Trade Reforms in a Global Competition Model: the Case of Chile*

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June 7, 2005

Abstract

We use a global competition model of international trade to characterize the effects of trade reforms occurred in Chile at the end of the 70s. We calibrate the model and evaluate its results using a comprehensive plant-level dataset for the period 1979-96. The model is able to explain many of the effects of liberalization reforms on industry performance. We proceed by exploring the impact of preferential trade agreements negotiated by Chile in recent years with the European Union and the North American Free Trade Agreement.

JEL Codes: F11, F17, L11, O24.

*Acknowledgements : We would like to express our gratitude to Jonathan Eaton for his advice and constant support. Special thanks to James Levinsohn, Nina Pavnick, Amil Petrin and James Tybout for providing the data for this study. We benefited from comments and discussions with Kristin Aarland, Angelo Mele, Silvana Melitsko, Paolo Opromolla and Karl Walentin. The usual disclaimer applies. Correspondence to: aai208@nyu.edu, luca.opromolla@nyu.edu.

1 Introduction

In the late 1970s Chile's economy faced a number of economic reforms aimed at increasing growth and efficiency. Among these economic reforms, numerous studies have highlighted trade reforms as pre-eminent. Previous to this period, Chile had pursued a policy of import-substitution aimed at protecting local firms from international competition. This situation changed when the government removed non-tariff restrictions and drastically reduced tariff rates.

Many studies have already explored the effects of trade reforms on industry performance in Chile and in other developing countries. In an influential volume Roberts and Tybout (1996) organized a collection of papers describing the response of heterogenous producers to several policy conditions. The strength of these papers is that they based their conclusions on very detailed micro-level datasets. A common result is that trade reforms lead factors to reallocate toward more productive plants. Pavnick (2002), using a shorter version of the plant-level dataset used here, found evidence that within plant productivity improvement can be attributed to liberalized trade for plants belonging to the import-competing sector.

Recently, Melitz (2003) and Bernard, Eaton, Jensen and Kortum (2003) (BEJK thereafter) have shown how trade opening has sector-specific effects, creating new markets for more productive firms and putting pressure on less productive ones. A distinctive feature of this line of research is that it analyzed changes in the structure of the industry from a general equilibrium prospective. Most of the previous studies concentrated on the effect of policy changes in partial equilibrium, viewing how changes in local policy affect outcomes treating prices and competition as unchanged.

In this paper we attempt to explain some stylized facts of Chile's reform by using a global competition model. The model is based on the work of BEJK, which features international competition of several countries in a Ricardian environment. Using a comprehensive plant-level dataset for the period 1979-1996, we explore the effects of reducing trade barriers simulating the policy scenario prevalent in Chile, a small developing country, in the late 70s. We explore to what extent we can account for several facts in the data. The model quite successfully captures the main changes happening in the manufacturing sector right after the trade reforms: an increase in overall productivity and its components (change in productivity of continuing plants, reallocation of inputs, exiting and entrant plants), dynamics of entry/exit of plants, relative productivity of exiting plants and changes in employment.

Since the model comes to terms with plant-level facts quite well we go on to explore the flexibility of the calibrated model to study the effect of Preferential Trade Agreements (PTAs hereafter) on the performance of the manufacturing sector in Chile. From the beginning of 2000 Chile has pursued a strategy of additive regionalism negotiating PTAs with its main trading partners. Since Viner (1950) the theories of PTAs or Custom Unions have identified potential benefits and costs for the home country and the world. It has been argued that the welfare effects of regional trade agreements are ambiguous at the theoretical level. As an example, Wonnacott (1986) and others have argued that if PTAs are signed among natural trade partners, then the trade creation effect will outweigh the trade diversion effect.

The BEJK global competition model is especially suited to evaluate the effects of a PTA. We use the model calibrated for Chile to evaluate the effect of recent trade agreements with NAFTA and the European Union. We find evidence of potential large benefits for Chile of negotiating PTAs with its main trading partners. Our estimates for a bilateral reduction in tariffs with NAFTA and the European Union leads to an increase in measured productivity of 15 percent with a net employment creation of 28 percent.

The remainder of the paper is organized as follows. In the next section we lay out the main stylized facts of trade reforms, industry dynamics, and exporters' characteristics. In Section 3, we present the theoretical model upon which we based the analysis. Section 4 compares the model quantitative implications for the trade reforms of the end of the 70s with the plant-level statistics and present the model quantitative predictions for the preferential trade agreements scenarios. Section 5 concludes.

2 Industry Facts

In this section we present stylized facts concerning the effects of trade liberalization reforms at the end of the 70s on the manufacturing sector. We also show some facts related to the productivity advantage of exporters, which will be important for the implementation of the model.

2.1 Trade Liberalizations and Industry Structure

Before 1974 the Chilean manufacturing sector was highly protected: high and differentiated tariffs rates, quotas, multiple exchange rates and domestic regulations were favoring the manufacturing sector at the expense of agriculture and import-competing producers over exporters.[1] Between 1974 and 1979 Chile underwent a series of macroeconomic and microeconomic reforms aimed at reducing the fiscal deficit and the inflation rate, deregulating the domestic market and opening the country to international trade. The reduction in trade protection evolved in several stages: the average (unweighted) tariff rate decreased from 105 percent in 1973 to 65 percent in 1975; a new target structure of effective tariff rates ranging from 10 percent to 35 percent was achieved and started to have effect at the end of 1977; by June 1979 a uniform 10 percent nominal tariff rate was in effect. Table 1 reports the effective protection rates by three-digit sectors after 1974.

The effects of trade opening on the industrial sector were substantial. We study them by using a plant-level dataset, the Encuesta Nacional Industrial Anual (ENIA) conducted annually by the Chilean government statistical office (Instituto Nacional de Estadistica (INE)). This is an unbalanced panel dataset covering all Chilean manufacturing plants with ten or more workers. The dataset extends from 1979 to 1996, includes information on approximately 11,000 plants altogether, with about 4,800 plants per year. It contains detailed information on production, value added, sales, employment and wages (both white-collar and blue-collar), exports, investment, depreciation, energy consumption, balance sheet information and other plant characteristics. Data on plant-level exports were only collected after 1990. We start by looking at the dynamics of plants entry and exit.[2]

Before turning to the analysis of the dynamics of entry and exit we need to discuss a feature of the data: due to truncation when we have, for a given year, a missing plant we cannot say, at least through direct information, if this plant has closed (at least temporarily) has not reported to the statistical office or has reduced the number of employees to under ten. This is due to the design of the survey which was originally conceived as a cross section and was only later transformed into a panel by using plant identification codes and SIC industrial codes. In order to deal with this feature of the data we adopt a conservative strategy and consider, in this section, only those plants that belong to one of the following three categories: surviving plants (plants which stay in the sample for the entire 1979-1996 period), entering plants (enter the database sometime between 1980 and 1996 and stay in until the end of the period), exiting plants (enter the database in 1979 and exit sometime, without entering again,

[1] See Aedo and Lagos (1984), Corbo and Sanchez (1985) and Tybout (1996).

[2] Unfortunately, the data do not allow identification of multi-plants firms. Indirect evidence (positive purchases of material from other establishments within the same firm) shows that about 90% of the manufacturing firms are single-plant. We will conduct our analysis focusing on plants only.

between 1980 and 1996).[3] All the other plants (which enter and exit multiple times) are not considered in the entry/exit analysis: this reduces the number of plants in the dataset by about 30 percent to a total of 7,624 plants. Moreover, about 11 percent of the remaining plants switch 3-digits industry code at some point during the period over which they are observed. We do not consider these plants either. Overall, we drop 37 percent of the plants which account for 22 percent of total output. Figure 1 shows the original number of plants in the survey, the number of plants dropped at each stage and the number of plants in the final sample from 1979 to 1996. The elimination strategy does not affect the pattern of entry and exit observed in the data since the number of plants dropped per year is fairly constant.[4]

Figure 2 shows the number of entering, exiting and surviving plants in the manufacturing sector from 1979 to 1996. The number of operating plants follows a dramatic U-like pattern whose turning point is in 1986, when the number of operating plants is 56 percent the number of plants which were active in 1979, seven years earlier. This pattern is the result of a steady decrease in the number of exiting plants and an increasing number of entering plants.

This pattern might suggest a strong adjustment in the industry. However, a closer look at the dynamics in terms of size reveals a somewhat different picture. Entrants tend to be smaller, in terms of value of production, than existing producers. In particular, an entrant produces 27.5 percent of the average output level of all incumbent plants in the industry (see Table 2). On average, the entrants in each year are responsible for approximately 1.4 percent of each manufacturing industry‘s output, this share increasing over the sample period. The exit variables reflect a similar pattern: the average size of plants exiting the market is about 25 percent the size of nonexiting plants; the average market share of all exiting plants is 1.3 percent, with a decreasing pattern over time.[5] If we look at size in terms of number of workers, the size of the average entering and exiting plant is still smaller than their respective counterparts but the difference is consistently smaller: an entrant's and exiters' labor force is half as large as the labor force of an incumbent (or nonexiting) plant.

[3] Liu (1993) adopts the same strategy using ENIA data for the 1979-1986 period.

[4] We performed a robustness check using a sample which includes also plants that entered after 1979, reported information for x consecutives years ($x \geq 1$) and exited before 1996. The number of plants considered increase by 11% on average and all the results in the paper don't change significantly.

[5] Dunne et al. (1988) compute this set of entry/exit statistics using data for U.S. firms for the period 1962-82. Like us, they find that entering and exiting firms are substantially smaller than incumbent and nonexiting firms, respectively. However, for U.S. data, entering and exiting firms are responsible for a larger share (about 15%) of the manufacturing industry output and entry and exit rates are fairly stable over time.

2.2 Exporters Productivity Advantage

We now turn to the comparison of exporting and non-exporting plants. Recall that this information will be used to calibrate the model to the data. One out of five Chilean manufacturing plants exports part of their output. Among these, almost five out of ten export less than 10 percent of their total production and only slightly more than two out of ten export more than half of their output . These ratios are quite stable over the years for which we have export information, from 1990 to 1996. BEJK using data for the U.S. and Eaton, Kortum and Kramarz (2004) using French data, also conclude that there is a high degree of heterogeneity across firms in the extent of their export participation. Figure 3 compares the productivity, measured as value added per worker, of exporting and non-exporting plants. The distribution of exporters productivity is shifted to the right with respect to the productivity distribution of non-exporting plants. Exporting plants are, on average, more productive than non-exporting plants: value added per worker at the average exporting Chilean plant is 85 percent higher than at the average plant that does not export. This result surpasses previous findings for U.S. and French data: BEJK show that the productivity advantage of U.S. plants is about 33 percent overall and 15 percent relative to nonexporters within the same 4-digits industry while Eaton et al. (2004) find that the French exporting firms' value added per worker is 12.5 percent higher than nonexporting counterparts.

3 A Model of Global Competition

Our main objective in this study is to explain several facts related to the manufacturing sector in Chile. BEJK (2003)'s model provides a useful framework to study the effects of falling trade barriers on the structure and performance of the manufacturing industry. We calibrate the model to fit plant-level data from ENIA for 1992. Then we use the model to observe to what extent it captures the impact of trade reforms at the end of the 70s. Additionally, we ask what the model can say about the effects of signing PTAs with foreign countries. This section outlines briefly the global competition model stating the most important assumptions and predictions of the framework in relation to our analysis. We then present how we take the model to the data.

3.1 The BEJK framework

There are N countries which trade a continuum of goods indexed by j on the unit interval. In each country consumers have CES preferences over this bundle of goods. Therefore, consumer optimization implies the following expenditure on good j in country n

$$X_n(j) = \left(\frac{P_n(j)}{p_n}\right)^{1-\sigma} x_n$$

where $P_n(j)$ is the price of good j in country n, x_n is aggregate expenditure in country n, $\sigma > 0$ is the elasticity of substitution across goods and p_n, the aggregated price index for the economy in country n, is given by

$$p_n = \left[\int_0^1 P_n(j)^{1-\sigma} dj\right]^{1/(1-\sigma)}$$

On the production side, heterogeneity is driven by differences in underlying efficiency across plants. In each country there are multiple potential producers of each good j with different levels of efficiency. The k^{th} most efficient producer of good j in country i hires $1/Z_i^k(j)$ units of a unique composite input to produce one unit of the good. Each plant produces only one type of good, there are no fixed costs and technology has constant returns to scale. Each plant is a potential candidate to provide the good to the domestic market and eventually to export it to any other country. The k^{th} most efficient producer of good j in country i can deliver the good in country n at a unit cost

$$C_{ni}^k(j) = w_i d_{ni} \frac{1}{Z_i^k(j)}$$

where w_i is the unit cost of the composite input (which varies across countries), $d_{ni} \geq 1$ is the number of units that need to be shipped from country i for one unit to be delivered in country n. Geographic barriers, represented by the parameter d_{ni}, satisfy a triangular inequality constraint which assures that the cost of moving goods from country i to country n is bounded from above by the cost of moving them via some third country k. It is worth noting that factor costs and efficiency affect the potential exporting plant in the same way independently of the destination. The only factor that relates the source and the destination countries is the trade barrier parameter d_{ni}.

In each country n, each good j is provided by one and only one plant which proves to be the lowest cost provider of that good to country n. The unit cost of the minimum cost provider to market n is

$$C_n^1(j) = \min_{i=1,\dots,N} \left\{ C_{ni}^1(j) \right\}$$

In order to explain heterogeneity in plants measured productivity, defined as the value of output per unit input, Bertrand competition is introduced. Bertrand competition prevents the lowest cost provider from raising its price over the second-lowest unit cost supplier to the market. Given that a plant from country i^* is the low-cost supplier of good j to market n its markup is

$$M_n(j) = \frac{P_n(j)}{C_n^1(j)} = \min \left\{ \frac{C_n^2(j)}{C_n^1(j)}, \overline{m} \right\}$$

where $P_n(j)$ is the price charged by the lowest-cost plant, $C_n^2(j)$ is the unit cost of the second-lowest cost provider to market n and $\overline{m}$ is the upper bound on the markup as in Dixit-Stiglitz (1977).[6] Comparisons of measured productivity across plants reflect only differences in their markups. The model implies that, on average, plants that are more efficient charge a higher markup, hence variation in efficiency can generate heterogeneity in measured productivity across plants. The model also implies that more efficient plants are more likely to export and to have higher domestic sales than plants that don't export.

In order to apply the model to the data we do not actually need to estimate the highest efficiency $Z_i^1(j)$ and the next highest efficiency $Z_i^2(j)$ for each country i and good j. We can treat efficiency levels as random variables and transform the lowest unit cost function of good j in each country i as

$$C_{ni}^k(j) = w_i d_{ni} \left(\frac{U_i^k(j)}{T_i} \right)^{1/\theta}$$

where $U_i^k(j)$ are random variables drawn, independently across countries i and goods j, from a parameter-free distribution, T_i is a parameter that represents the overall efficiency of country i and θ is a parameter that governs the heterogeneity of efficiency and thus determines the scope for gains from trade due to comparative advantages.[7] Moreover, as BEJK show, bilateral trade shares π_{ni} and absorption x_n summarize all we need to know about each country-specific parameter T_i, w_i and d_{ni}.

The model is simulated J times. For each market i and good j let $\Omega_i(j)$ be the set of countries which buy good j from country i. In our simulation we treat each j for which $\Omega_i(j)$

[6] Notice that the second-lowest cost provider to market n can either be the minimum cost provider (to market n) from country $i \neq i^*$ or the second-lowest cost provider (to market n) from country i^*.

[7] The cdfs of the parameter-free distributions are: $\Pr[U_i^1 \leq u_1] = 1 - e^{-u_1}$ and $\Pr[U_i^2 \leq u_2 | U_i^1 = u_1] = 1 - e^{-u_2 + u_1}$ respectively. Since $U_i^k(j) = T_i Z_i^k(j)^{-\theta}$ It can be shown that $Z_i^1(j)$ and $Z_i^2(j)$ are jointly drawn from a bivariate version of the Fréchet distribution.

is nonempty as a product with a corresponding active plant in country i.[8] For each active plant it is possible to calculate: i) total sales, ii) whether the plant exports and how much, iii) total production cost, iv) employment and v) total productivity.

3.2 General Equilibrium and Scenarios

The model described above represents the situation before the trade shocks. In this section we explain how the model relates changes in trade barriers to changes in the price of intermediates. As a preliminary step, we need to specify in more detail the nature of the unique composite input: we assume that production combines labor, with wage W_i, and intermediates, which are a representative bundle of manufactures with price index p_i so that the cost of an input bundle in country i is

$$w_i = W_i^{\beta} p_i^{1-\beta}$$

(where labor units are chosen to eliminate the constant).

In each country i, the manufacturing sector faces an elastic supply of labor at wage W_i, the latter being determined in the market of a tradeable nonmanufactured good which serves as numeraire. A change in trade barriers affects trade patterns by modifying producers' cost of exporting their goods. This, in turn, influences the price of intermediate goods in the receiving countries, the choice between different factors of production and the corresponding industry equilibrium.

For each wage, the price index of manufacturing goods, p_n, is determined by the trade in intermediate goods. BEJK show that this can be represented by

$$p_n^{-\theta} = \sum_{i=1}^{N} (T_i W_i^{-\theta\beta} d_{ni}^{-\theta}) p_i^{-\theta(1-\beta)} \quad (1)$$

We are interested in how changes in d_{ni} (trade shocks) determine changes in the price of intermediates. In appendix A it is shown that totally differentiating equation (1) with respect to d_{ni} and p_n we obtain in matrix notation

$$d \log P = \left[I_n - (1-\beta)\Pi\right]^{-1} diag(\Pi D')$$

where P is an $N \times N$ matrix whose typical element is P_n, Π is an $N \times N$ matrix whose typical element π_{ni} is the fraction of goods country n buys from country i, D is a matrix with the n^{th}

[8] Notice that if the set $\Omega_i(j)$ is a singleton then $\Omega_i(j) = \{i\}$. This is a consequence of the triangular inequality constraint on d_{ni} which implies that any plant that exports its good will also sell it at home. Notice that the converse is not true, that is, only a fraction of active plants will succede in exporting anywhere.

row and i^{th} column element given by $\frac{dd_{ni}}{d_{ni}}$, the percentage change in d_{ni} due to trade reforms and $diag(.)$ is an operator which transforms an $N \times N$ matrix into an $N \times 1$ vector whose elements are the elements of the diagonal of the matrix. With this equation we calculate the change in prices after the trade shock. Measured (deflated) productivity is given by

$$q(j) = \frac{1}{p}\frac{W}{\beta}\left[M^c(j) - (1-\beta)\right] \tag{2}$$

where M^c is the composite markup across all markets, i.e., total revenues over total costs.

Therefore a decrease in the price of intermediates implies a gain in efficiency. Since W is kept fixed by assumption, it also implies that real wages increase by the same proportion.

To study the effect of two type of trade reforms on the manufacturing industry we study the behavior of the model under two transformations of the D matrix. These two different specifications of the shock matrix represent i) a reduction in Chile's trade barriers representing changes occurred in the country by the end of the 70s and ii) a bilateral reduction in trade barriers for the countries which recently signed trade agreements with Chile.

We study a fall in trade barriers, to represent the situation of Chile at the end of the 70s, by letting $\frac{dd_{cl,i}}{d_{cl,i}} = d_1$ for all i, where the index cl is the row corresponding to Chile in the shock matrix D and d_1 is the percentage reduction in trade barriers. To represent the effect of PTAs we set $\frac{dd_{i,j}}{d_{i,j}} = d_2$ for $i \in B$ and $j \in B - \{i\}$, where B is the set of countries participating to the PTA and d_2 is the agreed tariff reduction.

3.3 Calibration

To evaluate the quantitative importance of the predictions of the model we take it to the data. The purpose of the calibration is to set the stage for analyzing how different kinds of trade shocks affect the structure of the manufacturing sector. We use the framework outlined in Section 3 which describes a global competition model among manufacturing industries in different countries. In this model, a fall in Chile's trade barriers changes the relative value of the competition inducing changes in the pattern of trade and performance of the manufacturing sector in Chile.

In order to evaluate these changes we calibrate two parameters of the model as in BEJK. We search for θ and σ in order to match the productivity and sales advantage of exporting vs nonexporting plants observed in the ENIA dataset. To make the results comparable to BEJK we calibrate the model for 1992 data. We use data on bilateral trade for Chile's 43 major trading partners[9] from Feenstra (2000) and plant-level data from the ENIA. In our sample of plant-level data from ENIA, exporters have, on average, 85 percent higher value added per worker than nonexporters and their domestic shipments are on average 4.3 times higher than those of nonexporting plants. We estimate θ, the parameter governing the degree of heterogeneity in plants productivity, to be 2.85 and σ, the elasticity of substitution, to be 2.45, both values being smaller than those estimated by BEJK for the USA ($\theta = 3.6$ and $\sigma = 3.79$). A lower value of θ means higher productivity advantage of exporting plants which is consistent with the estimated sample moments of Chile and US.

Table 3 shows, in detail, of how the data generated by the model compare with the statistics observed in the data. Our results underpredict the fraction of exporting plants found in the sample by 16 percent. This deviation is smaller as compared with BEJK who overpredict the number of exporting plants by 30 percent.

The model matches quite well the skewness of the fraction of revenues from exports among Chilean exporting plants. As in BEJK, most of exporters sell a small fraction abroad. However, in our case we seem to perform better than BEJK for the higher percentiles of the distribution. Finally, we obtain a standard deviation of the log of value added per worker of about 0.57 in the simulated data while in the actual sample is about 1.0. Indeed, these results seem to suggest that the model's fit is capturing the main facts of the plant-level data.

4 Quantitative Analysis of Trade Reforms

In this section we study the quantitative implications of trade reforms using the calibrated model presented in Section 3. We begin with an analysis of the effects of the trade liberalization reforms that Chile experienced at the end of the 70s. We compare steady state outcomes of a fall in trade barriers on different indicators of the manufacturing industry. Next we consider the potential benefits of preferential trade agreements. We use the most recent data available to us to estimate the effects of eliminating the uniform nominal tariff rate with several trading blocks.

[9] Those countries represent about 95 percent of the total volume of exports from Chile.

4.1 Effects of Trade Liberalization Reforms

In this subsection we report how the calibrated model responds to a fall in trade barriers of similar magnitude to the one observed in Chile at the end of the 70s. For this experiment we use the values of θ and σ obtained in Section 3. For the situation before and after the tariff reduction we use trade flows, exports and production data for the thirty most important trading partners of Chile in 1980.

We consider a uniform reduction in Chile's trade barriers by 50 percent. As described in Section 2, Chile's effective protection rate decreased by about 58 percent from 1977 to 1979. Given that we use 1980 as our starting period and that the effects of the reduction might show up only after a positive time lag this seems a plausible scenario.

Table 4 summarizes the results of this experiment, showing the effects of the trade policy shock on the steady state of the model and comparing them with the data. While identifying the effects of trade reforms we have to take into account other major economic and political events affecting Chile during the 1980s and in particular the recession which hit the economy in 1982-83. Historical evidence from the pre-recession period 1980-81 can therefore be considered as a good starting point to judge the "goodness of fit" of the model. Reaching the new steady state requires however more time and therefore we report, in Table 4, changes in various statistics for two periods: from 1980 to 1981 and from 1980 to 1983.[10] According to the model, a fall in barriers of 50 percent has large effects on the efficiency and composition of the manufacturing sector. Consistent with the theory we predict an increase of aggregate productivity, measured as value added per worker, of 24.1 percent. In the data (see Panel A) we find that overall productivity actually rose by 9.7 percent from 1980 to 1981, declined from 1981 to 1982 as the recession hit the economy and rose again from 1982 to 1983, reaching a level 23 percent higher than in 1980. Following the methodology outlined in Foster et al. (2001), we decompose the change in aggregate productivity $(q_{t+1} - q_t)$ from year t to year $t+1$ into the contribution of exiting plants (x), entering plants (n), reallocation among surviving plants (c) and productivity gains for continuing incumbents. Denoting the set of plants of

[10] Another reason for reporting statistics for the 1980-83 period is that Chile temporarily increased its tariffs to 35% from the end of 1983 to mid 1985, when tariffs were reduced to 20%.

each type as Ω_k, $k = n, x, c$:

$$\begin{aligned} q_{t+1} - q_t &= \sum_{j \in \Omega_c} s_t(j)[q_{t+1}(j) - q_t(j)] + \sum_{j \in \Omega_c} [s_{t+1}(j) - s_t(j)][q_t(j) - q_t] \\ &+ \sum_{j \in \Omega_c} [s_{t+1}(j) - s_t(j)][q_{t+1}(j) - q_t(j)] + \sum_{j \in \Omega_n} s_{t+1}(j)[q_{t+1}(j) - q_t] \\ &+ \sum_{j \in \Omega_x} s_t(j)[q_t - q_t(j)] \end{aligned}$$

where $q_t(j)$ is the period-t productivity of plant j as defined in equation (2) and $s_t(j)$ is the period-t employment share of plant j as a fraction of total manufacturing employment. Panel A of Table 4 reports the results of the decomposition for the model and the data. According to the model, the increase in productivity is due to the combined effects of four factors. First, a 17.3 percent rise in the productivity of continuing plants which gain from a 21 percent decline in the price of intermediates goods (as cheaper imports replace domestically produced inputs). The second factor is the change in the set of active plants: the number of plants decreases by 19.5 percent and since exiting plants are on average 45 percent less productive than nonexiting plants, overall productivity rises by another 6.2 percent. The third factor is the reallocation of production among continuing plants which accounts for another 4.4 percent increase in overall productivity. Finally, as continuing plants expand and start selling to new markets their average productivity advantage decreases and this accounts for a decrease in overall productivity of 3.8 percent. The data, both for the period 1980-81 and for the period 1980-83, seem to be consistent with these predictions in terms of sign and (for the period 1980-83) levels. Moreover, the model also captures the relative importance of each of the productivity components. Panel B of Table 4 reports the ratios between each of the addends on the right-hand-side of equation (2) and the change in aggregate productivity (the left-hand-side of equation (2)). As Pavnick (2002) suggested, both within plant productivity improvements and the reshuffling of resources from less to more efficient producers play a role.

According to the theory, the number of plants decreases by 19.5 percent: these plants are less efficient than average and they tend to sell only in the domestic market. Table 4 and Section 2 show that the number of plants in fact decreased by 12 percent from 1980 to 1981 and by 29 percent from 1980 to 1983. Given that the recession probably reinforced the exit of less productive plants, the model seems to capture quite well this trend in the economy. Exiting plants are about 70 percent less productive than nonexiting plants in 1980-81. The model predicts a decrease in employment of 6.5 percent which describes quite well the actual trend in the short and medium period: a decrease of 8 percent between 1980 and 1981 and of 13 percent between 1980 and 1986. Furthermore, the relative importance of gross job creation and destruction are also consistent with the data.[11] Finally, the model suggests an increase in exports by 68 percent and imports by 93 percent while actual data show a decrease in exports and an increase in imports in the short run.

Overall the model seems to capture quite well the main changes in the manufacturing sector after the trade reforms, showing a fair precision and ability to identify the relative importance of different factors. With this in mind we use the model, in the next section, to analyze recent changes in the trade policy of Chile.

4.2 Potential Benefits of Preferential Trade Agreements

In the past five years Chile has negotiated a series of preferential trade agreements (PTAs) with its main trading partners. Since the year 2000 it has entered PTAs with United States, the European Union, Korea and other European countries. According to Harrison et al (2001) Chile has followed a policy of additive regionalism in which a country starts a process of negotiating bilateral free trade agreements with all its important trading partners. Theoretically, the effects of entering PTAs are ambiguous and their benefits are therefore a matter of empirical analysis. Popular general equilibrium methods to evaluate trade policies are based on scale economies and imperfect competition (Melo and Tarr,1992). We show that a global competition model with a ricardian structure is also suitable for the analysis of trade policies.

We evaluate the effects on the performance of the manufacturing sector in Chile of entering PTAs with two important trading blocks, NAFTA and EU and with all the Chilean trading partners. For this experiment we mantain the same values for the elasticity of substitution σ and efficiency parameter θ obtained in Section 3. Now we use data for trade flows and production from 1996, as a way to account for the fact that Chile has increased the number of countries with which it trades.

Table 5 depicts the effects of two PTA scenarios on different aspects of the manufacturing industry. Changes are relative to Chile's 1996 initial conditions. Scenario I represents the results of bilaterally decreasing the tariff rate from 11 percent to 6 percent with countries

[11] Job creation from period t to period $t+1$ is defined as the sum of the number of workers of entering plants and of the increase in the number of workers of continuing plants. Job destruction is defined as the sum of the number of workers of exiting plants and of the decrease in the number of workers of continuing plants.

member of NAFTA and the European Union.[12] According to our results a PTA leads to a 15 percent increase in productivity, measured as value added per worker, with a reduction in the number of plants of 16 percent. As the price of intermediates are cheaper real wages decrease by 13 percent. The net effect on employment reaches 27 percent. The effects of lower tariffs are large in terms of the trade balance. Exports and imports increase by 222 percent and 129 percent respectively.

The second scenario, labelled `global trade`, represents the effects of entering trade agreements with all Chilean trading partners. We explore this scenario as a measure of the potential gain (upper bound) of negotiating PTAs with all countries. Manufacturing plants gain 43 percent in measured productivity mainly due to an increase in the productivity of continuing firms. Manufacuring real wages increases by 42 percent. In relation to the previous scenario we observe an increase in the net employment creation reaching 36 percent. Exports and imports increase by 602 and 374 percent respectively. Our results suggest that the potential gain of extending PTAs with Chile's trading partners are large in terms of aggregated productivity and employment.

We also calculated the change in government revenue as a result of the two scenarios. Government revenue is calculated as the tariff rate multiplied by the value of imports. According to our estimates government revenue rises by 25 percent in scenario I and by 159 percent in scenario II. The fact that the government gains from a reduction in tariffs is the result of a large increase in imports in the experiment. A lower elasticity of subsbtitution, which means a small demand response to price difference, will imply a lower sensitivity of imports to changes in tariff rates and a potentially negative impact on government revenues. Other policy studies obtain goverment revenue losses and calculate replacement tax options, in which the government levies taxes in order to compensate for the loss produced by the reduction of tariffs (Harrison et-al, 2002). This type of analysis does not consider the reallocations of resources that a global competition model delivers that may result in government revenue increases as in our experiment.

Since the model presented in this section is stylized, the particular numbers offered should be seen as preliminary. A potential area of research should focus on improving the current specification to allow for other sectors in the economy as well as goverment. These extensions may help to improve the estimation of the real welfare effects of alternative trade options.

[12] We have chosen a reduction in nominal tariff of 45 percent as in Harrison et-al (2001).

5 Conclusions

Trade theory has recently recognized the importance of heterogeneity of individual producers. Several potential explanations have been provided to account for plant-level facts mainly in developed countries. In this paper we use the model developed by BEJK to explain several plant-level facts for a small developing economy. Our findings indicates that a model of global competition is also consistent with several features of the Chilean manufacturing sector.

We use a calibrated version to revisit an issue that had previously been studied using partial competitive equilibrium models. We study the effects of a trade shock similar to what Chile experienced in its trade reforms at the end of the 70s.

The model proves to be able to account for the main developments in the manufacturing sector and, in particular, is able to predict the effect of trade opening on the different components of aggregate productivity. It also account fairly well for several indicators of entry-exit and employment with a reasonable level of accuracy.

Finally, we also use the model to explore the effects of preferential trade agreements on the performance of the manufacturing industry. We find evidence of potentially large benefits for Chile of negotiating PTAs with its main trading partners.

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Appendix A: The Price Equation

BEJK show that the joint distribution of the lowest cost C_{1n} and second-lowest cost C_{2n} of supplying some good to country n is:

$$\begin{aligned} G_n(c_1, c_2) &= \Pr[C_{1n} \le c_1, C_{2n} \le c_2] \\ &= 1 - e^{-\Phi_n c_1^\theta} - \Phi_n c_1^\theta e^{-\Phi_n c_2^\theta} \end{aligned}$$

for $c_1 \le c_2$, where:

$$\Phi_n = \sum_{i=1}^{N} T_i (w_i d_{ni})^{-\theta}$$

is a cost parameter that summarizes the effect of the absolute and comparative advantage parameters, the cost of the inputs and the trade barriers around the world.

To derive the effect of a trade shock on the price of intermediates, refer to equation (1) and rewrite it as

$$\Phi_n = \sum_{i=1}^{N} T_i (W_i^\beta d_{ni})^{-\theta} p_i^{-\theta(1-\beta)} = \sum_{i=1}^{N} \phi_i {d_{ni}}^{-\theta} \Phi_i^{1-\beta}$$

using $p_i = \gamma \Phi_i^{-1/\theta}$ twice, which represents the exact price index in country i under the assumption $\sigma < 1 + \theta$ and where $\phi_i = \gamma^{\theta\beta} T_i W_i^{-\theta\beta}$ and γ is a function of θ and σ.

Let us total differentiate this expression keeping W_i and T_i constant:

$$d\Phi_n = -\theta \sum_{i=1}^{N} \phi_i {d_{ni}}^{-\theta-1} \Phi_i^{1-\beta} dd_{ni} + (1-\beta) \sum_{i=1}^{N} \phi_i {d_{ni}}^{-\theta} \Phi_i^{-\beta} d\Phi_i$$

Divide the above by Φ_n

$$\frac{d\Phi_n}{\Phi_n} = -\theta \sum_{i=1}^{N} \underbrace{\frac{\phi_i {d_{ni}}^{-\theta} \Phi_i^{1-\beta}}{\Phi_n}}_{\pi_{ni}} \frac{dd_{ni}}{d_{ni}} + (1-\beta) \sum_{i=1}^{N} \underbrace{\frac{\phi_i {d_{ni}}^{-\theta} \Phi_i^{1-\beta}}{\Phi_n}}_{\pi_{ni}} \frac{d\Phi_i}{\Phi_i}$$

where π_{ni} is the fraction of goods country n buys from country i

$$d \log \Phi_n = \frac{d\Phi_n}{\Phi_n} = -\theta \sum_{i=1}^{N} \frac{dd_{ni}}{d_{ni}} \pi_{ni} + (1-\beta) \sum_{i=1}^{N} \pi_{ni} \frac{d\Phi_i}{\Phi_i}$$

Now, we can rearrange terms as:

$$(1 - (1-\beta)\pi_{nn})\, d \log \Phi_n = -\theta \sum_{i=1}^{N} \frac{dd_{ni}}{d_{ni}} \pi_{ni} + (1-\beta) \sum_{i \ne n} \pi_{ni} \frac{d\Phi_i}{\Phi_i}$$

and switch to matrix notation

$$[I_n - (1-\beta)\Pi]\, d\log\Theta = -\theta diag(\Pi D')$$

$$d\log\Theta = -\theta\left[I_n - (1-\beta)\Pi\right]^{-1} diag(\Pi D') \tag{a1}$$

where Θ is an $N \times 1$ vector whose representative element is Φ_n, Π is an $N \times N$ matrix whose representative element is π_{ni}, D is an $N \times N$ matrix where the representative element $\frac{dd_{ni}}{d_{ni}}$ is the percentage change in country n trade barriers versus country i and $diag(.)$ is an operator which transform an $N \times N$ matrix into an $N \times 1$ vector whose elements are the elements of the diagonal of the matrix.

Using

$$d\log P = -\frac{1}{\theta} d\log\Theta$$

we can rewrite equation (a1) as:

$$d\log P = \left[I_n - (1-\beta)\Pi\right]^{-1} diag(\Pi D')$$

Appendix B: Data Sources

Our empirical work combines macro-level data on world bilateral trade flows and gross production in the manufacturing sector with micro-level data on Chilean manufacturing plants. The latter has been described in Section 2.[13] Trade data come from the World Trade Analyzer (WTA) database assembled by Statistics Canada which contains bilateral trade flows for all countries over 1980-1997, classified according to a 34 manufacturing industry basis used by the U.S. Bureau of Economic Analysis (Feenstra (2000)). Data on gross production for the manufacturing sector comes from OECD (STAN dataset), UNIDO and World Development Indicators. Real value of output is computed by using an industry level price deflator constructed by the Banco Central de Chile. Real values of the other variables are obtained by using, in most cases, 3-digits sector specific deflators derived directly from the plant-level dataset.

[13] We refer the reader to Liu (1993) for a more comprehensive description of the plant data.

Table 1: Effective Protection in Chile, 1974-1979

		Effective Protection (%)					
ISIC	Industries	1974	1975	1976	1977	1978	1979
312	Food	161	105	48	28	16	12
313	Beverages	203	119	47	32	19	13
314	Tobacco	114	68	29	19	11	11
321	Textiles	239	138	74	49	28	14
323	Leather Products	181	98	46	36	21	13
322/324	Footwear and apparel	264	164	71	48	27	14
331	Wood products	157	93	45	28	16	15
332	Furniture	95	58	28	17	11	11
341	Paper and paper products	184	114	62	37	22	17
342	Printing	140	75	40	32	20	12
355	Rubber products	49	55	54	43	26	15
351/352	Chemicals	80	53	45	24	16	13
353/354	Petroleum	265	101	17	0	12	13
369	Non-metallic minerals	128	87	55	32	20	14
371	Iron and steel	127	86	64	38	25	17
381	Metal products	147	101	77	52	27	15
382	Non-electric machinery	96	72	58	35	19	13
383	Electric machinery	96	72	58	35	19	13
384	Transport equipment	-	-	-	-	-	-
390	Miscellaneous	-	-	-	-	-	-
	Mean	151.4	92.2	51	32.5	19.7	13.61
	Standard deviation	60.4	29.4	15.7	12.5	5.3	1.7
	Range	216	111	60	52	17	6

Source: Aedo and Lagos (1984)

Table 2: Entry and Exit Variables for the Chilean Manufacuring Sector (Averages over all 3-digits Sectors)

	1980-82	1983-85	1986-88	1989-91	1992-94	1995-96
Entrant Rate (ER)						
	.006	.026	.055	.048	.071	.160
Entrant Market Share (ESH)						
Number of Workers	.006	.014	.027	.025	.034	.072
Output	.003	.005	.019	.010	.015	.032
Entrant Relative Size (ERS)						
Number of Workers	.842	.531	.538	.532	.490	.498
Output	.401	.205	.399	.216	.207	.219
Exiter Rate (XR)						
	.130	.073	.044	.022	.018	.026
Exiter Market Share (XSH)						
Number of Workers	.074	.032	.02	.011	.013	.015
Output	.035	.012	.006	.006	.006	.010
Exiter Relative Size (XRS)						
Number of Workers	.538	.409	.467	.494	.697	.566
Output	.240	.153	.136	.258	.335	.386

Notes: the statistics are calculated using all 3-digits industry sectors but we drop entering plants if their output is greater than 3 standard deviations times the mean output of entering plants to eliminate outliers. See Dunne et al. (1989) for details on how to calculate entry/exit statistics.

Table 3: Chile's Export Facts: Simulated and Actual Data, 1992

	Percentage of all plants	
Export status	Simulated	Actual
No exports	94.8	80.1
Some exports	5.2	19.6
Export Intensity of exporters	Percentage of exporting plants	
	Simulated	Actual
0 to 10	69.2	53.78
10 to 20	11.1	10.31
20 to 30	1.1	5.51
30 to 40	7.1	4.90
40 to 50	6.1	3.27
50 to 60	1.7	5.00
60 to 70	1.4	4.29
70 to 80	1.4	6.43
80 to 90	0.5	3.88
90 to 100	0	2.65

Table 4: Effects of Trade Refoms: 50 Percent Reduction in Chile's Trade Barriers

	Model	1980-81	1980-83
Panel A: Main Statistics (Percentage Changes)			
Industry			
Aggregate Productivity	24.1	9.7	21.0
continuing plants	17.3	6.5	16.5
entering plants	0	0	-.1
exiting plants	6.2	3.5	9.4
reallocation among continuing plants	4.4	2.1	2.9
cross term for continuing plants	-3.8	-2.4	-6.7
Number of Plants	-19.5	-12	-28.7
Relative Productivity of Exiters	55	30	20.9
Employment			
Change in total employment	-6.5	-8	-26
Gross job flows: created	14.7	7.1	17.2
Gross job flows: destroyed	21.2	15.5	43.5
Trade			
Chile exports	68.3	-26	-33.8
Chile imports	93.4	33	-49.2
Panel B: Relative Importance of Productivity Components			
Continuing plants	.72	.67	.79
Entering plants	0	-.04	-.05
Exiting plants	.26	.36	.45
Reallocation among continuing plants	.18	.22	.14
Cross term for continuing plants	-.16	-.25	-.32
Total	1	1	1

Notes: Panel A) on each row, except for "Relative Productivity of Exiters", we report the predicted percentage change in the relevant statistic under the column "model" and the actual percentage change from 1980 to 1981 and from 1980 to 1983 in the last two columns; "Relative Productivity of Exiters" refers to the average value added per worker of exiting plants with respect to nonexiting plants: the second column contains the model prediction while the last two columns contain the 1980-81,1980-1983 average actual relative productivity.

Table 5: Effects of Two Alternative PTAs on Industrial and Trade Outcomes (percent changes)

	Scenario I (NAFTA, EU)-Chile	Scenario II Global Trade
Industry		
Aggregated Productivity	15.1	43
Plan exiting	16.0	20
Real wages	13.4	43.9
Employment		
Change in total employment	27.9	36
Gross job flows: created	48.5	60.4
Gross job flows: destroyed	20.6	23.1
Trade		
Chile exports	222	662
Chile imports	129	374

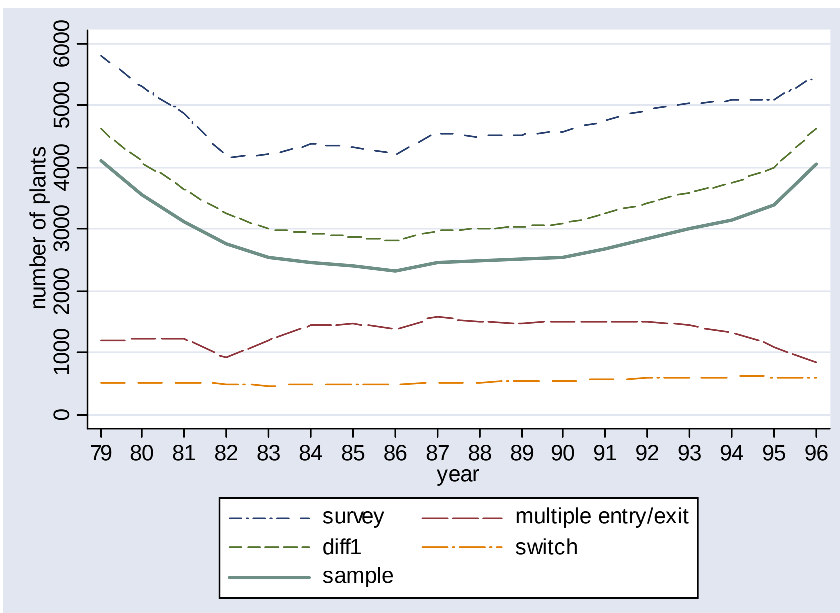

Figure 1: Number of Plants in the Survey, Number of Plants Dropped and Number of Plants in the Sample, 1979-1996

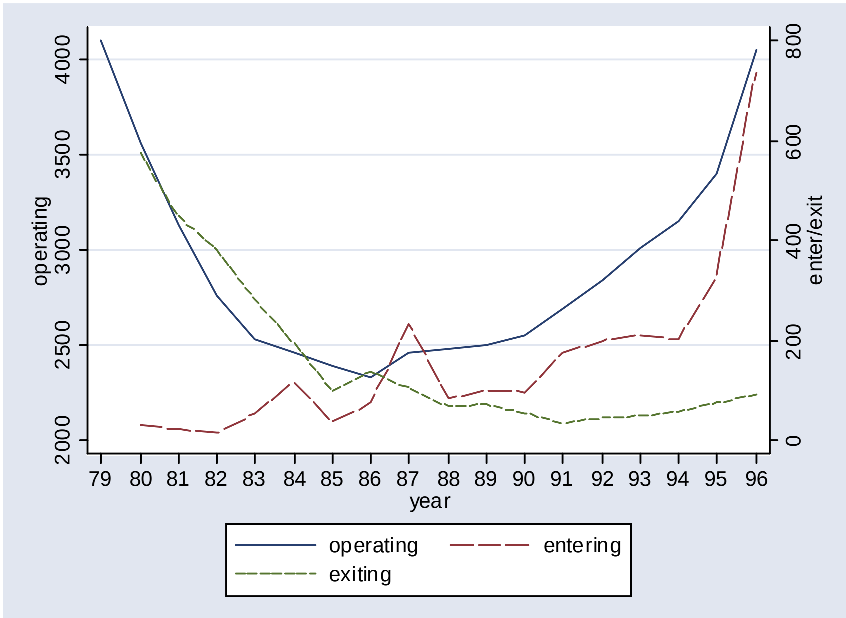

Figure 2: Number of Surviving, Entering and Exiting Plants , 1979-1996

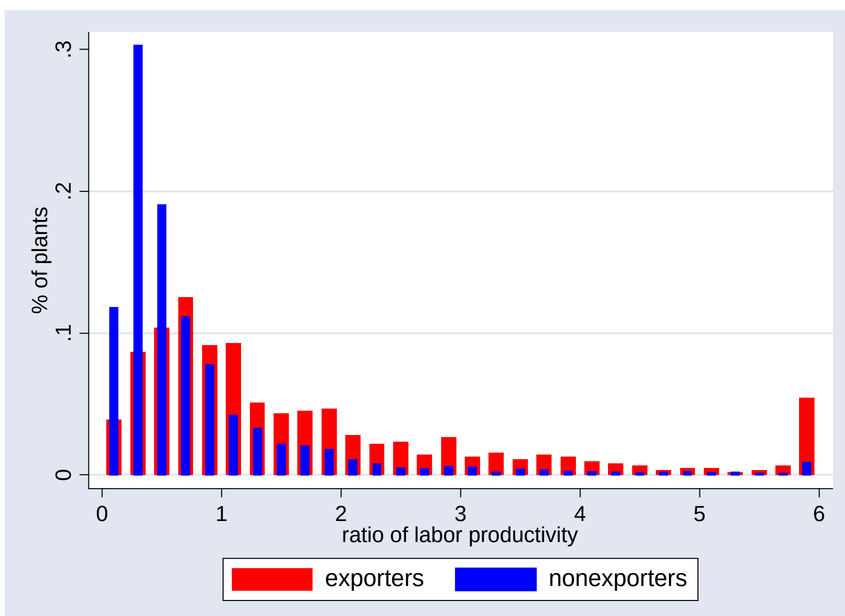

Figure 3: Ratio of Plant Labor Productivity to Overall Mean: Exporters vs. Non-exporters, 1992