre-reform period covered only 6% of imports in 1995.[4] Table 1 reports the reduction in tariff protection during this period for a number of countries in the region.[5]

2.2 Firing Costs

The trade reforms in Latin America were implemented in highly regulated and rigid labor markets. In particular, firing costs in Latin America were among the highest in the world. Firing costs impede firm's ability to fire workers and usually fall into one of the following categories: 1) advance notification costs; 2) compensation for dismissal; 3) seniority premiums for dismissed workers; 4) foregone wages during any trial in which the worker contests dismissal; and 5) specific regulations that govern collective dismissals.

Table 2 reports the level of firing costs for a set of Latin American countries. The firing costs for employees with one year of service averaged two months of wages, ranging from one month of wages in Uruguay to four months of wages in Mexico. The firing costs for employees with ten years of service averaged eleven months of wages, ranging from five in

[4]See also Edwards (1994) for a comprehensive overview of the trade liberalization reforms in Latin America.

[5]While many of the Latin American countries liberalized trade in the late 1980s, a few countries liberalized earlier. Chile's major trade reform started in 1974. Argentina initiated a trade liberalization reform in 1976, which however was reversed in 1982, and a new trade reform in 1991. Bolivia's trade reform started in 1986.

Brazil to twenty-three in Venezuela.

Heckman and Pagés (2000) compute a cardinal index of the level of firing costs for most of the industrialized and Latin American countries. This job security index measures the expected discounted cost in multiples of monthly wages at the time a worker is hired, of dismissing that worker in the future. Table 3 reproduces their main finding – firing costs are substantially higher in Latin America than in most industrialized countries. For instance, the level of firing costs in Argentina, Mexico, and Colombia is almost three times higher than those in Germany and France – two European countries that are generally considered to have highly regulated labor markets. Even though Heckman and Pagés (2000) measure their index at the end of the 1990s, evidence from Lora (1997) suggests that the labor markets in Latin America changed very little in the 1980-2000 period – the level of rigidity that we observe at the end of the 1990s was not much different than the one in the 1980s. In particular, Lora (1997) constructs indices of the reforms in Latin America. The index on trade liberalization increased by 80% between 1985 and 1995 indicating a substantial trade opening of the Latin American economies. The index on labor market reforms for the same period increased by only 5% indicating that the labor markets remained highly regulated and virtually unchanged.[6]

One major exception is Chile. Pagés and Montenegro (1999) and Edwards and Edwards (2000) compute the job security index for Chile for the 1960-1997 period and show that at the start of the trade reform in 1974 it declined dramatically from 4.2 down to 1.2. Therefore, Chile emerges as a Latin American country which implemented a trade liberalization reform in the presence of deregulated and flexible labor markets.

2.3 The Intersectoral Reallocation of Labor

The United Nations Industrial Organization (UNIDO) 3-digit dataset provides data on the number of workers employed in 28 sectors in manufacturing for various countries.[7,8]

[6]See also the IADB (1997).

[7]Nicita and Olarreaga (2001) provide a detailed description of this dataset.

[8]The nature of the UNIDO dataset requires us to restrict the analysis in this section to manufacturing only. However, this is not a serious drawback since most of the distortions caused by trade restrictions affect mainly the manufacturing sector and that is where we should observe the main resource reallocation after a trade reform. Further, the manufacturing sector in the developed and the Latin American countries accounts for around 85% of all exports.

As Wacziarg and Wallack (2004) point out, there are 20 countries in the dataset with a trade liberalization episode. Heckman and Pagés (2000) and Edwards and Edwards (2000) provide information of the level of firing costs for 11 of these countries − New Zealand, Chile, Poland, Uruguay, Argentina, Mexico, Spain, Colombia, Turkey, Ecuador, and Bolivia. Table 4 lists, for each of these countries, the years for which sectoral employment data is available in the UNIDO dataset, the trade liberalization dates for these countries as reported in Wacziarg and Wallack (2004), and the job security index during the five years following the trade liberalization reform.

2.3.1 The Annual Intersectoral Reallocation Index

In order to study the degree of sectoral reallocation of workers after trade reforms, I construct the following index. Denote by H_t^s the amount of labor employed in sector s in period t as a fraction of all employed workers in manufacturing. Then

$$C_t^s = |H_t^s - H_{t-1}^s| \tag{1}$$

measures the absolute change in the share of sector s in year t as compared to year $t-1$. The annual intersectoral reallocation index in year t, I_t^a, is defined as

$$I_t^a = \frac{1}{2}\sum_{s=1}^{S} C_t^s \tag{2}$$

and measures the fraction of workers who in year t are working in a different sector than in year $t-1$. Figure 1 shows the annual sectoral reallocation index for all countries in the sample. The countries are ordered according to the level of their firing costs in the years following the trade liberalization reform − New Zealand is the country with the lowest level of firing costs while Bolivia is the country with the highest. The trade liberalization date (next to the country's name) is taken from Wacziarg and Wallack (2004). The figure indicates that countries with low firing costs − such as New Zealand, Chile, and, to some extent, Poland − experience an increase in the sectoral reallocation of workers in the years following their trade reforms. The rest of the countries have much higher levels of firing costs and do not exhibit any significant changes in their sectoral reallocation of workers around the time of their trade reforms. In order to explore the data in a systematic way, I use the following regression:

$$I^a_{i,t} = \beta_0 + \beta_1 Z_i + \beta_2 D_{i,t} + \beta_3 D_{i,t} * FC_i, \tag{3}$$

where $I^a_{i,t}$ is the annual intersectoral reallocation index for country i in year t, Z_i is a dummy variable for country i, $D_{i,t}$ is a variable which takes the value of 1 in each of the five years following the trade liberalization reform of country i and 0 otherwise, and FC_i is the job security index for country i during the five years after its trade reform. The country dummy variable Z_i captures the usual level of sectoral reallocation in country i. The variable $D_{i,t}$ and its interaction with the firing cost variable FC_i capture whether the sectoral reallocation of workers differs after a trade reform from the usual pattern observed for each particular country and whether this difference is systematically related to the level of job security in those countries.[9] For example, a positive coefficient β_2 and a negative coefficient β_3 would indicate that the sectoral reallocation of workers increases after a trade reform and that this increase is more pronounced for countries with lower firing costs.[10]

Table 5 presents the results. The main finding is that there is a significant increase in the sectoral reallocation of workers in the years following a trade reform − the β_2 coefficient is positive and statistically significant at the 1% level. However, this increase is observed only in the countries with a low level of firing costs − New Zealand, Chile, Poland, and, to some extent, Uruguay. The negative coefficient β_3 indicates that the rest of the countries have a level of firing costs which is high enough to eliminate any possible increase in the sectoral reallocation of workers after a trade reform. In particular, the increase in the reallocation index during the five years following the trade reform, as compared to a country's normal level of the reallocation index, equals $\beta_2 + \beta_3 * FC$. Chile's index, for instance, increases by 0.013 ($= 0.0197 - 0.0057 * 1.2$) over its normal level of 0.03. Mexico's index, on the other hand, increases only by 0.002 ($= 0.0197 - 0.0057 * 3.13$) over its normal level of 0.02.

Appendix I provides a detailed description of the data used in the analysis and a comprehensive sensitivity analysis with respect to, among other things, (i) the countries used

[9]There is almost no variation in the firing cost variable for a country over time. Therefore, we do not need to include it as a separate control in the regression − all the cross-sectional differences are captured by the country dummy variables Z_i.

[10]The results are similar when I include for each country a separate dummy for the years which follow after the five post-reform years.

in the analysis, (ii) different definitions of the annual intersectoral reallocation index, (iii) different number of years considered after a trade reform, and (iv) alternative trade liberalization dates. In all of these specifications the main result remains unchanged − the sectoral reallocation of workers increases after a trade reform but only in the countries with a low level of firing costs.[11]

In an important study, Wacziarg and Wallack (2004) − using similar empirical specifications and the UNIDO and the International Labor Organization (ILO) datasets − find that there is no increase in the sectoral reallocation of labor after a trade reform. This is not surprising given that most of the countries in the sample liberalized trade in the presence of highly regulated labor markets. Wacziarg and Wallack (2004) provide a robust sensitivity analysis of their results with respect to the extent to which trade reforms were expected, the endogeneity of trade reforms, barriers to factor mobilty, and the simultaneous implementation of other counteractive government policies. In order to investigate the importance of firing costs they divide the sample of countries into two groups − those with a job security index below the average and those above the average. The results indicate that in both groups there is no statistically significant increase in the sectoral reallocation of workers after a trade reform.

In my empirical analysis of the effect of firing costs I go one step further and exploit all the information coming from the variation in the level of firing costs in these countries. Table 4 and Figure 1 suggest that even within the sample of low firing cost countries there is significant heterogeneity in terms of firing costs and worker reallocation − the countries with lower firing costs (New Zealand and Chile) have a higher sectoral reallocation after their trade reforms than the countries with a higher level of firing costs (Poland and Uruguay). As a result, the quantitatively small increase in the reallocation of workers after the trade reforms in Poland and Uruguay might offset to some extent the larger increases observed in New Zealand and Chile. Indeed, on a sample similar to the one in Wacziarg

[11] One could expect that the effect of trade liberalization on the sectoral reallocation is smaller in larger economies, as there is more scope in smaller countries to become specialized in just a few sectors. If in the regression, instead of the level of firing costs, I use an interaction with the number of workers employed in the manufacturing sector around the time of the trade reform, the β_3 coefficient is close to zero and statistically insignificant, indicating that size has no effect on the sectoral reallocation of workers after a trade reform.

and Wallack (2004), if instead of the flexible firing cost measure I use a dummy variable indicating whether a country is a high or a low firing cost country, I find no statistically significant increase in the sectoral reallocation of workers after a trade reform in both groups.[12] This indicates that exploiting the variation in the level of firing costs provides important additional information.

2.3.2 Chile and Mexico

Figure 2 provides a concrete illustration of the above analysis by plotting the reallocation index for two Latin American countries with different levels of firing costs − Chile and Mexico. While Chile implemented its trade reform in an environment with low firing costs, Mexico liberalized trade in the presence of high firing costs. The facts on the sectoral reallocation of workers in these two countries are also important in view of the fact that the model will be used to study the post-reform performance of both these countries.

The annual reallocation index shows that there is very little increase in the sectoral reallocation in Mexico after its trade reform while the amount of reallocation in Chile is considerable. I also plot a cumulative version of the annual intersectoral reallocation index which measures the fraction of workers who in year t are working in a different sector than in a base year.[13] In this case I choose as a base year the year immediately before the trade reform.[14] The cumulative index also shows that while Mexico did not experience a large increase in the sectoral reallocation of labor during its post-reform years, the amount of reallocation in Chile was quite substantial − seven years into the reform 16% of its workers were employed in a different sector than before the reform as compared to 8% of the workers in Mexico.[15]

[12]See Appendix I.

[13]Denote by H_t^s the amount of labor employed in sector s in period t as a fraction of all employed workers in manufacturing. Then $B_t^s = |H_t^s - H_{base\ year}^s|$ measures the absolute change in the share of sector s in year t as compared to some base year. The cumulative intersectoral reallocation index in year t, I_t^c, is defined as $I_t^c = \frac{1}{2}\sum_{s=1}^{S} B_t^s$.

[14]Sachs and Warner (1995) report 1986 as the trade liberalization date for Mexico while Wacziarg and Wallack (2004) report 1987. While the trade liberalization in Chile started in 1974, the UNIDO dataset starts in 1976 and we are restricted to using 1976 as the base year for Chile.

[15]The results for Chile are not driven by a declining manufacturing sector in terms of employment and value added. First, in the UNIDO dataset the number of workers employed in Chilean manufacturing in 1980 was approximately the same as that in 1976. Second, Alvarez and Fuentes (2003) report that the share of manufacturing in GDP was 17% in the early 1970s and 15.4% in the 1975-1985 period. Therefore, the increase in the index indeed indicates that some sectors (such as food products, beverages, and wood

Therefore, the picture that emerges from the empirical analysis is that a country that liberalizes trade in a rigid labor market environment − such as Mexico − faces a prolonged period of labor reallocation across sectors. A country which liberalizes trade in a flexible labor market environment, however, − such as Chile − experiences a quick and substantial reallocation of labor across sectors. Given the high degree of rigidness of labor markets in most of the countries that implemented trade reforms, it is not surprising that when studying major trade reforms in the 1970-2000 period Papageorgiou, Michaely, and Choksy (1991) and Wacziarg and Wallack (2004) find surprisingly little intersectoral reallocation of labor after the reforms.[16]

The evidence presented above, while strong, may not be conclusive since the countries studied might differ in many other dimensions − for example, there might have been other reforms that accompanied the trade reforms, or various other shocks might account for the different patterns of the observed labor reallocation. To further assess the impact of labor market regulations I build a quantitative general equilibrium model which allows us to isolate the effect that labor market regulations have on the intersectoral reallocation of labor after trade reforms.

3 The Model

I build a sectoral model of a small open economy with sector-specific human capital, firing costs, and tariffs. The model is a small open economy version of the island-economy models previously studied by Lucas and Prescott (1974), Alvarez and Veracierto (2000), and Kambourov and Manovskii (2008a).

products) have expanded in the 1976-1982 period while others (such as textiles, electric machinery, and transport equipment) have contracted. Similarly, the results for Mexico are also not driven by a declining employment level in manufacturing which is almost constant in the 1985-1991 period.

[16] Levinsohn (1999) uses a firm-level dataset for Chile for the 1979-1986 period to study the patterns of job reallocation within and between industrial sectors. He finds that between-sector employment shifts explain anywhere from 0% to 25% of the excess job reallocation observed in the data. It may be problematic, however, to relate these reallocation patterns to the 1974 trade reform. First, by 1979 the trade reform is over and, as the evidence from the UNIDO dataset shows, most of the reallocation across sectors has already been achieved. Therefore, it is natural to expect relatively more job reallocation within sectors rather than between sectors during the 1979-1986 period. Second, Chile went through a deep financial crisis in the early 1980s and many of the patterns on job reallocation observed during that period might reflect this shock rather than the trade reform shock.

Preferences. The economy is populated by a continuum of individuals with measure one. They die each period with probability δ and are replaced by newly-born workers. Individuals are risk-neutral and maximize

$$E\sum_{t=0}^{\infty}\beta^t(1-\delta)^t\tilde{c}_t, \tag{4}$$

where $\tilde{c}_t$ is a composite good. It is derived from a CES aggregation

$$\tilde{c}_t = \left(\int_0^1 \kappa_i c_i^{\rho}\, di\right)^{\frac{1}{\rho}}, \tag{5}$$

where c_i is the consumption of the good produced in sector i and κ_i is the weight of that good in the CES aggregation.

Using standard arguments one can show that domestic demand, y_i^d, for good i is determined by total income in the economy, Y, a price index P, and the good's price, p_i. In particular, domestic demand is

$$y_i^d = \left(\frac{Y}{P}\right)\left(\frac{\kappa_i}{p_i}\right)^{\frac{1}{1-\rho}}, \tag{6}$$

where the price index P is equal to

$$P = \int_0^1 \kappa_i \left(\frac{\kappa_i}{p_i}\right)^{\frac{\rho}{1-\rho}} di. \tag{7}$$

Technology. The economy consists of a continuum of sectors each producing a good that is part of the composite good $\tilde{c}$ defined in (5). All goods are tradable and each good c_i faces a world price p_i^w. Sectors are heterogeneous with respect to their productivity and the world price of their product. In equilibrium, sectors that can sell their product at a high world price, and/or are more productive, will attract more workers and will be net exporters in the economy while the sectors whose goods have low world prices and/or are less productive will be net importers. In addition to these purely technological differences, sectors also differ with respect to their tariff protection. By implementing import substitution policies policy makers usually attempt to protect the less productive sectors in an economy by imposing tariffs on similar foreign goods. As a result, they create a protected and an unprotected group of sectors in the economy. In order to capture such a sectoral heterogeneity in terms of productivity, world prices, and tariff protection I separate all sectors in the economy into two groups called clusters. All sectors located in cluster k have the same common productivity factor α_k, face the same world price for their products p_k^w, and face the same level of tariff protection τ_k. Therefore, the triple $\Omega = (\alpha, p^w, \tau)$ determines the cluster to which each sector belongs, and equals $\Omega_1 = (\alpha_1, p_1^w, \tau_1)$ for all sectors in cluster 1 and $\Omega_2 = (\alpha_2, p_2^w, \tau_2)$ for all sectors in cluster 2.

Output in sector i, belonging to cluster k, is produced according to the production function

$$y_i^s = \alpha_k z_i l_i^\gamma, \qquad 0 < \gamma < 1, \tag{8}$$

where α_k is a common productivity factor for all sectors in cluster k, z_i is an idiosyncratic productivity shock particular to that sector only, and l_i is the number of efficiency units of labor employed in the sector. The sectors in one cluster have a different mean productivity level than the sectors in the other cluster. All sectors within a cluster, however, while facing the same productivity level over a long period of time, experience idiosyncratic productivity shocks that would cause their productivity to fluctuate around the mean productivity in the cluster. It is important to have this margin in the model since in the presence of uncertainty firing costs affect not only firms' firing but also their hiring decisions.

In the absence of the idiosyncratic shocks, z, the comparative advantage of a sector is determined jointly by the relative productivity of the sector's cluster, α, and the world price for its product, p^w. Given the assumption that there are only two clusters in the economy, I assume cluster 2 to be the one with the comparative advantage, i.e. $p_1^w \alpha_1 < p_2^w \alpha_2$, implying that more workers would be employed in cluster 2. As a result, in the absence of trade distortions, the sectors in cluster 2 will be exporting some of their goods, while the economy would be importing some of the goods produced in the sectors in cluster 1. Import substitution policies will be introduced in the model by imposing a tariff on the goods produced by the sectors in cluster 1. Because of the tariff, some labor resources would be inefficiently reallocated toward the sectors in cluster 1, which is precisely the type of inefficiency that a trade reform aims at eliminating.

The idiosyncratic productivity shocks z are assumed to evolve according to the following

AR(1) process:

$$\ln(z') = \phi \ln(z) + \epsilon', \tag{9}$$

where $\epsilon' \sim N(0, \sigma_\epsilon^2)$ and $0 < \phi < 1$. I denote the transition function for z as $Q(z, z')$.

It is assumed that there is a fixed factor in each sector, set equal to 1, such that the production function exhibits constant returns to scale in labor and the fixed factor. Each period firms rent labor and the fixed factor in competitive spot markets in each sector. As a result, even though in the analysis each sector is represented by a single firm, that firm is in fact representative of a large number of small firms that operate in a competitive environment and pay each factor of production its marginal product.

In each sector, a fraction of the income is paid out as wages to labor, while the rest is paid out as returns to the fixed factor. I assume that all individuals in the economy hold the same portfolio of shares of firms. That implies that the returns to the fixed factors are aggregated across all sectors in the economy and are redistributed back to individuals as dividend income Π.

Human Capital. Workers in a sector are of three experience levels: type 2 workers are most productive, type 1 − less productive, while type 0 workers are the least productive. The efficiency units of labor employed in a sector are:

$$l_i = (a_0 g_{0i} + a_1 g_{1i} + a_2 g_{2i}), \qquad a_0 < a_1 < a_2, \quad \sum_{j=0}^{2} a_j = 1 \tag{10}$$

where g_{0i}, g_{1i}, and g_{2i} are the number of type 0, type 1, and type 2 workers employed in the sector, respectively.

Unemployed individuals search for a new sector and search is undirected in the sense that the probability of arriving in a specific sector is the same across all sectors. When an individual arrives in a sector she starts as an inexperienced worker − type 0. Each period an employed type 0 worker advances to the next level of experience − being a type 1 worker − with probability λ_1. Similarly, type 1 workers become type 2 workers in a sector with probability λ_2. If an individual chooses to leave her sector, she loses all of her sector-specific experience, stays one period unemployed, and then arrives in a new sector.

The rationale for adding human capital into the model is that even in the absence of any labor market regulations, the sectoral reallocation of labor could be slow after trade reforms if workers have accumulated significant levels of human capital in their sectors. Explicitly including human capital in the model would allow us to isolate only the effect of labor market regulations. Section 6.3.2 discusses the importance of human capital by comparing the results from the benchmark model with human capital to those from a model without human capital.

Prices. Since output is sold at a price p_i, the income received by each sector i is

$$Y_i = p_i y_i^s. \tag{11}$$

Since this is a small-open economy, the price p_i at which the production of each sector i is sold and bought is determined by the world price p_i^w and the existing tariffs τ_i. The price cannot exceed the world price plus the tariff since in that case foreign firms are willing to sell at $p_i^w(1+\tau_i)$. The price could not be lower than p_i^w since domestic firms could export their product and sell it at p_i^w. Therefore,

$$p_i^w \leq p_i \leq p_i^w(1+\tau_i), \text{ for all } i. \tag{12}$$

Exports, Imports, and Tariff Revenues. The proceeds from tariffs are redistributed to all individuals as lump-sum transfers R. Denote the domestic demand for the output of sector i as y_i^d. Given the domestic supply and demand for the good produced in sector i, we can determine the net export of good i – NX_i – as

$$NX_i = y_i^s - y_i^d. \tag{13}$$

If $NX_i > 0$, then the country is a net exporter of good i. Alternatively, if $NX_i < 0$, then the country is a net importer of good i.[17] The revenues from tariffs are

$$R = \left| \int_{NX_i<0} p_i^w \tau_i NX_i \, di \right| \tag{14}$$

Then, total income in the economy is

$$Y = \int_0^1 Y_i \, di + R, \tag{15}$$

[17]The country is not allowed to borrow from the rest of the world as a result of which it cannot run a current account surplus or deficit. This assumption is inconsequential since individuals are risk-neutral.

Firing Costs. Conceptually, I model firing costs as a tax which firms have to pay when their employment levels decline.[18] Further, I use the findings in Alvarez and Veracierto (2000) who show that, in terms of allocations, modeling firing costs as being paid by the worker is equivalent to modeling explicitly the firms' hiring and firing decisions and making the firm pay the firing costs. In the model, Type 0 workers do not face a firing cost if they are fired. This allows the model to capture the fact that a fraction of the labor force is initially hired under temporary contracts, that may last for up to a year, that do not fall under the firing cost laws. If type 1 and type 2 workers decide to reallocate across sectors they are subject to a firing cost. Let ν_1 be the firing cost paid by a type 1 worker, and ν_2 be the firing cost paid by a type 2 worker.[19] Government proceeds from the firing costs are redistributed back to everyone in the economy as lump-sum transfers T.

While a substantial part of firing costs do constitute a cost that is actually lost for the employer-employee pair, a fraction of them is a transfer from firms to workers.[20] Lazear (1990) noted that under the assumption of no obstacles to bonding, firms and workers can enter into a contract that would completely negate any effects of the transfer component of firing costs − i.e. workers would make in the beginning a lump-sum payment equal to the expected firing cost the firm may face in the future. Most of the literature, however, (see Bentolila and Bertola (1990), Hopenhayn and Rogerson (1993), and Alvarez and Veracierto (2000)) model firing costs as firing taxes upon job separation assuming that the transfer component from the firm to the worker cannot be offset by a contract, and therefore affects firms' firing and hiring decisions. Lazear (1990) studies the data for the OECD countries

[18]Firing costs are only distortive in this environment and there are no benefits associated with them. In that respect, I follow the literature on firing costs − e.g., Hopenhayn and Rogerson (1993) and Alvarez and Veracierto (1999) − which has mainly focused on the costs associated with these policies and does not attempt to measure any benefits that may be associated with them. Alvarez and Veracierto (2001) investigate the insurance role of severance payments and find it to be quantitatively small − the effects on search, job destruction, and productivity dominate the welfare implications of this labor market policy.

[19]Under this setup, firing costs are conditional on sectoral rather than firm tenure. If human capital is sector-specific while firing costs are conditional on firm tenure, then firms in a sector have an incentive to rotate workers often, keeping them always with a low firm tenure, and avoiding in this case the firing costs. To preclude this from happening I assume also that there is a clause that prohibits firms from swapping workers in an attempt to avoid paying the firing costs. With that clause in effect, firm tenure and sectoral tenure are equivalent. Alvarez and Veracierto (2000) consider a similar in spirit assumption when modeling temporary contracts and studying their effects.

[20]See Alvarez and Veracierto (2001), Delacroix (2003), and Garibaldi and Violante (2005) for environments which model and discuss both the transfer and the tax component of firing costs and study their effects.

and concludes that, although theoretically severance payments might not have an effect on firms' decisions, in fact they alter firms' behavior significantly. Heckman and Pagés (2000) review the major empirical studies and point out that the consensus is that, both for the industrial and the Latin American countries, severance payments increase employment and unemployment durations, decrease labor force participation and employment, and have an ambiguous effect on unemployment.

4 Equilibrium

Equilibrium will be formulated recursively. Let ψ_0, ψ_1, and ψ_2 denote respectively the number of type 0, type 1, and type 2 workers in a sector at the beginning of a period. Then, at the beginning of a period a sector is characterized by the following state variables $(\psi_0, \psi_1, \psi_2, z; \alpha, p^w, \tau)$. The first four state variables, $(\psi_0, \psi_1, \psi_2, z)$, are particular to that sector only, while the last three, (α, p^w, τ), are the same for all sectors in a cluster. If we define $\psi = (\psi_0, \psi_1, \psi_2)$, then the state of a sector in the beginning of a period is given by $(\psi, z; \Omega)$.

Let U be the measure of unemployed individuals each period, V^s be the value of leaving a sector, Y be the income in the economy, and P be the price index in the economy. Consider the decision problem of an individual who at the beginning of a period is in sector $(\psi, z; \Omega)$ and who takes as given U, V^s, Y, and P. Define $V_0(\psi, z; \Omega)$ as the value of a type 0 worker who has just arrived in sector $(\psi, z; \Omega)$. Similarly, define $V_1(\psi, z; \Omega)$ as the value of a type 1 worker in sector $(\psi, z; \Omega)$, and $V_2(\psi, z; \Omega)$ as the value of a type 2 worker in sector $(\psi, z; \Omega)$. Every period, individuals will be receiving, regardless of the fact whether they choose to stay in their sector or not, the lump-sum transfers T, R, and Π. These lump-sum transfers, however, will not affect workers' decisions to reallocate, so I omit them in the value functions below. Then,

$$\begin{aligned} V_0(\psi, z; \Omega) &= \max \{V^s, w_0(\psi, z; \Omega) + \\ &\quad \beta(1-\delta) \int ((1-\lambda_1)V_0(\psi', z'; \Omega) + \lambda_1 V_1(\psi', z'; \Omega))\, Q(z, dz') \Big\}, \end{aligned} \tag{16}$$

$$\begin{aligned} V_1(\psi, z; \Omega) &= \max \{V^s - \nu_1, w_1(\psi, z; \Omega) + \\ &\quad \beta(1-\delta) \int ((1-\lambda_2)V_1(\psi', z'; \Omega) + \lambda_2 V_2(\psi', z'; \Omega))\, Q(z, dz') \Big\}, \end{aligned} \tag{17}$$

$$V_2(\psi, z; \Omega) \quad = \quad \max\left\{V^s - \nu_2, w_2(\psi, z; \Omega) + \beta(1-\delta)\int V_2(\psi', z'; \Omega)Q(z, dz')\right\}, \quad (18)$$

Define

$$g(\psi, z; \Omega) = (g_0, g_1, g_2) \quad (19)$$

as the number of workers of each type that will stay and work this period on the island. Then, the law of motion for the starting distribution of workers on an island, given the policy functions, is

$$\begin{aligned} \psi' = (\psi_0', \psi_1', \psi_2') &= \Gamma(g(\psi, z; \Omega)) \\ &= (\delta + (1-\delta)U + (1-\lambda_1)(1-\delta)g_0, \\ &\quad \lambda_1(1-\delta)g_0 + (1-\lambda_2)(1-\delta)g_1, \\ &\quad \lambda_2(1-\delta)g_1 + (1-\delta)g_2). \end{aligned} \quad (20)$$

In steady state, there is a sector invariant distribution for each cluster, $\mu_1(\psi, z)$ and $\mu_2(\psi, z)$.

$$\mu_1(\Psi', Z') = \int_{\{(\psi,z):\psi'\in\Psi'\}} Q(z, Z')\mu_1(d\psi, dz), \quad (21)$$

$$\mu_2(\Psi', Z') = \int_{\{(\psi,z):\psi'\in\Psi'\}} Q(z, Z')\mu_2(d\psi, dz). \quad (22)$$

4.1 Definition

A steady state equilibrium consists of value functions $V_j(\psi, z; \Omega)$, for $j = 0, 1, 2$, island employment rules $g(\psi, z; \Omega)$, an invariant measure $\mu_1(\psi, z)$ for cluster 1, an invariant measure $\mu_2(\psi, z)$ for cluster 2, the value of search V^s, the measure U of workers switching islands, a price index P, a price function $p(\psi, z; \Omega)$, total income Y, and tariff revenues R, such that:

1. Given V^s, $g(\psi, z; \Omega)$, U, and $p(\psi, z; \Omega)$, $V_j(\psi, z; \Omega)$, for $j = 0, 1, 2$, maximize individual's utility.

2. Wages in a sector are competitively determined, i.e. a worker with a given level of experience is paid her marginal revenue product.

3. The island employment rule $g(\psi, z; \Omega)$ is consistent with individual decisions.

4. $p(\psi, z; \Omega)$ should be consistent with domestic demand and domestic supply.

5. Individual decisions are compatible with the invariant distributions

$$\mu_1(\Psi', Z') = \int_{\{(\psi,z):\psi' \in \Psi'\}} Q(z, Z')\mu_1(d\psi, dz),$$

$$\mu_2(\Psi', Z') = \int_{\{(\psi,z):\psi' \in \Psi'\}} Q(z, Z')\mu_2(d\psi, dz).$$

6. For an island $(\psi, z; \Omega)$, the feasibility conditions are satisfied:

$$0 \leq g_j(\psi, z; \Omega) \leq \psi_j \qquad \text{for } j = 0, 1, 2.$$

7. The aggregate feasibility condition is satisfied:

$$U = 1 - \int_{\Omega_1} \sum_{j=0}^{2} g_j(\psi, z; \Omega_1)\mu_1(d\psi, dz) - \int_{\Omega_2} \sum_{j=0}^{2} g_j(\psi, z; \Omega_2)\mu_2(d\psi, dz).$$

8. V^s is generated by V_0, μ_1, and μ_2:

$$V^s = (1 - \delta)\beta \left[\int_{\Omega_1} V_0(\psi, z; \Omega_1)\mu_1(d\psi, dz) + \int_{\Omega_2} V_0(\psi, z; \Omega_2)\mu_2(d\psi, dz) \right].$$

9. The equilibrium prices on each island, p_i, are consistent with the price index P defined in (7).

10. Tariff revenues, R, are consistent with domestic demand, domestic supply, and tariffs.

11. $p(\psi, z; \Omega)$, $g(\psi, z; \Omega)$, $\mu_1(\psi, z)$, $\mu_2(\psi, z)$, and R generate total income, Y:

$$\begin{aligned} Y &= \int_{\Omega_1} p(\psi, z; \Omega_1) y^s(g(\psi, z; \Omega_1), z)\mu_1(d\psi, dz) \\ &+ \int_{\Omega_2} p(\psi, z; \Omega_2) y^s(g(\psi, z; \Omega_2), z)\mu_2(d\psi, dz) + R. \end{aligned} \tag{23}$$

4.2 Equilibrium Properties

Having defined equilibrium, we now turn to a more detailed analysis of how the model works. The discussion in this section aims at (i) illustrating how various variables in the model are determined in equilibrium, (ii) emphasizing certain equilibrium properties, and (iii) outlining an algorithm for computing the equilibrium.

All workers who are in a sector at the beginning of a period, having observed the starting worker distribution ψ, and the productivity shock z, have to decide whether to stay in that sector or to reallocate to another one. There are two layers of information that they take as given when making their decision. First, at the aggregate level, they take as given U − the number of unemployed workers every period, V^s − the value of leaving the sector, Y − total income in the economy, and P − the price index in the economy. Second, at the sectoral level, individuals take as given g − the number of workers of type 0, type 1, and type 2 that will choose to stay in their sector this period, and p_i − the price of the good in that sector. With all this information in hand, individuals can decide whether to stay in their current sector of employment or to look for a new one.

Since there is a continuum of firms in each sector, wages are determined competitively. Workers in a sector receive wages that are equal to their marginal revenue product (their marginal product times the price at which the good produced could be sold). Therefore, wages in sector i, in cluster k, are

$$w_{0i} = p_i \alpha_k z \gamma a_0 (a_0 g_{0i} + a_1 g_{1i} + a_2 g_{2i})^{\gamma-1} \tag{24}$$

$$w_{1i} = p_i \alpha_k z \gamma a_1 (a_0 g_{0i} + a_1 g_{1i} + a_2 g_{2i})^{\gamma-1} \tag{25}$$

$$w_{2i} = p_i \alpha_k z \gamma a_2 (a_0 g_{0i} + a_1 g_{1i} + a_2 g_{2i})^{\gamma-1} \tag{26}$$

The value of leaving the sector is given by V^s and the level of firing costs. Knowing p_i and the number of individuals that would choose to stay and work in the sector this period reveals this period's wages. Further, workers know also next period's starting distribution in the sector, uniquely determined by U and g. Therefore, they can compute their value of staying and compare it to their value of leaving.

4.2.1 Consistency at the Sectoral Level: Determining p_i and g

In equilibrium, of course, whatever individuals take as given has to be achieved. At the sectoral level workers take as given g − the number of workers type 0, type 1, and type 2 that will choose to stay in the sector, and p_i − the price in that sector. Individuals' decisions have to be consistent with the assumed values for g and p_i.

Consistency of the Sectoral Prices p_i. Note that, as discussed in Section 3, the domestic demand for a good i is determined by total income in the economy, Y, the price index P, and its price, p_i. In particular, domestic demand, plotted on Figure 3, is given by equations (6) and (7).

This period's output in sector i is determined by z and g: $y_i^s = \alpha z(a_0 g_0 + a_1 g_1 + a_2 g_2)^\gamma$. If domestic supply y_i^s falls in region 1 in Figure 3, then $p_i = p_i^w(1+\tau_i)$ and some of the excess demand would be satisfied with imports. A lower price is not consistent with equilibrium since foreign firms would not enter the market and then domestic demand would exceed domestic supply. A higher price is also not consistent since competition from foreign firms would push it down to $p_i^w(1+\tau_i)$.

If domestic supply y_i^s falls in region 2 in Figure 3, then p_i has to be such that $y_i^d = y_i^s$. The price is between the world price p^w and $p_i^w(1+\tau_i)$ which makes foreign firms unwilling to import and domestic firms unwilling to export. As a result the equilibrium price has to clear the domestic market for good i.

If domestic supply y_i^s falls in region 3 in Figure 3, then $p_i = p^w$ and some of the excess supply would be exported. A lower price is not consistent with equilibrium since neither domestic nor foreign firms will sell domestically in that case. A higher price is also not consistent since competition from domestic firms would push it down to p_i^w.

We can define for each sector i, the level of domestic demand if the price were equal to the world price plus the tariff, $d_i^1 = y_i^d(p^w(1+\tau))$, and the level of domestic demand if the price were equal to the world price $d_i^2 = y_i^d(p^w)$, as shown in Figure 3. Then, equilibrium prices have to satisfy the following conditions:

- If $y_i^s \geq d_i^2$, then $p_i = p^w$;
- If $y_i^s \leq d_i^1$, then $p_i = p^w(1+\tau)$; and
- If $d_i^1 \leq y_i^s \leq d_i^2$, then p_i is such that $y_i^d = y_i^s$.

Figure 4 shows the equilibrium pricing function $p_i(\psi, z; \Omega)$.

Consistency of the Sectoral Employment Policies g. After all workers decide whether they want to stay in their current sector or not, exactly g have to choose to stay and work in the sector. For instance, suppose that workers in sector i assume that all other workers in the sector would choose to stay and work – i.e. $g = \psi$. We can compute then real output y_i^s in the sector and, as Figure 4 shows, determine the consistent price p_i. Let us define the following full-employment value functions – $V_j^F(\psi, z; \Omega)$, as the value of a Type j worker who stays and works in sector $(\psi, z; \Omega)$ when all other workers also decide to stay and work in that sector. If

- $V_0^F(\psi, z; \Omega) \geq V^s$,
- $V_1^F(\psi, z; \Omega) \geq V^s - \nu_1$, and
- $V_2^F(\psi, z; \Omega) \geq V^s - \nu_2$,

then the full-employment policy $g = \psi$ is a consistent policy for this sector.

However, if some workers find that the value of leaving the sector is higher than what they can receive under the full-employment policy $g = \psi$, then this particular policy is not consistent and some workers would have to leave the sector.

Type 0 workers would be the first to leave a sector since for any policy g, they have the lowest value V^F and the highest value of search net of the firing cost. Then, if necessary, Type 1 workers would be the next to leave, while Type 2 workers would be the last to leave.

As Type 0 workers start leaving the sector, the value of staying $V_j^F(\psi, z; \Omega)$ for all three types would be strictly increasing since i) the consistent price p_i is weakly decreasing in total output y_i^s (and therefore in g_0), ii) wages are strictly decreasing in g_0, and iii) the value functions $V_j(\psi, z; \Omega)$ are weakly decreasing in g_0. Type 0 workers would be leaving until either $V_0^F(\psi, z; \Omega) = V^s$ or $g_0(\psi, z; \Omega) = 0$.

If all Type 0 workers decide to leave, then we need to check whether Type 1 workers are willing to stay and work if the sector-employment policy is $g = (0, \psi_1, \psi_2)$. If indeed $V_1^F \geq V^s - \nu_1$, then they will be willing to stay and the employment policy $g = (0, \psi_1, \psi_2)$ would be a consistent policy. If not, then Type 1 workers would also start leaving until either $V_1^F(\psi, z; \Omega) = V^s - \nu_1$ or $g_1(\psi, z; \Omega) = 0$

Finally, if all Type 1 workers decide to leave, then we need to check whether Type 2 workers are willing to stay and work if the sector-employment policy is $g = (0, 0, \psi_2)$. If indeed $V_2^F \geq V^s - \nu_2$, then they will be willing to stay and the employment policy

$g = (0, 0, \psi_2)$ would be a consistent policy. If not, then Type 2 workers would also start leaving until $V_2^F(\psi, z; \Omega) = V^s - \nu_2$.

4.2.2 Consistency at the Aggregate Level: Determining U, V^s, Y, and P

All workers in the economy take as given the aggregate variables $\Theta = (U, V^s, Y, P)$ and in equilibrium Θ should be consistent with individuals' decisions. Given Θ, there exist

- Individual value functions $V_j^\Theta(\psi, z; \Omega)$ for $j = 0, 1, 2$;
- Sectoral employment functions $g_j^\Theta(\psi, z; \Omega)$ for $j = 0, 1, 2$; and
- Sectoral price functions $p_i^\Theta(\psi, z; \Omega)$.

Further, U and $g_j^\Theta(\psi, z; \Omega)$ give rise to an unique sector-invariant distributions $\mu_1^\Theta(\psi, z; \Omega)$ in cluster 1, and $\mu_2^\Theta(\psi, z; \Omega)$ in cluster 2.

First, in equilibrium the number of unemployed workers each period has to be U:

$$U = 1 - \int_{\Omega_1} \sum_{j=0}^{2} g_j^\Theta(\psi, z; \Omega_1) \mu_1^\Theta(d\psi, dz) - \int_{\Omega_2} \sum_{j=0}^{2} g_j^\Theta(\psi, z; \Omega_2) \mu_2^\Theta(d\psi, dz).$$

Second, the value of leaving a sector has to be V^s:

$$V^s = (1 - \delta)\beta \left[\int_{\Omega_1} V_0^\Theta(\psi, z; \Omega_1) \mu_1^\Theta(d\psi, dz) + \int_{\Omega_2} V_0^\Theta(\psi, z; \Omega_2) \mu_2^\Theta(d\psi, dz) \right]. \tag{27}$$

Third, total income in the economy has to be Y:

$$\begin{aligned} Y &= \int_{\Omega_1} p^\Theta(\psi, z; \Omega_1) y^s(g^\Theta(\psi, z; \Omega_1), z) \mu_1^\Theta(d\psi, dz) \\ &+ \int_{\Omega_2} p^\Theta(\psi, z; \Omega_2) y^s(g^\Theta(\psi, z; \Omega_2), z) \mu_2^\Theta(d\psi, dz) + R. \end{aligned} \tag{28}$$

Finally, the price index, P, should be as determined in equation (7), and tariff revenues, R, should be consistent with domestic demand, domestic supply, and tariffs.

5 Trade Reforms and Labor Market Regulations: The Case of Chile

In order to study the effect of labor market regulations on an economy that implements a trade liberalization reform, I perform the following experiment. I model a country that has significant trade and labor market distortions, and refer to this equilibrium allocation as the distorted economy steady state. Then I study the behavior of the economy under two scenarios. First, a trade reform is implemented by reducing tariffs while keeping the firing costs in place, and I follow the economy along its transition toward the new steady state.[21] Second, I perform a new experiment in which both tariffs and firing costs are completely eliminated. I refer to the equilibrium allocation in which there are no trade and labor market distortions as the non-distorted economy steady state. Comparing the results from both experiments would quantitatively show the effect that firing costs have on the economy during trade liberalization episodes. In particular, I calibrate the model to Chile. In the early 1970s Chile was a closed economy with high tariffs and high firing costs. In 1974, Chile implemented a far-reaching trade reform accompanied by a labor market reform which drastically reduced the level of firing costs in the country.

There are a number of issues that are important for the calibration. First, some of the calibration targets in the distorted economy steady state could be affected by factors that are not explicitly modeled in this paper. Second, the transition that we observe in the data could differ from the one predicted by the model if other factors, apart from the elimination of trade and labor market distortions, also changed − such as a capital account liberalization, a tax reform, and privatization. In order to isolate only the effect of trade and labor market distortions I follow the following calibration strategy. First, I start by calibrating the non-distorted economy steady state − I calibrate to Chile in the early 1990s, an economy which exhibits no distortions. Second, in order to obtain the steady state for the distorted economy, I introduce trade and labor market distortions by calibrating the tariff and firing costs parameters to observable levels in the data for Chile in the early 1970s. Of course, the distorted economy steady state would differ from the actual steady state of the Chilean distorted economy since one would imagine that Chile faced numerous other distortions that are not modeled in this paper. Nevertheless, in this way I will be able to isolate only the quantitative effect of the existence of labor market distortions during the trade reform episode.

[21] The algorithm for computing transitions in the model is described in Appendix II.

5.1 Benchmark Calibration: a Non-Distorted Economy

The benchmark non-distorted economy is calibrated to data for the Chilean manufacturing sector in the early 1990s. This choice is motivated by the fact that I consider Chile to be an economy without distortions in this period. First, this is fifteen years after Chile's trade reform implying that the transition toward the new steady state is over. Second, trade restrictions and firing costs are already negligible. I omit the earlier years in the 1980s because there might be still some post-reform reallocation going on and because Chile went through a serious financial crisis in the early 1980s. The later years in the 1990s are omitted because we observe a tendency toward a slight increase in labor market regulations and firing costs during that period.

General Parameters

The model period is a quarter. $\delta = 0.00625$ is chosen to generate an expected working lifetime of 40 years (or 160 model periods). I use $\beta = 0.99024$ in order to match an annual interest rate of 4%. I select the curvature parameter $\gamma = 0.68$ to match a labor share of output of 68%. κ is set equal to one implying that the goods produced in different sectors are equally valued by individuals while the substitutability parameter ρ is set equal to 0.[22]

Human Capital Accumulation Parameters

The probability of becoming a type 1 and a type 2 worker were chosen so that it takes 1 year on average for a worker on a temporary contract to become a type 1 worker and additional 6 years to become a type 2 worker. Then, $\lambda_1 = 0.25$ and $\lambda_2 = 0.04167$. The distribution parameters in the production function − a_0, a_1, and a_2 − were chosen to match the facts that experienced workers in a sector are approximately 16% more productive than the inexperienced ones (see Kambourov and Manovskii (2008b)), and that workers on temporary contracts are 20% less productive than other workers (see Aguirregabiria and Alonso-Borego (2004)). That implies that $a_0 = 0.2857$, $a_1 = 0.3312$, and $a_2 = 0.3831$.

[22] For broad categories of consumption goods the elasticity of substitution is low − Stockman and Tesar (1995) report a value of 0.44 in the case of tradable and nontradable goods. If we divide consumption goods into more disaggregated categories, the elasiticity of substitution is higher − Bernard, Eaton, Jenson, and Kortum (2003) estimate a value of 3.79 in a model of monopolistic competition. As a result, I use as a starting point in my benchmark calibration the neutral value of 1 (i.e. $\rho = 0$).

Policy Parameters: Tariffs and Firing Costs

The tariffs in cluster 1 and cluster 2, τ_1 and τ_2 respectively, are set equal to zero. Firing costs for Type 1 and Type 2 workers, ν_1 and ν_2, are also set equal to zero.

Parameters Obtained by Solving the Model

The comparative advantage of one cluster over the other is determined by the relative value of $p_1^w \alpha_1$ and $p_2^w \alpha_2$. Without loss of generality, I set $p_1^w = p_2^w = 1$ and let the ratio $\alpha = \alpha_2/\alpha_1$ determine the comparative advantage of each cluster.

There are three parameters left to be calibrated: the relative productivity of both clusters $-$ α, the persistence in the sectoral log shocks $-$ ϕ, and the standard deviation of the innovations to the sectoral log shocks $-$ σ_ϵ. They are set in order to match three targets for the Chilean manufacturing sector in the early 1990s. The first target is an exports-to-output ratio of 36% in the manufacturing sector.[23] The second target is an annual intersectoral reallocation index of 0.027. The third target is the fact that 14% of workers are employed in sectors that experience a change of 10% or more in employment as compared to a year ago. Each of the parameters affects simultaneously all of the three targets. As a result, in order to find the parameter values that best match the targets we need to solve the model. Despite this, intuitively, α has a significant impact on the exports-to-output ratio in the model economy $-$ the higher α is, the further apart both clusters are, and the higher the exports-to-output ratio. ϕ and σ_ϵ both affect the annual intersectoral reallocation index. The last target, however, provides further identification of the two parameters by capturing whether the overall observed reallocation is due to the fact that all sectors change their employment by a little or a few sectors change it by a lot. The calibration determines that $\alpha = 1.790$, $\phi = 0.920$, and $\sigma_\epsilon = 0.102$. Tables 6 and 7 list the values of the calibrated parameters.

5.2 Benchmark Calibration: a Distorted Economy

All parameters in the distorted economy are the same as in the non-distorted economy with the exception of tariffs and firing costs $-$ those are calibrated to Chilean data in the early 1970s. As a result, τ_2, the tariff in cluster 2, is set to zero while τ_1, the tariff in

[23] Appendix III discusses this choice of the value for the target.

cluster 1, is set to match a tariff rate of 80%. The firing cost for type 1 workers, ν_1, is set to match a level equal to ten monthly wages, while the firing cost for type 2 workers, ν_2, is set to match sixteen monthly wages. The model economy would differ along some dimensions from the actual performance of Chile in 1974 because there are many other important distortions that are left out of the analysis. However, calibrated in this way, the initial steady state describes how the Chilean economy would have looked in 1974 if the only distortions at that time were high tariff rates and high firing costs. As a result, by liberalizing both the trade and labor market distortions, and comparing it to the path the model economy would follow if only trade distortions were lifted, I can quantitatively assess the post-reform Chilean performance and the costs of implementing trade reforms without liberalizing the labor market.

6 Results

In this section I describe the results from the calibrated model. Before I analyze the transitional dynamics, I describe the performance of the model in steady state.

6.1 Steady State Analysis

I compare the steady state characteristics of three economies with different trade and labor market restrictions. I study an economy, denoted by Economy 1, which has high tariffs and high firing costs. Economy 2 is an economy with no tariffs and high firing costs while Economy 3 is an economy with no tariffs and no firing costs. The steady state statistics for each of these economies are shown in Table 8.

The results indicate that liberalizing trade and the labor market is unambiguously beneficial. A steady state comparison of an economy which has high trade and labor market restrictions (Economy 1) with an economy that has none (Economy 3) reveals that the latter economy performs much better − in steady state real output is 6.1% higher and labor productivity is 7% higher. The economy without distortions exhibits higher intersectoral reallocation of workers and higher exports-to-output ratio. Distortions cause the labor force to be approximately equally distributed between cluster 1 and cluster 2. The optimal allocation, however − as seen in the economy without distortions, is to have more than 80% of the labor force in cluster 2.

Table 8 provides additional insights. It allows us also to compare the steady state performance of two economies without trade distortions – one with high firing costs (Economy 2) and another without firing costs (Economy 3). In terms of the amount of intersectoral reallocation of labor, the two economies look very different – as expected, firing costs decrease the intersectoral reallocation of labor. Despite that, however, the two economies are very similar in terms of output, labor productivity, and welfare. In the presence of high firing costs, labor reallocates less as a result of which resources are misallocated and output, productivity, and welfare decline. This, however, is offset by two factors. First, by staying in their sector a larger fraction of the labor force becomes experienced. Second, in the presence of firing costs reallocation is smaller which leads to a higher level of employment. As a result, in steady state the overall effect of firing costs on output, productivity, and welfare is not substantial.

6.2 Transition Analysis

In order to study the effects of firing costs in trade liberalization episodes, I compare the behavior of two economies which have the same starting point – high tariffs and high firing costs. The first economy, however, implements a trade liberalization reform simultaneously with the elimination of the firing costs (the case of Chile) while the second economy implements a trade liberalization reform without eliminating the high firing costs (the counterfactual experiment).

In the presence of tariffs, slightly more than 50% of the labor force works in cluster 2. The optimal allocation of workers in the absence of tariffs requires that more than 80% of the labor force works in cluster 2. Therefore, a trade liberalization reform leads to the reallocation of almost 30% of the labor force. Even in an extremely rigid labor market the labor force will eventually reallocate since new labor market entrants, who are not subject to firing costs, can move toward the comparative advantage sectors in the economy. Firing costs, however, significantly slow down this process of reallocation. In the absence of firing costs most of the required reallocation is completed by the end of the fifth year. In the presence of firing costs, however, seven years after the trade reform only 71% of the required reallocation is implemented.

Figure 5 conveys a similar message − firing costs hinder the intersectoral reallocation of labor after trade liberalization reforms.[24] For example, in 1981 the cumulative reallocation index in the data and in the model with labor reform was 0.12. In the model without a labor reform (the dotted line) the index was substantially lower − 0.075.

Note that the calibration did not target the intersectoral reallocation index over the transition. Nevertheless, the path of the index for the economy which eliminates both the trade and the labor market distortions (the Chilean case) is quantitatively close to the path of the reallocation index for Chile after its reforms. In particular, until 1981 the cumulative intersectoral reallocation index in the model matches the data almost exactly while after that it is slightly lower than the levels observed in the data. This result indicates that the level of trade and labor market distortions were important in determining the degree of initial misallocation of resources and subsequent labor reallocation in the post-reform years. Similarly, even though the annual intersectoral reallocation index is not targeted, the model without firing costs is quantitatively close to the levels observed in the data while the model with firing costs exhibits a substantially lower reallocation index. In particular, while during the 1976-1981 period, the annual index is, on average, 0.041, in the model with no firing costs it is 0.034, while in the model with firing costs it is 0.016.

The slow reallocation of labor affects the behavior of the other variables during the transition period. The increase in the exports-to-output ratio is also slowed down. The trade reform leads to an increase in the exports-to-output ratio from 0.13 to 0.36. In an economy with no labor market restrictions, after five years the ratio is close to its value in the new steady state. In the presence of firing costs, however, after seven years it is around 0.29 − still significantly below its value in the new steady state. The model does well in matching the exports-to-output ratio in the early 1970s although this is not targeted − it is 0.13 in the model and 0.12 in the data.[25]

Labor productivity in Chilean manufacturing has increased by 28% in the 1973-1980 period (see Gwynne (1986)). Part of this substantial increase was due to the fact that

[24]The cumulative intersectoral reallocation index in the model is computed with respect to 1976. That makes the comparison with the data easier since while Chile initiated its trade reform in 1974 the UNIDO dataset allows us to compute the reallocation index for Chile from 1976 on.

[25]See Appendix III.

Chile implemented significant economic reforms during the period, including a trade liberalization reform. Part of it, however, was also due to the normal long-term growth in labor productivity which is not associated with significant economic reforms − a feature which is not built into the model. In particular, in the case of a 2% annual long-term increase in labor productivity, Chile would have experienced a 15% increase in labor productivity over the 1973-1980 period even if it did not implement any reforms. Since the model abstracts from such a trend in technological progress, it is appropriate to relate its results only to the fraction of labor productivity growth which is not accounted for by the long-term trend in labor productivity. Labor productivity in the model increases by 6% during the 1973-1980 period which is more than 50% of the observed increase in the data. This indicates that the process of reallocation of workers across sectors − the main source of labor productivity growth in the model − is a quantitatively important determinant of labor productivity growth after a trade reform. This mechanism, however, does not account for all of the increase in labor productivity. The rest of the increase could be accounted for by other effects of the trade reform not captured by the model − such as an increase in technology adoption, capital accumulation, and worker reallocation within sectors − or by other economic reforms.

The costs of not liberalizing the labor market are significant. Table 9 shows the percentage increase in real output, labor productivity, and welfare for two economies − one which implements both trade and labor reforms and another which liberalizes only trade. This change is relative to the case when no trade and labor reforms are implemented.

Trade and labor reforms increase real output by 2.5%, 4.2%, and 4.6% after 2, 5, and 7 years respectively. If the country does not liberalize the labor market, the increase in real output will be only 1.6%, 3.2%, and 3.5%. This implies, as shown in Table 10, that 2 years after a trade reform a country which did not liberalize its labor market is foregoing 36% of the possible increase in real output while 5 years after the trade reform the foregone amount of real output is 25%. Similarly, the foregone increase in labor productivity 2 and 5 years after the trade reform is 32% and 29% while the foregone increase in welfare is 11% and 13%. While the economy will eventually reallocate, the existing high firing costs slow down this process, prolong the transition period, and delay the expected benefits from the trade reform. As reported in Table 11, trade liberalization increases the present discounted value of future real output by 4.1%.[26] If firing costs are not eliminated, as much as 20% of these benefits would be lost. Similarly, while the gain in labor productivity from a trade reform is 6.1%, almost 30% of these gains will be lost if the economy does not also liberalize its labor market.

6.3 Sensitivity Analysis

In this section I study the sensitivity of the results with respect to the main parameters in the model. I perform two different in nature sensitivity analyses. First, without recalibrating the model, I study the sensitivity of the results with respect to changes in the relative productivity of both clusters − α, the persistence in the sectoral log shocks − ϕ, and the standard deviation of the innovations to the sectoral log shocks − σ_ϵ. Second, I recalibrate the model and study the sensitivity of the results with respect to an increase in the labor share − γ, a shorter model period, and no human capital.

6.3.1 Comparative Statics

In the benchmark case α, ϕ, and σ_ϵ were calibrated by matching three targets in the data. Therefore, changing any of these three parameters implies that the targets can no longer be exactly matched. As a result, the purpose of a sensitivity analysis with respect to changes in these parameters is to provide a better understanding of how the model works and provide a check as to whether the results are sensitive to such changes. The top panel in Table 12 reports the new values of the targets. The next panel reports the employment in both clusters in the steady state with high tariffs and high firing costs and in the steady state with no tariffs and no firing costs.[27] The table also reports the amount of reallocation across clusters achieved seven years after the trade reform in the presence of firing costs. Finally, the table reports the benefits in terms of real output from the trade reform − i.e., in the case in which both trade and labor market distortions are eliminated − as well as the fraction of these benefits that will be lost if the labor market had not been liberalized.

[26] Because we take the transition periods into account this is less than the 6.1% obtained when we compare only steady states.

[27] The employment in both clusters in the steady state with no tariffs and high firing costs is similar to the one in the steady state with no tariffs and no firing costs.

The results in Table 12 show that the main findings from the benchmark calibration are robust to changes in α, ϕ, or σ_ϵ. First, increasing or decreasing these parameters has a predictable, but not dramatic, effect on the results. Second, the presence of firing costs has a quantitatively important impact on the sectoral reallocation of workers. In all of the cases, if firing costs are not eliminated then seven years after the trade reform only from 60% to 80% of the required reallocation across sectors will be achieved. Finally, the foregone benefits of not liberalizing the labor market are quantitatively important in all cases − from 10% in the case of lower persistence and standard deviation of the log shocks to 33% in the case of lower relative productivity of cluster 2.

6.3.2 Recalibrating the Model

In order to investigate the response of the model to an increase in the labor share γ, a shorter model period, or no sector-specific human capital, the model is recalibrated. In particular, for each of these cases, α, ϕ, and σ_ϵ are recalibrated to match the same three statistics as in the benchmark case. The top panel in Table 13 reports the recalibrated values of α, ϕ, and σ_ϵ required to match the three targets. The next panel reports the employment in both clusters in the steady state with high tariffs and high firing costs and in the steady state with no tariffs and no firing costs. Finally, the table reports the benefits in terms of real output from the trade reform − i.e., in the case in which both trade and labor market distortions are eliminated − as well as the fraction of these benefits that will be lost if the labor market had not been liberalized.

Higher labor share, γ. In order to match the targets with a higher γ all three parameters − α, ϕ, and σ_ϵ − have to decrease. The decline in α is particularly important since it leads to smaller gains from trade. Even though the benefits from trade decline, however, a larger fraction of them is lost if the labor market is not liberalized − when γ is 0.85 the gains from trade are 3.1% but 31% will be lost if the labor market is not liberalized.

Shorter Model Period. In the benchmark calibration search is undirected and workers who are searching for a new sector have the same probability of ending on any of the sectors in the economy. This assumption, however, is not as extreme as it seems. Workers are not forced to work in a sector they do not like and can continue searching until they find a suitable sector. As a result, those sectors which are more productive will eventually end up with more workers than the less productive sectors. Furthermore, the fact that the model period is a quarter in the benchmark case implies that workers who are searching for a new sector can sample four sectors in a year − this is a high enough frequency to allow workers to quickly reallocate from the less productive to the more productive sectors. Empirical evidence on the extent to which search is directed is not readily available. The fact that the model closely matches the annual and cumulative intersectoral reallocation indices over the transition periods, without explicitly targeting them, suggests that undirected search with a model period of a quarter is a reasonable assumption.

In order to investigate the importance of the assumption of undirected search I compute and recalibrate a version of the model with a model period of 6.5 weeks − half the model period in the benchmark case. As expected, the reallocation across sectors in the aftermath of the trade reform is faster than in the benchmark case − seven years after the reform, in the presence of firing costs, 85% of the intersectoral reallocation is achieved. Nevertheless, the effect of firing costs is still quantitatively quite significant − if the country does not liberalize its labor market, in terms of real output, it will lose 13% of the benefits from the trade reform (which are one percentage point higher than in the benchmark case).

No Human Capital. The rationale for including human capital in the analysis so far was the fact that it is reasonable to expect that human capital by itself, even in the absence of any labor market regulations, could slow down the intersectoral reallocation of labor after a trade reform. Naturally, having accumulated human capital in their sectors of employment, experienced workers would not find it optimal to reallocate. As a result, the required reallocation of workers across sectors would eventually be achieved only as less experienced workers and new-comers into the labor market move toward the sectors in which the country has a comparative advantage. In order to investigate whether the existence of human capital is important for the results obtained in the benchmark case, either directly or through its interaction with firing costs, I repeat the analysis in a version of the model without human capital. All workers in a sector have the same level of experience and they are all subject to the same firing cost. The results from this experiment suggest that both firing costs and human capital play a role in the benchmark analysis. Firing costs do play an important role since in both models they slow down the intersectoral reallocation of workers and reduce the benefits from a trade reform. Human capital, however, does play a role as well − in the absence of human capital, the foregone benefits from not liberalizing the labor market are less than half of what they are in the benchmark case. This finding is reminiscent of the insights provided by Albuquerque and Rebelo (2000) who highlight the importance of irreversible capital investment in understanding the observed persistence in the industrial configuration of a country after a trade reform. Instead, however, the emphasis in this paper is on the importance of human capital investment and labor market regulations.

7 The Case of Mexico

In this section I use the model to study the effect of labor market regulations on the performance of the Mexican economy after its trade reform in 1986. This analysis provides several significant insights. First, it is important to see whether the model would be useful when applied to a country other than Chile. Mexico's trade and labor market distortions were quantitatively different from those in Chile. In addition, it is conceivable that the variability of the sectoral productivity shocks were different as well. Second, Mexico's trade reform was more gradual − tariffs were initially reduced only partially, and were eliminated only after 1988.[28] Third, Mexico is a country which implemented a trade reform without liberalizing the labor market. Then, the experiments from the model analysis would indicate the extent to which Mexico could have done better by liberalizing the labor market as well.

I follow the same calibration strategy as in the case of Chile with one exception: since data is available for the pre-reform years in Mexico, I calibrate all the parameters in the model to the Mexican distorted economy in the early 1980s. Some of the parameters are the same as those for Chile as reported in Table 6. In addition, I calibrate to a level of tariffs of 60% and firing costs of eight monthly wages for inexperienced workers and fourteen monthly wages for experienced workers. Finally, I calibrate $\alpha = 1.7$, $\phi = 0.935$, and $\sigma_\epsilon = 0.11$ in

[28] Hanson and Harrison (1999) provide the average tariffs and import-license requirements for two-digit industries in Mexico from 1984 till 1990.

order to match an exports-to-ouput ratio in manufacturing of 0.16, an annual intersectoral reallocation index of 0.014, and the fact that 8% of workers are employed in sectors which experienced a change of 10% or more in their employment size.

The transition analysis implements a gradual trade reform − initially tariffs are reduced from 60% down to 30% and then, three years into the trade reform, are eliminated completely. As mentioned above, Mexico did not liberalize its labor market and kept the high level of firing costs in the economy. In order to quantify the effect of these labor market regulations on the Mexican economy during its trade reform, I study the calibrated model economy under two scenarios: (i) the case in which a trade reform is implemented in the presence of firing costs, and (ii) the case in which the trade reform is accompanied by a labor market reform which completely eliminated firing costs in the economy.

Table 14 reports statistics from the various steady states. The main points are similar to those already discussed for the Chilean case. First, eliminating trade and labor market distortions is beneficial − real output increases by 4.1%. Second, tariffs lead to a misallocation of resources in the economy although not as much as in Chile − before the trade reform 60% of the labor force is employed in cluster 2 while optimally more than 80% should be working there. Third, in the economies without trade distortions (Economy 2 and 3) the one with high firing costs exhibits much lower levels of sectoral reallocation of workers. Finally, in steady state, firing costs do not have a large quantitative impact on real output, real output per worker, and welfare.

Figure 6 plots the cumulative intersectoral reallocation index for Mexico from the data and from the model under both scenarios − with and without a labor market reform. Although this index is not targeted the model does a reasonable job in tracking the reallocation index in the data − it is close to the levels observed in the data early in the transition and slightly higher in the later periods. The important insight from the model, however, is that the observed reallocation would have been substantially higher in Mexico if it had eliminated the labor market restrictions at the outset of its trade reform. Further, during the 1986-1996 period, the annual intersectoral reallocation index is 0.020 in the data, 0.023 in the model in the presence of firing costs (the Mexican case), and 0.049 in the model without firing costs (the counterfactual experiment).

Table 15 further indicates that the foregone benefits − in terms of real output, real output per worker, and welfare − of not liberalizing the labor market are quantitatively substantial. In particular, in terms of the present discounted value of real output and real output per worker Mexico lost 30% and 39% of the benefits from its trade liberalization reform.

The analysis in this section reinforces the point that data from trade liberalization episodes alone might not be sufficient to understand the effects of firing costs after a trade reform. The trade liberalization experience varies substantially across countries − e.g., in terms of the magnitude and length of the reform. In a large dataset we might be able to control for that but in smaller datasets, such as the UNIDO dataset, this is less feasible. As a result, we need a quantitative theory in order to fully understand the effect of firing costs on the sectoral reallocation of workers after a trade reform. In particular, one could conjecture that the negligible amount of sectoral reallocation after Mexico's trade reform is due not to the presence of high firing costs but rather to such factors as a smaller degree of pre-reform distortion in the economy and a more gradual trade reform. The analysis from using the model, which incorporates both features, indicates that the effect of firing costs is quantitatively large − had Mexico liberalized its labor market at the outset of its trade reform it would have experienced a fast reallocation of workers across sectors and would have experienced a substantially higher increase in real output, productivity, and welfare than it actually did.

8 Concluding Remarks

I argue that in order to understand the effects of trade reforms one needs to take into account the specific features of the local labor markets. Barriers to trade lead to significant distortions in domestic prices and cause an inefficient allocation of resources across sectors. An expected outcome of a trade reform is a significant sectoral reallocation of labor in the economy. The amount and speed of the reallocation, however, will also depend on the particular characteristics of the labor market − a flexible labor market will facilitate the required reallocation of labor while a highly restrictive labor market will slow it down. This paper studies the effect of labor market regulations, in particular firing costs, on the performance of an economy that implements a trade liberalization reform. I find that if a country does not liberalize its labor market at the outset of its trade reform, then the intersectoral reallocation of workers will be considerably slower and as much as 30% of the gain in real output and labor productivity in the years following the trade reform will be lost. From a policy standpoint, these results imply that trade liberalization reforms are desirable but need to be complemented by labor market reforms in order to be successful.

This paper is a first step toward incorporating the specific features of local labor markets into the study of trade reforms. Future work could further investigate the importance of labor market reforms by adding to the analysis features which were left out of this analysis, such as capital mobility, economies of scale, firm heterogeneity within sectors, and technology adoption.

Since the analysis in this paper is focusing on trade liberalization reforms, it seems appropriate to focus on the reallocation of workers between sectors rather than within sectors. Some distortions – such as trade distortions – affect nonuniformly the sectors in the economy while having a more uniform impact on the firms within those sectors. As a result, they mostly affect the sectoral employment of workers rather than the distribution of workers within sectors and eliminating these distortions will mainly result in the reallocation of workers between sectors rather than within sectors. To the extent that trade reforms also lead to some reallocation within sectors, one could expect that labor market regulations would impede that reallocation as well. Therefore, we could interpret the findings as providing a lower bound on the effect of labor market regulations on the reallocation of workers after a trade reform. Other distortions, however, such as capital market imperfections and subsidies to firms based on their size or geographical location, might mostly affect the distribution of workers within sectors rather than between sectors and eliminating these distortions will mainly result in the reallocation of workers within sectors rather than between sectors. In order to study the impact of such distortions, either separately or together with sectoral-level distortions, and capture the heterogeneity across sectors and across firms within sectors we would need to move toward theoretical frameworks which explicitly model firm dynamics within sectors.

Table 1: Tariff Reduction in Latin America 1995 vs. 1986, Average Tariffs (in Percent).

	1986	1995
Brazil	87	15
Paraguay	29	9
Uruguay	45	9
Venezuela	42	12
Mexico	41	13
Colombia	58	11
Peru	79	17

Source: IADB Report, 1997.

Table 2: Dismissal Costs, 1995 vs. 1985, Multiples of Last Monthly Wage.

	One Year of Tenure		Ten Years of Tenure	
	1985	1995	1985	1995
Brazil	1.5	1.5	2	5
Paraguay	1.3	1.5	8	8
Uruguay	1	1	6	6
Venezuela	3	3	23	23
Argentina	3	3	12	6
Mexico	4.2	4.2	11	11
Colombia	2.5	1.5	13	15
Bolivia	4	4	13	13

Source: IADB Report, 1997, based on information from Ministries of Labor.
Notes: Includes notification period.

Table 3: Job Security Index across OECD and Latin American Countries, End of the 1990s.

Job Security Index (Monthly Wages)			
OECD Countries		*Latin American Countries*	
New Zealand	0.22	Brazil	1.79
Australia	0.44	Paraguay	2.17
Canada	0.55	Uruguay	2.23
Germany	1.14	Venezuela	2.96
France	1.14	Argentina	2.98
UK	1.46	Mexico	3.13
Greece	1.80	Colombia	3.49
Spain	3.16	Bolivia	4.76

Source: Heckman and Pagés (2000).
Notes: This index, developed by Pagés and Montenegro (1999), measures the expected discounted cost (in multiples of monthly wages), at the time a worker is hired, of dismissing that worker in the future.

Table 4: Years Available in the UNIDO Dataset, Trade Liberalization Dates, and the Level of the Job Security Index.

	Years Available in UNIDO	Trade Liberalization Date	Job Security Index
New Zealand	1976-1997	1987	0.22
Chile	1976-1998	1976	1.20
Poland	1976-1998	1990	1.22
Uruguay	1976-1997	1990	2.23
Argentina	1976-1990, 1993-1994	1976	2.98
Mexico	1976-1998	1987	3.13
Spain	1976-1998	1979	3.16
Colombia	1976-1998	1991	3.49
Turkey	1976-1998	1990	3.97
Ecuador	1976-1997	1991	4.04
Bolivia	1976-1998	1986	4.76

Notes: The trade liberalization dates are taken from Wacziarg and Wallack (2004). The job security index for all countries except Chile is taken from Heckman and Pagés (2000) while the job security index for Chile is provided by Edwards and Edwards (2000). The table lists the value of the index during the five years following a trade liberalization reform using the Wacziarg and Wallack (2004) trade liberalization dates.

Table 5: The Annual Intersectoral Reallocation of Workers After a Trade Reform.

	Coefficient	Standard Error
Argentina (Intercept)	0.0214***	(0.0028)
Chile	0.0087**	(0.0036)
Colombia	-0.0020	(0.0036)
Ecuador	0.0141***	(0.0036)
Spain	-0.0047	(0.0036)
Mexico	-0.0014	(0.0036)
New Zealand	-0.0034	(0.0037)
Poland	-0.0086**	(0.0036)
Turkey	0.0023	(0.0036)
Uruguay	0.0113***	(0.0037)
β_2	0.0197***	(0.0041)
β_3	-0.0057***	(0.0014)

Notes: The table lists the results from the following regression:

$$I^a_{i,t} = \beta_0 + \beta_1 Z_i + \beta_2 D_{i,t} + \beta_3 D_{i,t} * FC_i,$$

where $I^a_{i,t}$ is the annual intersectoral reallocation index for country i in year t, Z_i is a dummy variable for country i, $D_{i,t}$ is a variable which takes the value of 1 in each of the five years following the trade liberalization reform of country i and 0 otherwise, and FC_i is the job security index for country i during the five years after its trade reform. See Appendix I for a detailed discussion of the data.

*** − statistically significant at the 1% level; ** − statistically significant at the 5% level; * − statistically significant at the 10% level;

Table 6: Parameters Calibrated Without Solving the Model, the Benchmark Non-Distorted Economy.

General Parameters		Human Capital Parameters		Policy Parameters	
β	0.99024	a_0	0.2857	τ_1	0.0
δ	0.00625	a_1	0.3312	τ_2	0.0
γ	0.68	a_2	0.3831	ν_1	0.0
ρ	0.0	λ_1	0.25	ν_2	0.0
p_1^w	1.0	λ_2	0.04167		
p_2^w	1.0				

Table 7: Parameters Calibrated by Solving the Model, the Benchmark Non-Distorted Economy.

α	1.790
ϕ	0.920
σ_ϵ	0.102

Table 8: Steady State Analysis, the Case of Chile.

	Economy 1	Economy 2	Economy 3
Real Output		5.4	6.1
Real Output per Worker		5.5	7.0
Welfare		8.8	9.5
Labor Force			
Percentage Employed in Cluster 1	42.75	15.97	15.53
Percentage Employed in Cluster 2	56.42	83.03	82.74
Exports-to-Output Ratio	0.13	0.35	0.36
Intersectoral Reallocation			
Percentage Switching Sectors	0.83	1.00	1.73
Intersectoral Reallocation Index	0.011	0.012	0.027

Notes: Economy 1 is an economy with high tariffs and high firing costs. Economy 2 is an economy with no tariffs and high firing costs. Economy 3 is an economy with no tariffs and no firing costs. Real output, real output per worker, and welfare are represented as a percentage change relative to Economy 1.

Table 9: Transition Analysis, the Case of Chile, Percentage Changes.

		Years After the Trade Reform			
		2	3	5	7
Real Output	Trade and Labor Reform	2.5	3.7	4.2	4.6
	Only Trade Reform	1.6	2.6	3.2	3.5
Real Output per Worker	Trade and Labor Reform	5.2	5.5	5.6	6.0
	Only Trade Reform	3.5	3.8	4.0	4.3
Welfare	Trade and Labor Reform	6.4	7.6	8.1	8.6
	Only Trade Reform	5.7	6.5	7.1	7.5

Notes: The percentage increase in real output, real output per worker, and welfare is relative to the economy without trade and labor reforms.

Table 10: Transition Analysis, Foregone Benefits from Not Liberalizing the Labor Market, in Percent.

	Years After the Trade Reform			
	2	3	5	7
Real Output	36	30	25	24
Real Output per Worker	32	31	29	27
Welfare	11	15	13	13

Notes: This table reports the foregone benefits from not liberalizing the labor market at the outset of a trade reform.

Table 11: Benefits of Liberalizing the Labor Market, Present Discounted Values, the Case of Chile.

	Only Trade Reform	Trade and Labor reform
Real Output	3.3	4.1
Real Output per Worker	4.4	6.1
Welfare	7.3	8.1

Notes: The results take into account both the transition and the new steady state values.

Table 12: Sensitivity Analysis, Comparative Statics with Respect to Changes in α, ϕ, and σ_ϵ.

	Benchmark (1)	α=1.580 (2)	α=2.000 (3)	ϕ=0.890 (4)	ϕ=0.950 (5)	σ_ϵ=0.084 (6)	σ_ϵ=0.120 (7)
Targets:							
Exports-to-Output Ratio, in Percent	36	31	39	35	40	35	37
Reallocation Index*100	2.7	3.1	2.4	1.5	5.7	1.8	3.8
Employment in Sectors with a Change $\geq$ 10%	0.14	0.17	0.12	0.09	0.30	0.10	0.17
Employment in the Steady State with Tariffs and with Firing Taxes:							
Employment in Cluster 1	43	46	39	44	41	44	42
Employment in Cluster 2	56	53	60	56	58	55	57
Employment in the Steady State without Tariffs and without Firing Taxes:							
Employment in Cluster 1	16	21	12	15	17	16	16
Employment in Cluster 2	83	77	86	84	79	83	82
Effect of Firing Costs on Worker Reallocation	0.71	0.60	0.80	0.69	0.78	0.68	0.73
Benefits from Trade Reform, in Percent (Labor Market Liberalized)	4.1	3.0	4.6	4.2	4.6	4.4	4.0
Foregone Benefits, in Percent (If Labor Market Not Liberalized)	20	33	12	10	26	10	23

Notes: Column (1) reports the statistics in the benchmark calibration of the model in which the relative productivity of both clusters $\alpha = 1.79$, the persistence in the sectoral log shocks $\phi = 0.92$, and the standard deviation of the innovations to the sectoral log shocks $\sigma_\epsilon = 0.102$. The rest of the table reports how the statistics change if we change the values of α, ϕ, or σ_ϵ. See Section 6.3.1 for a detailed discussion.

Table 13: Sensitivity Analysis with Respect to Changes in γ, a Shorter Model Period, and No Human Capital.

	Benchmark (1)	γ=0.85 (2)	γ=0.92 (3)	Shorter Model Period (4)	No Human Capital (5)
Parameters:					
α	1.790	1.319	1.183	1.887	1.808
ϕ	0.920	0.905	0.901	0.944	0.927
σ_ϵ	0.102	0.098	0.091	0.057	0.066
Employment in the Steady State with Tariffs and with Firing Taxes:					
Employment in Cluster 1	43	50	52	42	50
Employment in Cluster 2	56	50	48	57	50
Employment in the Steady State without Tariffs and without Firing Taxes:					
Employment in Cluster 1	16	17	17	13	15
Employment in Cluster 2	83	81	81	86	84
Benefits from Trade Reform, in Percent (Labor Market Liberalized)	4.1	3.1	2.5	5.2	5.1
Foregone Benefits, in Percent (If Labor Market Not Liberalized)	20	31	46	13	8

Notes: Column (1) reports the statistics in the benchmark calibration of the model in which the labor share $\gamma = 0.68$ and the model period is a quarter. The rest of the table reports how the statistics change if the model is recalibrated with a higher value for γ, a model period of 6.5 weeks, or without sector-specific human capital. See Section 6.3.2 for a detailed discussion.

Table 14: Steady State Analysis, The Case of Mexico.

	Economy 1	Economy 2	Economy 3
Real Output		3.9	4.1
Real Output per Worker		4.3	5.7
Welfare		5.8	6.1
Labor Force			
Percentage Employed in Cluster 1	39.81	18.42	18.25
Percentage Employed in Cluster 2	59.18	80.21	79.29
Exports-to-Output Ratio	0.16	0.34	0.35
Intersectoral Reallocation			
Percentage Switching Sectors	1.01	1.37	2.46
Intersectoral Reallocation Index	0.014	0.015	0.041

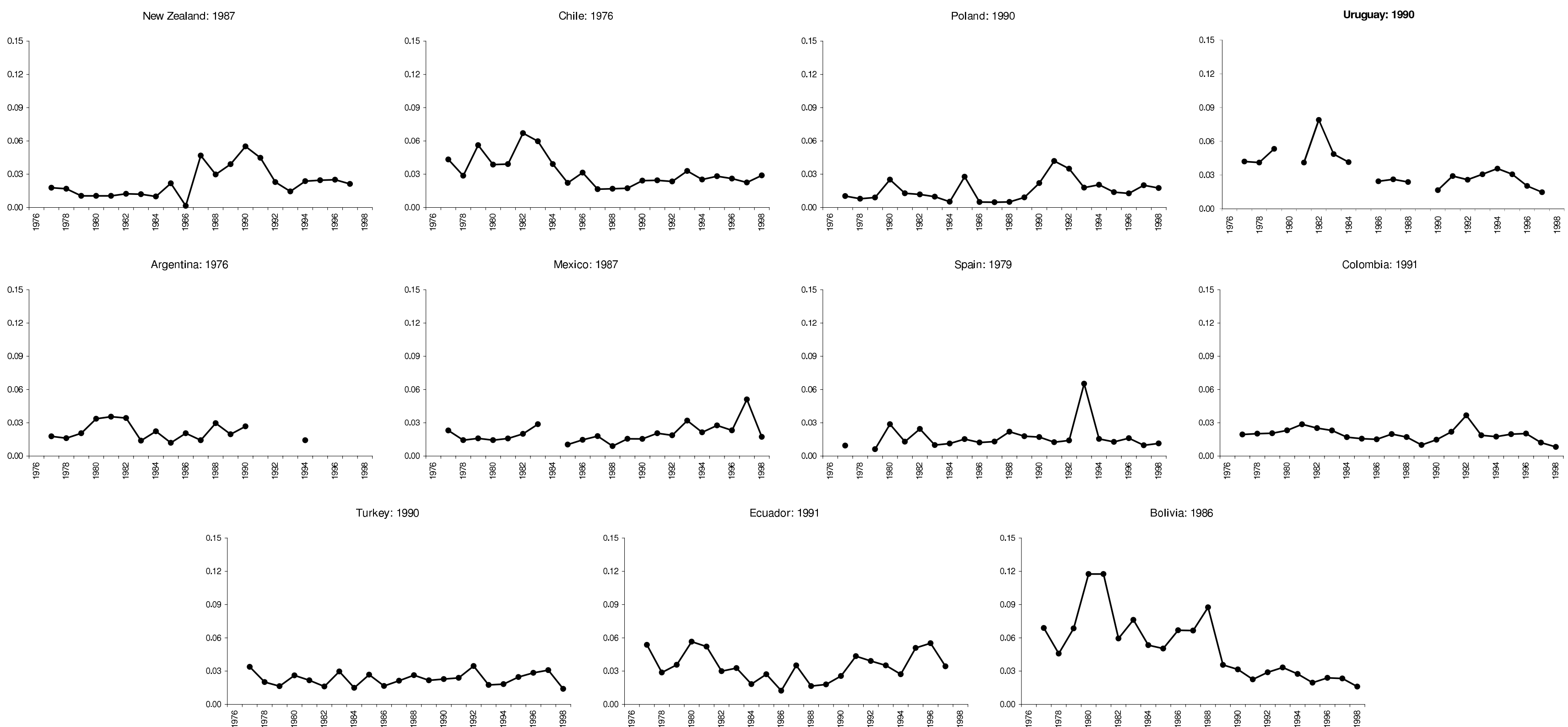
Notes: Economy 1 is an economy with high tariffs and high firing costs. Economy 2 is an economy with no tariffs and high firing costs. Economy 3 is an economy with no tariffs and no firing costs. Real output, real output per worker, and welfare are represented as a percentage change relative to Economy 1.

Table 15: Benefits of Liberalizing the Labor Market, Present Discounted Values, The Case of Mexico.

	Only Trade Reform	Trade and Labor reform
Real Output	2.1	3.0
Real Output per Worker	3.1	5.1
Welfare	4.1	5.0

Notes: The results take into account both the transition and the new steady state values.

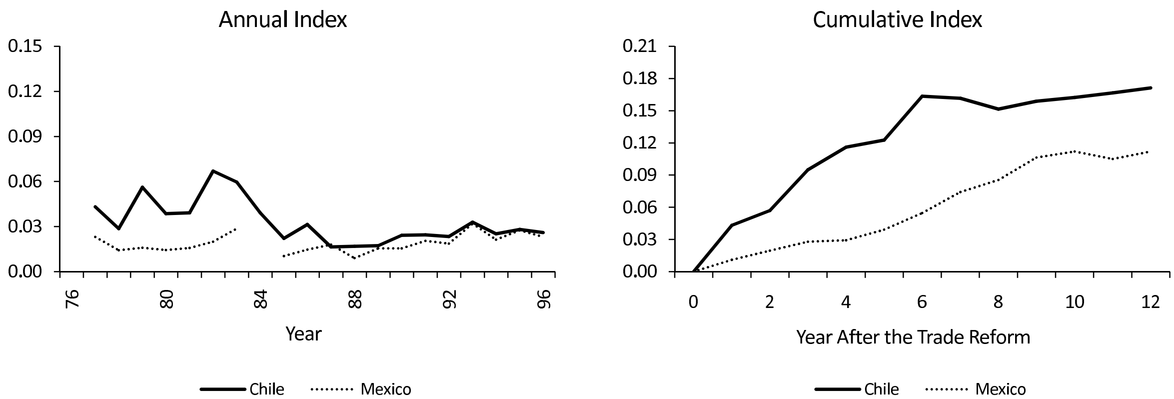
Figure 1: The Sectoral Reallocation of Labor, 1976-1998, Annual Index.



Source: UNIDO Dataset.

Note: The annual intersectoral reallocation index measures the fraction of workers who in year t are working in a different sector than in year $t-1$. The trade liberalization date (next to the country's name) is taken from Wacziarg and Wallack (2004). The countries are ordered according to the level of their firing costs in the years following the trade liberalization reform – New Zealand is the country with the lowest level of firing costs while Bolivia is the country with the highest. As a measure of the level of firing costs I use the job security index developed by Pagés and Montenegro (1999) as listed in Table 4. See Appendix I for a detailed description of the data and a comprehensive sensitivity analysis.

Figure 2: The Sectoral Reallocation of Labor in Chile and Mexico, Annual and Cumulative Index.



Source: UNIDO Dataset.
Notes: The annual sectoral reallocation index measures the fraction of workers who in year t are working in a different sector than in year $t-1$. The cumulative sectoral reallocation index measures the fraction of workers who in year t are working in a different sector than in the base year. The base year is 1985 for Mexico and 1976 for Chile.

Figure 3: Consistent Prices, p_i in Equilibrium: I.

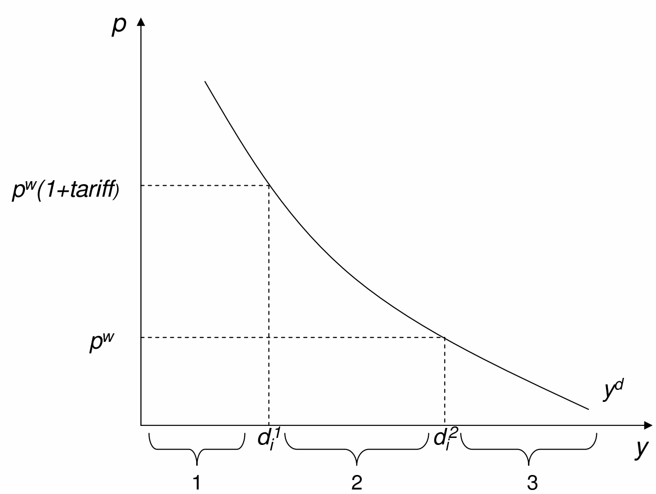


Figure 4: Consistent Prices, p_i in Equilibrium: II.

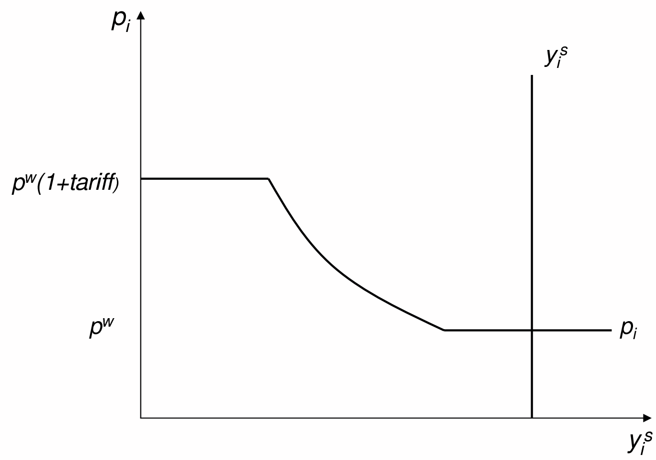
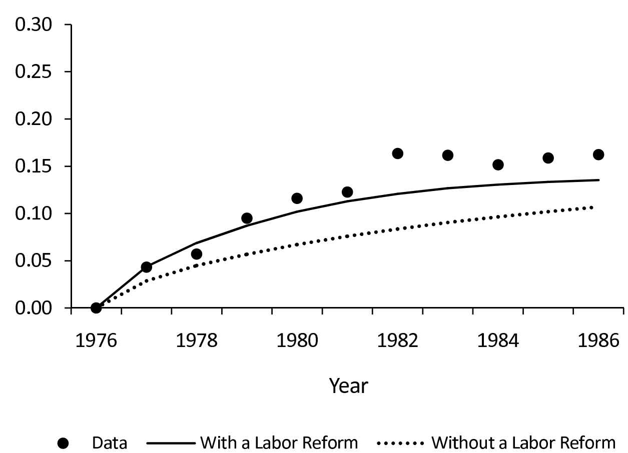
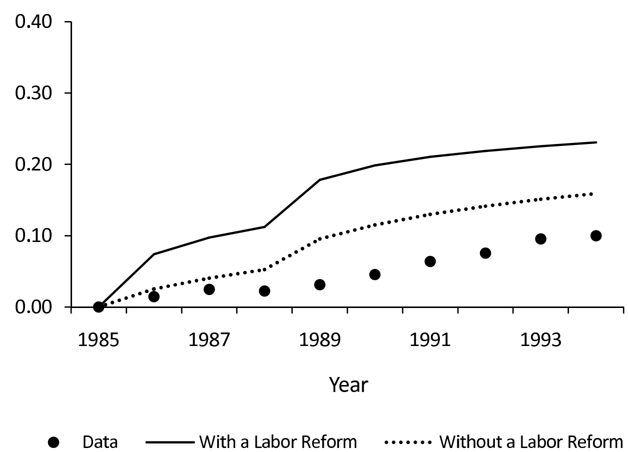


Figure 5: The Cumulative Intersectoral Reallocation Index in Chile, Model and Data.



Notes: The cumulative intersectoral reallocation index in the model is computed with respect to 1976. That makes the comparison with the data easier since while Chile initiated its trade reform in 1974 the UNIDO dataset allows us to compute the reallocation index for Chile from 1976 on.

Figure 6: The Cumulative Intersectoral Reallocation Index in Mexico, Model and Data.



Notes: The cumulative intersectoral reallocation index is computed with respect to 1985.

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APPENDICES

I Description of the Data and Sensitivity Analysis

The United Nations Industrial Organization (UNIDO) 3-digit dataset provides data on the number of workers employed in 28 sectors in manufacturing for various countries. The sectors are listed according to the ISIC 3 digit classification: 311 – Food products; 313 – Beverages; 314 – Tobacco; 321 – Textiles; 322 – Wearing apparel except footwear; 323 – Leather products; 324 – Footwear except rubber or plastic; 331 – Wood products except furniture; 332 – Furniture except metal; 341 – Paper and products; 342 – Printing and publishing; 351 – Industrial chemicals; 352 – Other chemicals; 353 – Petroleum refineries; 354 – Miscellaneous petroleum and coal products; 355 – Rubber products; 356 – Plastic products; 361 – Pottery china earthenware; 362 – Glass and products; 369 – Other non-metallic mineral products; 371 – Iron and steel; 372 – Non-ferrous metals; 381 – Fabricated metal products; 382 – Machinery except electrical; 383 – Machinery electric; 384 – Transport equipment; 385 – Professional and scientific equipment; 390 – Other manufacturing products.

There are 20 countries in the dataset with a trade liberalization episode. Heckman and Pagés (2000) and Edwards and Edwards (2000) provide information on the level of firing costs for 11 of these countries – New Zealand, Chile, Poland, Uruguay, Argentina, Mexico, Spain, Colombia, Turkey, Ecuador, and Bolivia.

I.1 Sensitivity Analysis

Section 2.3.1 studies whether there is an increase in the annual intersectoral reallocation index in the five years following a trade reform and whether such an increase is systematically related to the level of firing costs in a given country. The specification used in the analysis is:

$$I^a_{i,t} = \beta_0 + \beta_1 Z_i + \beta_2 D_{i,t} + \beta_3 D_{i,t} * FC_i,$$

where $I^a_{i,t}$ is the annual intersectoral reallocation index for country i in year t, Z_i is a dummy variable for country i, $D_{i,t}$ is a variable which takes the value of 1 in each of the five years following the trade liberalization reform of country i and 0 otherwise, and FC_i is the job security index for country i during the five years after its trade reform.

The main data restrictions for this benchmark case are:

- *Bolivia:* Bolivia is excluded from the analysis since, as seen in Figure 1, the annual intersectoral reallocation index for Bolivia exhibits an inexplicable structural break in 1988 – two years after the trade reform. In particular, the reallocation index is more than twice lower in the 1989-1998 period than in the 1977-1988 period. A trade reform is unlikely to cause such a dramatic decline in the reallocation index – it is rather the case that either Bolivia experienced other significant changes or there was a change in the methodology used for collecting the data.

- *Mexico:* The UNIDO dataset starts reporting the number of workers employed in sectors 322, 324, 332, 342, 356, 361, 385, and 390 in Mexico only after 1984. Therefore, the series in the period 1976-1983 differs from the one during the 1984-1998 period. While consistent within each of these periods, in 1984 – the year when the employment in the additional sectors is added – the sectoral series experiences a structural break. As a result, I delete the 1984 observation for Mexico from the analysis.

- *Uruguay:* The UNIDO dataset reports the number of workers employed in sectors 353 and 354 in Uruguay in 1980-1984 and 1989-1997, but does not report it in 1976-1979 and 1985-1988. While consistent within each of these periods, in 1980, 1985, and 1989 – the years when the employment in these two sectors is added or removed – the sectoral series experiences a structural break. As a result, I delete the 1980, 1985, and 1989 observations for Uruguay from the analysis.

- *Spain:* The sectoral employment series in 1976 and 1977 differs from the one during the 1978-1998 period. As a result, I delete the 1978 observation for Spain from the analysis.

Below, I provide a sensitivity analysis with respect to these data restrictions, as well as a few additional sensitivity checks. Table A-1 lists the results from the sensitivity analysis. In all of these specifications the main result remains unchanged – β_2 is positive, β_3 is

Table A-1: The Annual Intersectoral Reallocation of Workers After a Trade Reform, Sensitivity Analysis.

	β_2	Stand. Error	β_3	Stand. Error
Benchmark	0.0197***	(0.0041)	-0.0057***	(0.0014)
With Bolivia	0.0168***	(0.0050)	-0.0042***	(0.0016)
With Outliers	0.0182***	(0.0067)	-0.0061***	(0.0023)
With Bolivia and Outliers	0.0147**	(0.0070)	-0.0042*	(0.0023)
4 Years After the Reform	0.0145***	(0.0055)	-0.0033*	(0.0018)
6 Years after the Reform	0.0170***	(0.0013)	-0.0046***	(0.0013)
2-Year IRI	0.0205**	(0.0083)	-0.0058**	(0.0029)
Sachs and Warner (1995) Dates	0.0138***	(0.0042)	-0.0037**	(0.0015)
Alternative JS Index	0.0160***	(0.0035)	-0.0045***	(0.0012)
Without Spain	0.0197***	(0.0040)	-0.0056***	(0.0014)
With Bolivia and Without Spain	0.0170***	(0.0051)	-0.0041**	(0.0016)
Without Argentina	0.0198***	(0.0041)	-0.0057***	(0.0014)

Notes: *** − statistically significant at the 1% level; ** − statistically significant at the 5% level; * − statistically significant at the 10% level.

negative, and both coefficients are highly statistically significant − indicating that the sectoral reallocation of workers increases after a trade reform but only in the countries with a low level of firing costs.

- *With Bolivia:* Bolivia is included in the analysis.
- *With Outliers:* The following observations are included in the analysis − 1984 for Mexico, 1978 for Spain, and 1980, 1985, and 1989 for Uruguay.
- *With Bolivia and Outliers:* Bolivia and the following additional observations are included in the analysis − 1984 for Mexico, 1978 for Spain, and 1980, 1985, and 1989 for Uruguay.
- *4 Years After the Reform:* The $D_{i,t}$ variable takes the value of 1 in each of the four years following the trade liberalization reform of country i and 0 otherwise.
- *6 Years After the Reform:* The $D_{i,t}$ variable takes the value of 1 in each of the six years following the trade liberalization reform of country i and 0 otherwise.

- *2-Year IRI:* The intersectoral reallocation index is defined as a two-year reallocation index. In particular, denote by H_t^s the amount of labor employed in sector s in period t as a fraction of all employed workers in manufacturing. Then

$$C_t^s = |H_t^s - H_{t-2}^s|$$

measures the absolute change in the share of sector s in year t as compared to year $t-2$. The two-year intersectoral reallocation index in year t, I_t^b, is defined as

$$I_t^b = \frac{1}{2}\sum_{s=1}^{S} C_t^s,$$

and measures the fraction of workers who in year t are working in a different sector than in year $t-2$.

- *Sachs and Warner (1995) Dates:* For some of the countries in the sample Sachs and Warner (1995) provide slightly different trade liberalization dates than Wacziarg and Wallack (2004). In particular, they give 1986 as the trade liberalization date for New Zealand, 1991 for Argentina, 1986 for Mexico, 1960 for Spain, 1989 for Turkey, and 1985 for Bolivia. In this specification, I use the Sachs and Warner (1995) trade liberalization dates in the analysis. I drop Argentina and Spain from the analysis since the UNIDO dataset does not provide sectoral employment data around their Sachs and Warner (1995) liberalization dates.

- *Alternative JS Index:* Heckman and Pagés (2000) provide an alternative estimate of the Job Security index for Colombia and Spain. This specification uses an index of 0.8850 for Colombia and 4.5670 for Spain.

- *Without Spain:* Spain is excluded from the analysis.

- *With Bolivia and Without Spain:* Bolivia is included in the analysis while Spain is excluded.

- *Without Argentina:* Argentina is excluded from the analysis.

Finally, I divide the sample of countries into two groups − those with a job security index below the average (New Zealand, Chile, Poland, and Uruguay) and those above the average. I redefine FC_i to be a dummy variable equal to 0 if country i belongs to the high firing cost group and 1 otherwise. On a sample similar to the one in Wacziarg and Wallack (2004) $-$ comparable to the results from the regression with Bolivia and with the outlier observations $-$ I find that $\beta_2 = -0.0003$ while $\beta_3 = 0.0092$. Both coefficients are highly statistically insignificant (with standard errors of 0.0038 and 0.0063, respectively).

II Computing Transitions

The following algorithm is used in computing transitions.

1. Compute the initial steady state and the new steady state.
2. Assume the transition takes N periods.
3. Guess $\Theta = \{U_t, V_t^s, Y_t, P_t\}_{t=0}^N$.
4. Given Θ, going from the last transition period to the first one (backwards), compute the value and policy functions (V, g).
5. Given (V, g), compute $\tilde{\Theta} = \{\tilde{U}_t, \tilde{V}_t^s, \tilde{Y}_t, \tilde{P}_t\}_{t=0}^N$.
6. If $\tilde{\Theta}$ is the same as Θ, then the transition is computed. If not then go to (3) and make a new guess (either $\tilde{\Theta}$ or a convex combination between $\tilde{\Theta}$ and Θ).

III Calibrating the Exports-to-Output Ratio in Manufacturing in Chile

The Early 1990s. Alvarez and Fuentes (2003) report that $\frac{y^m}{y^T}$, the share of the manufacturing sector in GDP, in Chile in the early 1990s is in the 0.19-0.25 range, depending on two different measurement methodologies used by the Chilean Central Bank. In addition, they report that $\frac{EX^m}{EX^T}$, the share of manufacturing exports in all exports, in the early 1990s is 0.30. Ffrench-Davis (2002) reports that $\frac{EX^T}{y^T}$, the exports to GDP ratio, in the early 1990s is 0.30. This implies that $\frac{EX^m}{y^m}$, the exports-to-output ratio in manufacturing, is in the range 0.36-0.47 since

$$\frac{EX^m}{y^m} = \left(\frac{EX^m}{EX^T}\right)\left(\frac{EX^T}{y^T}\right)\left(\frac{y^T}{y^m}\right).$$

The United Nations Industrial Organization (UNIDO) dataset provides data on total output (in US Dollars), value added (in US Dollars), and exports (in US Dollars) for all three-digit manufacturing sectors in Chile for the 1981-1998 period. It also provides data on total output (in US Dollars), value added (in US Dollars), and exports (in US Dollars) for all 81 manufacturing sectors in Chile for 1986 and 1989-1998. This information is insufficient to compute the exports-to-output ratio in manufacturing in terms of value added. However, if we assume that, for each sector in every year, the ratio of value added exports to total exports is the same as the ratio of value added to total output, then we can compute the exports-to-output ratio in manufacturing, in terms of value added. Both at the 3-digit and 4-digit level it is around 0.30.

In the benchmark calibration for Chile I use the value of 0.36 and then provide a comprehensive sensitivity analysis of the benchmark case, including cases when the exports-to-output ratio is slightly higher or lower.

The Early 1970s. Using information from Alvarez and Fuentes (2003) and Ffrench-Davis (2002) for the early 1970s we can determine that the exports-to-output ratio in manufacturing in Chile in the early 1970s is in the 0.12-0.15 range. The UNIDO dataset does not provide information on total output, value added, and exports for this period.