EMPIRICAL STUDIES OF INTERNATIONAL TRADE

AND MULTINATIONAL FIRMS

IN ARGENTINA, BRAZIL AND CHINA

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Abstract

This dissertation consists of three empirical studies, grouped in three chapters. In Chapter 1, I develop and estimate a model of demand, supply and trade in cars for Argentina and Brazil. Trade is subject to two non-tariff barriers: a quota on bilateral net imports and a trade balance constraint, which are modeled as additional costs imposed to firms. I estimate the shadow value attached to them together with the cost of production of each car model. By modeling the behavior of firms in two countries, rather than in one, I am able to capture the strategic interaction across markets. In addition, it allows me to estimate the supply parameters by minimum distance instead of by a perfect fit method, and without the need to make functional form assumptions on the cost side (as is the usual practice in the literature).

In Chapter 2, I apply the methodology and results from Chapter 1 to the evaluation of a change in trade policy. I simulate a change in policy that will occur in 2006 when trade in cars is fully included in MERCOSUR. The change in policy implies the adoption of a common external tariff and the removal of the non-tariff barriers studied in Chapter 1. I estimate the separate effects of these changes in policy on prices, trade flows and welfare.

In Chapter 3, I study the introduction of new varieties of goods in the manufacturing sector in China. I compare the performance of foreign and domestic firms using firm-level data. Once observed firm characteristics are accounted for, I find that firms with more than 50 percent of foreign ownership introduce on average twice as many more new goods as private domestic firms; while fully foreign-owned firms introduce three times more new goods. Foreign firms are subsidiaries of multinationals and have more experience in the introduction and production of these new varieties. I measure these two advantages with

the cost of innovation (R&D and purchases of technology) and total factor productivity. These measures of efficiency explain between 13 and 33 percent of the difference in the number of new goods.

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Contents

Chapter 1

The automobile market in Argentina and Brazil

1.1 Introduction

In many applications of the empirical Industrial Organization literature estimating marginal costs from a model of firm behavior has become a preferred practice to computing marginal costs directly from accounting data. The use of accounting data has been criticized for delivering biased marginal costs that are affected by the firms' accounting procedures and manipulation for tax purposes. In the alternative approach, the researcher only needs data on sales, prices and other controls to estimate a demand function, while the cost side is estimated by fitting the demand side into a model of firm behavior. The marginal cost is estimated, rather than measured using its book value.

I focus on a case with differentiated products. The method mentioned above consists on specifying a full structural model of the behavior of the firms - including the choice variables, the nature of the competition and other factors influencing the market -

which can be summarized by a system of first order conditions that describes the firms' maximizing behavior. Such system includes quantities, prices, marginal costs and demand price derivatives (or elasticities). If prices, quantities and price derivatives are observed, the marginal cost of each differentiated product can be estimated by finding the values of the cost that satisfy the system of first order condition. Firms choose prices (or quantities) given a demand function and marginal costs; the researcher works backwards, given the observed prices and the demand function the marginal cost that generated those decisions can be pinned down. In practice, the demand functions are not observed and need to be estimated, either as a first step or jointly with the supply side.

In many applications, the supply side is affected by policy or market structure parameters that are unknown and need to be estimated jointly with the marginal cost of production. In the trade literature, Goldberg (1995) estimates a model of these characteristics to measure the impact of the Japanese VERs on export of automobiles to the U.S. during the 1980s. She models the profit maximization behavior of firms including the export restrictions and estimates one parameter for each year in which the VER was in place that reflects the cost imposed by the trade policy on Japanese firms. Berry, Levinsohn and Pakes (1999) run a similar exercise with a different demand specification.

In cases such as these two, the number of parameters to estimate in the supply side (marginal costs of production plus trade policy parameters) exceeds the number of first order conditions and there are not enough degrees of freedom to estimate all parameters jointly. Both Goldberg and Berry, Levinsohn and Pakes specify a parametric functional form for the cost function in which production cost depends on physical attributes of the automobiles. Instead of estimating the marginal cost of each car, they reduce the number of parameters by estimating the coefficients of a cost function (plus the trade policy parameters). This procedure side-steps the problem, but imposes further functional forms assumptions on a method that is already substantially relying on structure.

In my application, I estimate a model of supply and trade policy in the automobile sector in Argentina and Brazil during 1996-1999. During this period, there were two non-tariff barriers (NTBs) in place both from the Argentine and from the Brazilian sides. There was a quota on bilateral *net* imports, and there was a trade balance constraint on global trade. Both of these restrictions were applied to each firm and in each of the two countries.

I model the behavior of the firms in Argentina and in Brazil and incorporate the effects of the NTBs into the price decision making. Since firms are subsidiaries of multinational corporations, the same agents are located in the two countries and maximize profits jointly in the two markets. They produce different car models in Argentina, Brazil and the rest of the world and trade the different models across subsidiaries located in different countries. In terms of the estimation, this translates into observing two sets of quantities, prices and demand derivatives (one in Argentina and one in Brazil) while only one set of marginal costs (since each model is produced in only one country). I develop a minimum distance estimator that takes advantage of this additional information. The information on multiple equilibrium outcomes (in this case two) gives me enough degrees of freedom to estimate the production cost and the trade policy parameters directly from the behavior of firms, without imposing functional form assumptions on production costs.

This approach can be applied to any application in which there is market level data on more than one "market" but only one production cost. It is natural to apply the procedure to trade models, it is also suitable for closed-economy industrial organization applications in which there is demand data on different jurisdictions.

On the demand side, I adopt the random-coefficient model of Berry (1994) and Berry, Levinsohn and Pakes (1995). The procedure to estimate the supply side, however, is independent of the chosen demand model.

In Section 2, I describe the characteristics of the automobile market in Argentina and Brazil and the trade policy; in Section 3, I formalize the description of the industry into a model of oligopoly with differentiated products; the estimation details of the supply side can be found in Section 4. Section 5 describes the logit model with random coefficients of the demand side, and the estimation procedure; Section 6 presents a description of the data and the results of the estimation both of supply and demand parameters.

1.2 Automobile market and trade policy

Automobiles are produced in Argentina and Brazil by subsidiaries of multinational corporations associated with local investors. The firms located in the area are Ford, General Motors, Chrysler, Fiat, Volkswagen, Mercedes Benz, Peugeot-Citroën, Renault, Toyota and Honda (Chrysler and Mercedes Benz merged in 2000 and formed Daimler-Chrysler). There are no purely domestic firms, and the participation of local capital in the joint ventures with the above mentioned multinationals is minoritarian.

All of these firms have production facilities in both countries. Renault, Toyota and Peugeot-Citroën have regional headquarters in Argentina, while the remaining firms are primarily based in Brazil. Generally, the car models produced in Argentina are different from the models produced in Brazil. In some cases, there are overlaps of the main production lines across the two countries, but final models differ in engine size or design details. For example, between 1996 and 1997, Honda manufactured the Accord in Argentina and the Civic in Brazil (different production lines); while between 1996 and 1999, the Ford Escort was mainly produced in Argentina with the exception of the 2-door version that was produced in Brazil (same production line but different final models).

Firms trade models between Argentina and Brazil and also import and export from and to the rest of the world. The largest fraction of trade is bilateral, other destinations of exports are Latin America and Europe, primarily Italy and France, but this varies substantially by year. Cars produced in Argentina and Brazil are mostly compact, small and medium sized while models imported from third countries include larger vehicles and SUVs. Between Argentina and Brazil, the second country tends to specialize in the smaller models.

In Argentina, imports from Brazil receive a different treatment than imports from other countries, and vice versa in Brazil. Trade policy is subject to continuous negotiations both between the two countries and between authorities and firms.

In this paper, I estimate a model of supply and demand for cars during the period 1996-1999. The reason for choosing this period is that firms where subject to a peculiar intertemporal non-tariff barrier by which imports and exports had to balance for each firm, in each of the two countries, for the entire 4 year period in question. Moreover, Argentina and Brazil formed a customs union together with Uruguay and Paraguay in 1995 - MERCOSUR - and although the agreement did not include trade in cars in 1995, the years 1996-1999 were established as an initial period to phase-out tariffs and non-tariff barriers. I describe these policies in more detail next.

Tariffs for bilateral trade were zero during 1996-1999, however, trade between the two partners was subject to annual quotas on *net* imports, with the purpose of balancing trade in units. For example, in the case of Argentina, the total number of cars imported from Brazil minus the total number of cars exported to Brazil could not exceed a given limit (quota). These quotas were negotiated by the two countries and then arbitrarily assigned to firms, presumably based on past participation on the market.

Imports from third countries were subject to different tariff levels in Argentina and Brazil. The following table displays the average tariff levels applied to finished vehicles with origin in the "rest of the world" during 1996-1999 (imports from Uruguay receive special treatment as well, but I do not describe that here).

	ARGENTINA	BRAZIL
1996	7%	35%
1997	10%	32%
1998	14%	28%
1999	17%	35%

External tariffs gradually increased in Argentina because the objective was to converge to a common external tariff of 35 percent, established in the MERCOSUR negotiations.

Finally, both bilateral imports and imports from third countries were subject to a trade balance constraint both in Argentina and in Brazil: the total value of imports was restricted to be less or equal to the total value of exports. This constraint applies to each firm and in each country, for the entire period. I refer to this non-tariff barrier as the *global trade balance constraint* (GTB) to emphasize that it applies both to bilateral trade and trade with the rest of the world. To compute trade balance, exports are multiplied by a factor of 1.2 (this coefficient can in principle be managed to introduce slack into the constraint; in practice, it remained constant during the 4 year period); in addition, firms were granted export credits that could be included as part of exports for the purpose of computing the constraint. Net exports of auto-parts, exports of capital goods and a percentage of investment were considered export credits (which were not multiplied by 1.2); firms could also buy export credits from independent components producers.

For a given firm, the constraint in Argentina takes the following form

$$\begin{pmatrix} \text{Imports from Brazil} \\ + \\ \text{Imports from} \\ \text{other countries} \end{pmatrix} \leq 1.2 \begin{pmatrix} \text{Exports to Brazil} \\ + \\ \text{Exports to} \\ \text{other countries} \end{pmatrix} + \begin{pmatrix} \text{Export} \\ \text{credits} \end{pmatrix}.$$

Firms face an analogous constraint in Brazil and have to satisfy both of them intertemporally, during 1996-1999. At the beginning of the period, each firm presented an investment and trade plan for the following four years, which had to be approved by the authorities.

The following table summarizes the trade policy during 1996-1999,

BILATERAL IMPORTS	OTHER IMPORTS
Tariff: 0%	Tariff > 0%
Quota on net imports	-
Global trade balance	Global trade balance

There is no arbitrage between bilateral imports and imports from other countries. For example, a car entering Argentina from Brazil is consider a bilateral import if it was actually produced in Brazil. If it was produced elsewhere, it is considered an import from the "rest of the world" and subject to the appropriate trade restrictions. In addition, there are regional content agreements: a car produced in Brazil is subject to the "bilateral imports" trade policy if 60 to 70 percent of its components originated in MERCOSUR countries. The exact percentages vary by year and depend on the year of introduction of the car model (new car models are allowed to have larger fractions of foreign components).

The policy described above applies to firms that are actually located in Argentina and Brazil. Cars are also imported into these two countries by firms that do not have production facilities in the region. Among the most important during 1996-1999 are Rover, Isuzu and Daewoo. These firms represent less than 10 percent of the combined market and are subject to a completely different trade regime (they face traditional import quotas and higher tariff levels). Throughout this paper, I focus only on demand and supply for cars produced domestically in Argentina or Brazil or imported by local producers. There are other firms, that have merged or established partnerships with firms that do have local production (for example, Alfa Romeo and Fiat); they are subject to the trade regime described above and I do include them in the analysis by considering that their car models are traded by the local firms.

1.3 Model of firm behavior

I model the supply side of the car market as a differentiated-product oligopoly with price competition. There are F multinational corporations with subsidiaries in the two countries, indexed by f. Each firm produces some car models in Argentina, some models in Brazil and some models in the rest of the world. In each of the two countries, firms sell cars produced domestically, cars imported from the partner (Argentina or Brazil) and cars imported from other countries. A_{ft}, B_{ft} and W_{ft} are the sets of cars produced by firm f in period t in Argentina, Brazil and the rest of the world, respectively, and sold in Argentina; while A'_{ft}, B'_{ft} and W'_{ft} denote the sets of cars sold in Brazil. In principle the sets of cars sold in Argentina and Brazil can differ.

The same model is not produced in more than one country, and models are indexed by j. Producers face constant marginal costs for each model, given by c_j. For modeling purposes, it would be possible to specify a more general cost function in which the marginal cost depended on the quantity produced. However, for estimation purposes, it would require data on total quantity produced, which is not available for cars produced in countries other than Argentina and Brazil. The constant marginal cost assumption side-steps this restriction imposed by data availability.

Demands for model j in period t are fully observed by the firms and given by $q_{jt}^{a}\left(\mathbf{P}_t^a\right)$ and $q_{jt}^{b}\left(\mathbf{P}_t^b\right)$, in Argentina and Brazil respectively; where $\mathbf{P}_t^a$ is the price vector of all car models sold in Argentina and $\mathbf{P}_t^b$ its counterpart in Brazil. Demand functions vary by country and by time period, and they are independent across countries and time. In particular, it is assumed that demand is static and individuals do not consider future changes in prices in current decisions.

Bilateral imports are free of taxes, whereas outside imports face a tariff τ_t^a in Argentina and τ_t^b in Brazil. These tariffs are different in the two countries and vary by year. Tariffs are applied to the price at which car models are traded internationally, not the price at which they are sold to consumers. Since all trade is intra-firm, firms can in principle choose convenient transfer prices to minimize the effects of tariffs and NTBs and to switch profits across countries depending on corporate tax rates. However, in practice, authorities in the two countries elaborate ex-ante lists of values per model from which the values reported by firms cannot disagree substantially; the testimony of industry experts suggests that these values are reasonably close to the costs of production. Since I do not observe the prices at which firms trade internationally in the data, I assume that firms trade at marginal cost.

Let p_j^a be the retail price of model j in Argentina, and p_j^b the price of the same model in Brazil. Profits in country h (with $h = a,\, b$) of multiproduct firm f are given by the sum of profits for each good produced by f in Argentina, Brazil and the rest of the world and sold in country h. Demand is a function of all prices in country h, summarized in the price vector $\mathbf{P}_t^h$ that includes the prices of cars sold by firm f and also the prices of the cars offered by competitors. Profits in period t in Argentina and Brazil are, respectively

$$\begin{aligned} \pi_{ft}^a &= \sum_{j \in A_{ft}} \left(p_{jt}^a - c_{jt}\right) q_{jt}^a \left(\mathbf{P}_t^a\right) + \sum_{j \in B_{ft}} \left(p_{jt}^a - c_{jt}\right) q_{jt}^a \left(\mathbf{P}_t^a\right) + \\ &\quad + \sum_{j \in W_{ft}} \left(p_{jt}^a - c_{jt}\left(1 + \tau_t^a\right)\right) q_{jt}^a \left(\mathbf{P}_t^a\right) \end{aligned} \tag{1.1}$$

$$\begin{aligned} \pi_{ft}^b &= \sum_{j \in A'_{ft}} \left(p_{jt}^b - c_{jt}\right) q_{jt}^b \left(\mathbf{P}_t^b\right) + \sum_{j \in B'_{ft}} \left(p_{jt}^b - c_{jt}\right) q_{jt}^b \left(\mathbf{P}_t^b\right) + \\ &\quad + \sum_{j \in W'_{ft}} \left(p_{jt}^b - c_{jt}\left(1 + \tau_t^b\right)\right) q_{jt}^b \left(\mathbf{P}_t^b\right) \end{aligned} \tag{1.2}$$

Firms compete in prices taking the demand functions and the price of the competitors as given. In each time period, they choose two prices for each car model, one for Argentina $\left(p_{jt}^a\right)$ and one for Brazil $\left(p_{jt}^b\right)$. Furthermore, characteristics of the products and entry-exit decisions are assumed to be exogenous to the pricing decision. Since each firm produces more than one car model, when setting the price of a particular model they take into account the effect of a marginal increase in price both on the quantity demanded of that particular model and on the quantities demanded of all other models manufactured by the same firm.

As described so far, the problems in the two countries are independent because of the constant marginal cost assumption, meaning that prices in Brazil (or in any other country) do not affect prices in Argentina and vice versa. For this same reason, the problem of setting prices in other countries is disregarded. However, the price decisions need to contemplate the restrictions imposed by trade policy. The non-tariff barriers link the decisions in the two countries.

Imports by each firm, in each country, are subject to the intertemporal global trade balance constraint (GTB), by means of which the cumulative value of imports during period T^0 cannot exceed the cumulative value of exports. In addition, there is an annual quota for net imports from the trade partner (measured in units).

The Argentine and Brazilian GTBs for firm f can be written respectively as

$$\sum_{t\in T^0}\left(\sum_{j\in B_{ft}} c_{jt}q^a_{jt}\left(\mathbf{P}^a_t\right)+\sum_{j\in W_{ft}} c_{jt}\left(1+\tau^a_t\right)q^a_{jt}\left(\mathbf{P}^a_t\right)\right)\leq 1.2\sum_{t\in T^0}\sum_{j\in A'_{ft}} c_{jt}q^b_{jt}\left(\mathbf{P}^b_t\right)+X^a_f \tag{1.3}$$

$$\sum_{t\in T^0}\left(\sum_{j\in A'_{ft}} c_{jt}q^b_{jt}\left(\mathbf{P}^b_t\right)+\sum_{j\in W'_{ft}} c_{jt}\left(1+\tau^b_t\right)q^b_{jt}\left(\mathbf{P}^b_t\right)\right)\leq 1.2\sum_{t\in T^0}\sum_{j\in B_{ft}} c_{jt}q^a_{jt}\left(\mathbf{P}^a_t\right)+X^b_f$$

where T^0 denotes the period in which the GTB was in place. The left-hand side corresponds to firm f's imports, and the right-hand side to its exports. Exports of finished vehicles are multiplied by 1.2. Export credits from the acquisition or export of capital goods and net exports of components are included in the exogenous terms X^a_f and X^b_f.

Exports to other countries are also exogenous to the pricing decision in Argentina and Brazil and are therefore included in X_f^a and X_f^b as well.

The bilateral quantitative constraints dictate that, in aggregate, net imports cannot exceed a negotiated annual limit (quota) in each country. I model each firm's constraint as a lower and an upper bound on net imports of the Brazilian subsidiary, $\underline{Q}_{ft}$ and $\overline{Q}_{ft}$, exogenously assigned.[1] The lower bound is the (negative of the) quota in Argentina, and the upper bound the quota in Brazil. Thus,

$$\underline{Q}_{ft} \leq \left(\sum_{j \in A'_{ft}} q_{jt}^b \left(\mathbf{P}_t^b \right) - \sum_{j \in B_{ft}} q_{jt}^a \left(\mathbf{P}_t^a \right) \right) \leq \overline{Q}_{ft} \tag{1.4}$$

Each firm maximizes profits during T^0 subject to the global and bilateral constraints. Given the particular ownership structure of the firms, in which the same corporations are located in Argentina and Brazil, the constraints link the equilibria in the two countries. When firms set prices, they add to the usual determinants of equilibrium (competition among firms and among products within the same firm) considerations of trade balance in both countries. They manipulate imports and exports in both locations to satisfy the constraints. Hence, prices in Brazil affect prices in Argentina, and vice versa.

Let λ_f^a and λ_f^b be the Lagrange multipliers associated with the GTBs of Argentina and Brazil respectively; and μ_{ft}^a and μ_{ft}^b denote the multipliers associated with the bilateral quantitative constraint (μ_{ft}^a is associated with the lower bound, the quota in Argentina, and μ_{ft}^b with the upper bound, the quota in Brazil). The first two are constant because there is a single cumulative constraint, the latter two, on the other hand, vary from year to year.

[1] Anecdotal evidence suggests that they were assigned according to previous shares in imports and production.

Let $\mathbf{q}_{ft}^{h}$ and $\mathbf{p}_{ft}^{h}$ be the vectors of quantities and prices of firm f in country h, and $\mathbf{\Delta}_{ft}^{h}$ its matrix of partial derivatives of demand with respect to price, with $\mathbf{\Delta}_{ft(ij)}^{h} = \partial q_{it}^{h} / \partial p_{jt}^{h}$. The first order conditions for firm f in period t and in countries a and b (Argentina and Brazil) can be written in matrix form as

$$\begin{aligned} q_{ft}^{a}\left(\mathbf{P}_{t}^{a}\right) + \Delta_{ft}^{a}\left(\mathbf{P}_{t}^{a}\right)\left(\mathbf{p}_{ft}^{a} - \mathbf{c}_{ft}^{*a}\right) &= 0 \\ q_{ft}^{b}\left(\mathbf{P}_{t}^{b}\right) + \Delta_{ft}^{b}\left(\mathbf{P}_{t}^{b}\right)\left(\mathbf{p}_{ft}^{b} - \mathbf{c}_{ft}^{*b}\right) &= 0 \end{aligned} \tag{1.5}$$

where $\mathbf{c}_{ft}^{*h}$ is the vector of *adjusted marginal costs*, defined as the production marginal costs augmented by the implicit costs imposed by the trade taxes and restrictions. The definition of adjusted marginal costs follows directly from the first order conditions and is given by

$$\begin{aligned} c_{jt}^{*a} &= \begin{cases} c_{jt} & \text{for } j \in A_{ft} \\ c_{jt}\left(1 + \lambda_{f}^{a} - 1.2\lambda_{f}^{b}\right) + \left(\mu_{ft}^{a} - \mu_{ft}^{b}\right) & \text{for } j \in B_{ft} \\ c_{jt}\left(1 + \tau_{t}^{a}\right)\left(1 + \lambda_{f}^{a}\right) & \text{for } j \in W_{ft} \end{cases} \\ c_{jt}^{*b} &= \begin{cases} c_{jt}\left(1 + \lambda_{f}^{b} - 1.2\lambda_{f}^{a}\right) - \left(\mu_{ft}^{a} - \mu_{ft}^{b}\right) & \text{for } j \in A'_{ft} \\ c_{jt} & \text{for } j \in B'_{ft} \\ c_{jt}\left(1 + \tau_{t}^{b}\right)\left(1 + \lambda_{f}^{b}\right) & \text{for } j \in W'_{ft} \end{cases} \end{aligned} \tag{1.6}$$

For a car produced and sold in Argentina $(j \in A_{ft})$ the cost relevant for the price decision is the marginal cost of production - there is no adjustment. In the case of a car produced in a third country and imported into Argentina $(j \in W_{ft})$, the relevant cost is the production cost augmented by the percentage increase due to the tariff $(1 + \tau_{t}^{a})$ and the shadow increase in cost due to the GTB constraint $(1 + \lambda^{a})$. When a car is imported from Brazil to Argentina $(j \in B_{ft})$, the cost does not need to be increased by a tariff since the bilateral tariff is zero, but there are two NTBs that apply, the GTB and the net quota on imports. The cost of imports from Brazil is increased by $(100 \times \lambda^a)$ percent because each unit imported tightens the Argentine GTB; at the same time, each such export from Brazil helps relax the Brazilian GTB. This reduces the cost by $\left(100 \times 1.2\lambda^b\right)$ percent. The net effect of the GTB in Argentina is $\lambda^a - 1.2\lambda^b$, which can be positive or negative. In addition, there is the cost imposed by the net quota, given by $\mu^a - \mu^b$. If the bound in binding in Argentina, μ^a is positive and μ^b is zero. This cost is additive and not multiplicative because the quota applies to units and not values.

Notice that, as opposed to production costs, adjusted costs of a given model may differ in the two countries due to different tariff levels or to different impacts of the NTBs; therefore c_{jt}^{*a} is not necessarily equal to c_{jt}^{*b}.

Stacking the first order conditions for the two countries, all time periods and all firms, the system can be written as

$$q(\mathbf{P}) + \Delta(\mathbf{P})(\mathbf{P} - \mathbf{c}^*(\mathbf{c}, \boldsymbol{\lambda}, \boldsymbol{\mu})) = 0 \tag{1.7}$$

where $\mathbf{q}$, $\mathbf{P}$ and $\mathbf{c}^*$ are the stacked quantity, price and adjusted cost vectors across firms, years and countries, and $\boldsymbol{\Delta}$ is a block diagonal matrix, with $\boldsymbol{\Delta}_{ij} = 0$ when products i and j are produced by different firms, sold in different countries or in different time periods. The adjusted cost $\mathbf{c}^*(\mathbf{c}, \boldsymbol{\lambda}, \boldsymbol{\mu})$ satisfies the definition in (1.6). This notation will be useful in the estimation section that follows.

1.4 Estimation of the supply parameters

In this section I describe how to estimate the marginal cost of production of each car model and the shadow cost of the non-tariff barriers - the Lagrange multipliers - described in Section 1.3. Since marginal cost may vary over time due to changes in input prices, technical change and other factors, I estimate a different marginal cost per model and per time period. The estimators are derived from the firms' first order conditions in (1.7). Intuitively, the estimators are defined as the costs of production and shadow costs of NTBs that satisfy the firm behavior described in the previous section, given prices, quantities and the matrix of price derivatives. Firms observe marginal costs, the trade restrictions and a demand function for each model, and choose the optimal prices (and jointly the equilibrium quantities). If the researcher observes prices, quantities and the matrix of price derivatives, then, the marginal costs that generated the observed equilibrium outcome can be estimated under a particular assumption about how firms behave (i.e. the FOCs).

The data consists of information on prices and quantities sold for each car model, in each country. As a first step, it is necessary to obtain an estimate of the matrix of price derivatives, as this is not directly observed in the data, and that implies estimating demand functions for the two countries, $q_{jt}^{a}\left(\mathbf{P}_{t}^{a}\right)$ and $q_{jt}^{b}\left(\mathbf{P}_{t}^{b}\right)$. Once there are estimates for the demand functions available, an estimate for the matrix of price derivatives, $\widehat{\mathbf{\Delta}}$, can be constructed.

The supply model and the estimation method are general enough that they do not depend on the specification of the demand side. The choice of a demand model depends mainly on available data (individual vs. aggregate data, long or short time-series) and their different implications for welfare evaluation. I adopt the random coefficients logit model of Berry (1994) and Berry, Levinsohn and Pakes (1995). A detailed description of the method and my empirical implementation can be found in Section 1.5. In what follows, I describe the supply-side estimation for any given estimate of the matrix of derivatives $\widehat{\mathbf{\Delta}}$, that is consistent and normally distributed, with variance Σ_{Δ}.

Consider first the hypothetical case of a closed economy with J different car models and one time period. Since there are no trade barriers, the effective marginal cost is simply the cost of production (there are no Lagrange multipliers), so that $\mathbf{c}^* = \mathbf{c}$. The FOCs can be written as $\mathbf{q} + \mathbf{\Delta}(\mathbf{P} - \mathbf{c}) = 0$. The supply parameter to be estimated is the $(J \times 1)$ vector of production costs; while the information available is the observed prices and quantities and the estimated matrix of price derivatives. The FOCs are a system of J equations. Given $\mathbf{P}$, $\mathbf{q}$, and $\widehat{\mathbf{\Delta}}$, the estimator for the marginal cost of production is the vector $\widehat{\mathbf{c}}$ that solves the system of FOCs

$$\widehat{\mathbf{c}} = \mathbf{P} + \widehat{\mathbf{\Delta}}^{-1}\mathbf{q}. \tag{1.8}$$

The system of FOCs is just identified and there is a unique solution for $\widehat{\mathbf{c}}$, which is the marginal cost that predicts the outcomes $\mathbf{q}$, $\mathbf{p}$ and $\widehat{\mathbf{\Delta}}$ given the firm behavior.

This is a perfect fit method where there are no residuals. That does not mean, however, that the vector of marginal costs is estimated without error. There are estimation errors derived from the fact that the matrix of price derivatives is estimated rather than observed. The estimator of the marginal cost is consistent and asymptotically normal (provided $\widehat{\mathbf{\Delta}}$ satisfies these characteristics, too) and its variance is a function of the variance of the estimated matrix of price derivatives. The variance of $\widehat{\mathbf{c}}$ can be estimated either via the delta-method or by simulation, by taking different samples of the matrix of price derivatives from a normal distribution with mean $\widehat{\mathbf{\Delta}}$ and variance $\widehat{\Sigma}_{\Delta}$ (where $\widehat{\Sigma}_{\Delta}$ is an estimator for Σ_{Δ}) and recomputing $\widehat{\mathbf{c}}$ for each draw.

Inverting the system of FOCs to get just-identified estimates of the marginal costs is the common practice in the literature. Goldberg (1995) and Berry, Levinsohn and Pakes (1999) use a variant of this method to evaluate the impact of the Japanese VER on exports of cars to the U.S.; Petrin (2002) to quantify the effect of the introduction of the minivan; Nevo (2000) and (2001) to investigate market power and mergers in the cereal industry.

This perfect-fit method is problematic when there are other supply parameters to estimate. Suppose that there is still one country, one time period and J car models. Assume that the FOCs take the following form $\mathbf{q} + \boldsymbol{\Delta}\left(\mathbf{P} - \mathbf{c}^*\left(\mathbf{c}, \varphi\right)\right)$. In addition to the vector of production costs given by $\mathbf{c}$, there is an $(R \times 1)$ vector of parameters, φ, that affects price decisions through the adjusted marginal costs $\mathbf{c}^*$ in the same fashion as $\boldsymbol{\lambda}$ and $\boldsymbol{\mu}$ in the model in the previous section. The number of price equations (FOCs) is the same as the number of car models and adjusted marginal costs, J, while the number of parameters to be estimated is $J + R$ ($\mathbf{c}$ and φ). The system of FOCs is underidentified; there are no degrees of freedom to estimate both $\mathbf{c}$ and φ.

For example, Goldberg (1995) and Berry, Levinsohn and Pakes (1999) estimate the impact of Japanese VERs on imports of automobiles to the U.S. using a Lagrange multiplier approach. The parameters of interest in this case are the production cost of each car model, c_{jt}, and one Lagrange multiplier for each year in which the VER was in place, φ_t. The adjusted marginal costs can be written in this case as $c^*_{jt} = c_{jt} + \varphi_t * I_{jt}$, where I is an indicator variable that equals one when a model is imported from Japan. The Lagrange multiplier φ enters additively because the VER applies to units and not values (same as μ in the quota on net bilateral imports between Argentina and Brazil). They observe prices and quantities sold in the U.S., estimate a matrix of price derivatives and derive a set of FOCs. The number of FOCs is the same as the number of marginal costs of production, consequently, there are no degrees of freedom left to recover both $\mathbf{c}$ and $\boldsymbol{\varphi}$ as in (1.8).

To reduce the number of parameters to be estimated, both Goldberg (1995) and Berry, Levinsohn and Pakes (1999) add more structure to the supply side. They assume a functional form for the cost function by means of which the marginal cost depends on observable characteristics of the model, like origin, type of vehicle, size and performance. Let x_{jt} be a vector of observed characteristics of model j in period t, and ω_{jt} a linear combination of unobserved characteristics; they write the marginal cost as $c_{jt} = f\left(x'_{jt}\gamma\right) + \omega_{jt}$. Under this specification, the number of estimating parameters reduces to to the dimension of φ plus the dimension of γ. They first recover $\mathbf{c}^*$ by inverting the FOCs as in (1.8) and then estimate the parameters of interest from a second step regression of the following form,

$$\widehat{c}^*_{jt} = f\left(x'_{jt}\gamma\right) + \varphi_t * I_{jt} + \omega_{jt} \tag{1.9}$$

This method has the potential problem of spreading misspecifications of the cost function to the estimation of the supply parameters.

Consider now the two-country model with trade restrictions described in Section 1.3. The FOCs can be written as $\mathbf{q}+\Delta\left(\mathbf{P}-\mathbf{c}^*\left(\mathbf{c},\boldsymbol{\lambda},\boldsymbol{\mu}\right)\right)=0$, where $\mathbf{c}^*$ is the vector of adjusted marginal costs defined as a function of the vector of production costs and the trade policy parameters according to (1.6). There is one FOC and one adjusted marginal cost for each price-quantity observation.

The dimension of $\mathbf{c}$ is smaller than the dimension of $\mathbf{c}^*$ and the number of FOCs. To simplify the argument, suppose that exactly the same car models are sold in Argentina and Brazil (that is, the sets A_{ft}, B_{ft} and W_{ft} are equal to the sets A'_{ft}, B'_{ft} and W'_{ft} for all firms f and time periods t). At time t, car model j is produced in only one location - Argentina, Brazil or the rest of the world - and therefore there is only one production cost, c_{jt}; but it is sold in two locations - Argentina *and* Brazil- and therefore there are two prices, p^a_{jt} and p^b_{jt}, and two adjusted marginal costs, c^{*a}_{jt} and c^{*b}_{jt}. In the more general case in which the sets of available vehicles differ in the two countries, there are some cars that are sold only in Argentina, some cars that are sold only in Brazil and some cars that are sold in both countries. Provided there are some cars sold in both countries, the dimension of $\mathbf{c}$ is strictly smaller than the number of FOCs (and the dimension of $\mathbf{p}$ and $\mathbf{c}^*$) and the system of FOCs is overidentified in $\mathbf{c}$. This overidentification allows for the estimation of the trade policy parameters and the costs of production jointly.

Notice that there are two Lagrange multipliers per firm per year for the bilateral quantitative restrictions (μ^a_{ft} and μ^b_{ft}) and two Lagrange multipliers per firm for the multiperiod global trade balance constraints (λ^a_f and λ^b_f). Although this increases the number of unknowns, the system remains overidentified since in my model many goods are produced by a few firms (this means that there are many pricing equations with few unknown Lagrange multipliers).[2]

Instead of the "perfect-fit" method employed by previous authors for the one-country

[2]In addition, I observe prices and quantities by semester, hence there are four pricing equations per year. The number of Lagrange multipliers does not increase because of using semestral data.

case, in which the costs are just-identified, I propose a minimum-distance procedure. The estimator of $(\mathbf{c}, \boldsymbol{\lambda}, \boldsymbol{\mu})$ makes the system of first order conditions as close to zero as possible given the estimator of the price derivatives, as dictated by the following criterion function

$$\left(\widehat{\mathbf{c}}, \widehat{\boldsymbol{\lambda}}, \widehat{\boldsymbol{\mu}}\right) = \arg\min_{(\mathbf{c},\boldsymbol{\lambda},\boldsymbol{\mu})} \left(\mathbf{q} + \widehat{\Delta}\left(\mathbf{P} - c^*(\mathbf{c}, \boldsymbol{\lambda}, \boldsymbol{\mu})\right)\right)^T \widehat{W}_1 \left(\mathbf{q} + \widehat{\Delta}\left(\mathbf{P} - c^*(\mathbf{c}, \boldsymbol{\lambda}, \boldsymbol{\mu})\right)\right) \quad (1.10)$$

where $\widehat{W}_1$ is a square weighting matrix, with its dimension equal to the number of price equations. For efficiency, $\widehat{W}_1$ can be the inverse of an estimator of the variance of the price equations. However, as I explain below, for computational simplicity I use the identity matrix.

This procedure has considerable advantages over the perfect-fit method. First, it provides a test of the model in the sense that one can test whether the first order conditions are close enough to zero. On the other hand, the fact that the minimum-distance estimator of the two-country case does not satisfy the FOCs does not mean that firms are not maximizing profits. The FOCs are satisfied when evaluated at the unobserved true value of the demand derivatives, costs and Lagrange multipliers. Second, and more important, there are enough degrees of freedom to estimate the Lagrange multipliers together with the marginal costs without further functional form assumptions about the cost function.

The actual computation of the estimates is not as cumbersome as it may be suggested by their dimension if the identity matrix is used (or more generally, any block-diagonal matrix with zeros for different firms and years). The estimator of the marginal costs has an analytical solution given a value of the Lagrange multipliers. Hence, the numerical search can be limited to the latter $(\boldsymbol{\lambda}$ and $\boldsymbol{\mu})$. The distance function unfolds into the sum of one "distance" per firm. For each firm, there is a two-dimensional search over λ_f^a and λ_f^b, with T nested one-dimensional searches over $\left(\mu_{ft}^a - \mu_{ft}^b\right)$. μ_{ft}^a and μ_{ft}^b are indeed separately identified since the two constraints to which they associate cannot be binding at the same time. If $\mu_{ft}^{a}-\mu_{ft}^{b}$ is positive, then μ_{ft}^{a} is positive and μ_{ft}^{b} zero, and vice versa. If $\mu_{ft}^{1}-\mu_{ft}^{b}$ is zero, then both multipliers are zero and none of the bilateral constraints are binding.

The estimators for the Lagrange multipliers of the GTB ($\boldsymbol{\lambda}$) are constrained to be non-negative during the non-linear search. As a result, there is a truncation at zero in their distribution and asymptotically they are not normally distributed. Since these parameters are estimated jointly with the costs of production and the Lagrange multipliers associated with the net quotas, the distribution of these two sets of coefficients is affected by the truncation and is not normal either. To estimate their variance, I take draws from the estimated distribution of the matrix of price derivatives, $N\left(\widehat{\boldsymbol{\Delta}}, \widehat{\Sigma}_{\Delta}\right)$ and recompute $\left(\widehat{\mathbf{c}}, \hat{\boldsymbol{\lambda}}, \hat{\boldsymbol{\mu}}\right)$ for each of these draws; I compute 90 percent confidence intervals with the results.

1.5 Demand

1.5.1 Discrete choice model

I model demand using a random-coefficient logit approach. Consumers in Argentina and Brazil are assumed to choose only one car or none among all available models by maximizing a utility function defined over the characteristics of the different products and allowed to vary across individuals. Aggregate demand is obtained by the aggregation of individual choices. This same approach has been used in the estimation of demand for cars by Berry (1994), Berry, Levinsohn and Pakes (1995) and Berry, Levinsohn and

Pakes (1999). Goldberg (1995), Petrin (2002) and Berry, Levinsohn and Pakes (2004) use other multinomial logit models to estimate demand for automobiles and include data on individual choices.

A more straightforward way of modeling aggregate demand for differentiated products would be to write a full system with a demand function for each product that depends on all prices and other control variables, like the linear expenditure demand system (LES) and the almost ideal demand system (AIDS) (see Deaton and Muellbauer (1980)). A limitation in the application of this approach is that the number of demand parameters increases exponentially with the number of available choices. In the present context, there are many car models available and the demand parameters easily outnumber the price-quantity observations of prices and quantities.

In my model, there are two countries and different time periods. Demand parameters differ across countries but not across time. Since demands are independent across countries and time, I describe the utility and demand functions for one country and year for simplicity of notation. At the end of the section I explain how the model is expanded to accommodate two countries and many time periods.

Utility of consumer i from purchasing product j, U_{ij}, is given by

$$U_{ij} = \alpha_i (y_i - p_j) + x_j' \beta_i + \xi_j + \varepsilon_{ij} \tag{1.11}$$

where y denotes income and p price. I distinguish between two types of product characteristics: those that are observed by the econometrician like size, horsepower and country of origin (denoted by x) and other unobserved characteristics, such as shape, popularity of the model and consumers' subjective perceptions of quality of the vehicle and reputation of the manufacturer. ξ is a linear combination of the latter. This simplified form is adopted because without further information I am only able to recover this composite *unobservable*. The unobservable ξ could in principle differ by individual. However, I estimate the model with market-level data, which does not allow for the estimation of different ξ's. Both x and ξ are observed by consumers, and by firms when setting prices.

The marginal utilities of after-purchase income, α_i, and of product characteristics, β_i, are specific to an individual. ε is a zero-mean random idiosyncratic term. It is independent and identically distributed across individuals and products, following a type I extreme-value distribution. Under this assumption, the difference between two random terms $(\varepsilon_j - \varepsilon_h)$ follows a logistic distribution, which facilitates the computation of the probabilities of choosing each good.

The marginal utilities are parameterized as a linear combination of characteristics of the consumers, summarized by a vector ν

$$\alpha_i = \alpha_o + \sum_r \alpha_r \nu_{ir}; \qquad \beta_{ki} = \beta_{ko} + \sum_r \beta_{kr} \nu_{ir} \qquad k = 1, ...K; r = 1, ...R \tag{1.12}$$

where K and R are the number of characteristics of the vehicles and individuals, respectively.

Consumers' characteristics are those individual variables relevant to the vehicle choice problem such as income, family size, number of children and age, as well as random tastes for each characteristic. As a result, marginal utility of income varies with income level and different individuals have different tastes for each car characteristic. For simplicity of notation, I write each random coefficient as a function of all individual characteristics. If a more restrictive form is desired, the appropriate weight can be set to zero.

Both the additive random term and the variable marginal utilities are introduced to allow for heterogeneity across individuals. Without heterogeneity all individuals would choose the same vehicle. With the sole addition of the additive random term, individuals choose different cars but they all have the same expected utility from each model, and in particular the same expected first choice. Moreover, deviations from the expected first choice are not explained by characteristics of the cars or of the individuals. This implies that substitution across products is only determined by market shares and does not depend on product characteristics. Hence, two very different models might end up being closer substitutes than two similar models. The logistic distribution assumption on the error term adds the independence of irrelevant alternatives property, which has been extensively documented in the multinomial logit literature. The use of variable coefficients eliminates these awkward substitution patterns.

Individuals can choose not to purchase a new vehicle. This choice is usually referred to as the *outside alternative*. In this case, utility, given by U_{io}, depends on income and the utility of the alternative to a new car or reservation utility u_i.

$$U_{io} = \alpha_i y_i + u_i + \varepsilon_{io} \tag{1.13}$$

The reservation utility, which can be interpreted as the utility derived from either having a used car or using a different means of transportation, is assumed to be individual specific and is modeled as a linear combination of individual characteristics.

$$u_i = u_o + \sum_r u_r \nu_{ir} \tag{1.14}$$

For each consumer, the utility from purchasing each product can be normalized with respect to the expected utility when no car is purchased, by subtracting the latter. Thus

$$\widetilde{U}_{ij} = -u_i - \alpha_i p_j + x_j' \beta_i + \xi_j + \varepsilon_{ij} \tag{1.15}$$

where $\widetilde{U}_{ij}$ is the excess utility of car j relative to the outside alternative.

Each individual chooses the product with the highest normalized utility, which in turn is a function of product and individual characteristics and of the utility parameters. I summarize these parameters with the vector $\boldsymbol{\theta} = (\alpha_o, ...\alpha_R \,; \beta_{1o}, ...\beta_{KR} \,; u_o, ...u_R)$. Let $\mathbf{P}$, $\mathbf{x}$ and $\boldsymbol{\xi}$ denote the vectors of prices, observable characteristics of the cars and unobservables, respectively. Given the type I extreme-value distribution of the additive random terms, the probability $\sigma_j(\boldsymbol{\theta}, \nu_i)$ that car j is individual $i's$ preferred alternative has the following closed-form solution

$$\sigma_j(\boldsymbol{\theta}, \nu_i) = P\left(\widetilde{U}_{ij} \geq \widetilde{U}_{ih}, \forall h | \boldsymbol{\theta}; \nu_i; \mathbf{P}, \mathbf{x}, \boldsymbol{\xi}\right) = \frac{e^{-u_i - \alpha_i p_j + x_j \acute{\beta}_i + \xi_j}}{1 + \sum_{h=1}^{J} e^{-u_i - \alpha_i p_h + x_h \acute{\beta}_i + \xi_h}} \tag{1.16}$$

Note that these probabilities are conditional on ν_i, the vector of individual characteristics. The marginal probability of a random consumer choosing car j is obtained by integrating over the population distribution of ν and it is equal to the market share of product j. Aggregate demand is the market share multiplied by the number of individuals in the market, N. Let G be the cumulative distribution function of ν over the population of individuals. Then, aggregate demand for model j is

$$q_j = N \int \sigma_j(\boldsymbol{\theta}; \nu_i; \mathbf{P}, \mathbf{x}, \boldsymbol{\xi}) \, dG(\nu_i) \tag{1.17}$$

Besides the level of demand, I am also interested in the price derivatives, as they are needed in the characterization and later estimation of the first order conditions of the firms. Because individuals have heterogenous tastes they react differently to a price change. Let $\eta_{jk}(\boldsymbol{\theta}, \nu_i)$ denote the change in the probability of individual i choosing product j when there is a change in the price of product k, that is $\eta_{jk}(\boldsymbol{\theta}, \nu_i) = \frac{\partial \sigma_j(\boldsymbol{\theta}, \nu_i)}{\partial p_k}$. The aggregate response to a change in price, $h_{jk} = \frac{\partial q_j}{\partial p_k}$, is once again obtained by integrating the individual responses over the distribution of idiosyncratic characteristics ν_i, which gives

$$h_{jk} = N \int \eta_{jk} \left(\boldsymbol{\theta}; \nu_i; \mathbf{P}, \mathbf{x}, \boldsymbol{\xi}\right) dG\left(\nu_i\right) \tag{1.18}$$

with

$$\eta_{jk}\left(\boldsymbol{\theta}, \nu_i\right) = \begin{cases} -\alpha_i \sigma_j\left(\boldsymbol{\theta}, \nu_i\right)\left(1 - \sigma_j\left(\boldsymbol{\theta}, \nu_i\right)\right) & \text{for } k = j \\ \alpha_i \sigma_j\left(\boldsymbol{\theta}, \nu_i\right) \sigma_k\left(\boldsymbol{\theta}, \nu_i\right) & \text{for } k \neq j \end{cases} \tag{1.19}$$

In my study, there are two countries (a and b) and different years (t). There is one vector of demand parameters for each country, $\boldsymbol{\theta}^a$ and $\boldsymbol{\theta}^b$, which is constant across time. Observed characteristics of the cars (x) are the same in the two countries since characteristics are used to define a same product (if x_j^a is different from $x_{j'}^b$, j and j' are considered to be different models), but they may change over the years. The distribution of characteristics of the consumers (G), the prices $(\mathbf{P})$ and the unobservables $(\boldsymbol{\xi})$ may vary by country and year.[3] Let t and h denote time and country, respectively. Aggregate demand in country h in period t is

$$q_{jt}^h = N_t^h \int \sigma_j\left(\boldsymbol{\theta}^h; \nu_{it}^h; \mathbf{P}_t^h, \mathbf{x}_t^h, \boldsymbol{\xi}_t^h\right) dG_t^h\left(\nu_{it}^h\right) \tag{1.20}$$

Notice that demand is written as a function of the *vector* of characteristics $\mathbf{x}_t^h$, which is indexed by h even though observable characteristics of cars are the same in both countries. This allows for the possibility of having different car models available in the two countries. In such a case (as it indeed happens in my data), the *vector* of characteristics is not the same.

[3]Unobservables differ across markets because they include subjective perceptions.

1.5.2 Estimation

The demand parameters to be estimated are the marginal utilities of income and product characteristics and the mean alternative utilities. I summarize these parameters with the vector $\boldsymbol{\theta} = (\alpha_o, ...\alpha_R; \beta_{1o}, ...\beta_{KR}; u_o, ...u_R)$, where R is the number of individual characteristics and K the number of car characteristics. I separately estimate different parameters for Argentina and Brazil. For simplicity of notation, I do not include the country superscript h in this section. I use the method developed by Berry (1994) and Berry, Levinsohn and Pakes (1995), which I lay out below.

I do not observe individual choices, only aggregate sales of each vehicle in different markets (time periods and regions), their prices and characteristics, and a sample from the distribution of individual characteristics in the population of each market. Identification of coefficients that vary by individual with only aggregate data is possible because the differences in aggregate choices in different markets are tied to differences in the distribution of demographics. For example, if it is observed that in a particular market both the average household size and the share of station wagons are larger than in other markets, it can be concluded that (other things equal) large households derive higher utility from station wagons than smaller households (β_k is higher). The actual procedure is more complex and it involves comparing the entire distributions of individual characteristics, not just the means.

One important issue is that $\boldsymbol{\xi}$ is not observed by the econometrician, but it is observed by the individuals and firms. Firms set prices given the demand function, which includes $\boldsymbol{\xi}$. In addition, some elements of $\boldsymbol{\xi}$ (for example, the shape of the car) affect production costs. Thus, price is correlated with $\boldsymbol{\xi}$ both via demand and cost. As price is an explanatory variable in the demand equation and the unobservables are the error term, instruments are needed to obtain consistent estimates. The difficulty is that, in contrast to the usual instrumental variables setting, ξ_{jt} is not an additive random term but enters the demand equation non-linearly, and I need to invert the system of demand equations to solve for $\boldsymbol{\xi}$.

Cost shifters (such as input prices) that vary across products could in principle be used as instruments but I do not have this kind of information. To solve this problem, the standard practice in the literature is to use demand-side instruments. Equilibrium prices depend on a product´s own characteristics and also on the characteristics of other alternatives. Intuitively, the price of a car depends on how close in the space of characteristics it is to others, and whether these substitutes are produced by the same firm or by competitors. The instruments that I use are a car's own characteristics, the average characteristics of the cars manufactured by the same firm and the average characteristics of models produced by its competitors.[4] The identifying assumption is that unobservable characteristics are mean independent from observable characteristics, $E\left(\xi_{jt}|\mathbf{x}\right) = 0$. Hence, if the instruments $\mathbf{z}$ are linear combinations of $\mathbf{x}$, they satisfy the orthogonality conditions

$$E\left(z_{jt}\xi_{jt}\right) = 0 \tag{1.21}$$

where j indexes the vehicle and t the time period.

[4] Berry, Levinsohn and Pakes (1995) use the sum of characteristics of same-firm and rival models, instead of the average, and they show that these instruments are optimal based on Chamberlain (1986) and Pakes (1994). In practice, however, the matrix of instruments constructed in this way is nearly collinear. The use of averages avoids the problem.

The aggregate demand system from equations (1.16) and (1.17) can be written as

$$q_{jt} = N_t \int \frac{e^{-u_{it}-\alpha_{it}p_{jt}+x_{jt}'\beta_{it}+\xi_{jt}}}{1+\sum_{h=1}^{J} e^{-u_{it}-\alpha_{it}p_{ht}+x_{ht}'\beta_{it}+\xi_{ht}}} dG(\nu_{it}) \qquad j=1,...J; t=1,...T_j \tag{1.22}$$

Let T be the number of time periods and T_j the number of time periods in which product j is available. There are $\sum_j T_j$ demand equations. There are also T equations that restrict the market shares to add up to one in each market; together with the market size, this implies T demand equations for the outside alternative.

Let $\xi(\boldsymbol{\theta}, G)$ be the vector of unobservables $\boldsymbol{\xi}$ that solves the non-linear system above.[5] I need this vector, given $\boldsymbol{\theta}$ and G, to construct the orthogonality conditions (1.21). Thus, it is necessary to compute the integral in equation (1.22), which does not have a closed-form solution. This integral is the expected value of the probability that a random individual chooses model j. I estimate it using a simulation method (Pakes (1986), Lerman and Manski (1981)), which involves estimating an expectation with a sample average. I sample n_s consumers from the distribution G.[6] I compute the individual probabilities for each of the consumers (at a given value of $\boldsymbol{\theta}$) and I average them. More formally, the solution for the unobservables can be defined as follows. Let G_{n_s} be the empirical distribution of the sample of n_s consumers, and i_s the subindex for the sampled consumers. $\xi(\boldsymbol{\theta}, G_{n_s})$ is

[5] Berry (1994) establishes its existence and uniqueness, provided all shares are strictly positive and some mild regularity conditions are satisfied.

[6] G may be a known parametric distribution or an empirical distribution (i.e. a household survey). In my case, I take draws of income and family size from household surveys, and draws from a standard normal to simulate the random alternative utilities.

defined as the vector of unobservables that solves the system[7,8]

$$q_{jt} = \frac{N_t}{n_s} \sum_{i_s} \frac{e^{-u_{i_s t} - \alpha_{i_s t} p_{jt} + x_{jt}' \beta_{i_s t} + \xi_{jt}}}{1 + \sum_{h=1}^{J} e^{-u_{i_s t} - \alpha_{i_s t} p_{ht} + x_{ht}' \beta_{i_s t} + \xi_{ht}}} \qquad j = 1, ...J; t = 1, ...T_j \tag{1.23}$$

This form of simulation-based estimator is used to estimate the price derivatives.

The vector of unobservables is used to construct the sample analogue of the orthogonality conditions.

$$g(\boldsymbol{\theta}, G_{n_s}) = \frac{1}{J} \sum_{j} \frac{1}{T_j} \sum_{t} z_{jt} \xi_{jt}(\boldsymbol{\theta}, G_{n_s,t}) \tag{1.24}$$

The estimator is the vector of parameters $\hat{\boldsymbol{\theta}}$ that minimizes an appropriate norm of the sample moment conditions

$$\hat{\boldsymbol{\theta}} = \arg\min_{\boldsymbol{\theta}} g(\boldsymbol{\theta}, G_{n_s})^T \widehat{W}_2 g(\boldsymbol{\theta}, G_{n_s}) \tag{1.25}$$

$\widehat{W}_2$ is an $L \times L$ weighting matrix (where L is the number of instruments) that is arbitrarily chosen. For efficiency, $\widehat{W}_2$ is the inverse of a consistent estimator of the variance of the orthogonality conditions (it gives more weight to the moments with lower variance). Hence, in practice the estimation is carried out in two steps.

To estimate the price derivatives, I use a simulation-based estimator of the integral in equation (1.18). I take a sample of n_s consumers and compute the individual derivatives at the estimated value of the demand parameter $\hat{\boldsymbol{\theta}}$. I average them and multiply by the market size to obtain the expected value of the derivative and the aggregate response, respectively.

$$h(\widehat{\boldsymbol{\theta}}, G_{n_s,t}) = \frac{N_t}{n_s} \sum_{i_s} \eta \left(\widehat{\boldsymbol{\theta}}, \nu_{i_s,t} \right) \tag{1.26}$$

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[7] $\xi(\boldsymbol{\theta}, G_{n_s})$ is an approximation of $\xi(\boldsymbol{\theta}, G)$.

[8] Berry, Levinsohn and Pakes (1995) provide a contraction mapping algorithm to solve for $\xi(\theta, G_{n_s})$ recursively.

The estimator h is written as a function of $\hat{\boldsymbol{\theta}}$ and G_{n_s} to emphasize the fact that it depends on the estimated value of the demand parameters and the sample of n_s individuals.

Computing Standard Errors

The estimators of the utility function parameters and the price derivatives are consistent and asymptotically normal. Consider the estimator of the parameters of the utility function, $\hat{\boldsymbol{\theta}}$. Its variance is dictated by the variance of the orthogonality conditions. In the usual GMM case, that is the variance in the process generating the data, associated to the model's error term (the unobservables $\boldsymbol{\xi}$ in this model). In the model described in this paper, there is an additional source of variance: the error in the estimation of the integral in equation (1.22), which translates into writing the orthogonality conditions in terms of $\xi(\boldsymbol{\theta}, G_{n_s})$ instead of $\xi(\boldsymbol{\theta}, G)$. In cases in which the market shares of the goods are computed by aggregating the choices of a sample of individuals, there is yet a third source of error: the error in the estimation of the "observed " market shares. In this paper I work with the entire population, hence the market shares are truly observed.

In other applications, the number of simulation draws is high enough that the simulation error can be disregarded. In this case, however, the numerical minimization of the GMM distance function involves solving for $\xi(\boldsymbol{\theta}, G_{n_s})$ in each iterative step, and computational tractability imposes a limit on the sample size, n_s. (I use 100 individuals per time period and country). This means that the error in approximating $\xi(\boldsymbol{\theta}, G)$ with $\xi(\boldsymbol{\theta}, G_{n_s})$ is significant and its variance must be taken into account.

In this section, I discuss some practical aspects of how to estimate standard errors.

A more thorough discussion about the asymptotic distributions can be found in the appendix. Let S_1 and S_2 denote the two sources of variance, respectively. The asymptotic variance of $\hat{\boldsymbol{\theta}}$ is

$$\Sigma_\theta = \left(\Gamma W_2 \Gamma\right)^{-1} \Gamma W_2 \left(S_1 + S_2\right) W_2 \Gamma \left(\Gamma W_2 \Gamma\right)^{-1}, \tag{1.27}$$

where Γ is the limit of the matrix of derivatives of the orthogonality conditions with respect to $\boldsymbol{\theta}$, and W_2 is the limit of the weighting matrix. I estimate these two matrices using their sample analogues evaluated at $\hat{\boldsymbol{\theta}}$.

I assume that the unobservables are uncorrelated across products but not necessarily across time and estimate the first variance with

$$\hat{S}_1 = \frac{1}{J} \sum_j \left(\sum_t \frac{z_{jt} \xi_{jt}(\hat{\boldsymbol{\theta}}, G_{n_s})}{T_j} \right) \left(\sum_t \frac{z_{jt} \xi_{jt}(\hat{\boldsymbol{\theta}}, G_{n_s})}{T_j} \right)'. \tag{1.28}$$

Alternatively, an error component model can be specified. The estimator that I use has the advantage of not imposing a parametric assumption on the covariance within products.

To estimate the second source of variance, S_2, I use the same method as Berry, Levinsohn and Pakes (1995), which consists of taking different samples of individuals G_w, computing the unobservables $\xi(\hat{\boldsymbol{\theta}}, G_w)$ and the orthogonality conditions $\left(\frac{1}{J}\sum_j \sum_t \frac{z_{jt}\xi_{jt}(\hat{\boldsymbol{\theta}}, G_w)}{T_j}\right)$ at the estimated value $\hat{\boldsymbol{\theta}}$ for the different samples, and computing their empirical variance.

There are also two error terms in the computation of the estimator of the price derivatives, $h\left(\hat{\boldsymbol{\theta}}, G_{n_{s'}}\right)$: the error due to evaluating the price derivatives at the estimated value of the demand parameters $\hat{\boldsymbol{\theta}}$ instead of the true value $\boldsymbol{\theta}$ and the error in the estimation of integral (1.18). However, the second error term is of a smaller order of magnitude in this case because the number of simulation draws is large. The estimation of $h\left(\hat{\boldsymbol{\theta}}, G_{n_{s'}}\right)$ is not as computationally intensive as the search for $\hat{\boldsymbol{\theta}}$ and I use a much larger sample of individuals, n_s', to compute it (1,000 draws). The asymptotic distribution is dominated by the first error term and the second source of variance can be safely disregarded.

I estimate the first component of the variance of $h\left(\hat{\boldsymbol{\theta}}, G_{n_s\prime}\right)$ by taking draws from the asymptotic distribution of $\hat{\boldsymbol{\theta}}$. $h\left(\hat{\boldsymbol{\theta}}, G_{n_s\prime}\right)$ is evaluated at the different random draws of $\boldsymbol{\theta}$, keeping the distribution $G_{n_s\prime}$ constant and finally, the empirical variance of h is computed.

Were it necessary to compute the variance on the second error term for the price derivatives, it could be estimated in the same fashion as second source of variance of the demand parameters $\hat{\boldsymbol{\theta}}$. The value of $\boldsymbol{\theta}$ is kept fixed at the estimated value $\hat{\boldsymbol{\theta}}$, and different samples of individuals G_w are taken; the price elasticity $h(\hat{\theta}, G_w)$ is evaluated at each distribution of individuals and its empirical variance is the estimator for the second term variance.

1.6 Data and results

The data consist on semestral observations of sales, average prices and vehicle characteristics from 1996 to 2000, for each car model in Argentina and Brazil. There are 123 different models in Brazil, and 128 in Argentina, not all of them available in all time periods. The data sources for quantities and prices are associations of car dealers and car manufacturers - the *Asociación de Concesionarios de Automóviles de la República Argentina* (Acara) and the *Associação Nacional dos Fabricantes de Veículos Automotores* (Anfavea) for Argentina and Brazil, respectively; - data on characteristics of vehicles are from the specialized publications *Megaautos* and *Quatro Rodas*.

The total number of vehicles and the share of each corporation during the convergence period (1996-1999) are presented in Tables 1 and 2 for Brazil and Argentina, respectively. The market in Brazil is dominated by Fiat, General Motors and Volkswagen. Together they account for 85% of the approximately 5 million units that were purchased during these four years. Ford follows with an important participation in the number of imports, both from Argentina and extra-zone. Approximately 18% of extra-zone imports belong to Peugeot-Citroën. Given that only about 200,000 units are of extra-zone origin (3.8%), the participation of the firm is not very significant in the Brazilian market, however, its presence is relevant in the analysis of the changes in trade flows.

The market is smaller in Argentina, with about a million cars during the entire period. Regarding the origin of the vehicles, 70% is domestic (versus 83% in Brazil), 14.4% are imports from Brazil and 16% are external imports. Participation of firms is more evenly distributed, with Fiat and Renault accounting for 46% of total units, followed by Volkswagen, Ford, Peugeot-Citroën and General Motors. Most imports from Brazil are accounted by Ford (50%) and General Motors (35%). External imports are mainly conducted by Ford, Peugeot-Citroën and Volkswagen.

The characteristics that I include in the estimation of demand are length, horsepower and dummy variables for hatchback models, station wagons, sport utility vehicles (SUVs) and minivans. I introduce variable coefficients for the constant, price and length. The variability in the constant is determined by the different alternative utilities of the individuals. I denote the deviation from the mean alternative utility by Z_i and assume that they are independent across individuals and follow a standard normal distribution. The alternative utility can be written as $u_i = u_o + u_1 Z_i$, where u_o is the mean alternative utility and u_1 its standard deviation. The price coefficient depends on income and takes the functional form $\alpha_i = \alpha_o + \alpha_1/y_i$. The length coefficient varies with family size. In particular length is interacted with a dummy variable B_i with ones for families with more than two children. The random coefficient is $\beta_i = \beta_o + \beta_1 \times B_i$.

I sample income and family size from household surveys and deviations from the mean alternative utility from a standard normal.[9] I take one hundred draws per semester and country. Households in Brazil are surveyed only annually. However, the semestral disaggregation of sales, prices and product characteristics is still important to estimate of the non-random part of the coefficients. In the Argentine data, household characteristics and sales, but not prices, are disaggregated in four geographical regions. For the purpose of demand estimation, the regions are different markets and their treatment is analogous to that of different time periods. For the estimation of supply parameters, I aggregate regional demands and price derivatives in the same period, as I only observe prices at the national level. To estimate the price derivatives I take a sample of 1300 and 2000 individuals per period and region in Argentina and Brazil, respectively.

Results from the estimation of the demand coefficients are shown in Table 3. The first two rows correspond to the alternative utility. The estimates are $\hat{u}_i^a = 13.5 - 0.9 \times Z_i$ and $\hat{u}_i^b = 7.7 - 0.8 \times Z_i$, which implies that the estimated distributions of the reservation utilities are $u_i^a \sim N(13.5, 0.9)$ and $u_i^b \sim N(7.7, 0.8)$. Notice that the signs of the coefficients are inverted with respect to the ones reported on the table. This is because the alternative utility corresponds to the outside alternative, and it is subtracted from the utility of all other products in the normalization in (1.15). Also note that the coefficients of the

[9] I use the Encuesta Permanente de Hogares (EPH) for Argentina, and the Pesquisa Nacional por Amostra de Domicílios (PNAD) for Brazil.

deviations enter the equation with negative sign. This is a consequence of using the same distribution (a standard normal) for all markets. When markets are identical, the signs of the coefficients are not identified, in the sense that the vector $-\mathbf{Z}$ generates the same choices as $\mathbf{Z}$. Still the inclusion of this variable is relevant because the variance of the mean utility is recovered.

The main results are the price coefficients, shown in the second two rows. The marginal utilities of income are $\hat{\alpha}_i^a = 0.19 + 0.17/y_i$ and $\hat{\alpha}_i^b = 0.09 - 0.03/y_i$. The coefficients on length and horsepower have the expected signs and the marginal utility of length is larger for families with more than two children. Utility is higher for hatchback models, SUVs and minivans, and lower for station wagons, all relative to sedan models.

The average marginal utility of income over the sample of consumers is 0.25 in Argentina and 0.08 in Brazil. Figure 1 plots the distribution of $\hat{\alpha}_i^a$ and $\hat{\alpha}_i^b$.[10] Using the marginal utilities, I estimate own and cross-price derivatives and elasticities for each car.

Regarding supply, I estimate the marginal cost for each car model, which are time varying. For each firm, I estimate two Lagrange multipliers for the global trade balance constraint (GTB), one for Argentina and one for Brazil, and eight multipliers for the bilateral quotas (four years and two countries).

Table 4 displays the (actual) average price and (estimated) elasticity, production cost and percentage mark-up by country and origin. In Argentina, the mean elasticity is 3.4, and the mean price and production cost are \$16,700 and \$11,300, respectively, with an

[10] There are 41600 individuals in Argentina (1300 individuals in 4 regions and 8 semesters and 16000 in Brazil (2000 individuals in 8 semesters).

average price-cost margin of 50%.[11,12] Production cost is on average lower for domestic than Brazilian cars ($10,600 and $11,600), while elasticities are similar. However, the price of domestic cars is on average higher ($15,700 compared to $15,100). This finding reflects the GTBs and the inter-country interaction of firms. I argue below that the GTBs are more restrictive in Brazil and that Argentine subsidiaries set lower prices for Brazilian goods to encourage Brazilian exports. The average cost of extra-zone imports is higher than the average cost of MERCOSUR vehicles ($14,700).

In Brazil, demand elasticity is relatively low (1.7), while the average percentage mark-up is 60%, 10% higher than in Argentina. The mean production cost of MERCOSUR cars is about a thousand dollars lower in Brazil than in Argentina. This is the result of different compositions of demand, as the cost of a given product is by assumption the same in both countries. The price of imports from Argentina is higher than the price of domestic cars ($15,900 compared to $14,300), while costs are very similar (9.5 and 9.4) and demand elasticity is higher for Argentine cars. This finding is the opposite of what occurs in Argentina and it is explained by the same argument: Argentine imports are discouraged in Brazil because the GTB is more restrictive. The average price of extra-zone imports is 29,000 dollars, which is high compared to the production cost, the mark-up, and the price in Argentina. It is a consequence of the high external tariff.

The Lagrange multipliers for the GTB are displayed in the first two columns of Table 5.

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[11] The mark-ups are substantially higher than profit margins since they do not include import and trade taxes.

[12] Berry, Levinsohn and Pakes (1995) estimates of own-price elasticity are relatively higher. The lowest elasticity that they report is 3, for the Lexus in 1983.

Since the constraint is intertemporal there is only one multiplier per firm and country (λ_f^a and λ_f^b). The Lagrange multipliers represent the increase in profits that would result from an exogenous increase in export credits (acquisition or exports of capital goods and net exports of components). For example, in the case of General Motors, a 1 dollar increase of export credits in Argentina generates an increase in profits of 40 cents. The same increase in export credits in Brazil, implies that profits go up by 43 cents. In Brazil, these increases range from 14 to 62 cents. Whereas in Argentina, several multipliers are very small and not significantly different from zero, which signals that the price decisions of those firms would be similar without the Argentine GTB. The Lagrange multipliers are significant for Ford, General Motors and Peugeot-Citroën, and they represent hypothetical increases in profits of 50, 40 and 30 cents per 1 dollar increase in export credits. It is also statistically significant for General Motors, although small.

The multipliers can also be interpreted as an adjustment in the marginal cost due to the GTBs, as defined in equation (1.6). For outside imports, the multipliers are the percentage increase in costs. For example, λ^a is 0.5 in the case of Ford, which means that in Argentina the cost of extra-zone imports is 50% higher than the cost of production. For intra-zone imports there other considerations: internal imports tighten one GTB but loosen the other. The third and fourth columns of Table 5 show the percentage adjustment in intra-zone import costs due to the GTBs. To continue with the example of Ford, the adjusted cost of internal imports in Argentina is 25% lower than the production cost. Thus, prices are lower (than what they would be if there was no GTB) and exports higher. The opposite happens in Brazil, where the cost of Argentine products is 3% higher than the production cost, because imports add the cost of tightening the constraint even more. The decrease in costs of internal imports in Argentina ranges from 11% to 57%. In Brazil, the cost of internal imports increases between 3% and 48%, with the exception of General Motors, whose costs decrease by 5%.[13]

Table 6 reports the estimates of the Lagrange multipliers for the bilateral constraint. I estimate the difference $\mu^0 = \mu^a - \mu^b$. If this difference is positive I assign the values $\hat{\mu}^a = \hat{\mu}^0$ and $\hat{\mu}^b = 0$.[14] A positive value for μ^a and a zero for μ^b, as is the case for the Volkswagen corporation in 1996, means that Argentine net internal imports are as high as allowed by the quota (the lower bound of the constraint is met). In other words, the Argentine subsidiary is importing from Brazil as much as possible without a further increase in its exports. The opposite happens when μ^b is positive, as is the case of Chrysler in 1997. In the majority of the cases, μ^a is positive and μ^b is zero. This is consistent with the results in Table 5 that suggest that the GTB constraint works in the direction of increasing Argentine imports of Brazilian products.[15]

The difference $\mu^a - \mu^b$ is interpreted as the additional cost imposed by the bilateral quota (it is not a percentage increase). In the case of Volkswagen in 1996, Brazilian products sold in Argentina exceed their production cost by 170 dollars, while the cost of

[13]This is the addition in costs due to the GTB, the effect of the bilateral quota has to be contemplated, too.

[14]Since the multipliers are non-negative, the standard errors do not define proper confidence intervals in the case in which the coefficients are not significant. The distribution of the estimator has a mass point at zero (the probability of a negative value corresponds to zero).

[15]Notice that the bilateral constraint, which in most cases restricts Argentine internal imports, is likely to mitigate the effect of the GTB.

Argentine models sold in Brazil is 170 dollar lower.

The fact that the μ_f^h's are different across firms suggests that the quotas were inefficiently distributed among the corporations and that firms could benefit from trading import rights among each other.

1.7 Conclusions

In this paper I estimate a model of demand and supply of cars in Argentina and Brazil that incorporates two non-tariff barriers: a quota on bilateral net imports and a trade balance constraint. By modeling the behavior of firms in two countries, rather than in one, I am able to capture an additional strategic component of firm behavior - the interaction across markets. In addition, the data on two different markets allows me to estimate the supply parameters (including the shadow cost of the trade policy constraints) by minimum distance instead of by a perfect fit method, and without the need to make functional form assumptions on the cost side as is the usual practice in the literature.

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Appendix 1.A. Asymptotic distribution of the demand parameters

This is a sketch of a proof of the asymptotic distribution of the utility function parameters $\hat{\boldsymbol{\theta}}$. For a complete and formal proof of consistency and asymptotic normality see Berry, Linton and Pakes (2004).

The FOCs for the minimization of the GMM distance function in (1.25) are

$$D_\theta g(\widehat{\boldsymbol{\theta}}, G_{n_s})^T \widehat{W}_2 g(\widehat{\boldsymbol{\theta}}, G_{n_s}) = 0$$

where $D_\theta g(\boldsymbol{\theta}, G)$ is the matrix of partial derivatives of $g(\boldsymbol{\theta}, G)$ with respect to $\boldsymbol{\theta}$. By performing a Taylor expansion of $g(\widehat{\boldsymbol{\theta}}, G_{n_s})$ around the true value of the parameters $\boldsymbol{\theta}_o$ the FOCs can be written as

$$D_\theta g(\widehat{\boldsymbol{\theta}}, G_{n_s})^T \widehat{W}_2 \left(g(\boldsymbol{\theta}_o, G_{n_s}) + D_\theta g(\widetilde{\boldsymbol{\theta}}, G_{n_s})(\widehat{\boldsymbol{\theta}} - \boldsymbol{\theta}_o) \right) = 0$$

where $\widetilde{\boldsymbol{\theta}}$ is the mean value of the expansion. Adding and subtracting $g(\boldsymbol{\theta}_o, G_o)$ inside the parenthesis, multiplying some terms by $\sqrt{J}$ and $\sqrt{n_s}$ and solving for $(\widehat{\boldsymbol{\theta}} - \boldsymbol{\theta}_o)$ gives

$$\begin{aligned} \sqrt{J}(\widehat{\boldsymbol{\theta}} - \boldsymbol{\theta}_o) &= -\left(D_\theta g(\widehat{\boldsymbol{\theta}}, G_{n_s})^T \widehat{W}_2 D_\theta g(\widetilde{\boldsymbol{\theta}}, G_{n_s}) \right)^{-1} D_\theta g(\widehat{\boldsymbol{\theta}}, G_{n_s})^T \widehat{W}_2 \times \\ & \left(\sqrt{J} g(\boldsymbol{\theta}_o, G_o) + \frac{\sqrt{J}}{\sqrt{n_s}} \sqrt{n_s} [g(\boldsymbol{\theta}_o, G_{n_s}) - g(\boldsymbol{\theta}_o, G_o)] \right) \end{aligned}$$

Since $g(\boldsymbol{\theta}_o, G_o) = \frac{1}{J} \sum_j \frac{1}{T_j} \sum_t z_{jt} \xi_{jt}(\boldsymbol{\theta}_o, G_o)$ this term explains the error in $(\widehat{\boldsymbol{\theta}} - \boldsymbol{\theta}_o)$ associated to the model's structural error term ξ_{jt} (the unobservable characteristics). The term $g(\boldsymbol{\theta}_o, G_{n_s}) - g(\boldsymbol{\theta}_o, G_o)$ is equal to $\frac{1}{J} \sum_j \frac{1}{T_j} \sum_t z_{jt} \left(\xi_{jt}(\boldsymbol{\theta}_o, G_{n_s}) - \xi_{jt}(\boldsymbol{\theta}_o, G_o) \right)$, which comprises the error in the simulation-based estimator used to compute the unobservables ξ_{jt}.

Define Γ, W_2, S_1 and S_2 as

$$\begin{aligned}
\Gamma &= \lim_{J\to\infty} E\left[D_\theta g(\boldsymbol{\theta}_o, G_o)\right] \\
W_2 &= \lim_{J\to\infty} \widehat{W_2} \\
S_1 &= \lim_{J\to\infty} E\left(Jg\left(\boldsymbol{\theta}_o, G_o\right) g\left(\boldsymbol{\theta}_o, G_o\right)'\right) \\
S_2 &= \lim_{J\to\infty} \frac{J}{n_s} E\left(n_s \left[g\left(\boldsymbol{\theta}_o, G_{n_s}\right) - g\left(\boldsymbol{\theta}_o, G_o\right)\right]\left[g\left(\boldsymbol{\theta}_o, G_{n_s}\right) - g\left(\boldsymbol{\theta}_o, G_o\right)\right]'\right)
\end{aligned}$$

Berry, Linton and Pakes establish that $\sqrt{\frac{J}{n_s}}\sqrt{n_s}\left(g(\boldsymbol{\theta}_o, G_{n_s}) - g(\boldsymbol{\theta}_o, G_o)\right) \rightarrow N\left(0, S_2\right)$ provided $\frac{J^2}{n_s}$ is bounded. They also show that this bound is determined by the substitution pattern across products.

The asymptotic distribution of $\widehat{\boldsymbol{\theta}}$ is

$$\sqrt{J}(\widehat{\boldsymbol{\theta}} - \boldsymbol{\theta}_o) \rightarrow_d N\left(0, \left(\Gamma W_2 \Gamma\right)^{-1} \Gamma W_2 \left(S_1 + S_2\right) W_2 \Gamma \left(\Gamma W_2 \Gamma\right)^{-1}\right) = N\left(0, V_\theta\right)$$

S_1 and S_2 are the two *sources of variance* discussed in Section 1.5.2.

Appendix 1.B. Asymptotic distribution of the price derivatives

$h(\widehat{\boldsymbol{\theta}}, G_{n_s})$ is the estimator of the price derivatives defined as

$$h(\widehat{\boldsymbol{\theta}}, G_{n_s'}) = N\frac{1}{n_s'}\sum_{i_s} \eta\left(\widehat{\boldsymbol{\theta}}, \nu_{i_s}\right)$$

It depends on the estimator of the utility function parameters $\widehat{\boldsymbol{\theta}}$ and it is estimated with a sample of individuals n_s'.

By performing a Taylor expansion around $\boldsymbol{\theta}_o$ the estimator can be written as

$$h(\widehat{\boldsymbol{\theta}}, G_{n_s'}) = h(\boldsymbol{\theta}_o, G_{n_s'}) + D_\theta h(\widetilde{\boldsymbol{\theta}}, G_{n_s'})(\widehat{\boldsymbol{\theta}} - \boldsymbol{\theta}_o)$$

Subtracting the true price derivatives $h(\boldsymbol{\theta}_o, G_o)$ (evaluated at $\boldsymbol{\theta}_o$ and using the characteristics of the entire population, summarized by the distribution G_o) and multiplying by $\sqrt{J}$ and $\sqrt{n'_s}$ where necessary gives

$$\sqrt{J}\left(h(\widehat{\boldsymbol{\theta}}, G_{n'_s}) - h(\boldsymbol{\theta}_o, G_o)\right) = D_\theta h(\widetilde{\boldsymbol{\theta}}, G_{n'_s})\sqrt{J}(\widehat{\boldsymbol{\theta}} - \boldsymbol{\theta}_o) + \frac{\sqrt{J}}{\sqrt{n'_s}}\sqrt{n'_s}\left(h(\boldsymbol{\theta}_o, G_{n'_s}) - h(\boldsymbol{\theta}_o, G_o)\right)$$

There are two error terms in the estimation of $h(\widehat{\boldsymbol{\theta}}, G_{n_s})$. The first error is due to the use of $\widehat{\boldsymbol{\theta}}$ instead of $\boldsymbol{\theta}_o$. The second error is the simulation error in the computation of the integral in equation (1.26) , which is equal to $h(\boldsymbol{\theta}_o, G_{n'_s}) - h(\boldsymbol{\theta}_o, G_o)$. As I discuss in section 4.3, the first term dominates the asymptotic distribution as the number of sampled individuals n'_s in the estimation of (1.26) is large enough to make the second error term of a smaller order of magnitude.

Let

$$H = \lim_{J\to\infty} E\left[D_\theta h(\theta_o, G_o)\right]$$

Then,

$$\sqrt{J}\left(h(\widehat{\theta}, G_{n'_s}) - h(\theta_o, G_o)\right) \to N\left(0, HV_\theta H'\right)$$

TABLE 1. Market Shares by Firm - BRAZIL
Convergence Period 1996 - 1999

	All Goods	Domestic Products	Imports from Partner	Imports from Outside
Chyrsler	0.5	0	1.4	7.2
Fiat	29.3	32.0	18.2	7.8
Ford	11.1	9.3	21.1	15.9
General Motors	23.2	27.2	4.9	0
Honda	0.7	0.8	0	2.5
Mercedes Benz	0.3	0.2	0.1	2.7
Peugeot-Citroën	1.0	0	2.2	18.5
Renault	1.2	0.4	5.8	2.7
Toyota	0.3	0.2	0.3	3.8
Volkswagen	32.4	29.8	46.0	39.1
Total number of units	**5,176,605**	**4,283,403**	**698,431**	**194,771**
Share by origin	100	82.7	13.5	3.8

TABLE 2. Market Shares by Firm - ARGENTINA
Convergence Period 1996 - 1999

	All Models	Domestic Models	Imports from Partner	Imports from Outside
Chyrsler	1.2	0.6	0	5.0
Fiat	23.3	29.4	10.0	8.7
Ford	15.5	7.2	49.4	20.7
General Motors	8.2	4.0	35.1	1.9
Honda	0.6	0.05	1.4	2.2
Mercedes Benz	0.2	0.02	0.4	1.0
Peugeot-Citroën	12.2	12.4	0	22.5
Renault	22.4	28.9	2.3	12.5
Toyota	0.8	0.1	0.5	3.9
Volkswagen	15.7	17.4	1.0	21.6
Total number of units	**1,047,730**	**730,065**	**150,710**	**166,955**
Share by origin	100	69.7	14.4	15.9

TABLE 3. Utility Function Parameters

	ARGENTINA	BRAZIL
Constant $(-u_o)$	-13.5 (27.4)	-7.7 (33.4)
Constant * N(0,1) $(-u_1)$	0.9 (0.6)	0.8 (0.9)
Price $(-\alpha_o)$	-0.19 (0.05)	-0.09 (0.03)
Price * 1/Income $(-\alpha_1)$	-0.17 (0.08)	0.03 (0.01)
Length (β_o)	4.2 (0.3)	0.4 (0.2)
Length * More than 2 children (β_1)	1.0 (0.5)	0.4 (14.7)
Length Square	-0.5 (1.5)	0.1 (3.0)
Horsepower	3.3 (1.3)	0.4 (0.1)
Hatchback	0.1 (0.5)	0.4 (1.0)
Station Wagon	-0.7 (0.3)	-0.6 (0.2)
SUV or Minivan	0.5 (1.5)	0.5 (0.5)
Category Dummies	Yes	Yes
Test of Overidentifying Restrictions Critical Value: 23.68	20.84	17.45
Mean price coefficient $-\int(\alpha_o+\alpha_1/y_i)dF(\nu_i)$	-0.25 (0.11)	-0.08 (0.03)

FIGURE 1. Distribution of the Marginal Utility of Income

ARGENTINA

BRAZIL

TABLE 4. Price, Elasticity, Production Cost and Mark-up
Convergence Period (1996 - 1999)

	All Models	Domestic Models	Imports from Partner	Imports from Outside
ARGENTINA				
Quantity of Vehicles	1,047,730	730,065	150,710	166,955
Mean Price (thousands of dollars)	16.7	15.7	15.1	22.4
Mean Price Elasticity	-3.4 (0.2)	-3.3 (0.2)	-3.3 (0.2)	-3.7 (0.9)
Mean Production Cost (thousands of dollars)	11.3 [9, 14]	10.5 [9, 13]	11.6 [10, 14]	14.7 [11, 17]
Mean Percentage Mark-up (percentage)	50 [42, 79]	53 [51, 76]	37 [15, 72]	48 [34, 96]
BRAZIL				
Quantity of Vehicles	5,176,605	4,283,403	698,431	194,771
Mean Price (thousands of dollars)	15.1	14.3	15.9	29.0
Mean Price Elasticity	-1.7 (0.3)	-1.5 (0.1)	-1.8 (0.2)	-4.0 (0.5)
Mean Production Cost (thousands of dollars)	9.7 [6, 11]	9.5 [6, 10]	9.4 [6, 10]	15.3 [12, 17]
Mean Percentage Mark-up (percentage)	60 [14, 123]	62 [14, 124]	52 [11, 131]	39 [26, 84]

TABLE 5. Global Trade Balance Constraint (GTB)

	Lagrange Multipliers		Adjustment in Cost of Imports from Partner (percentage)	
	Argentina λ^a	Brazil λ^b	Argentina $\lambda^a - 1.2\lambda^b$	Brazil $\lambda^b - 1.2\lambda^a$
Chrysler	0.02 *(0.76)*	0.29 *(0.80)*	-33 [-436, -2.6]	27 [2.2, 357]
Fiat	0 *(0.06)*	0.15 *(0.95)*	-19 [-36, -1.2]	15 [1.0, 30]
Ford	0.50 *(0.97)*	0.62 (0.31)*	-25 [-30, 1.2]	3 [-25, 24]
General Motors	0.40 (0.13)*	0.43 (0.18)*	-11 [-25, 9]	-5 [-20, 21]
Honda	0 *(0.01)*	0.37 (0.12)*	-45 [-71, -27]	37 [22, 59]
Mercedes Benz	0 *(0.24)*	0.15 *(0.60)*	-18 [-610, 12]	15 [-15, 508]
Peugeot-Citroën	0.30 (0.05)*	0.43 *(0.84)*	-21 [-200, 3.5]	7 [-503, 63]
Renault	0 *(0.005)*	0.48 (0.12)*	-57 [-94, -36]	48 [30, 78]
Toyota	0 *(0.13)*	0.27 *(0.93)*	-33 [-100, -11]	27 [9, 84]
Volkswagen	0 *(0.05)*	0.14 *(0.88)*	-16 [-44, -0.2]	14 [0.2, 37]

* Standard errors for estimators that are significantly different from zero at the 5% sign level (two-tail test)

Parentheses and Italics indicate that the estimator is not significantly different from ze the 5% significance level. Since the multipliers cannot be negative, the distribution of t estimator is truncated at zero. The numbers between parentheses indicate the probabilit the estimator is strictly positive

TABLE 6. Lagrange Multipliers for the Bilateral Constraint

	1996		1997		1998		1999		Difference in Cost Adjustments
	ARG	*BRA*	*ARG*	*BRA*	*ARG*	*BRA*	*ARG*	*BRA*	
	μ^a	μ^b	μ^a	μ^b	μ^a	μ^b	μ^a	μ^b	$(1+1.2)(\lambda^b-\lambda^a)$
Chrysler	-	-	0	2.41	0	0.94	0.76	0	59
Fiat	0.16	0	0.19	0	0.18	0	1.82	0	34
Ford	0.04	0	0.15	0	0.25	0	0.76	0	28
General Motors	0	0.29	0.32	0	0.30	0	0.54	0	6
Honda	-	-	0.59	0	4.22	0	5.94	0	82
Mercedes Benz	-	-	-	-	0	0.18	2.05	0	34
Peugeot-Citroën	0	0.75	0	0.33	0.18	0	0.82	0	28
Renault	0	0.40	0.20	0	0.55	0	1.89	0	105
Toyota	-	-	-	-	0	0.38	4.01	0	60
Volkswagen	0.17	0	0.27	0	0.30	0	1.13	0	30

A dash (-) indicates no bilateral trade

Chapter 2

A customs union with multinational firms

2.1 Introduction

In this paper I estimate the economic effects of adopting a customs union in the context of an oligopolistic market with multinational firms and trade balance constraints. I focus on the impact of trade reforms on trade volumes, prices, and economic welfare. To do this, I study the automobile markets in Argentina and Brazil in the context of MERCOSUR, a regional trade agreement between Argentina, Brazil, Uruguay and Paraguay.

The policy experiment that I examine has some unique features. While Argentina and Brazil agreed to form a customs union in the car market by 2006, the transition involves changes in tariffs and elimination of non-tariff barriers (NTBs) including trade balance constraints and bilateral quotas. In particular, the trade reform that is now taking place involves two main and distinctive instruments. First, the member countries agreed to set a common external tariff on imports of cars from the rest of the world that is higher than the pre-agreement tariff rate. Since Brazil was levying a much higher tariff on cars than Argentina prior to the reform, this leveling of tariffs implies a slight increase in Brazilian taxes and a sharp increase in Argentine taxes. This is a movement away from free trade that should be more relevant in Argentina than in Brazil. Second, both countries have agreed to fully eliminate the NTBs. This is a clear movement towards free trade in both countries.

The automobile market in MERCOSUR is dominated by multinational firms that simultaneously produce in both countries, are involved in bilateral trade, and import from the rest of the world. The strategic interaction between the subsidiaries of the same corporations in Argentina and Brazil and the complexity of the trade policy provide a rich environment for economic analysis and broaden the scope for econometric measurement.

The empirical strategy that I use comprises the estimation of demand and supply for cars to recover the structural parameters of both the Argentine and Brazilian markets. I use these parameters to simulate an equilibrium under a customs union an assess its impact on quantities, prices, profits, trade volume and welfare.

On the demand side, I adopt the random-coefficient model of Berry (1994) and Berry, Levinsohn and Pakes (1995). On the supply side, I characterize the behavior of multinational firms in oligopolistic competition and derive the first order conditions for profit maximization taking into account the strategic interdependence caused by the interaction of firms, not only with competitors but also with subsidiaries in other countries. With these FOCs and the parameters of demand estimated with the Berry, Levinsohn and Pakes (1995) procedure, I can recover the marginal costs of production for different car models and for different firms and the shadow costs imposed by the non-tariff barriers

(NTBs). The estimation of demand and supply is the same as in Chapter 1 and the reader is referred to this Chapter for a detailed presentation of the model, estimation methods and results.

The oligopoly model is general enough that I can use it to characterize the optimal behavior of firms, conditional on demand, for different policy scenarios. I proceed to derive a set of FOCs for all firms in three different equilibria, each capturing different elements of the trade reform. I begin by describing the equilibrium during the initial situation in 1996-1999. Then, I characterize an equilibrium without NTBs, in which the bilateral quotas and the trade balance constraints are removed but the tariffs rates remain at the pre-customs union level. Finally, I define the customs-union equilibrium, which adds the adoption of a common external tariff to the elimination of non-tariff barriers. By comparing these equilibria, I am able to identify the main economic effects of the trade policies being adopted by these countries in this particular market.

I find that under a customs union, prices of vehicles are on average 659 dollars lower in Argentina and consumers are better off by 393 dollars per vehicle than during the initial situation. The opposite happens in Brazil where cars are 100 dollars more expensive and consumers suffer a loss in welfare of 204 dollars per vehicle. Tariff revenue increases in both countries, and in Brazil it more than offsets the loss in consumer welfare.

Using a decomposition of the policy changes, I find that the elimination of non-tariff barriers dominates the leveling of tariffs for all the effects that I measure. It is easy to see why this is true in Brazil, since the common external tariff does not increase much. But the result is true even in Argentina where the adjustment in tariffs is substantial. In particular, imports from the rest of the world increase under the new regime even though tariffs against these goods become more discriminatory.

Another finding is that, in the customs union, imports from Brazil decrease in Argentina. The strategic interaction between subsidiaries in the two countries explains this seemingly counterintuitive result. The existing trade balance constraints distort the price decisions of the firms and trade between partners in the initial equilibrium. When NTBs are eliminated, the directions of change in bilateral flows are a priori unpredictable.

Previous evaluations of trade policy in automobile markets have looked at the voluntary export restraint (VER) of Japanese vehicles in U.S. that was set up in 1981. Dixit (1988) calibrates a model with two differentiated products, American and Japanese. He computes the optimal tariff on cars and finds that restricting Japanese imports, by means of a higher tariff, would have been welfare enhacing for the U.S. Feenstra (1984) and (1988) estimates the increase in prices of Japanese cars that was due to the VER. He shows that part of the increase in prices is explained by an upgrade in quality. Goldberg (1995) and later Berry, Levinsohn and Pakes (1999) estimate more complete models of supply and demand in the U.S. market and simulate the counterfactual equilibrium without the VER. These papers have very different predictions: while Goldberg finds that the VER was binding in the first years after it was imposed, Berry, Levinsohn and Pakes suggest the opposite.

There are several elements that clearly differentiate my analysis from this literature. First, the policy experiment is more complex and it involves the individual identification of the effects of two simultaneous changes in policy, the elimination of NTBs and the leveling of tariffs. Second, I model the behavior of multinational automobile producers in two separate markets, Argentina and Brazil. This requires modeling the strategic interaction among firms and among the subsidiaries within a firm. Finally, I am able to estimate production cost and the shadow cost of NTBs (represented by Lagrange multipliers) with fewer assumptions on functional forms.

The paper is organized as follows. Section 2 provides a brief description of the automobile trade policy in Argentina and Brazil pre and post-MERCOSUR; Section 3 lays out a model of demand and supply; Section 4 discusses the modeling of the changes in policy; Section 5 covers the estimation strategy; while Section 6 reports the results

2.2 Trade policy timeline

Automobiles are produced in Argentina and Brazil by subsidiaries of multinational corporations associated with local investors. The firms located in the area are Ford, General Motors, Chrysler, Fiat, Volkswagen, Mercedes Benz, Peugeot-Citroën, Renault, Toyota and Honda (Chrysler and Mercedes Benz merged in 2000 and formed Daimler-Chrysler). All of these firms have production facilities in both countries and regional headquarters where they develop joint strategies for Argentina and Brazil.

Firms trade models between Argentina and Brazil and also import and export from and to the rest of the world. The largest fraction of trade is bilateral, other destinations of exports are Latin America and Europe. Trade in finished vehicles is a large fraction of bilateral trade. Just as an example, in 1997, imports of cars accounted for more than 17% of Brazilian imports from Argentina, and 10% of Argentine imports from Brazil.

There are also car manufacturers that do not have production facilities in the area and that only import cars. The most important among these in terms of sales during the second half of the 1990's are Rover, Isuzu and Daewoo. These firms are subject to a different -more restrictive- trade regime in both countries and account for less than 10 percent of domestic sales in each Argentina and Brazil. Throughout this paper, I focus on demand and supply for cars produced domestically in Argentina or Brazil or imported by local producers.

Historically, the industry has been heavily protected in Argentina and Brazil with very few imports during the 1980s. The first liberalization episode took place in 1990 when the two countries agreed to eliminate tariffs for bilateral imports, but kept tariffs for imports from other countries. They also set "quotas" on *net* imported units in both countries, that were in place until the year 2000. By these quotas, the number of imported units could not exceed the number of exported units by more than a negotiated limit; their purpose was to balance bilateral trade in units. For example, in the case of Argentina, the total number of cars imported from Brazil minus the total number of cars exported to Brazil could not exceed a given limit (quota). These quotas were negotiated by the two countries and then arbitrarily assigned to firms, presumably based on past participation on the market. Each country kept its own tariff rate on imports from the rest of the world and later imposed a *global trade balance constraint* (GTB) (further described below) that restricted the total value of imports to be less or equal to the total value of exports. Trade of vehicles grew rapidly and accounted for a large part of total bilateral trade.

In 1995, Argentina, Brazil, Uruguay and Paraguay formed a customs union (MERCOSUR), which implies free internal trade between partners (no tariffs or NTBs) and a common external tariff for imports from outside the union. The automobile sector received a different treatment from other goods. The sector was initially left out of the agreement and its incorporation was scheduled for 2000. The years 1996-1999 were established as an initial period to phase-out tariffs and non-tariff barriers and the MERCOSUR trade partners signed bilateral agreements that regulated trade until the customs union was fully achieved. I refer to this transition from the beginning of 1996 the beginning of 2000 as the *convergence period*. The change in trade barriers from the convergence period to the customs union is the focus of this study.

Before the formal adoption of MERCOSUR, at the beginning of 1995, the tariff for outside vehicles was 2 percent in Argentina and 32 percent in Brazil. The MERCOSUR members agreed to adopt a common external tariff of 35 percent by the end of 1999. Convergence to the common rate was gradual in Argentina, with steady trimestral increases. In Brazil, it was more erratic, although never higher than 35 percent (it reached 35 percent in 1996 and in 1999). The following table shows the average yearly tariffs during 1996-1999.

	ARGENTINA	BRAZIL
1996	7%	35%
1997	10%	32%
1998	14%	28%
1999	17%	35%

The tariff for bilateral trade was zero since 1990 and continued to be zero during 1996-1999 and afterwards. The implementation of non-tariff barriers was more complicated as it involved two different policy interventions. From 1996 to 1999, imports were subject to an intertemporal global trade balance constraint (GTB) in each country, which stipulated that for each firm the value of imports could not exceed the value of exports (plus other export credits) during the entire convergence period. To compute trade balance, both imports from the partner and the rest of the world were included in these constraints. Exports were multiplied by a factor of 1.2. In addition, firms were granted export credits that could be included in the value of exports in the trade balance constraints. Investment in capital goods and net exports of auto-parts were considered export credits (which were not multiplied by 1.2). Firms could also buy export credits from independent spare-part producers. In addition to the GTB, there were the quotas on net bilateral imports described above.

In 2000 the two non-tariff barriers (NTBs) were eliminated. However, the objective of free trade between partners agreed upon in 1995 was not achieved. The NTBs were replaced by a bilateral trade balance constraint that established that the annual value of exports to the partner should be equal to the value of imports. To be more precise, in each country, the value of imports is restricted to be less or equal to the value of exports multiplied by a "deviation coefficient" that is subject to annual adjustments to gradually loosen the constraint. As a consequence, a *managed customs union* was arranged: tariffs were zero for internal trade and uniform for external trade, but trade between partners was not free of NTBs (there were no NTBs for external imports, though). Implementation of the full customs union was deferred until 2006. The following table summarizes the different regimes

Convergence Period (1996-1999)	Managed Customs Union (2000-2005)	Customs Union (2006)
Internal tariff: 0% Different external tariff (≤35%) Global Trade Balance (GTB) Quota for net Imports	Internal tariff: 0% Common external tariff (35%) Bilateral Trade Balance	Internal tariff: 0% Common external tariff (35%)

In this study, I compare the policy during the convergence period with the policy during the customs union. I estimate cost production cost using observed data during 1996-1999 and then use the results to predict counterfactual outcomes for the policy that will be implemented in 2006.

Vehicles imported by firms without production facilities in Argentina and Brazil (BMW, Rover, Daewoo, etc.) were subject to a completely different trade regime. During 1995-1999, there was a quota restricting the number of imported units of finished vehicles in each country, in addition, these firms faced higher tariffs that "local" firms. At the beginning of 1995, the tariff for importers was 35 percent in Argentina and 70 percent in Brazil. Both this tariffs converged to the external tariff of 35 percent during the convergence period. These imports were not subject to trade balance constraints.

2.3 Model

In this section I describe a model of firm behavior and demand. Firm behavior depends on trade policy, since trade restrictions impose either direct (tariffs) or indirect (NTBs) costs that are taken into account by firms when choosing prices. In particular, I model the behavior of firms under the trade policy that was in place under the convergence period. In Section 2.4, I describe the model when the trade policy corresponds to a customs union, as expected for 2006. On the demand side, I adopt the discrete choice logit model by Berry (1994) and Berry, Levinsohn and Pakes (1995).

Firms

I model the supply side of the car market as a differentiated-product oligopoly with price competition. There are F multinational corporations with subsidiaries in Argentina and Brazil, indexed by f. In each of the two countries, firms sell cars produced domestically, cars imported from the partner (Argentina or Brazil) and cars imported from other countries. A_{ft}, B_{ft} and W_{ft} are the sets of cars produced by firm f in period t in Argentina, Brazil and the rest of the world, respectively, and sold in Argentina; while A'_{ft}, B'_{ft} and W'_{ft} denote the sets of cars sold in Brazil. In principle, the sets of cars sold in Argentina and Brazil can differ.

Models are indexed by j. Producers face constant marginal costs for each model, given by c_j and demand functions in Argentina and Brazil given by $q^a_{jt}\left(\mathbf{P}^a_t\right)$ and $q^b_{jt}\left(\mathbf{P}^b_t\right)$, where $\mathbf{P}^a_t$ is the price vector of all car models in Argentina and $\mathbf{P}^b_t$ its counterpart in Brazil. Bilateral imports are free of taxes, whereas outside imports face a tariff τ^a_t in Argentina and τ^b_t in Brazil. Trade is intra-firm, and firms are assumed to trade at marginal cost, consequently, the tariff rates are applied to the marginal costs.

Firms compete in prices and choose two prices for each car model, a price in Argentina, p^a_{jt}, and a price in Brazil, p^b_{jt}. Profits derived from sales in Argentina by multiproduct firm f in period t are given by the sum of profits for each good produced by f in Argentina,

$\left(\sum_{j\in A_{ft}}\left(p^a_{jt}-c_{jt}\right)q^a_{jt}\left(\mathbf{P}^a_t\right)\right)$, in Brazil, $\left(\sum_{j\in B_{ft}}\left(p^a_{jt}-c_{jt}\right)q^a_{jt}\left(\mathbf{P}^a_t\right)\right)$, and in the rest of the world, $\left(\sum_{j\in W_{ft}}\left(p^a_{jt}-c_{jt}\left(1+\tau^a_t\right)\right)q^a_{jt}\left(\mathbf{P}^a_t\right)\right)$. Profits in Brazil can be expressed in an analogous manner, summing over the sets A'_{ft}, B'_{ft} and W'_{ft}. Notice that the cost of imports from third countries includes tariffs.

When choosing prices, firms need to satisfy the NTBs. The Argentine and Brazilian GTBs for firm f can be written respectively as

$$\sum_{t\in T^0}\left(\sum_{j\in B_{ft}}c_{jt}q^a_{jt}\left(\mathbf{P}^a_t\right)+\sum_{j\in W_{ft}}c_{jt}\left(1+\tau^a_t\right)q^a_{jt}\left(\mathbf{P}^a_t\right)\right)\leq 1.2\sum_{t\in T^0}\sum_{j\in A'_{ft}}c_{jt}q^b_{jt}\left(\mathbf{P}^b_t\right)+X^a_f \tag{2.1}$$

$$\sum_{t\in T^0}\left(\sum_{j\in A'_{ft}}c_{jt}q^b_{jt}\left(\mathbf{P}^b_t\right)+\sum_{j\in W'_{ft}}c_{jt}\left(1+\tau^b_t\right)q^b_{jt}\left(\mathbf{P}^b_t\right)\right)\leq 1.2\sum_{t\in T^0}\sum_{j\in B_{ft}}c_{jt}q^a_{jt}\left(\mathbf{P}^a_t\right)+X^b_f$$

where T^0 denotes the period in which the GTB was in place. The left-hand side corresponds to firm f 's imports, and the right-hand side to its exports. Exports to other countries, credits from the acquisition or export of capital goods and net exports of components are included in the exogenous terms X^a_f and X^b_f.

The bilateral quantitative constraints can be modeled as a lower and an upper bound on net imported units of the Brazilian subsidiary, $\underline{Q}_{ft}$ and $\overline{Q}_{ft}$, exogenously assigned. The lower bound is the (negative of the) quota in Argentina, and the upper bound the quota in Brazil.

Each firm maximizes profits during T^0 subject to the global and bilateral constraints. The objective function can be written as a Lagrangian that includes profits and the NTBs as restrictions. Let λ^a_f and λ^b_f be the Lagrange multipliers associated with the GTBs of

Argentina and Brazil, respectively; and μ^a_{ft} and μ^b_{ft} denote the multipliers associated with the bilateral quantitative constraint (μ^a_{ft} is associated with the lower bound, the quota in Argentina, and μ^b_{ft} with the upper bound, the quota in Brazil).

The first order conditions can be written in matrix form as

$$q(\mathbf{P}) + \Delta(\mathbf{P})\left(\mathbf{P} - \mathbf{c}^*\left(\mathbf{c}, \boldsymbol{\lambda}, \boldsymbol{\mu}, \boldsymbol{\tau}^a, \boldsymbol{\tau}^b\right)\right) = 0 \tag{2.2}$$

where $q(\mathbf{P})$ and $\mathbf{P}$ are the vectors of quantities and prices stacked across firms, years and countries, and $\Delta(\mathbf{P})$ is a block diagonal matrix of derivatives of the demand function with respect to price, replacing $\Delta_{ij} = 0$ when products i and j are produced by different firms or sold in different countries or belong to different time periods. The vector $\mathbf{c}^*$ represents the *adjusted marginal costs*, defined as the production marginal costs augmented by the implicit costs imposed by the trade taxes and restrictions. The definition of adjusted marginal costs follows directly from the first order conditions and is given by

$$c^{*a}_{jt} = \begin{cases} c_{jt} & \text{for } j \in A_{ft} \\ c_{jt}\left(1 + \lambda^a_f - 1.2\lambda^b_f\right) + \left(\mu^a_{ft} - \mu^b_{ft}\right) & \text{for } j \in B_{ft} \\ c_{jt}\left(1 + \tau^a_t\right)\left(1 + \lambda^a_f\right) & \text{for } j \in W_{ft} \end{cases} \tag{2.3}$$

$$c^{*b}_{jt} = \begin{cases} c_{jt}\left(1 + \lambda^b_f - 1.2\lambda^a_f\right) - \left(\mu^a_{ft} - \mu^b_{ft}\right) & \text{for } j \in A'_{ft} \\ c_{jt} & \text{for } j \in B'_{ft} \\ c_{jt}\left(1 + \tau^b_t\right)\left(1 + \lambda^b_f\right) & \text{for } j \in W'_{ft} \end{cases}$$

For a car produced and sold in Argentina ($j \in A_{ft}$) the cost relevant for the price decision is the marginal cost of production (there is no adjustment). In the case of a car produced in a third country and imported into Argentina $(j \in W_{ft})$, the relevant cost is the production cost, augmented by the percentage increase due to the tariff $(1 + \tau^a_t)$ and the shadow increase in cost due to the GTB constraint $(1 + \lambda^a)$. When a car is imported from Brazil to Argentina $(j \in B_{ft})$, the cost does not need to be increased by a tariff since the bilateral tariff is zero, but there are two NTBs that apply, the GTB and the net quota on imports. The cost of imports from Brazil is increased by $(100 \times \lambda^a)$ percent because each unit imported tightens the Argentine GTB; at the same time, each such export from Brazil helps relax the Brazilian GTB. This reduces the cost by $\left(100 \times 1.2\lambda^b\right)$ percent. The net effect of the GTB in Argentina is $\lambda^a - 1.2\lambda^b$, which can be positive or negative. In addition, there is the cost imposed by the net quota, given by $\mu^a - \mu^b$. If the bound in binding in Argentina, μ^a is positive and μ^b is zero. This cost is additive and not multiplicative because the quota applies to units and not values.

Consumers

I model demand using a discrete choice approach. The normalized utility of consumer i from purchasing car j in period t and country h is given by

$$U_{ijt}^h = \alpha_{it}^h \left(y_{ijt}^h - p_{jt}^h\right) + x_{jt}\acute{}\beta_{it}^h + \xi_{jt}^h - u_{it}^h + \varepsilon_{ijt}^h, \tag{2.4}$$

where p and y denote price and income, x are observed car characteristics, ξ an unobserved (by the researcher) component of utility, u is the alternative utility when no car is purchased, and ε an independent and identically distributed logit error term. The utility function has been normalized by the value of the outside alternative; the normalized expected utility when no car is purchased is $\alpha_{it}^h y_{ijt}^h$.

The utility parameters α, β and u vary by individual. They are a linear combination of a vector of individual characteristics v_{it} and can be written as $\alpha_{it}^h = \alpha_o^h + \sum_r \alpha_r^h \nu_{itr}^h$, $\beta_{ki}^h = \beta_{ko}^h + \sum_r \beta_{kr}^h \nu_{itr}^h$ and $u_{it}^h = u_o^h + \sum_r u_r^h \nu_{itr}^h$. K and R are the dimensions of x and ν; k and r index characteristics of the cars and of the consumers. I summarize the demand parameters in country h with the vector $\boldsymbol{\theta}^h$.[1]

According to the logit specification, the probability that car j is individual $i's$ preferred alternative has the following closed-form solution

$$\sigma_{jt}^h\left(\mathbf{P}_t^h,\boldsymbol{\theta}^h|\nu_{it}^h\right)=\frac{e^{-u_{it}^h-\alpha_{it}^h p_{jt}^h+x_{jt}\acute{}\beta_{it}^h+\xi_{jt}^h}}{1+\sum_{k=1}^J e^{-u_{it}^h-\alpha_{it}^h p_{kt}^h+x_{kt}^h\acute{}\beta_{it}^h+\xi_{kt}^h}} \tag{2.5}$$

In period t and country h there are a total of N_t^h consumers. Aggregate demand for car j in period t and country h is the unconditional probability of choosing j multiplied by the number of consumers. Let G_t^h be the cumulative density function of v_{it}^h; aggregate demand is given by,

$$q_{jt}^h\left(\mathbf{P}_t^h,\boldsymbol{\theta}^h,G_t^h\right)=N_t^h\int\sigma_{jt}^h\left(\mathbf{P}_t^h,\boldsymbol{\theta}^h|\nu_{it}^h\right)dG_t^h\left(\nu_{it}^h\right) \tag{2.6}$$

Besides the level of demand, I am also interested in the price derivatives. The aggregate response to a change in price is once again obtained by integrating the individual responses over the distribution of idiosyncratic characteristics ν_{it}^h, which gives[2]

$$\frac{\partial q_{jt}^h}{\partial p_{kt}^h}\left(\mathbf{P}_t^h,\boldsymbol{\theta}^h,G_t^h\right)=N_t^h\int\frac{\partial\sigma_{jt}^h}{\partial p_{kt}^h}\left(\mathbf{P}_t^h,\boldsymbol{\theta}^h|\nu_{it}^h\right)dG_t^h\left(\nu_{it}^h\right) \tag{2.7}$$

Let $\boldsymbol{\theta}$ be the stacked vector $\left(\boldsymbol{\theta}^a,\boldsymbol{\theta}^b\right)$, and let $\mathbf{G}$ represent the collection of cumulative density functions of individual characteristics across time and countries. The aggregate demand and price derivatives can be stacked over cars, time and the two countries to construct the vector of quantities $q\left(\mathbf{P},\boldsymbol{\theta},\mathbf{G}\right)$ and the matrix of derivatives $\Delta\left(\mathbf{P},\boldsymbol{\theta},\mathbf{G}\right)$.

[1] $\boldsymbol{\theta}^h=\left(\alpha_o^h,...\alpha_R^h\,;\,\beta_{1o}^h,...\beta_{KR}^h\,;\,u_o^h,...u_R^h\right)$.

[2] Given the functional form of the demand function, the individual derivatives are given by

$$\frac{\partial\sigma_{jt}^h}{\partial p_{kt}^h}\left(\mathbf{P}_t^h,\boldsymbol{\theta}^h|\nu_{it}^h\right)=\begin{cases}-\alpha_{it}^h\sigma_{jt}^h\left(\boldsymbol{\theta}^h,\nu_{it}^h\right)\left(1-\sigma_{jt}^h\left(\boldsymbol{\theta},\nu_{it}^h\right)\right) & \text{for } k=j\\ \alpha_{it}^h\sigma_{jt}^h\left(\boldsymbol{\theta}^h,\nu_{it}^h\right)\sigma_{kt}^h\left(\boldsymbol{\theta}^h,\nu_{it}^h\right) & \text{for } k\neq j\end{cases}$$

These are the same matrices as in the firms' FOCs with the difference that the dependence on the demand parameters is made explicit. The equilibrium vectors $\mathbf{q}$ and $\mathbf{P}$ solve the FOCs given (2.6) and (2.7).

2.4 Customs union equilibrium

The model in Section 2.3 describes the equilibrium under the trade regime during the *convergence period* $(1996 - 1999)$, characterized by the presence of non-tariff barriers and different tariff schedules in the two countries. In this section I model the effects of forming a customs union - as it is scheduled to fully occur in 2006 - on trade flows, prices and welfare. In Section 2.5, I estimate these effects empirically.

The exercise does not constitute a prediction for 2006; it is a counterfactual evaluation. It provides an answer to the question of what would have happened in 1996-1999, had the trade policy been the one that will be implemented in 2006. Counterfactual prices and trade flows are computed given the characteristics of individuals, macroeconomic conditions, characteristics of cars, car models and firm location that prevailed during 1996-1999. In particular, I determine new equilibrium quantities and prices, but other firm's decisions such as entry and exit, relocation across borders and characteristics of car models are kept constant after the change in policy.

The changes in trade policy to achieve a full customs union consist on the elimination of the NTBs and the adoption of a common external tariffs. I describe two counterfactual equilibria: an equilibrium without NTBs, in which the GTB constraint and the bilateral quota for net imports are removed but the tariff schedules remain unchanged, and a full customs union equilibrium, in which NTBs are eliminated and a uniform external tariff is adopted. By introducing an intermediate equilibrium (no NTBs but different external tariffs), I decompose the transition to a customs union into two sequential changes in policy: the removal of NTBs (given the asymmetric tariff schedule) and the adoption of a common external tariff (given that the NTBs were already removed).

More specifically, let $(\mathbf{q}^0, \mathbf{P}^0)$ denote the actual prices and quantities during the convergence period 1996-1999, $(\mathbf{q}^1, \mathbf{P}^1)$ the counterfactual equilibrium where NTBs are eliminated, and $(\mathbf{q}^2, \mathbf{P}^2)$ the final counterfactual equilibrium where NTBs are eliminated and a common external tariff is adopted. The effect of the NTBs can be assessed by comparing $(\mathbf{q}^1, \mathbf{P}^1)$ and $(\mathbf{q}^0, \mathbf{P}^0)$, while the difference between $(\mathbf{q}^2, \mathbf{P}^2)$ and $(\mathbf{q}^1, \mathbf{P}^1)$ measures the effect of the change in tariffs. The full effect of the customs union is given by the difference between $(\mathbf{q}^2, \mathbf{P}^2)$ and $(\mathbf{q}^0, \mathbf{P}^0)$.

These changes in policy can be incorporated into the model by redefining the adjusted marginal costs so that their new definition reflects the new trade policy. The elimination of the NTBs is modeled by setting the Lagrange multipliers equal to zero. The three equilibria can be summarized as follows,

	Actual trade policy during 1996-1999	Elimination of NTBs	Common external tariff
Tariffs	$\boldsymbol{\tau}^a, \boldsymbol{\tau}^b$	$\boldsymbol{\tau}^a, \boldsymbol{\tau}^b$	τ
Global trade balance	$\boldsymbol{\lambda}^a \neq 0, \boldsymbol{\lambda}^b \neq 0$	$\boldsymbol{\lambda}^a = \boldsymbol{\lambda}^b = \mathbf{0}$	$\boldsymbol{\lambda}^a = \boldsymbol{\lambda}^b = \mathbf{0}$
Quota for net imports	$\boldsymbol{\mu}^a \neq 0, \boldsymbol{\mu}^b \neq 0$	$\boldsymbol{\mu}^a = \boldsymbol{\mu}^b = \mathbf{0}$	$\boldsymbol{\mu}^a = \boldsymbol{\mu}^b = \mathbf{0}$
Equilibrium	$\mathbf{q}^0, \mathbf{P}^0$ (observed)	$\mathbf{q}^1, \mathbf{P}^1$	$\mathbf{q}^2, \mathbf{P}^2$

Consider first the intermediate equilibrium without NTBs but with different external tariffs. The equilibrium prices $\mathbf{P}^1$ satisfy

$$q\left(\mathbf{P}^1\right) + \Delta\left(\mathbf{P}^1\right)\left(\mathbf{P}^1 - \mathbf{c}^*\left(\mathbf{c}, \boldsymbol{\lambda} = \mathbf{0}, \boldsymbol{\mu} = \mathbf{0}, \boldsymbol{\tau}^a, \boldsymbol{\tau}^b\right)\right) = 0, \tag{2.8}$$

and the equilibrium quantities are given by $\mathbf{q}^1 = q\left(\mathbf{P}^1\right)$.[3] The adjusted marginal costs are defined as a function of the new policy parameters as

$$c_{jt}^{*a} = \begin{cases} c_{jt} & \text{for } j \in A_{ft} \\ c_{jt} & \text{for } j \in B_{ft} \\ c_{jt}\left(1+\tau_t^a\right) & \text{for } j \in W_{ft} \end{cases} \tag{2.9}$$

$$c_{jt}^{*b} = \begin{cases} c_{jt} & \text{for } j \in A'_{ft} \\ c_{jt} & \text{for } j \in B'_{ft} \\ c_{jt}\left(1+\tau_t^b\right) & \text{for } j \in W'_{ft} \end{cases}.$$

The adjustment in costs only includes the tariff on imports from the rest of the world. The elimination of NTBs makes the inter-country strategic component irrelevant and firms set prices independently in Argentina and Brazil.

The movement from the convergence period equilibrium to the counterfactual equilibrium without NTBs involves removing trade barriers. Compare the definitions of adjusted costs in the convergence period (given by equation 2.3) and in the counterfactual equilibrium without NTBs (equation 2.9). The adjusted cost of imports from third countries (W and W') is lower without the NTBs - the term $(1+\lambda)$ is eliminated in the latter definition, - consequently, we expect an increase in outside imports after the

[3] To keep notation tractable, I am not explicitely including the demand parameters and the distribution of individual characteristics as exogenous variables in the demand function and the matrix of price derivatives.

change in policy.[4] On the other hand, the removal of NTBs does not imply a reduction in the adjusted cost of *bilateral* imports. This is due to the particular form of the global trade balance constraint (GTB) and the fact that trade is intra-firm. Consider the effect of a marginal exported car from Brazil to Argentina when the GTB is in place. This car tightens the GTB in Argentina (since it constitutes an additional import from the Argentine point of view) but relaxes the GTB in Brazil (since it is an export from the Brazilian point of view) furthermore, exports are multiplied by 1.2. Suppose that for a given firm the GTB is more restrictive in Brazil (as it is found in Chapter 1), then that firm has the incentive to ship cars from Brazil to Argentina with the purpose of relaxing the GTB in Brazil and allowing the Brazilian subsidiary to import more units from third countries.[5] In such a case, there is more bilateral trade, at least in one direction, than there would be without the GTB. The GTB can artificially create trade and in such a case, the removal of the GTB would imply less trade (at least in one direction).

To measure the change in consumers' welfare I use the compensating variation, defined as the negative of the change in income that leaves utility unchanged after a change in

[4] This is not strictly true since the comparative statics of an exogenous change in marginal costs in an oligopoly model with differentiated products and price competition does not have a definite sign either for changes in prices or quantities. Intuitively, prices of a given model decrease and quantities increase when there is a decrease in the marginal cost of that car; formally, however, there is not an inequivocal prediction from changes in cost due to policy.

[5] The quota on net imports imposes a limit to this arbitrage.

prices.[6] The change in income $\Delta y_{it}^{h,1}\left(\mathbf{P}_t^{h,0},\mathbf{P}_t^{h,1},\boldsymbol{\theta}^h|.\right)$ satisfies

$$\max_j\left(\alpha_{it}^h\left(y_{it}^h+\Delta y_{it}^{h,1}-p_{jt}^{h,1}\right)+x_{jt}\acute{}\beta_{it}^h+\xi_{jt}^h+\varepsilon_{ijt}^h\right)= \tag{2.10}$$
$$\max_j\left(\alpha_{it}^h\left(y_{it}^h-p_{jt}^{h,0}\right)+x_{jt}\acute{}\beta_{it}^h+\xi_{jt}^h+\varepsilon_{ijt}^h\right)$$

This is the change in individual welfare due to the elimination of NTBs. I am interested in aggregate welfare. Let $\widetilde{G}_t^h$ be the joint distribution of ν_t^h and ε_t^h in the population. The aggregate compensating variation in country h and time t is the expected individual compensating variation multiplied by the market size, N_t^h.

$$CV_t^h=-N_t^h\int\Delta y_{it}^{h,1}\left(\mathbf{P}_t^{h,0},\mathbf{P}_t^{h,1},\boldsymbol{\theta}^h|\nu_{it}^h,\varepsilon_{it}^h\right)d\widetilde{G}_t^h(\nu_{it}^h,\varepsilon_{it}^h) \tag{2.11}$$

The second step in the transition to the customs union involves the adoption of the common external tariff τ of 35 percent. The equilibrium prices $\mathbf{P}^2$ satisfy the FOCs

$$q\left(\mathbf{P}^2\right)+\Delta\left(\mathbf{P}^2\right)\left(\mathbf{P}^2-\mathbf{c}^*\left(\mathbf{c},\boldsymbol{\lambda}=\mathbf{0},\boldsymbol{\mu}=\mathbf{0},\boldsymbol{\tau}^a=\tau,\boldsymbol{\tau}^b=\tau\right)\right)=0, \tag{2.12}$$

and the adjusted costs are defined as

$$c_{jt}^{*a} = \begin{cases} c_{jt} & \text{for } j\in A_{ft} \\ c_{jt} & \text{for } j\in B_{ft} \\ c_{jt}\left(1+\tau\right) & \text{for } j\in W_{ft} \end{cases} \tag{2.13}$$
$$c_{jt}^{*b} = \begin{cases} c_{jt} & \text{for } j\in A'_{ft} \\ c_{jt} & \text{for } j\in B'_{ft} \\ c_{jt}\left(1+\tau\right) & \text{for } j\in W'_{ft} \end{cases}.$$

[6] This is the definition given in Hicks (1939) and Mas-Colell, Winston and Green (1995). A positive compensating variation implies an increase in welfare.

The adoption of a uniform external tariff is a movement away from free trade since both countries raise their tariffs for outside imports, which are therefore expected to decrease. In the usual textbook example, the constitution of a customs union involves the elimination of tariffs against the trade partner, hence the change is not entirely against free trade. In the present case, the tariff is already zero among partners.

The change in consumers' welfare from the adoption of a common external tariff, is the additional change in income $\Delta y_{it}^{h,2}\left(\mathbf{P}_t^{h,0},\mathbf{P}_t^{h,1},\mathbf{P}_t^{h,2},\boldsymbol{\theta}^h|.\right)$ required to achieved the original utility at the prices in the full customs union,[7]

$$\max_j\left(\alpha_{it}^h\left(y_{it}^h+\Delta y_{it}^{h,1}+\Delta y_{it}^{h,2}-p_{jt}^{h,2}\right)+x_{jt}\acute{}\beta_{it}^h+\xi_{jt}^h+\varepsilon_{ijt}^h\right)= \\ \max_j\left(\alpha_{it}^h\left(y_{it}^h-p_{jt}^{h,0}\right)+x_{jt}\acute{}\beta_{it}^h+\xi_{jt}^h+\varepsilon_{ijt}^h\right) \tag{2.14}$$

The aggregate compensating variation is obtained by integrating over individuals.

The full change to a customs union involves the simultaneous change in NTBs and tariffs. Outside imports presumably increase after the elimination of NTBs, while the increase in the external tariff is a movement in the opposite direction; the overall effect on outside imports is ambiguous. Regarding bilateral trade, the adoption of a higher external tariff should increase trade among partners, however, the effect of the elimination of the

[7] $\Delta y_{it}^{h,2}$ is different the change in income Δy_{it}^{h*} that satisfies

$$\max_j\left(\alpha_{it}^h\left(y_{it}^h+\Delta y_{it}^{h*}-p_{jt}^{h,2}\right)+x_{jt}\acute{}\beta_{it}^h+\xi_{jt}^h+\varepsilon_{ijt}^h\right)= \\ \max_j\left(\alpha_{it}^h\left(y_{it}^h-p_{jt}^{h,1}\right)+x_{jt}\acute{}\beta_{it}^h+\xi_{jt}^h+\varepsilon_{ijt}^h\right)$$

Δy_{it}^{h*} is the negative of the compensating variation for the movement from the equilibrium without NTBs to the full customs union equilibrium. However, it does not serve the purpose of decomposing the transition from the convergence period to the customs union equilibria because the base utilities are different.

NTBs on bilateral trade flows can be positive or negative. Whether trade increases or decreases in each direction has to be answered empirically. In the next section I describe briefly how to estimate these effects.

2.5 Estimation

In Section 2.5.1, I lay out the basics of the estimation of the supply and demand parameters (See Chapter 1 for a more formal and extensive treatment and for the empirical results); in Section 2.5 I describe the estimation details of the counterfactual equilibrium prices, quantities, trade flows and welfare.

2.5.1 Demand and supply parameters

I estimate the demand parameters $\boldsymbol{\theta}^a$ and $\boldsymbol{\theta}^b$ independently, following the method proposed by Berry (1994) and Berry, Levinsohn and Pakes (1995). I observe total sales, average prices and physical attributes of each car model by semester for each country (for Argentina I observe sales disaggregated by regions as well). I do not observe individual choices, therefore, coefficients that vary by individuals cannot be derived from differences in consumers. Instead, I exploit differences in population demographics across time (for both countries) and regions (for Argentina) and match these differences to differences in car models' market shares. For example, if in a particular market both the average household size and the share of station wagons are larger than in other markets, it can be concluded that (other things equal) large households derive higher utility from station wagons than smaller households.

The coefficients are actually estimated by GMM, since prices are correlated with the unobserved component of utility ξ. The unobserved component works analogously to an error term in a linear regression and is interacted with a set of instruments to construct sample analogues of the moment conditions.

The results are two sets of estimators, $\boldsymbol{\theta}^a$ and $\boldsymbol{\theta}^b$, that are consistent and asymptotically normal and that can be used to construct a demand function and a matrix of price derivatives that is needed to estimate the cost parameters and the counterfactual equilibrium later on. The demand functions and the price derivatives are defined by (2.6) and (2.7).[8] Both of them involve integrating individual demands or derivatives over the population distribution of individuals, with cdf G_t^h at time t in country h. Ideally, the estimated demand functions and derivatives would be the true functions evaluated at the estimated value of $\boldsymbol{\theta}^h$, that is $N_t^h \int \sigma_{jt}^h \left(\mathbf{P}_t^h, \widehat{\boldsymbol{\theta}}^h | \nu_{it}^h\right) dG_t^h \left(\nu_{it}^h\right)$ and $N_t^h \int \frac{\partial \sigma_{jt}^h}{\partial p_{kt}^h} \left(\mathbf{P}_t^h, \widehat{\boldsymbol{\theta}}^h | \nu_{it}^h\right) dG_t^h \left(\nu_{it}^h\right)$. However, since these integrals do not have a closed form solution, I estimate them by simulation, which involves taking a number n_s of draws from an empirical distribution of individuals with cdf $G_{n_s,t}^h$ and computing the sample mean. Let i_s index sampled individuals, the estimators for the demand function and price derivatives are, respectively,

$$q_{jt}^h \left(\mathbf{P}_t^h, \widehat{\boldsymbol{\theta}}^h, G_{n_s,t}^h\right) = \frac{N_t^h}{n_s} \sum_{i_s} \sigma_{jt}^h \left(\mathbf{P}_t^h, \widehat{\boldsymbol{\theta}}^h | \nu_{i_s t}^h\right) \tag{2.15}$$

[8] Aggregate demand is given by

$$q_{jt}^h \left(\mathbf{P}_t^h, \boldsymbol{\theta}^h, G_t^h\right) = N_t^h \int \sigma_{jt}^h \left(\mathbf{P}_t^h, \boldsymbol{\theta}^h | \nu_{it}^h\right) dG_t^h \left(\nu_{it}^h\right)$$

and the price derivatives by

$$\frac{\partial q_{jt}^h}{\partial p_{kt}^h} \left(\mathbf{P}_t^h, \boldsymbol{\theta}^h, G_t^h\right) = N_t^h \int \frac{\partial \sigma_{jt}^h}{\partial p_{kt}^h} \left(\mathbf{P}_t^h, \boldsymbol{\theta}^h | \nu_{it}^h\right) dG_t^h \left(\nu_{it}^h\right).$$

and

$$\frac{\partial q_{jt}^h}{\partial p_{kt}^h}\left(\mathbf{P}_t^h, \widehat{\boldsymbol{\theta}}^h, G_{n_s,t}^h\right) = \frac{N_t^h}{n_s}\sum_{i_s}\eta_{jt}^h\left(\mathbf{P}_t^h, \widehat{\boldsymbol{\theta}}^h | \nu_{i_s t}^h\right). \tag{2.16}$$

The draws from G_{n_s} are taken from two independent distributions, observed consumer characteristics (income and family size in this case) are drawn from household surveys while the alternative utilities (u) are drawn from a standard normal.

These results are used to construct the stacked vector of quantities $q\left(\mathbf{P}, \widehat{\boldsymbol{\theta}}, \mathbf{G}_{n_s}\right)$ and matrix of price derivatives $\widehat{\boldsymbol{\Delta}} = \Delta\left(\mathbf{P}, \widehat{\boldsymbol{\theta}}, \mathbf{G}_{n_s}\right)$, which can be evaluated at any price vector.

On the supply side, I obtain an estimate of the production cost of each car model and the shadow cost of the NTBs, measured by the Lagrange multipliers of the restrictions. I estimate $\mathbf{c}$, $\boldsymbol{\lambda}$ and $\boldsymbol{\mu}$ from the firms' FOCs by a minimum distance procedure. The estimators are those values of $\mathbf{c}$, $\boldsymbol{\lambda}$ and $\boldsymbol{\mu}$ that make the FOCs as close to zero as possible given $\mathbf{q}$, $\mathbf{p}$ and the estimator for the matrix of price derivatives, $\widehat{\boldsymbol{\Delta}}$.

The Lagrange multipliers of the GTB $(\boldsymbol{\lambda})$ are constrained to be non-negative during the non-linear search and, as a result, there is a truncation at zero in their distribution and asymptotically they are not normally distributed. Since these parameters are estimated jointly with the costs of production and the Lagrange multipliers associated with the net quotas, the distribution of these two sets of coefficients is affected by the truncation and is not normal either. To estimate their variance, I take draws from the estimated distribution of the matrix of price derivatives, $N\left(\widehat{\boldsymbol{\Delta}}, \widehat{\Sigma}_\Delta\right)$ and recompute $\left(\widehat{\mathbf{c}}, \hat{\boldsymbol{\lambda}}, \hat{\boldsymbol{\mu}}\right)$ for each of these draws. I compute 90 percent confidence intervals with the results. Since the estimates of the marginal costs are incorporated into the estimation of the counterfactual outcomes, the latter are not normally distributed either.

2.5.2 Counterfactual equilibrium

Using the estimators of the structural parameters of demand and supply, I simulate the equilibrium prices and quantities under the two counterfactual trade regimes: the equilibrium without NTBs, and the equilibrium without NTBs and with a common external tariff. The latter is the full implementation of the customs union.

Let $\widehat{\mathbf{P}}^1$ be the estimator of the equilibrium prices when NTBs are eliminated, and let $\widehat{\mathbf{P}}^2$ its counterpart when NTBs are eliminated and a common external tariff is adopted. They are defined by the following systems of equations

$$q\left(\widehat{\mathbf{P}}^1, \widehat{\boldsymbol{\theta}}, \mathbf{G}_{n_s}\right) + \Delta\left(\widehat{\mathbf{P}}^1, \widehat{\boldsymbol{\theta}}, \mathbf{G}_{n_s}\right)\left(\widehat{\mathbf{P}}^1 - \mathbf{c}^*\left(\mathbf{c}, \boldsymbol{\lambda} = \mathbf{0}, \boldsymbol{\mu} = \mathbf{0}, \boldsymbol{\tau}^a, \boldsymbol{\tau}^b\right)\right) = 0, \tag{2.17}$$

and

$$q\left(\mathbf{P}^2, \widehat{\boldsymbol{\theta}}, \mathbf{G}_{n_s}\right) + \Delta\left(\mathbf{P}^2, \widehat{\boldsymbol{\theta}}, \mathbf{G}_{n_s}\right)\left(\mathbf{P}^2 - \mathbf{c}^*\left(\mathbf{c}, \boldsymbol{\lambda} = \mathbf{0}, \boldsymbol{\mu} = \mathbf{0}, \boldsymbol{\tau}^a = \tau, \boldsymbol{\tau}^b = \tau\right)\right) = 0. \tag{2.18}$$

These are the FOCs described in Section 2.4, where the adjusted costs satisfy the definitions in (2.13) and (2.9), and the estimates for the demand function and the matrix of price derivatives are plugged in. The estimators for the equilibrium quantities, are defined as $\widehat{\mathbf{q}}^1 = q\left(\widehat{\mathbf{P}}^1, \widehat{\boldsymbol{\theta}}, \mathbf{G}_{n_s}\right)$ and $\widehat{\mathbf{q}}^2 = q\left(\mathbf{P}^2, \widehat{\boldsymbol{\theta}}, \mathbf{G}_{n_s}\right)$.

By comparing quantities and prices in the different equilibria I estimate the changes in prices and trade flows and I decompose these changes into those caused by the elimination of NTBs and those caused by the adoption of a uniform tariff. It is also possible to estimate the changes in tariff revenue, firms' profits and the compensating variation. The computation of changes in tariff revenue and profits is straightforward. I estimate the compensating variation using a simulation method analogous to the estimation of the aggregate demand function and the matrix of price derivatives. I first estimate the compensating variation for a sample of individuals and later compute the aggregate change in welfare by averaging over this sample.

Consider first the case of a change from $\mathbf{P}^0$ to $\widehat{\mathbf{P}}^1$ (notice that the first price vector is observed, since it corresponds to the actual equilibrium during 1996-1999, while the second is estimated). For each time period and country, I take n_s draws from the joint empirical distribution of individual characteristics v and logit error terms ε. I calculate the utility that each sampled consumer derives from each car model when prices are $\mathbf{P}_t^{h,0}$ and the demand parameters are $\widehat{\boldsymbol{\theta}}^h$, find the chosen car model (may also be not purchasing a car at all) and compute the achieved utility level. I repeat the exercise assuming that prices are $\widehat{\mathbf{P}}_t^{h,1}$ and adding $\Delta y_{i_s,t}^h$ to the income level; I find the preferred choice and the resulting utility and compare this utility level with the achieved utility under $\mathbf{P}_t^{h,0}$. Separately for each individual, I search over the change in income $\Delta y_{i_s,t}^h$, until the resulting utilities from the preferred choices are equal under $\mathbf{P}_t^{h,0}$ and $\widehat{\mathbf{P}}_t^{h,1}$ (notice that it is only necessary to recompute the utility under $\widehat{\mathbf{P}}_t^{h,1}$ in each iteration). Denote the solution by $\Delta y_{it}^{h,1}\left(\mathbf{P}_t^{h,0}, \widehat{\mathbf{P}}_t^{h,1}, \boldsymbol{\theta}^h\right)$. The estimator of the aggregate compensating variation is given by

$$\widehat{CV}_t^h = -\frac{N_t^h}{n_s}\sum_{i_s} \Delta y_{it}^{h,1}\left(\mathbf{P}_t^{h,0}, \widehat{\mathbf{P}}_t^{h,1}, \widehat{\boldsymbol{\theta}}^h\right). \tag{2.19}$$

The change in welfare due to the movement to prices $\widehat{\mathbf{P}}^2$ can be estimated in the same fashion.

In the simple case in which the marginal utility of income, α_i, is constant in income levels, the logit error terms, ε, can be integrated out of the individual compensating variation equation and the individual change in welfare has a closed form solution conditional on ν derived by McFadden (1981). The aggregate compensating variation is computed by averaging over a sample of individuals, as above.

I estimate the variance of the estimated quantities and prices, of the change in the trade flows, profits and tariff revenue, and of the compensating variation using the same method described in the estimation of supply parameters: I take a number of draws of $\boldsymbol{\theta}$ from its estimated asymptotic distribution - $N\left(\hat{\boldsymbol{\theta}}, \boldsymbol{\Sigma}_{\boldsymbol{\theta}}\right)$ - and recompute the supply parameters and counterfactual results for each draw. Since the supply parameters are not normal, the counterfactual results are not normal either, and I compute 90 percent confidence intervals instead of standard errors.

2.6 Results

In this section I describe the results of the counterfactual experiments. An extensive discussion of the results of the estimation of demand and supply during the convergence period can be found in Chapter 1, as well as a description of the data. The data consists on semestral observations on aggregate sales, average prices and physical attributes of each car model in Argentina and Brazil, and on household surveys for the two countries to use as the empirical distribution of consumer characteristics. I include size, horsepower and type of vehicle as characteristics of the vehicles and income and family size as characteristics of the consumers.

2.6.1 Argentina

In this section, I present the estimated changes in Argentine prices, quantities and welfare. First, I describe the effects of the elimination of NTBs (by comparing $\mathbf{P}^1$ and $\mathbf{q}^1$ with $\mathbf{P}^0$ and $\mathbf{q}^0$), then the effects of the adoption of a common external tariff (by comparing $\mathbf{P}^2$ and $\mathbf{q}^2$ with $\mathbf{P}^1$ and $\mathbf{q}^1$), and finally the aggregate effects of forming a customs union. In the next section, I repeat the same analysis for Brazil.

Table 1 reports the effects of the elimination of NTBs in Argentina. The removal of the GTB implies that the cost of external imports is reduced according to the shadow cost of the constraint ($100 \times \lambda^a$ percent). Although these multipliers are close to zero for several firms (see Chapter 1, Table 5), they are relatively high for Ford and Peugeot-Citroën (50% and 30%, respectively). These two corporations account for 43% of external imports and the sales-weighted average decrease in adjusted costs (measured by the multipliers) is 13.5%. This causes the price of external imports to decrease, on average, by 16.2% (approximately 3,600 dollars), and an increase in imported units of 77.9% (approximately 130,000 units).

In contrast with extra-zone imports, intra-zone imports become more costly with the elimination of the GTB. Before the elimination of the NTBs, an additional unit imported from Brazil tightens the GTB in Argentina (by $100 \times \lambda^a$ percent) but loosens the GTB in Brazil (by $100 \times 1.2\lambda^b$ percent). The net effect is a reduction in costs of internal imports because the GTB is more binding in Brazil than in Argentina. When the GTB is removed, the cost of MERCOSUR imports increases and so do prices, by 811 dollars (5.4%). The lower prices under the GTB work as an incentive to increase demand for Brazilian models that would help loosen the Brazilian GTB. When this incentive is removed, imports decrease by about 65,000 units (43.3%).[9] Notice, however, that the changes in quantities have wide confidence intervals.

The shadow cost of the bilateral quota acts in the opposite direction: removing the

[9] This means that 43% of MERCOSUR imports in Argentina (6% of the market), prior to the removal of NTBs, are explained by the distorsive effect of the trade balance and quotas.

quota should make imports less costly, since the constraint is, in general, binding for Argentine imports. Thus, if there were no quotas, the distortion created by the GTBs would be even larger.

The increased "competition" from extra-zone imports crowds out domestic models, whose purchases fall by 9.1% even though they are in average 1,000 dollars less expensive. This change in the price of domestic models is directly explained by the removal of the GTB: prior to the removal of the GTB, prices of domestic products were higher to make Brazilian imports more competitive. In average, prices decrease by 1,100 dollars per model, and consumers' increase in welfare is 606 dollars per vehicle purchased. Tariff revenue increases by 77.2%, virtually the same increase as the number of imported units, while profits drop by 19.3%. I show in the next section that combined profits in the two countries increase.[10,11]

Table 2 displays the estimated effects of convergence to a common tariff level. The adoption of the uniform tariff of 35%, higher than the existing tariff, implies an increase in the cost of extra-zone imports equal to the difference in tariffs before and after the policy. The average increase is 23% in Argentina (the increase is different for each trimester),

[10] The fact that a constraint is being removed does not actually imply that profits should increase, given the oligopolistic nature of the market. Quite the opposite, the NTBs increase the relative "cost" of domestic products, acting like a collusive device among firms. When they are removed, domestic prices and profits go down.

[11] There is not an accurate measure of a country's aggregate welfare in this context of multinational firms. In principle profits should not be computed in aggregate welfare as firms are of foreign origin. However, profits are estimated before taxes, and some corporations have a small participation of local capital.

which passes-through to prices: there is an increase of 2800 dollars (15.4%) in the price of external imports and a smaller increase in the price of domestic models (44 dollars). The price of MERCOSUR imports remains almost unchanged.

Sales of outside imports fall by approximately 120,000 units (40.3%), which are partially replaced by domestic production and internal imports. Moreover, since tariffs are ad-valorem, the composition of external imports moves towards less costly models. The average production cost decreases by 2,000 dollars.

The aggregate average price increase is 489 dollars, which results in a reduction in consumers' welfare of 214 dollars by purchased vehicle. Aggregate profits decrease by 3.1% while tariff revenue increases by 48%.

The aggregate effect of a customs union combines the results in the two previous sequential transitions. The total response in quantities, prices and welfare is presented in Table 3. The elimination of NTBs and the convergence to the common external tariff work in opposite directions. While after the removal of the GTB, Argentina imports more from outside and less from Brazil and consumers benefit from lower prices, the adoption of a uniform tariff encourages internal imports at the expense of outside models and prices increase yielding a welfare loss for consumers.

Table 3 shows that the effect of the elimination of NTBs predominates for all variables of interest, although the responses are significantly mitigated by the opposing effect of the raise in the external tariff. Prices of external imports decrease by 733 dollars, prices of domestic goods by 940 dollars, while internal imports become 800 dollars more expensive. There is a sharp decrease in imports from the partner: approximately 54,000 units, whereas sales of domestic models and outside imports raise by 5,200 and 10,469 units, respectively. The aggregate effect on consumers is positive (due to the reduction in prices) and amounts to 393 dollars per car, however, it is not very precisely estimated.

2.6.2 Brazil

The adjustment in Brazil's external tariff involved by the custom union is minor. The actual tariff is indeed 35% during 1996 and 1999 and the average tariff level during the convergence period is 33%, which means that the increase in costs due to the adoption of the common tariff is merely 2%. Results are, therefore, dominated by the removal of NTBs, and the effects of the tariff revision is comparatively negligible.

Table 4 displays the effects of the elimination of NTBs. The removal of the GTB induces a reduction in the cost of both external *and* internal imports (in contrast to Argentina) that causes an average decrease in prices of 700 dollars (4.6%) for internal imports and 4000 dollars (13.8%) for outside imports. The number of units imported from Argentina increase by 12.8%, while the increment in external imports is 117%.[12] The large response of outside imports is due to the substantial reduction in costs of 30% in average (given by the Lagrange multipliers λ_f^b). This is not the case for internal imports since the removal of the Argentine GTB (trough λ_f^a) and the bilateral constraints mitigate this effect.

Notice that there is a change in the composition of external imports in favor of models of higher production cost. After the removal of NTBs, the cost of external imports is on average 5,400 dollars higher. This is analogous to Feenstra's (1988) finding for Japanese

[12] Given the small participation of external imports in the market (3.8%), the 117% increase only amounts to approximately 230000 units, 4.4% of the Brazilian market.

VERs. He shows that when the VER is imposed, there is an upgrade in the quality of Japanese imports, since the restraint is measured over units, not over values. In contrast, the GTB is computed over values, therefore, when it is removed, more costly models can be imported. Prices of domestic goods increase, on average, 400 dollars.

Overall, there is a 92 dollar increase in prices in Brazil. Consumers are worse off by an amount of 203 dollars for purchased vehicle. Profits increase by 5.7%, a consequence of both higher prices and quantities. Tariff revenue raises by 205%, due to the increase in external imports and to the change in the composition of imports.

The impact of the change in tariffs on prices and quantities in Brazil goes in the same direction as in Argentina (see Table 5), but the magnitudes are much smaller. Overall prices increase by only 8 dollars (less than 0.1%) while consumers are 1 dollar worse off per purchased vehicle.

The net effects are presented in Table 6. As expected, total changes in Brazil are mostly explained by the elimination of NTBs, and the overall policy implies a movement towards free trade, both with respect to the MERCOSUR partner and the rest of the world. The prices of intra and extra-zone imports decline by 730 dollars (4.6%) and 3800 dollars (13.1%), respectively. Domestic prices increase by 413 dollars, with a substitution of domestic production by foreign models. In particular, there is a change in the composition of external cars in favor of more costly models. The increase in domestic prices generates a welfare loss to consumers of 203 dollars per car. The increase in tariff revenue (210%) is more than compensates the negative compensating variation.

2.7 Conclusions

In this paper I have measured the effects of adopting a customs union in the automobile market in Argentina and Brazil. The trade reform involves the removal of non-tariff barriers and the adoption of a common external tariff. My methodology consists on estimating structural demand and supply parameters that I use to predict outcomes in the customs union equilibrium. I estimate demand by using a random-coefficient approach. I model the behavior of multinational firms in Argentina and Brazil and develop a minimum distance estimator for the production costs and shadow cost of the NTBs.

My main finding is that the relevant effects on prices, trade and welfare are driven by the removal of bilateral quotas and trade balance constraints (the NTBs) rather than by the convergence to a common external tariff. This is as I expected for Brazil since tariffs increase only marginally in this country. It is also true for Argentina even though the increase in tariffs implied by the customs union is substantial.

The elimination of the NTBs comprises a movement towards free trade that leads to an increase in imports from the rest of the world in both countries. The interaction between the NTBs and the ownership structure of the firms (multinational corporations with subsidiaries in both countries) leads to asymmetric effects on intra-zone trade and welfare for each partner when these restrictions are removed. This asymmetry is also observed in the total effects of the customs union. In particular, internal imports decrease in Argentina and increase in Brazil, with an overall increase in bilateral trade.

Consumers in Argentina are better off after the customs union, while they are worse off in Brazil. The opposite is true for profits of Argentine and Brazilian subsidiaries, whereas aggregate profits across the two countries are higher after the change in policy.

Tariff revenue increases in both countries, and in Brazil more than compensates the loss suffered by consumers.

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TABLE 1. Elimination of NTBs
Argentina, 1996 - 1999

	All Models	Domestic Models	Imports from Partner	External Imports
Mean Change in Price (dollars)	-1,148 [-2828, -1048]	-987 [-3133, -887]	811 [135, 918]	-3,619 [-5612, -1786]
Mean Change in Price (percentage)	-6.9 [-17, -6]	-6.3 [-20, -6]	5.4 [0.9, 6]	-16 [-25, -8]
Change in Units (thousands)	-1.7 [-52, 636]	-66.4 [-584, 93]	-65.4 [-145, 22]	130.0 [51, 1376]
Change in Units (percentage)	-0.2 [-5, 61]	-9.1 [-80, 13]	-43 [-96, 15]	78 [31, 825]
Mean Change in Cost (dollars)	139 [-6101, 2762]	-240 [3038, 831]	0 [-3869, 1312]	204 [-8570, 5545]
Compensating Variatic by Unit Sold (dollars)	607 [-66, 1262]	Compensating Variation (millions of dollars)		635 [-69, 1322]
Change in Profits (percentage)	-19 [-30, 18]	Change in Profits (millions of dollars)		-1,165 [-2080, 1110]
Change in Revenue (percentage)	77 [13, 326]	Change in Revenue (millions of dollars)		197 [36, 779]

90% confidence intervals between square brackets
The estimators are not normally distributed

TABLE 2. Adoption of a Common External Tariff
Argentina, 1996 - 1999

	All Models	Domestic Models	Imports from Partner	External Imports
Mean Change in Price (dollars)	489 [417, 810]	44 [7, 620]	-9.1 [-98, 73]	2,886 [2265, 3237]
Mean Change in Price (percentage)	3.2 [0.6, 10.4]	0.3 [0.1, 8]	-0.06 [-12, 1.4]	15 [0.4, 23]
Change in Units (thousands)	-37.2 [-569, -20]	71.7 [45, 422]	10.7 [7, 57]	-119.6 [-1043, -75]
Change in Units (percentage)	-3.6 [-34, -1.6]	11 [6, 289]	13 [6, 986]	-40 [-70, -17]
Mean Change in Cost (dollars)	-639 [-1572, 5137]	39 [-114, 2874]	10 [-20, 3911]	-2,059 [-2951, 5546]
Compensating Variatic by Unit Sold (dollars)	-214 [-2079, 206]	Compensating Variation (millions of dollars)		-224 [-2179, 216]
Change in Profits (percentage)	-3.1 [-93, -1.2]	Change in Profits (millions of dollars)		-151 [-100387, -61]
Change in Revenue (percentage)	48 [25, 140]	Change in Revenue (millions of dollars)		217 [120, 1322]

90% confidence intervals between square brackets
The estimators are not normally distributed

TABLE 3. Customs Union
Argentina, 1996 - 1999

	All Models	Domestic Models	Imports from Partner	External Imports
Mean Change in Price (dollars)	-659 [-2372, -551]	-943 [-3110, -847]	802 [46, 881]	-733 [-3322, 1441]
Mean Change in Price (percentage)	-4.0 [-16, -1.3]	-6.0 [-20, -5.4]	5.3 [0.28, 6]	-3.3 [-15, 6]
Change in Units (thousands)	-39.0 [-87, 394]	5.2 [-240, 174]	-54.7 [-96, 40]	10.5 [-32, 420]
Change in Units (percentage)	-3.7 [-8, 37]	0.7 [-33, 24]	-36 [-64, 26]	6.3 [-19, 252]
Mean Change in Cost (dollars)	-500 [-3236, 1810]	-202 [-519, 884]	10 [-1410, 1470]	-1,856 [-6412, 3333]
Compensating Variatic by Unit Sold (dollars)	393 [-643, 1731]	Compensating Variation (millions of dollars)		412 [-674, 1814]
Change in Profits (percentage)	-22 [-32, -3.2]	Change in Profits (millions of dollars)		-1,316 [-2229, -207]
Change in Revenue (percentage)	162 [69, 723]	Change in Revenue (millions of dollars)		414 [188, 1719]

90% confidence intervals between square brackets
The estimators are not normally distributed

TABLE 4. Elimination of NTBs
Brazil, 1996 - 1999

	All Models	Domestic Models	Imports from Partner	External Imports
Mean Change in Price (dollars)	92 [-3909, 260]	412 [-3826, 622]	-734 [-4046, -159]	-3,997 [-6961, -1111]
Mean Change in Price (percentage)	0.6 [-26, 1.7]	2.9 [-27, 4.3]	-4.6 [-25, -1]	-14 [-24, -3.8]
Change in Units (thousands)	258.8 [-676, 269]	-58.4 [-1190, -29]	89.2 [-95, 150]	228.0 [134, 777]
Change in Units (percentage)	5.0 [-13, 5]	-1.4 [-27, -0.8]	13 [-13, 21]	117 [69, 399]
Mean Change in Cost (dollars)	707 [489, 3996]	-108 [-162, 2433]	823 [-42, 4813]	5,431 [-1852, 7560]
Compensating Variatic by Unit Sold (dollars)	-203 [-541, 655]	Compensating Variation (millions of dollars)		-1,050 [-2799, 3392]
Change in Profits (percentage)	5.7 [-43, 5.8]	Change in Profits (millions of dollars)		1,989 [-24701, 1991]
Change in Revenue (percentage)	205 [128, 396]	Change in Revenue (millions of dollars)		1,857 [1298, 3457]

90% confidence intervals between square brackets
The estimators are not normally distributed

TABLE 5 Adoption of a Common External Tariff
Brazil, 1996 - 1999

	All Models	Domestic Models	Imports from Partner	External Imports
Mean Change in Price (dollars)	8.7 [7.5, 14]	1.0 [1, 5.6]	0.7 [0.7, 3.6]	207.3 [166, 247]
Mean Change in Price (percentage)	0.06 [0.06, 0.1]	0.007 [0.007, 0.048]	0.005 [0.004, 0.031]	0.83 [0.75, 0.89]
Change in Units (thousands)	-2.3 [-3, -0.2]	4.2 [3, 13]	1.0 [0.7, 6]	-7.5 [-20, -4]
Change in Units (percentage)	-0.04 [-0.05, -0.005]	0.10 [0.09, 0.4]	0.13 [0.09, 0.8]	-1.77 [-3.6, -0.87]
Mean Change in Cost (dollars)	-15.9 [-59, -7.8]	0.5 [0.5, 13]	3.3 [2.8, 55]	-20.3 [-234, -7]
Compensating Variatic by Unit Sold (dollars)	-1.0 [-3, 6]	Compensating Variation (millions of dollars)		-5.1 [-14, 30]
Change in Profits (percentage)	-0.013 [-0.02, 0.1]	Change in Profits (millions of dollars)		-5.0 [-7.5, 31.2]
Change in Revenue (percentage)	1.4 [1.1, 2.9]	Change in Revenue (millions of dollars)		39.6 [28, 103]

90% confidence intervals between square brackets
The estimators are not normally distributed

TABLE 6. Customs Union
Brazil, 1996 - 1999

	All Models	Domestic Models	Imports from Partner	External Imports
Mean Change in Price (dollars)	100 [-3902, 312]	413 [-3823, 631]	-733 [-4045, -152]	-3,790 [-6753, -858]
Mean Change in Price (percentage)	0.7 [-26, 2]	2.9 [-27, 4]	-4.6 [-25, 0.9]	-13.1 [-23, -3]
Change in Units (thousands)	256.5 [-677, 267]	-54.2 [-1151, -24]	90.3 [-94, 152]	220.5 [130, 769]
Change in Units (percentage)	5.0 [-13, 5]	-1.3 [-27, -0.6]	12.9 [-14, 22]	113.2 [67, 395]
Mean Change in Cost (dollars)	691 [479, 4154]	-107 [-162, 2564]	826 [-30, 5781]	5,410 [-1755, 7548]
Compensating Variatic by Unit Sold (dollars)	-204 [-545, 649]	Compensating Variation (millions of dollars)		-1,055 [-2821, 3360]
Change in Profits (percentage)	5.7 [-43, 6]	Change in Profits (millions of dollars)		1,984 [-24691, 2027]
Change in Revenue (percentage)	210 [131, 445]	Change in Revenue (millions of dollars)		1,896 [1329, 3753]

90% confidence intervals between square brackets
The estimators are not normally distributed

Chapter 3

Introduction of new varieties of goods in the Chinese manufacturing sector

3.1 Introduction

This paper studies empirically the introduction of new varieties of goods in the Chinese manufacturing sector by foreign and domestic firms. The explored hypothesis is that foreign firms are technically more efficient than domestic firms and have advantages in the cost of innovation; and that, as a result, they introduce a larger number of new goods.

To motivate the empirical exercise, I develop a model of horizontal differentiation and monopolistic competition with firms that can choose to produce more than one variety. Firms are heterogeneous in two dimensions, they face different fixed costs to develop and set up production of a particular variety (cost of innovation), and they bear different marginal costs of production (technical efficiency or productivity). A firm finds that introducing a particular variety is profitable when the cost of innovation is lower than variable profits. This is more likely to happen when a firm is technically more efficient and when it faces lower costs of innovation. As a result, firms that are efficient in innovation and/or in production will introduce a larger number or varieties than their less advantaged counterparts. Additionally, the expected number of varieties introduced by one particular firm can be approximated by a Poisson distribution.

The model builds on Melitz's (2003) extension of Dixit and Stiglitz (1997) model of monopolistic competition to incorporate heterogenous firms. Melitz models heterogeneity as different unit input requirement, which is equivalent to differences in a constant marginal cost of production. I add heterogeneity in the fixed costs of innovation (that could be interpreted alternatively as a fixed cost of production) and I allow firms to choose the number of varieties that they introduce.

I then apply the arguments described in the model to the study of the number of new varieties introduced by foreign and domestic manufacturing firms in China during the period 1998-2000. The presumption is that, due to their condition as multinational corporations with headquarters and subsidiaries in other countries, foreign firms enjoy economies of scale and/or advantages gained from learning by doing in the development of goods and production and organization techniques across the countries where they have production facilities. For these reasons, they are expected to be more efficient both in innovation and production, and therefore to introduce a larger number of new varieties into the Chinese market.

Once firm characteristics such as size, market share and age are accounted for, I find that firms with more than 50 percent of foreign ownership introduce on average twice as many new goods as private domestic firms; fully foreign-owned firms (100 percent of foreign ownership) introduce three times as many new varieties as private domestic firms.

I use total factor productivity (TFP) and expenditure on Research and Development and purchases of technology from outside sources as proxies for efficiency in production and in innovation, respectively (higher expenditures on technology per new variety introduced indicate a higher cost of innovation). To compute TFP, I estimate a production function for each industry using the method developed by Olley and Pakes (1996) and derive a measure of TFP as the difference between output and the part of it that can be explained by input usage.

I propose a method to explore possible selection bias arising from the fact that foreign firms may face higher costs of entry. Entry costs impose a truncation on the distribution of observed technical efficiencies (TFP), since only firms that are able to cover the fixed cost are observed. If foreign firms do indeed need to pay more than domestic firms to enter the Chinese market, they will be technically more efficient on average by construction, even if their underlying distributions of productivities are the same. It is possible to test for different truncation points in the distribution of TFPs across foreign and domestic firm, by estimating the truncation points with the lowest observed TFP levels.

Foreign firms in particular industries - Electronic equipment, Household appliances, and Motor vehicles and vehicle parts - have a significant cost advantage both in production (TFP) and in innovation (expenditure on innovation per new product). In these same industries, advantages in productivity account for 13 to 31 percent of the difference in the number of varieties, while advantages in the cost of innovation account for only 0 to

2 percent of that same difference.

The plan for the paper is the following: Section 2 presents the model; Section 3 discusses the application and the data; Section 4 presents evidence that foreign firms introduce more new varieties of goods than domestic firms; and Section 5 explores differences in productivity and innovation costs as possible explanations for the advantage in innovation enjoyed by foreign firms.

3.2 Model

In this section, I develop a model of monopolistic competition with heterogeneous firms that produce more than one differentiated good. It is based on the Dixit and Stiglitz (1977) model of monopolistic competition with horizontal differentiation and Melitz's (2003) addition of heterogeneous firms. In Dixit and Stiglitz's model, firms are homogeneous and produce differentiated goods at the same constant marginal cost. In equilibrium they all charge the same price and receive the same profits. There is a fixed cost of entry and firms enter until variable profits are equal to this fixed cost, so that in equilibrium net profits are zero and there are no incentives for entry or exit. There is only one decision (entry) and one fixed cost to pin that decision down. Melitz extends this model to incorporate heterogeneous firms. Firms are homogeneous before entry and, after paying an entry fee, they learn their marginal costs of production, which are different across firms. In addition to the entry fee, there is a fixed cost to set up production. Firms that learn that their marginal cost is so high that variable profits are lower than the fixed cost of production choose to exit. Ex-ante (i.e. before entry) firms are homogeneous and they decide to enter until expected profits net of the entry fee are zero. The fixed cost of production pins down which firms stay in the market and which firms exit. There are two decisions (entry and stay-exit) and two costs to pin down both decisions (the entry fee and the fixed cost of production).

In the model that I develop in this section, firms can choose to produce many varieties. In addition to entry, they choose how many varieties to research and which of these to introduce into the market; there is a cost associated with each of these decisions. Firms are heterogeneous both in their efficiency in production (marginal cost) and in their ability to incorporate technology (fixed cost to develop a variety), and these differences determine which firms introduce more varieties.

The firm's decision-making process follows the following sequence: (1) firms pay a sunk fee to enter the market; after entry, they learn how efficient they are in developing and in producing different products (there are two parameters that capture these two different dimensions of efficiency). (2) Firms decide how many varieties they will start investigating; this means gathering information on development costs and profits associated with each variety. There is a cost associated with the information gathering that depends on the number of varieties investigated and it is common to all firms. A firm may choose to investigate zero varieties, which is equivalent to exiting the market immediately after entry. (3) Firms decide which of the investigated varieties to develop and to introduce into the market. They pay a fixed cost for each variety that they decide to introduce; furthermore, this fixed cost is different for each variety and determines which varieties are introduced and which are not. Given the assumptions on market structure and production technology, firms make a separate decision about each variety that depends solely on whether variable profits from sales net of fixed development and production costs are larger than zero. (4) After the firms have decided which varieties to introduce, they make price decisions subject to the residual demand faced for each variety.

Below, I describe this decision sequence backwards: I start by describing the price decision given the number of introduced varieties; then, I discuss which varieties are introduced given the total number of varieties investigated; thirdly, I explain how firms decide how many varieties to investigate. There is an additional step that involves the determination of the equilibrium number of firms and the price index.

Consumers are identical and their preferences are represented by a CES utility function over a continuum of differentiated goods in $[0, n^*]$. Let q_i be the quantity demanded of variety i, and $\sigma > 1$ the elasticity of substitution across the different varieties; the utility function can be written as,

$$U = \left[\int_0^{n^*} q(i)^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}}. \tag{3.1}$$

Given the exogenous income y and prices p_i, the resulting demand function for each variety takes the form

$$q_i = p_i^{-\sigma} P^{\sigma-1} y, \tag{3.2}$$

where P is the Dixit and Stiglitz price index defined by

$$P = \left[\int_0^{n^*} p(i)^{1-\sigma} di \right]^{\frac{1}{1-\sigma}}. \tag{3.3}$$

On the production side, there is a continuum of firms indexed by j over the interval $[0, J]$. Each firm produces a measure $n(j)$ of differentiated varieties. The aggregate measure of different varieties n^* satisfies

$$n^* = \int_0^J n(j)\, dj. \tag{3.4}$$

Hereafter, I will refer to J, $n(j)$ and n^* as the "number" of firms and varieties; it should be understood that each is a continuum.

The production technology is represented by a cost function for each variety i produced by firm j that takes the form

$$C^j(q_{ij}) = F_{ij} + c_j q_{ij}. \quad (3.5)$$

F_{ij} is the fixed cost to firm j of developing and setting up production of variety i, while c_j is the marginal cost of production; to simplify, I assume that a firm can produce all of its varieties at the same marginal cost.

The number of varieties introduced by each firm is small enough relative to the total number of varieties in the market, so that the effect of one firm in the aggregate price index is negligible and the index is taken as given in the profit maximization problem. Strategic effects across varieties produced by the same firm are disregarded as well, for the same reason. Under this assumption, firms act as monopolists over a residual demand with constant elasticity σ for each of their varieties.

Firms maximize variable profits given by $(p_{ij} - c_j)\, q(p_{ij})$, subject to the demand function in (3.2). Because the marginal cost is the same for all varieties produced by a given firm, and all goods enter the utility function symmetrically, firms choose the same price for all their own varieties and earn identical variable profits from each of them. Within a firm, varieties only differ in the fixed cost, which does not have any impact on the pricing decision. To emphasize this symmetry, I denote the price and variable profits for/from each variety produced by firm j by p_j and π_j, instead of indexing them as p_{ij} and π_{ij}. Under the CES utility assumption, prices are determined by a constant mark-up over the production cost that depends on the elasticity of substitution, $p_j = \frac{\sigma}{\sigma-1} c_j$. Variable profits take the form

$$\pi_j = k{c_j}^{1-\sigma} P^{\sigma-1} y, \tag{3.6}$$

with $k = \frac{(\sigma-1)^{\sigma-1}}{\sigma^{\sigma}}$.

The introduction of the different varieties involves two sequential processes and decisions. First, firms decide how many potential varieties to explore, N_j. In this exploration stage they gather information about the possible varieties, namely, the costs for developing and setting up production for each of them, and their associated profits. To perform this first overview, firms incur a cost represented by a function γ that is increasing and convex in the number of explored varieties, N_j. The function satisfies $\gamma(0) = 0$, $\gamma' > 0$, $\gamma'' > 0$. A number n_j of the explored varieties will prove to be profitable and will be furthered developed and introduced into the market at a fixed cost that differs by variety, F_{ij}. For simplicity, this fixed cost includes both the cost of research and development and the fixed cost of production. The cost of exploration, $\gamma(N_j)$, is the cost of learning the fixed costs F_{ij} for a number N_j of varieties; this is realized by taking N_j draws of F_{ij} from a normal distribution with mean $\overline{F}^j$ and unit variance. The mean differs by firm to capture the varying capabilities to incorporate technology; methodologically, it introduces correlation in the fixed costs drawn by a same firm.

The firm decision-making sequence can be solved backwards. In the second stage, firms take N_j draws of F_{ij}. A variety i is introduced if $\pi_j \geq F_{ij}$, which occurs with probability $\Phi\left(\pi_j - \overline{F}^j\right)$ (Φ denotes the cdf of the normal distribution); n_j is the number of successful draws, that is, the number of varieties for which $\pi_j \geq F_{ij}$.

For a given firm, each draw is an independent Bernoulli trial with the same probability of success, given by $\Phi\left(\pi_j - \overline{F}^j\right)$. Taking the number of trials (N_j) as given, the number of varieties introduced (n_j) follows a Binomial distribution. The expected number of varieties conditional on N_j is

$$E\left(n_j|N_j;\pi_j,\overline{F}^j\right)=N_j*\Phi\left(\pi_j-\overline{F}^j\right), \tag{3.7}$$

which is increasing in profitability and decreasing in development cost. If the number of trials is large enough and the probability of success is small, the distribution of n_j can be approximated by a Poisson with parameter $N_j*\Phi\left(\pi_j-\overline{F}^j\right)$. In the empirical section, I adopt a Poisson specification to explain the number of new varieties introduced by each firm.[1]

Prior to taking the draws of the fixed costs, the expected profit from a successful draw is $E\left(\pi_j-F_{ij}|\pi_j-F_{ij}\geq 0;\overline{F}^j\right)$. Firms choose N_j to maximize the expected profit from all successful draws, given by $E\left(\pi_j-F_{ij}|\pi_j-F_{ij}\geq 0;\overline{F}^j\right)*N_j*\Phi\left(\pi_j-\overline{F}^j\right)$, net of the exploration cost γ. Because the draws are normally distributed, the conditional expectation can be written in terms of the inverse Mill's ratio. The optimal number of

[1] To be able to describe the process generating the number of varieties by a Binomial or Poisson distribution, the trials need to be independent and the probability of success needs to be the same for all trials by a same firm. The assumption of $\pi_{ij}=\pi_j$ is not crucial for this result; varieties need to be identical ex-ante to taking the draws, but not necessarily ex-post (actually, if they were ex-post identical in every dimension either none or all varieties would be introduced). It is possible to relax the same variable profit assumption by introducing random costs of production and different demand functions. In this last case, goods enter the utility function asymmetrically, $U=\left[\int_0^{n^*}\beta(i)\,q(i)^{\frac{\sigma-1}{\sigma}}\,di\right]^{\frac{\sigma}{\sigma-1}}$. These richer assumptions do not add any significant insight into the development stage and come at the expense of complicating the pricing stage (in particular, the construction of the price index).

draws solves

$$\max_{N_j \geq 0} \left[\left(\pi_j - \overline{F}^j\right) + \frac{\phi\left(\pi_j - \overline{F}^j\right)}{\Phi\left(\pi_j - \overline{F}^j\right)} \right] \Phi\left(\pi_j - \overline{F}^j\right) N_j - \gamma\left(N_j\right). \tag{3.8}$$

For simplicity, write the objective function as $A\left(P, c_j, \overline{F}^j\right) N_j - \gamma\left(N_j\right)$; the dependence on P and c_j comes through π_j. Let $Lim_{N\to 0}\gamma'(N) = \gamma^* \geq 0$. Firms such that $A\left(P, c_j, \overline{F}^j\right) > \gamma^*$ choose to investigate a strictly positive number of varieties given by the solution to the first order conditions, $A\left(P, c_j, \overline{F}^j\right) = \gamma'\left(N_j\right)$; On the other hand, if $A\left(P, c_j, \overline{F}^j\right) \leq \gamma^*$, then $N_j = 0$, which is equivalent to exiting the market. The number of explored varieties is increasing in A, the expected profit from introducing one variety, and ultimately depends positively on the firm's profitability and negatively on the development costs.

The unconditional expectation - with respect to the number of draws - of the number of varieties for one firm is

$$E\left(n_j | \pi_j, \overline{F}^j\right) = N_j\left(P, c_j, \overline{F}^j\right) * \Phi\left(P, c_j, \overline{F}^j\right) \tag{3.9}$$

where $N_j\left(P, c_j, \overline{F}^j\right)$ solves (3.8). A firm that can obtain more profits from the varieties that it produces and that is more efficient in developing goods, chooses to investigate more varieties than a less advantaged firm; the probability of success for each variety is also higher. Consequently, the expected number of varieties that get introduced into the market is increasing in a firm's profits (represented here by efficiency in production) and decreasing in development costs.

In the next sections, I study the introduction of new varieties of goods by firms in the Chinese manufacturing sector and assess the roles played by advantages in productivity and innovation costs. In particular, I look at the different performances of foreign and domestic firms and examine whether there are systematic differences in productivity and in the cost of innovation between them. This exercise is not meant to be a test of the model. The model is as stylized as possible and provides basic guidelines for the empirical exercise, but does not describe some aspects of the exercise like ex-ante heterogeneity (foreign versus domestic firms) and dynamics in the introduction of varieties. In particular, I estimate the effects of productivity and innovation costs on the number of *new* varieties that firms introduce, rather than on the *total* number of varieties.

Equilibrium

In deriving the results above, the total number of firms and the price index were taken as exogenous, whereas these variables are in fact determined endogenously in equilibrium. Consider for a moment that the number of firms is fixed. The price index can be written as a function of the prices charged by each firm (which depend on the number of varieties introduced by each). The number of varieties depends in turn on the price index (through profits). These equations can be solved simultaneously for the equilibrium price index and number of varieties.

There is also the issue of how to determine the equilibrium number of firms. Firms can differ in two dimensions, the variable cost of production and the fixed costs of introducing varieties. The firm with expected profits from successful draws equal to the marginal increase in investigation costs evaluated at zero (γ^*) is the "cutoff" firm and is indifferent between exiting and investigating an infinitesimal number of varieties. Before entry, firms pay a sunk fee S and get a draw of $\left(c_j, \overline{F}^j\right)$ from a distribution common to all firms, afterwards they decide the number of varieties to investigate, N_j, the number of varieties to introduce, n_j, and the price for each of them, p_j. Firms enter until the expected profit net of the sunk fee is zero (that is, the expected profit before observing the realizations of c_j and $\overline{F}^j$, and the realizations of F_{ij} for all the varieties). The comparative statics results where more efficient firms (in terms of variable and fixed costs) introduce more varieties is left unchanged.

Consider the stage at which the firms choose the number of varieties to investigate to maximize expected profits, given by (3.8). The indirect expected profits function (optimized over N_j) is given by

$$A\left(P, c_j, \overline{F}^j\right) N_j\left(P, c_j, \overline{F}^j\right) - \gamma\left(P, c_j, \overline{F}^j\right). \tag{3.10}$$

This is the ex-post expected profit, after the realization of $\left(c_j, \overline{F}^j\right)$ and prior to the realizations of F_{ij}. In the fist step, firms choose to enter if the ex-ante expected profit, prior to the realization of $\left(c_j, \overline{F}^j\right)$, is higher than the entry fee S. Let G be the joint distribution of $\left(c_j, \overline{F}^j\right)$. The condition for free entry until expected profits are driven to zero can be written integrating over $\left(c_j, \overline{F}^j\right)$ as $F_{ij} \sim N\left(\overline{F}^j, 1\right)$

$$\int_{c_j}\int_{\overline{F}^j}\left[A\left(P, c_j, \overline{F}^j\right) N_j\left(P, c_j, \overline{F}^j\right) - \gamma\left(P, c_j, \overline{F}^j\right)\right] dG\left(c_j, \overline{F}^j\right) = S. \tag{3.11}$$

A definition of the price index in term of the primitives is needed to close the model. Plugging in the optimal prices for each variety, $p_i = \frac{\sigma}{\sigma-1}c_i$, into the definition of the price index in (3.3), the index becomes

$$P = \frac{\sigma}{\sigma-1}\left[\int_0^{n^*} c\left(i\right)^{1-\sigma} di\right]^{\frac{1}{1-\sigma}}. \tag{3.12}$$

To express the index in term of the model primitives, it is necessary to change variables and integrate over draws of $\left(c_j, \overline{F}^j\right)$. Consider the price decision of a firm that gets a draw c_j: all firms that get the same draw c_j charge the same price, and the density of firms that get c_j is $g_1\left(c_j\right) * J$, where J is the total number of firms that enter and g_1

is the marginal pdf of c_j. Consider the exploration decision of such firm: the expected number of varieties conditional on $\overline{F}^j$ is $N_j\left(P, c_j, \overline{F}^j\right) * \Phi\left(P, c_j, \overline{F}^j\right)$; the unconditional expectation is $\int_{\overline{F}^j} N_j\left(P, c_j, \overline{F}^j\right) * \Phi\left(P, c_j, \overline{F}^j\right) dG_2\left(\overline{F}^j\right)$, where G_2 is the marginal cdf of $\overline{F}^j$. The price index can then be written by integrating over c_j as well as

$$P^{1-\sigma} = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \int_{c_j} \left(\int_{\overline{F}^j} N_j\left(P, c_j, \overline{F}^j\right) \Phi\left(P, c_j, \overline{F}^j\right) dG_2\left(\overline{F}^j\right)\right) c_j^{1-\sigma} g_1\left(c_j\right) J dc_j \tag{3.13}$$

or

$$P^{1-\sigma} = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} J \int_{c_j} \int_{\overline{F}^j} c_j^{1-\sigma} N_j\left(c_j, P, \overline{F}^j\right) \Phi\left(c_j, P, \overline{F}^j\right) dG\left(c_j, \overline{F}^j\right) \tag{3.14}$$

Equations (3.8), (3.11) and (3.14) can be solved jointly for the equilibrium number of firms (J), the price index (P) and the rule of varieties to explore (N_j) as a function of the realization of the draws.

3.3 Overview and data

In the next two sections, I look at the new varieties of goods introduced by firms in 15 manufacturing industries in China. I investigate whether foreign firms introduce more goods than domestic firms and if the difference can be attributed to the two factors described in the model: advantages in productive efficiency and/or in the cost of innovation. China is an interesting case-study because it has received a considerable amount of foreign direct investment in the last years and a large fraction of it has taken place in the form of "greenfield" FDI, as opposed to the acquisition of domestic plants by foreign firms. When a new production plant is set up from scratch, there is more room for heterogeneity between foreign and domestic firms.

The presumption is that, due to their condition as multinational corporations with headquarters and subsidiaries in other countries, foreign firms enjoy economies of scale and/or learning by doing in the development of goods and production and organization techniques across the countries where they have production facilities. In the case in which a foreign firm develops a new product to introduce in markets other than China, the marginal decision of whether to introduce it in China or not depends on setup costs and costs of production, but not on costs of R&D, which are incurred only once; if it is a joint decision across countries, still the Chinese subsidiary does not need to bear the full cost by itself. A multinational firm may also choose to develop some goods in China; it is likely that these goods are relatively similar to goods developed by the same firm elsewhere and that they can take advantage of economies of scope and learning-by-doing effects in R&D. Similar arguments apply to technology to introduce new products that is obtained from outside sources (by purchasing a license): if the license is valid to produce in many countries, then the license cost faced by the Chinese subsidiary is only a fraction of the total cost; if a license is needed to produce in each country or if goods produced in each country are not the same and each one requires the purchase of a different license, it is anyway reasonable to argue that a large multinational corporation acquiring many licenses enjoys better prices than a smaller firm purchasing only a few licenses for the Chinese market.

On the production side, if the same good has been already introduced in other markets, there is some experience about how to setup and carry out production; and, independently of producing the same goods in China and elsewhere, corporations develop experience even about how to organize production chains and the firm itself.

Foreign firms can also be expected to be more productive because of selection. Less productive firms may find it profitable to produce in the domestic market, but they may not "make it" into foreign markets. Melitz (2003) formalizes this idea for exporting firms versus firms that only sell in the domestic market by including different fixed costs of entry. Helpman, Melitz and Yeaple (2004) extend the argument to include firms investing abroad. Fixed costs determine a cutoff below which firms are not profitable. If the fixed cost is larger for foreign firms than for domestic firms, the cutoff is higher for foreign firms and they result to be on average more productive even if the distribution of productivities is the same across both types of firms.

The hypothesis of economies of scale in R&D and learning by doing in R&D and production cannot be tested directly in the present context. What I do instead is to look at the number of new varieties introduced by firms over a three-year period, and at differences in productivity and differences in the costs of innovation using estimates of total factor productivity (TFP) and expenditure in R&D and purchases of technology from outside sources as proxies. Afterwards, I look at whether TFP and costs of innovation can explain the difference in the number of varieties introduced by each firm. I also look for evidence of selection based on different productivity cutoffs.

To compute TFP, I estimate a production function for each industry using the method developed by Olley and Pakes (1996) and compute TFP as the difference between output and the part of it that can be explained by input usage. This method has been used extensively in the trade and productivity literature. Among many examples, Pavcnik (2000) and Fernandes (2003) estimate changes in productivity at the firm level due to major trade liberalizations in Chile and Colombia, respectively; Bernard and Jensen

(2004) study the causal relation between changes in productivity and changes in exporting status of U.S. firms; and Smarzynska (2004) and Keller and Yeaple (2003), focus on whether there are productivity spillovers from foreign firms to domestic firms in Lithuania and the U.S., respectively.

I use firm-level data from the World Bank's 2001 Investment Climate Survey. This survey was run in collaboration with the Chinese National Bureau of Statistics and is part of the World Bank's larger project to study the business environment at the firm-level in Africa, Latin America, and South and East Asia. A total of 1,500 firms were interviewed in 2001 in five cities (Beijing, Tianjin, Shanghai, Guangzhou and Chengdu) by members of the Enterprise Survey Organization, of the Chinese National Bureau of Statistics. The surveyed unit is the main production facility of a firm. The General Managers of the main facilities responded to a questionnaire on ownership structure, relations with competitors, clients and suppliers, innovation, and market environment and investment climate. A second questionnaire about accounting data and characteristics of the labor force was answered by the Accountant or the Personnel Manager.

One thousand of these firms correspond to 27 different 3-digit and 4-digit level industries in the manufacturing sector, while the other 500 correspond to services. The original 27 industries were selected non-randomly with the purpose of focusing on the main sectors of the industry and on those with high growth and innovation rates. They can be categorized into 5 big groups: Apparel and Textiles, Household appliances, Vehicles and vehicle parts, Electronic equipment, and Electronic components. Two hundred firms were surveyed in each of these groups. Within these groups, firms were chosen randomly and their composition is therefore representative of the population. I work with the 1,000 firms in the manufacturing sector and I regroup the 27 industries into 15; otherwise, there are some industries with too few observations and it is not possible to estimate production functions consistently. A list of the final 15 industries and their industrial codes can be found in Table 1.

The data span the 1998-2000 period, however, firms were interviewed only once, in 2001. As a result, some questions are answered at the year level, while other answers involve information for the entire 3-year period in question. The accounting information on sales and input usage is yearly and most firms include the information for all three years; therefore, for the purpose of estimating a production function, the data are equivalent to a 3-year panel with no entry and exit of firms.

The questions on the introduction of new varieties of goods are answered for the entire 3-year period, that is, there is information on how many new varieties firms have introduced from the beginning of 1998 to the end of 2000, but not on how many per year. A new variety is not the same as a new production line; a new variety is defined as a good classified by the firm as different from all other previously existing goods that the same firm produces. To avoid problems of subjectivity, when a new good is similar to an old good that is being replaced, it is considered a new variety only if the price difference with respect to the old good is greater than 10 percent.

Table 2 provides some descriptive statistics. After discarding plants that were established after 1998, those with missing accounting information and some outliers for which the reported number of new varieties is more than one hundred,[2] the sample includes

[2]Discarded observations include both foreign and domestic firms and do not follow a particular pattern. The definition of what is considered a new variety is to some degree subjective and different firms possibly

859 firms - 589 domestic firms and 270 foreign firms. Within domestic firms, 47 percent are privately owned, 29 percent are state-owned and 23 percent are cooperatives or collectively owned by workers. I consider a firm to be foreign when there is some degree of foreign participation in its capital. Of the 270 firms with some degree of foreign ownership, 70 percent are majority foreign-owned firms (15 percent are fully foreign-owned and 55 percent have foreign participation between 50 and 99 percent) while the remaining 30 percent have less than 50 percent of foreign ownership.

Columns 2 to 4 display the median number of workers in 1998, the average output per worker in 1998 and the average number of new varieties introduced during the period 1998 - 2000, each by ownership type. The overall median number of workers is 269, and there are substantial differences across ownership types. State-owned firms are the largest (in terms of workers) and private domestic and fully foreign-owned firms are the smallest. The performance of foreign firms in terms of output per worker is better than the performance of domestic firms. Within foreign firms, those with more than 50 percent of foreign ownership outperform firms with less than 50 percent of foreign ownership; within domestic firms, private ones do better than state-owned firms and cooperatives. Firms introduce on average 3 new varieties of goods; foreign firms are above this average (3.6 new varieties for firms with less than 50 percent of foreign ownership and 4.5 and 4.8 new varieties for the other foreign firms), while domestic firms are below this average (private firms introduce 2.7 new varieties on average, state-owned firms introduce 2.8 varieties and

follow different criteria. As long as the definitions of new varieties are uncorrelated to the ownership structure of the firms, the differences in criteria do not introduce a bias. In addition, more than 97 percent of firms report introducing less than 20 new goods, and only 10 firms report introducing more than a hundred new goods. I do not include the latter to avoid these outlyers to drive results.

cooperatives 1.1 varieties).

In Figure 1, foreign firms are grouped by deciles of degree of foreign ownership. A large number of firms with more than 50 percent of foreign capital are in the 50 - 60 percent decile (74 firms out of 189). There is also a significant concentration of majority foreign-owned firms in the 90 - 100 percent decile (54 firms) - not all of these are fully foreign-owned firms, though, 13 of the 54 firms in the last decile have between 90 and 99 percent of foreign capital (not shown in Figure 1). Among foreign firms with less than 50 percent of foreign capital, the main concentration of firms occurs in the 20 - 30 percent decile (41 firms out of 81).

3.4 Foreign firms introduce more goods

I assume that the number of new varieties introduced by firm i, n_i, follows a Poisson distribution with parameter λ_i. Under this assumption, the conditional probability that firm i introduces n_i new varieties is $P(n_i|\lambda_i) = \frac{\lambda_i^{n_i} e^{-\lambda_i}}{n_i!}$, and both the mean and the variance of the number of new varieties is given by λ_i. The parameter λ_i is specific to each firm and it is a deterministic function of observable firm characteristics, x, and the ownership structure of the firm, represented by the dummy variables FOR_1, FOR_2 and $NONPRIV$.

In particular, I adopt a log-linear specification, so that

$$\lambda_i = \exp(x_i'\beta_0 + \beta_1 FOR_{1i} + \beta_2 FOR_{2i} + \beta_3 NONPRIV_i) \tag{3.15}$$

Observable firm characteristics included in x are size - measured by the logarithm of the number of workers,- self-reported market share, the logarithm of the age of the firm and dummy variables for firms that started operating in 1997 and 1998. FOR_1 and FOR_2 are indicator variables for firms with some degree of foreign ownership; firms with less than 50 percent of foreign participation in capital are included in FOR_1 (hereafter, minority foreign-owned firms), while FOR_2 comprises firms with foreign capital ranging from 50 to 100 percent (majority foreign-owned firms). $NONPRIV$ is equal to one for non-private domestic firms, that is, state-owned firms and collectively-owned firms. Private domestic firms are the baseline category. I also include city and industry effects that capture differences in the mean number of new varieties introduced across these two dimensions. In addition, these fixed effects control for potential selection of foreign firms into cities or industries where more varieties are introduced.

Different forms of the Poisson distribution are usually adopted when the dependent variable is a non-negative integer. In the innovation literature, many authors model the number of patent applications as a Poisson process: Hausman, Hall and Griliches (1984) and Crepon and Duguet (1997) study the effect of expenditure on R&D on patents; Blundell, Griffith and Van Reenen (1995) investigate the relation between patents and market power and "stock of knowledge." Other distributional assumptions are explored in Section 3.4.1 and results prove to be robust to different distributional specifications.

The log-linear specification is convenient because it guarantees that the expected number of new varieties is positive; moreover, the likelihood function is globally concave in (β_0, β_1, β_2, β_3). Compared to least squares, the Poisson specification handles count data more naturally. If OLS is used (where the expected number of varieties is linear in the explanatory variables instead of log-linear) the estimated expected number of new varieties is not necessarily non-negative. This problem does not arise when using non-linear least squares with a log-linear specification, however, there is the problem of how to treat the observations in which the number of new varieties is zero. The Poisson distribution models the probability of observing each non-negative integer, including zero, and therefore by-passes this problem.

The first column of Table 3 displays the results of the Poisson regression (3.15) of the number of new varieties on firm ownership. I find that firms with more than 50 percent of foreign participation introduce more new varieties of goods than private domestic firms, and that this difference is statistically significant. Firms with foreign capital lying between 1 percent and 50 percent, on the other hand, do not introduce more varieties than private domestic firms; as a matter of fact, the coefficient for this group of firms is negative, although not significant.

Because the regression function is not linear, the interpretation of the coefficients $\boldsymbol{\beta}$ is not straightforward. To provide a more intuitive interpretation of the results, the lower panel of Table 3 shows the incidence ratios of the explanatory variables, $\exp(\beta_k \Delta x_k)$. For an indicator variable, the incidence ratio is the ratio of the expected number of new varieties introduced by firms that belong to that particular category and by firms in the baseline category (private domestic firms). For example, the ratio of the expected number of varieties between majority foreign-owned firms and domestic firms is $\frac{\exp\left(x_i'\beta_0+\beta_2\right)}{\exp\left(x_i'\beta_0\right)} = \exp(\beta_2) = 2.02$, which means that these firms introduce roughly *twice* as many new varieties as private domestic firms - other things equal. The incidence ratios for minority foreign-owned firms and for non-private domestic firms are lower than one, implying that the underlying coefficients are negative; the number of new varieties introduced by non-private firms is 64 percent of the number of varieties introduced by private domestic firms. For continuous regressors, the incidence ratio is computed for a change of 10 percent. For example, a firm with 10 percent more workers introduces $\frac{\exp\left(x_i'\beta_0+10*\beta_{workers}\right)}{\exp\left(x_i'\beta_0\right)} = \exp\left(10*\beta_{workers}\right) = 3.6$ times more new varieties than a firm of similar characteristics. The number of new varieties is increasing in market share, the coefficient is statistically significant but small in magnitude. The age of a firm is not significant and neither are the dummy variables for firms that initiated operations in 1997 and 1998 (not shown in the table). Columns [2] and [3] present the results from similar regressions excluding city and industry effects. Results do not differ substantially from the original specification in column [1].

A priori, there may be a reverse causality problem with the market share: firms that have larger market shares have more incentives to do R&D and to introduce more goods; on the other hand, firms that introduce newer varieties gain a larger fraction of the market from its rivals. In column [4], I utilize the self-reported number of competitors as an instrument for market share. In a Poisson regression, the probability of observing each number of counts is specified, but there is no underlying distribution for the continuous error term. In a case in which there is a distribution for the error term, instruments can be introduced into the estimation by specifying an equation for the endogenous regressor and estimating the original equation plus the equation for the endogenous regressor jointly by FIML or LIML (depending on whether the last equation is structural or reduced form). In the Poisson case, however, it is not possible to specify the joint distribution of the two error terms for the reason stated above, and joint MLE is not viable.

I use a 2 step *control function* approach as in Blundell and Powell (2003 and 2004) instead of FIML or LIML. In the first step, I run an OLS regression of the market share on the number of competitors (the instrument) plus the other explanatory variables in regression (3.15) and compute the residuals.[3] In the second step, I estimate the Poisson regression including the residual from the first step as a regressor; these residuals control for the endogeneity of the market share. It is analogous to including the inverse Mills-ratio in Heckman's 2-Step estimator to control for selection.

The first step regression is a reduced form regression of market share on all explanatory variables plus the number of competitors. The assumption is not simply that the market share and number of competitors are correlated and that the number of competitors is uncorrelated to the error term - as would be the case in the instrumental variables case - but rather that the first step regression function correctly specifies the econometric model that determines the market share - as would be the case if using LIML. In addition, the error term in the first step regression is assumed to be uncorrelated to the error term in the second step regression.

Results from the control function regression are displayed in column [4] of Table 3. The coefficient on majority foreign-owned firms is larger than before but not substantially (foreign firms introduce 2.2 as many new goods as private domestic firms, instead of 2 as many new goods as in column [1]). The coefficient on market share is not statistically significant.

In equilibrium, the number of workers is determined jointly with the number of varieties. First of all, firms that introduce more varieties need to hire more workers to increase production; to minimize this reverse causality problem, I use the number of workers in 1998, the first year of data. Second, the number of new varieties and the

[3] More general non-parametric methods can be used instead (Blundell and Powell, 2004).

number of workers may depend on unobserved firm characteristics not included in the regression that affect scale. The number of workers is included as a scale variable and its coefficient should not be interpreted as the change in the number of new varieties predicted by a change in the number of workers of a particular firm; the coefficient has a reduced form interpretation that relates the number of workers and the number of varieties in equilibrium without predictive value. In column [5], I exclude the number of workers from the regression. The coefficient for majority foreign-owned firms is larger than before since these firms are on average larger than domestic firms, but the difference is not substantial.

Table 4 tests the sensitivity of the results to different definitions of foreign ownership. In columns [1] and [2], I include only one indicator variable comprising all firms with some degree of foreign ownership, the first column is a simple Poisson regression while the number of competitors is used as an instrument for market share in column [2] (using a control function as described above). The coefficient is lower than the coefficient for majority foreign-owned firms in the previous table; under this new specification, firms with some degree of foreign ownership introduce 1.6 and 1.7 times the number of new varieties introduced by private domestic firms. All other coefficients are similar to the results in the previous table. In columns [3] and [4], foreign ownership is a continuous variable that is equal to the share of the value of the firm in foreign hands. Again, I estimate two regressions, one without instruments and one instrumenting for market share. The coefficients on the foreign ownership variable are positive and significant but small in magnitude. For the regression without instruments, the incidence ratio for a change of 100 percent is 2 (not shown in the table), meaning that a firm with 100 percent of foreign ownership introduces twice as many goods as a private domestic firm. This effect is small when compared with Table 3 and suggests that firms with the highest share of foreign ownership are not introducing more goods than firms with foreign participation between 50 percent and 100 percent, as defined in column [1].

In Table 5, I explore three additional categories of foreign ownership. Column [1] shows that fully foreign-owned firms (100 percent of foreign share in ownership, labeled in the table as *Foreign 100%*) do not introduce more varieties of goods than firms with foreign ownership between 50 percent and 99 percent: they both introduce twice the number of varieties as private domestic firms (the coefficients are almost identical to the coefficient for majority foreign-owned firms in Table 4 (previous table)). In the second column I disaggregate fully foreign-owned firms into two categories: those that are owned by a foreign firm or multinational corporation (labeled in the table as *Foreign 100%)* and those who are owned by foreign individuals or foreign investors (labeled as *Foreign 100% - Investor*). The former (firms fully-owned by a foreign corporation) turn out to introduce more than 50 percent more new varieties than foreign firms with foreign ownership lying between 50 and 99 percent, and over *three* times more new varieties than private domestic firms. The latter (firms fully owned by foreign individuals or investors) do not introduce more new varieties than private domestic firms (the coefficient is actually negative, but not significant).[4]

This result indicates that what matters for the introduction of new products is not the foreign origin of capital per se, but rather that foreign firms be owned by multinationals.

[4]There are only 35 fully foreign-owned firms in the sample - 15 are owned by foreign firms and 20 by foreign investors.

Fully foreign-owned firms that are owned by multinationals can easily introduce new goods in China that they have developed elsewhere; whereas fully foreign-owned firms that are owned by an investor do not operate in other countries and do not have advantages in innovation capabilities over domestic firms.

In columns [3] and [4] of Table 5, I reestimate the two previous regressions using the number of competitors as an instrument for market share (including the first stage control function in the Poisson regression as described before). In this case, the coefficient of fully foreign-owned firms is larger than the coefficient on majority foreign-owned firm up to 99 percent of foreign capital even when firms owned by multinationals and firms owned by investors are grouped together. However, when the two categories of fully foreign-owned firms are included separately, the coefficient on fully foreign-owned firms owned by investors is negative, which is consistent with column [2] and its implications about the advantage of having production facilities in other countries enjoyed by multinationals.

Summarizing these findings, controlling for size, market share, age, industry and location, majority-owned foreign firms (50 percent to 100 percent of foreign capital) and firms owned fully by a foreign corporation introduce two and three times as many varieties as domestic firms, respectively; , collectively-owned domestic firms (state-owned and cooperatives), minority foreign-owned firms (1 percent to 50 percent foreign) and firms owned fully by a foreign individual or investor introduce fewer varieties than private domestic firms, but results are not significant in the last two cases.

The cutoff for the definition of minority and majority foreign-owned firms is not strict. The regression results are not dramatically different when the groups are defined taking 40 percent or 60 percent as cutoffs.

3.4.1 Sensitivity to distributional assumptions

As in any maximum likelihood estimation, the consistency of the results of the previous section depends on the validity of the distributional assumption. The Poisson assumption implies that both the mean and variance of the dependent variable are equal to the parameter λ. In many applications with count data, however, it is argued that the variance of the dependent variable can be higher than the mean - a phenomenon that is referred to as *overdispersion*. Naturally, the presence of overdispersion challenges the validity of the Poisson assumption and the consistency of the estimators.

Gourieroux, Monfort and Trognon (1984a, 1984b) show that, provided the distribution belongs to the linear exponential family - as is the case of the Poisson [5] - and provided the conditional mean is correctly specified, the estimators for the coefficients are consistent even if higher order moments of the distribution are not correctly specified. Under these assumptions, the estimators are not efficient and the standard errors need to be corrected to account for the misspecification of the second moment.[6] I performed this correction in the robust standard errors in Tables 3, 4 and 5, discussed above, and Table 6, discussed below. Gourieroux, Monfort and Trognon refer to these estimation

[5] Other distributions that belong to the linear exponential family are the Normal, Logistic, Gamma, Binomial and Negative Binomial distributions. More formally, a density function is linear exponential if it has the form $f(y) = \exp\left(r(\mu) + s(y) + t(\mu)\, y\right)$, where r, s and t are functions that satisfy $E(y) = -t'(\mu)^{-1} r(\mu)$ and $V(y) = t'(\mu)^{-1}$.

[6] The asymptotic variance-covariance matrix of the estimator β is $\left(A^{-1}BA^{-1}\right)$, where $A = -E\left(\frac{\partial^2 \log f_i}{\partial\beta\partial\beta'}\right)$ and $B = E\left(\frac{\partial \log f_i}{\partial\beta'}\frac{\partial \log f_i}{\partial\beta'}\right)$ and where the derivatives are evaluated at the true value of β. If the distribution is not correctly specified, the equality between A and $-B$ does not necessarily hold.

method as *Pseudo-Maximum Likelihood;* it is analogous to estimating a linear regression using Ordinary Least Squares in the presence of heteroskedasticity, when the linearity assumption is correct. The result is particularly relevant in the Poisson case because of the suspected overdispersion.

Overdispersion is usually attributed to two factors: unobserved heterogeneity and excess zeros (more zeros than the Poisson distribution can account for). In the first case, the conditional mean can be correctly specified but the variance can not, so that Poisson estimates can be consistent but not efficient. In the second case, the conditional mean is incorrectly specified, leading to inconsistent estimators in the Poisson case. Below, I explore the sensitivity of the results of the Poisson regression of the previous section to the results obtained under these alternative distributional assumptions - unobserved heterogeneity and excess zeros; I also compare the previous results with the results of a linear regression specification.

I adopt one of the simplest forms of unobserved heterogeneity. The number of new varieties follows a Poisson distribution with parameter λ as in the previous section. The difference is that λ is now a stochastic function of observed characteristics x and depends also on a scalar representing unobserved characteristics, ξ, with distribution F. In particular, let $\lambda_i = \exp(x_i'\beta + \xi_i)$ (for simplicity of notation, I include FOR_1, FOR_2 and $NONPRIV$ in x hereafter). The probability of introducing n new varieties conditional on observed characteristics x is given by

$$P(n_i|x_i) = \int_\xi \frac{\exp(x_i'\beta + \xi_i)^{n_i} e^{-\exp\left(x_i'\beta+\xi_i\right)}}{n_i!} dF(\xi_i) \tag{3.16}$$

Let $\exp(\xi)$ follow a Gamma distribution with mean one and variance σ_ξ^2. Then, the conditional distribution of the number of varieties, n, has a closed-form solution; it is a

Negative Binomial with $E[n_i|x_i] = \exp(x_i'\beta)$ and $V[n_i|x_i] = \exp(x_i'\beta)\left(1 + \sigma_\xi^2 \exp(x_i'\beta)\right)$. Note two things: (1) since $\sigma_\xi^2 > 0$, the conditional variance is larger than the conditional mean, (2) the conditional mean is the same as in the Poisson specification.[7]

To account for excess zeros, I adopt a process that is usually referred to as *zero-inflated Poisson.* There are two types of firms, those that do not participate in the introduction of new goods and those that *consider* introducing new goods (but may end up introducing zero new goods). A firm does not participate with probability $\Phi(z_i'\delta)$, where Φ is the Normal cdf and z are observed firm characteristics including the ownership dummies FOR_1, FOR_2 and $NONPRIV$. The number of goods introduced by firms that participate is distributed Poisson with parameter λ, where $\lambda_i = x_i'\beta + \xi_i$ and where $\exp(\xi)$ follows a Gamma distribution with mean one and variance σ_ξ^2 (ownership dummies are included in x). Let $P(n_i|x_i)$ be defined as in equation (3.16). The probability of introducing n new varieties conditional on observed characteristics x and z is given by

$$\pi(n_i|x_i, z_i) = \begin{cases} \Phi(z_i'\delta) + [1 - \Phi(z_i'\delta)]\, P(0|x_i) & \text{if } n_i = 0 \\ [1 - \Phi(z_i'\delta)]\, P(n_i|x_i) & \text{if } n_i > 0 \end{cases} \tag{3.17}$$

For more details on Poisson mixtures see Cameron and Trivedi (1998).

The results from the estimation of these alternative specifications are presented in Table 6. The first column corresponds to the Poisson-Gamma mixture (negative binomial) and the second column corresponds to the zero-inflated Poisson specification. The coefficients and incidence ratios can be directly compared to Table 3, column [1]. There is no substantial difference in the results, majority foreign-owned firms introduce over twice and slightly less than twice as many new varieties as private domestic firms in the

[7] In the Poisson case, $E[n_i|x_i] = V[n_i|x_i] = \lambda_i$.

negative binomial and zero-inflated Poisson specifications, respectively.

The last column of Table 6 displays the results from an OLS regression including the same variables as before. In this case the expectation is a linear function of the regressors and the coefficients can be interpreted directly. Majority foreign-owned firms introduce 2.6 more new varieties than private domestic firms, minority foreign-owned firms and non-private firms introduce less varieties than private firms and the coefficients are not significant. Other things equal, an increase on 10 percent in the number of workers translates into 4 more new varieties. Qualitative results are almost identical to the original Poisson specification (with the exception of the coefficient on non-private firms, which is not statistically significant in the linear case). The magnitude of the coefficient fore majority foreign-owned firms (2.6) can be compared to the difference in the expected values of new varieties between majority foreign-owned firms and private domestic firms in the Poisson specification. For a given firm, this difference is given by $\exp\left(x_i'\beta_0 + \beta_2\right) - \exp\left(x_i'\beta_0\right)$. I compute two aggregate measures, the difference evaluated at the mean level of x, and the average of the difference for each firm. The first difference is 1.88, while the second is 2.81. The OLS coefficient of 2.6 lies between these two values.

3.5 Profit and cost

The model in Section 3.2 describes two dimensions of firm-level heterogeneity that explain why firms choose to introduce a different number of varieties: efficiency in production and efficiency in research and development. In this section, I investigate whether there are systematic differences in these two dimensions of heterogeneity between domestic and foreign firms and assess the impact that both dimensions have on the number of varieties introduced by a firm. I decompose the total difference in the number of varieties introduced by domestic and foreign firms into the fractions explained by differences in productive efficiency and efficiency in innovation.

To measure efficiency in production, I estimate a Cobb-Douglas production function for each of the fifteen manufacturing industries in the sample and compute total factor productivity (TFP) for each firm. TFP is a measure of Hicks-neutral productive efficiency since it enters the production function in a multiplicative manner. Throughout the estimation, all firms in a given industry are assumed to be equally efficient in the use of inputs.

I approximate efficiency in innovation by the expenditure in R&D and purchases of technology from outside sources per new variety. For foreign firms, I consider expenditure by Chinese subsidiaries only, as the intention is to capture the cost of introducing new varieties in China, not worldwide. So, if a foreign firm has developed a new variety elsewhere, the R&D cost for this variety is zero in China; this captures the returns to scale advantage of foreign firms that do not need to duplicate R&D costs. I also compare the preferred ways of getting access to new varieties across firms.

3.5.1 Are foreign firms more productive?

I answer this question in two steps. I first estimate total factor productivity (TFP) for each firm and later I regress the estimated TFP on firm characteristics, including the ownership structure of the firms.

In the first step, I estimate a Cobb-Douglas production function where all firms in the same industry have the same time-invariant labor and capital coefficients but differ in a

Hicks-neutral efficiency parameter, or TFP. TFP is exogenous and can vary over time. The estimating equation takes the form,

$$\log Y_{ijt} = \alpha_{1j} \log L_{ijt} + \alpha_{2j} \log K_{ijt} + \omega_{ijt} + \varepsilon_{ijt} \tag{3.18}$$

where i, j and t index firm, industry and year, respectively; Y is output, and L and K are labor and capital. There are two Hicks-neutral technology shocks, ω and ε. The first component, ω, includes characteristics of the firm that are unobserved by the researcher but observed by the firm prior to making input decisions, such as managerial ability. It is independent across firms but serially correlated across time for a given firm. The second component, ε, is an independent and identically distributed (across firms and time) zero-mean shock, that is only observed by the firm ex-post. It includes, for example, unforeseeable waste or spoilage of inputs and loss of output. Total factor productivity is given by $\exp(\omega_{ijt} + \varepsilon_{ijt})$.

Labor and capital choices are endogenous to the firm and depend on the observed component of TFP, ω, since more efficient firms employ more inputs. As a result, in an OLS regression where $(\omega_{ijt} + \varepsilon_{ijt})$ is treated as the error term, labor and capital are correlated with the error and the resulting residuals are inconsistent estimators for TFP.

This endogeneity problem was first pointed out by Marschak and Andrews (1944), Griliches (1957) and Mundlak (1963). The latter proposed to treat ω as a time-invariant firm-level unobserved efficiency term, that is, $\omega_{ijt} = \omega_{ij}$, and to estimate the labor and capital coefficients by exploiting the variation in input usage and output within a same firm. I argue below that in the present case productivity may vary over time - because of the introduction of new varieties, - therefore ruling out the use of Mundlak's fixed effect estimator.

Another solution to the endogeneity problem is the use of instrumental variables. However, I cannot use generally plausible instruments such as input prices or lagged values of inputs. Differences in input prices are likely to reflect differences in quality (skill level in the case of workers) in addition to differences in the cost to access to the same inputs across firms. In the present case, this problem is exacerbated because I do not have data on different qualities of labor. Lagged inputs are only valid if the order of the lag is larger than the number of lags with non-zero serial correlation in the error term (for example, if $E(\omega_t \omega_{t-k}) \neq 0$, then, the k-th lagged values of inputs are not valid instruments). This requires a relatively long panel of firms; in this case, however, I only observe three years of input and output data.

Since I cannot safely use fixed effects or instrumental variables to account for unobserved efficiency, I use the method developed by Olley and Pakes (1996). The innovation introduced by Olley and Pakes consists of using investment to control for unobserved productivity in the regression function. They develop a dynamic model in which labor and investment - the choice variables - are a function of observed productivity and capital stock - the state variables; observed productivity follows a Markov process. They show that investment is strictly increasing in productivity for a given capital stock and that, consequently, the investment function can be inverted to express productivity as a function of investment and the capital stock. That is, productivity can be written as a function $\omega_{jt}(\log I_{ijt}, \log K_{ijt})$, where I is investment. Regression (3.18) can be estimated by introducing a non-parametric function of investment and the stock of capital to control for the unobserved shock ω, yielding a consistent estimator for the labor coefficient $\widehat{\alpha}_{1j}$. The coefficient on the capital stock cannot be separately identified from such a non-parametric function. The estimating equation becomes

$$\log Y_{ijt} = \alpha_{1j} \log L_{ijt} + \phi_{jt} (\log K_{ijt}, \log I_{ijt}) + \varepsilon_{ijt} \tag{3.19}$$

where $\phi_{jt} = \alpha_{2j} \log K_{ijt} + \omega_{jt} (\log I_{ijt}, \log K_{ijt})$ is the non-parametric function of investment and capital.

To identify the capital coefficient, Olley and Pakes impose the assumption that ω follows a Markov process and that investment in period t does not become part of the operating stock of capital until the following period, $t+1$. Observed productivity at time t is equal to the expectation of productivity at $t-1$ plus the unexpected innovation in productivity, ξ_t. Because of the Markov assumption, the expectation of ω_t in $t-1$ is a function of ω_{t-1} only. Productivity can then be written as $\omega_t = g(\omega_{t-1}) + \xi_t$, where g is an unknown function representing $E(\omega_t|\omega_{t-1})$ and ξ is the innovation in productivity. The coefficient α_{2j} can be estimated by non-linear least squares from

$$\log Y_{ijt} - \widehat{\alpha}_{1j} \log L_{ijt} = \alpha_{2j} \log K_{ijt} + g\left(\widehat{\phi}_{ijt} - \alpha_{2j} \log K_{ijt-1}\right) + \xi_{ijt} + \varepsilon_{ijt} \tag{3.20}$$

with a non-parametric approximation to g. The stock of capital, K, is not correlated with the innovation in productivity, ξ, because capital is determined by investment in the previous period, $t-1$, which does not depend on the innovation in productivity.[8] Total

[8] Ackerberg and Caves (2003) have pointed out that if the decision on labor and investment is taken jointly and depends on the same variables - capital and the realization of observed productivity - then the labor coefficient is not separately identified from the non-parametric function on investment and capital in the first step regression. They propose a different decision making sequence in which labor is chosen prior to the investment decision and depends on a *partial* realization of observed productivity. In practice, this timing assumption introduces an error term in the choice of labor and solves the indeterminacy of the labor coefficient in the first step.

factor productivity is estimated as

$$\eta_{ijt} = \log Y_{ijt} - \widehat{\alpha}_{1j} \log L_{ijt} - \widehat{\alpha}_{2j} \log K_{ijt} \tag{3.21}$$

where $\eta_{ijt} = \log TFP_{ijt}$.

The Investment Climate survey includes information on inputs and output for 1998, 1999 and 2000. Since the questionnaire is answered only once, in 2000, there is no entry and exit of firms in the panel. Labor is measured as labor expenditure deflated by the average wage in the region. This measure is preferred to the plain number of workers because differences in wages across firms within the same region may capture differences in workers' skill levels that affect the level of output. Capital is the book value of the stock of capital in real terms. Output is measured as value added: the cost of intermediate inputs in real terms is subtracted from total sales, which are deflated using 2-digit level price indices that differ by region.

I estimate separate regressions for each of the 15 industries. The number of firms by industry with non-missing and non-zero information on investment, inputs and output for the three-year period ranges from 21 to 96. The coefficients on labor and capital are different for each industry but are assumed constant over time. In principle, different coefficients can be estimated by year and region, but a large number of firms is needed in each industry. I use a fourth order polynomial with full interactions in investment and capital to account for the function ϕ in equation (3.19), and a fourth order polynomial in $\widehat{\phi}_{ijt} - \alpha_{2j} \log K_{ijt-1}$ to account for the function g in equation (3.20). Results are not significantly different when a third order polynomial is used instead. These polynomials are derived from a reduced form demand function for investment and reflect the market conditions in a particular industry, time and region. To control for changes in these market conditions, I estimate one polynomial for each industry and include year and region dummies in ϕ_j.[9]

Notice that in order to be able to include a given firm in the estimation, that firm needs to have a strictly positive level of investment; otherwise, the investment function is not strictly increasing in productivity and cannot be inverted to express productivity as a function of investment and capital in the first step. In practice, it is not unusual to find that the majority of firms report no investment for several years, which can reduce the sample size dramatically.[10] Because the Investment Climate Survey has purposively targeted high-growth sectors, a large fraction of the sample reports strictly positive investment. Between 70 and 80 percent of the firms producing apparel and leather goods, and vehicles and vehicles parts report non-zero investment; this fraction lies between 80 and 90 percent for the remaining sectors - electronic equipment, electronic components, and household appliances.

Results of production function coefficients by industry are displayed in Table 7. Industries are sorted by intensity in the use of labor. The most labor-intensive industries are the manufacturing of apparel and leather goods, where the ratio of the labor to capital coefficients, α_1/α_2, is above 2.4. Capital-intensive industries include the manufacturing of communications equipment, electron tubes, household appliances, and knitted textiles; the ratio α_1/α_2 ranges from 0.54 to 1.1 in these four cases. In all other industries - motor

[9] When a large number of firms is observed, full interaction terms between year and region dummies and all first order to fourth order terms in capital and investment can be included - which is equivalent to estimating different polynomials for each time period and region.

[10] Levinsohn and Petrin (2003) propose using intermediate inputs instead of investment to avoid this problem.

vehicles, vehicle parts, motorcycles, computers, audio and video, small appliances and other electronic components, α_1/α_2 is roughly between 1.4 and 2.

Productivity and ownership structure

Figure 2 shows the empirical density functions of the estimated η ($\log TFP$) for private domestic firms and majority foreign-owned firms (50 percent to 100 percent), averaged over the period 1998-2000, for 12 of the 15 industries (the excluded industries are the ones with the fewer number of observations). This graphs provide a first visual inspection of the distribution of productivities of foreign and domestic firms; if a pdf is to the right of the other and they intersect only once, there is first order stochastic dominance, where one of the implications is that it is more likely to get a higher draw from the right-most distribution. The first three graphs correspond to Apparel, Textiles and Leather, there is no evidence that foreign firms have a productivity advantage in these industries. In most remaining sectors, the pdf of majority foreign-owned firms stochastically dominates the pdf of private domestic firms (foreign firms are on average more productive); with the exceptions of the manufacture of electron tubes, of capacitors and resistors and of large household appliances.

As a more formal test for evidence of the existence (or absence) of productivity advantages in foreign firms, I regress estimated TFP on ownership structure and firm characteristics. The regression function takes the following form,

$$\eta_{ij} = x'_{ij}\delta_0 + \delta_1 FOR^1_{ij} + \delta_2 FOR^2_{ij} + \delta_3 NONPRIV_{ij} + \mu_{ij} \tag{3.22}$$

The ownership structure dummies are the same as in the Poisson regression: FOR^1, FOR^2 are dummies for minority and majority foreign-owned firms, respectively, and

$NONPRIV$ indicates that the firm is domestic and state or collectively owned. Other control variables are age, dummies for firms that started operating in 1998 and 1997 and industry and city effects. Since ownership variables are time invariant during the sample, there is no advantage from incorporating different time periods and the regression reduces to a cross-section of firms.

I run 2 separate regressions, one for industries in Textiles, Apparel and Leather (the first three industries in Figure 2) and a different regression for industries in Electronics, Machinery and Appliances. Hereafter, I refer to these two groupings of industries as Group 1 and Group 2, respectively. Table 8 displays the results from regression (3.22) with average TFP over the period 1998 to 2000 as the dependent variable; results are similar if TFP in 1998 is used instead. Column [1] shows the results for Group 1 (Textiles, Apparel and Leather) and column [3] the results for Group 2 (Electronics, Machinery and Appliances). Majority foreign-owned firms are on average 23 percent more productive than private domestic firms in industries in Group 2, while they have no advantage in industries in Group 1 (the coefficient is negative and not statistically significant).

The same pattern repeats when more categories of foreign ownership are included in the previous regression. In columns [2] and [4] (same table as before), I include two categories of fully foreign-owned firms (100 percent of foreign ownership): those owned by firms and those owned by investors. In these two regressions, the variable *Foreign 50%-100%* includes firms of up to 99 percent of foreign ownership. None of the categories of foreign firms have a productivity advantage in firms in Group 1 (coefficients are not significant - see column 2). Whereas in Group 2, firms with 50 to 99 percent of foreign capital are 22 percent more productive than private domestic firms; and fully foreign-owned firms that are owned by multinationals are 31 percent more productive than private domestic firms (column 4). On the other hand, fully foreign-owned firms that are owned by investors are not significantly more productive. This last finding supports the hypothesis of economies of scale and learning by doing, since firms owned by multinationals can take advantage of the experience that they have developed in other countries, while firms owned by investors cannot.

Minority foreign-owned firms (1 to 50 percent of foreign capital) are not more productive than domestic firms in either of the groups and specifications, furthermore, they are significantly less productive than domestic firms in Textiles, apparel and leather (30 percent less productive - columns 1 and 2). Non-private domestic firms are less productive than private domestic firms in Group 2, but the difference is not significant. In Group 1, newer firms are more productive. Regarding city effects, there is no differences in location for firms in Group 1; while in Group 2, firms located in Shanghai are the most productive, Beijing and Guangzhou follow, and firms in Tianjin and Chengdu are the least productive.[11]

Selection

Possible selection of foreign firms to most productive industries and cities is controlled for with industry and city effects. There is still a potential selection problem if firms of different origin face systematic differences in the costs of entry, as in Melitz (2003) and Helpman, Melitz and Yeaple (2004).[12] Suppose all foreign firms need to pay the same fixed

[11] Chengdu is an interior city, historically less developed than the other.

[12] Even another selection problem arises in the case of mergers and acquisitions, since foreign firms may be inclined to choose the most productive domestic firms.

cost of entry which is higher than the cost of entry paid by domestic firms. A firm finds it profitable to enter and/or to stay in the market (depending on when the uncertainty about profits unravels) if variable profits can cover the fixed costs, which translates into a cutoff for variable profits. If differences in variable profits depend solely on differences in TFP, the profitability condition can be expressed as a cutoff in the level of TFP necessary to find it profitable to stay in the market: firms with TFP above the cutoff can cover the fixed costs of entry while firms below the cutoff cannot and exit the market. Since the fixed cost of entry is higher for foreign firms than for domestic firms, the required TFP level is also higher for foreign firms. Consequently, the observed TFP levels are on average higher for foreign firms even in the case that the distribution of TFP is the same for both types of firms.

I address this question by estimating truncations in the distribution of TFP for foreign and domestic firms in each industry. Consider the distribution of TFP levels within a particular firm type (for example foreign) in one industry, and assume there is a cutoff, so that observed firms have TFP levels which are all above the cutoff (firms below the cutoff exit and are not captured in the data). As the number of firms goes to infinity, the lowest realized TFP converges to the cutoff level of TFP. Following this argument, I estimate the cutoffs for majority foreign-owned firms and private domestic firms in each industry by choosing the firms with the lowest estimates for TFP in each of the two ownership categories and industry. Let η_{Fj} and η_{Dj} be the estimators of the TFP cutoffs for foreign and domestic firms in industry j. They are defined by

$$\eta_{Fj} = \min_{\eta_{ij}} \{\eta_{1j}, \eta_{2j}, ...\} \text{ such that } i \text{ is a foreign firm} \quad (3.23)$$

$$\eta_{Dj} = \min_{\eta_{ij}} \{\eta_{1j}, \eta_{2j}, ...\} \text{ such that } i \text{ is a domestic firm.}$$

Table 9 displays the difference in cutoffs $(\eta_{Fj} - \eta_{Dj})$ for each industries. The difference is positive and significant only for two industries: Communications equipment and Motor vehicles.

Ten percent confidence intervals are constructed by bootstrapping firms and recomputing the cutoffs for each bootstrap sample. I take a thousand bootstrap samples of firms. For each sample, I reestimate the production function and measured TFP, and I find $\left(\eta_{Fj} - \eta_{D_j}\right)$ - they do not necessarily correspond to the same firm in each sample. With these results, I construct the 10 percent confidence interval for the difference in minimum measured TFP's by computing the 5 and 95 percentiles.[13]

Note that this is not strictly a test for the existence of cutoffs in TFP. When the difference is statistically significant, it means that the lower bounds of the supports of the distribution of TFP levels of firms that stay in the market are different for foreign and domestic firms; this may be due to the decision of firms to exit the market (cutoffs) or just to the fact that the supports of the full distributions (without the truncation resulting from selection) do not coincide. On the contrary, the *absence* of a statistically significant difference, is evidence that unequivocally contradicts the existence of cutoffs.

In the case of cutoffs, the selection bias arises because domestic firms with TFP levels between η_{Fj} and η_{Dj} stay in the market and are included in the sample in the estimation of (3.22) , while foreign firms with TFP in this range are not observed. In Table 8, column

[13] The result is suggestive of the absence of differences in productivity cutoffs for foreign and domestic firms - except for firms that manufacture communication equipment and motor vehicles. The formal validity of the procedure depends on the validity of the bootstrapped standard errors, which is not guaranteed because the procedure involves the estimation of a boundary parameter.

[5], I reestimate the regression of TFP on ownership of column [3] excluding the domestic firms with TFP between the two cutoff levels in the two industries with significant cutoffs (Communications equipment and Motor vehicles). That is, I take a uniform truncation point, given by η_{Fj} and include only firms that are above η_{Fj}, no matter their origin. In this case, majority foreign-owned firms are 20 percent more productive than their private domestic counterparts. As noted above, this method would not be correct if the difference in η_{Fj} and η_{Dj} is due to differences in the lower bounds of the support rather than on cutoffs. The regression is just a robustness check: majority foreign-owned firms are substantially more productive than domestic firms, even when the less productive domestic firms are not included in the comparison.

Productivity versus profitability

Theoretical production functions explain quantities of output with quantities of inputs. However, when production functions are estimated, quantities of output and some inputs are replaced with values. The basic reason to use values instead of quantities is that even at a very detailed industrial disaggregation, products are heterogeneous and quantities cannot be directly compared, using values is arguably a good way to control for differences in quality. It can be argued that there is also a pure practical reason to use values: that firm-level data usually includes only values and not firm-level prices. This is actually a similar reason as the first: a particular firm usually produces more than one product and there is no such thing as a firm-level price, values are needed even to compare or aggregate goods produced by the same firm.

Klette and Griliches (1996) have pointed out that the estimators from a production function regressions using values of output are inconsistent. The problem comes from the fact that the value of output includes both prices and quantities, while quantities can be directly linked to inputs through the production function, prices are the result of the interaction of supply and demand. Therefore, price times quantity is not reflecting just the production side, it also includes demand and market structure since prices are an equilibrium outcome that depend on these forces in addition to technology. Klette and Griliches focus on estimators of returns to scale, but the same argument can be applied to the estimators of TFP. The resulting estimates of TFP can be considered efficiency in generating value of output rather than just efficiency in production. To address this problem, it is necessary to include information about the demand and market structure into the estimation.

Katayama, Lu and Tybout (2003) use a model of oligopoly with differentiated products and extend the argument to different data scenarios. They show that firms that face a more inelastic demand are able to charge higher prices and they appear to be more productive according to the TFP estimates.

To sum up, it is likely that measured TFP is capturing profitability in a broader sense rather than strict technical efficiency. This issue is not particularly important in the context of the present application. In the model of section (3.2) , I show how the introduction of new varieties depends on profits. For expositional simplicity, profits differ by firm only because of differences in productive efficiency, but the model could be easily adapted to include demand parameters that vary per product. In this latter case, profits depend on both productive efficiency and the demand side (although the CES assumption does not allow for different demand elasticities and mark-ups are the same for all varieties even when they enter the utility function asymmetrically). Consequently, capturing a firm's profitability instead of productive efficiency would not bias the results in the present case, quite the contrary, it may be desirable to do so and give the correct interpretation of profitability rather than productivity to the TFP estimates.

One consequence of capturing profitability in addition to technical efficiency when measuring TFP in the present context is that measured TFP is presumably higher after firms introduce new varieties. The number of new varieties affects the value of output not only through quantities but also through prices; firms that introduce more new goods earn higher profits and are measured as more "productive.[14]" In Section 3.5.3, I include TFP as an explanatory variable in the Poisson regression of the number of new varieties. As I explain in that section, I use estimated TFP in 1998 instead of average TFP during 1998–2000 to avoid a reverse causality problem.

3.5.2 Is the cost of innovation lower for foreign firms?

I first take a look at different ways in which firms introduce new products by running three different probit regressions among firms that did introduce a positive number of new varieties. The dependent variables in each of these regressions are whether firms have transferred at least one new variety from a company in the same corporate group, whether they have purchased at least one license for a new product from a foreign source, and whether they have developed at least one new variety in-house (for multinational firms, this means in the subsidiaries located in China). The explanatory variables are ownership structure, captured by the same categories as in the TFP analysis

[14] As a consequence, a fixed effect estimator for TFP would not be accurate as it would be assumed that TFP is constant over time.

(majority foreign-owned, minority foreign-owned, private domestic, collectively owned), the logarithm of the number of workers, the logarithm of age, dummy variables for firms that started production in 1997 and 1998, industry and city fixed-effects.

Results are displayed in Table 10 and they can be interpreted straighforwardly: majority foreign-owned firms are 17 percent more likely to transfer new products from a firm in a the same corporate group than are private domestic firms, they are 38 percent more likely to purchase foreign licenses, and they are 19 percent less likely to develop products in-house. All results are significant. The difference in the probability of occurrence of any of these three events is not significant for minority foreign-owned firms and collectively-owned firms (the baseline category is private domestic firms).

The fact that foreign firms purchase more licenses and developed less products in the Chinese facilities than domestic firms do, does not imply that they have access to technology at a lower cost. It might well be the case that they need to purchase technology from outside sources because they are not efficient at in-house R&D. On the other hand, foreign multinationals transfer more goods from other firms in the same corporate groups, which is in fact an indicator of economies of scale in R&D production.

To address the question of whether foreign firms have a cost advantage in the introduction of new goods in a more direct way, I look at the expenditure on R&D plus expenditure on purchases of technology from outside sources over the period 1998-2000 per new variety successfully introduced, as a proxy for the average fixed cost of introducing new goods. For foreign multinationals, I only consider expenditure on R&D by the Chinese subsidiaries, to assess the marginal cost of introducing new varieties in China, not elsewhere.

Table 11 shows the results of a regression of this proxy for development costs on ownership structure categories (same as above). Controlling for total sales in 1998, self-reported market share, logarithm of age, dummies for firms that started operating in 1997 and 1998, and industry and city effects, majority foreign-owned firms have a cost advantage of 838 thousand dollars compared to private domestic firms (column [1]), although this estimated difference is not statistically significant. When instrumenting for market share with the self-reported number of competitors, the advantage for majority-owned foreign firms is 965 thousand dollars and significant at the 10 percent level. Fully foreign-owned firms are included separately in columns [3] and [4]. These firms have cost advantages of 1.6 and 1.2 million dollars per product in the least squares and instrumental variables regression, respectively. Minority foreign-owned firms are also more cost efficient than private domestic firms, on the four specifications, but the coefficients are imprecisely estimated.

3.5.3 How much does each factor explain?

Foreign firms in Group 2 (Electronics, Machinery and Appliances) appear to have a cost advantage over domestic firms, both in productivity and in the incorporation of new technology, as measured by TFP and expenditures on R&D and purchases of outside technology. In this section, I estimate the extent to which these differences affect the ability of firms to introduce new varieties of goods.

I reestimate the regressions that explain the number of new varieties (section (3.4)) including the estimates for TFP (η) and the expenditure of R&D and purchases of outside technology per new product introduced (RD) over the sample of firms that introduce a positive number of new varieties. RD is a proxy for the average cost of innovation. The Poisson regression takes the form,

$$E(n_i|.) = \exp(x_i'\beta_0 + \beta_1 FOR_{1i} + \beta_2 FOR_{2i} + \beta_3 NONPRIV_i + \beta_4 \eta_i + \beta_5 RD_i) \quad (3.24)$$

where x are firm characteristics (number of workers, market share, age and initial year dummies), FOR_1, FOR_2 and $NONPRIV$ are the ownership dummies, and n_i is the number of varieties introduced during the period 1998-2000. η is estimated TFP during 1998. The reason to use estimates for 1998 instead of 1999, 2000 or the average is that these measures may suffer from a reverse causality problem. As discussed above, TFP estimates may not only reflect technical efficiency but also include demand factors that affect prices and consequently the value of output used to compute TFP. In principle, measured TFP can be affected by the number of products introduced. Using estimates of TFP for 1998 minimizes this potential problem.

Using an estimated value of TFP instead of the true value does not lead to an inconsistent estimator for the vector $\boldsymbol{\beta}$. Unlike the case of measurement error in survey data, the error in the estimation of TFP converges to zero asymptotically since η is a consistent estimator for TFP. Ignoring the fact that TFP is previously estimated, however, does lead to inconsistent standard errors for $\boldsymbol{\beta}$. To compute consistent standard errors I take 100 bootstrap samples of firms and re-estimate the production functions, TFP and regression (3.24) for each sample.

Results from Poisson, Negative Binomial and Least Squares regressions are reported in Table 12, with and without instrumenting for market share (the instrument is the number of competitors). The effect of TFP on the number of new varieties is positive and significant in the three specifications. In the Poisson and Negative Binomial case an increase of 10 percent in TFP explains the introduction of approximately 50 percent more new varieties (see the incidence ratios in the lower panel). In the Least Squares specification, a 10 percent increase in TFP explains the introduction of 2.6 more new varieties. The coefficient of the cost of innovation (RD) has the expected negative sign (firms with higher cost of innovation introduce less new products) but it is not significant in any of the specifications.

Table 13 displays the results of similar regressions as Table 12, with the addition of exports as a fraction of total sales as an explanatory variable. Firms that export have access to larger markets and presumably could derive larger profits from the introduction of a new variety than a firm that operates only in the Chinese domestic market; this effect would lead to the introduction of more new varieties than domestic firms. Empirically, however, there is no correlation between the number of new varieties and exports; coefficients in Table 13 are not significant.

To assess the impact of cost heterogeneity on the number of new varieties, I perform a decomposition of the predicted number of new varieties for two groups of firms - majority foreign-owned and private domestic - on the different explanatory factors.

Consider firstly the case of a linear specification, as the Least Squares regression of Table 12. The conditional expectation takes the form,

$$E\left[n_i | x_i, \eta_{i,} RD_i\right] = x_i' \beta_0 + \beta_4 \eta_i + \beta_5 RD_i. \tag{3.25}$$

For simplicity of notation, I include the ownership variables FOR_1, FOR_2 and $NONPRIV$ in x. Let $\widehat{n}_F$ be the predicted number of products for foreign firms, evaluated at the mean of x, η and RD over the sample of majority foreign-owned firms. That is, $\widehat{n}_F = \overline{x}_F{}' \widehat{\beta}_0 + \widehat{\beta}_4 \overline{\eta}_F + \widehat{\beta}_5 \overline{RD}_F$, where $\overline{x}_F$, $\overline{\eta}_F$ and $\overline{RD}_F$ are the means of x, η, and RD over this particular sample. Let $\widehat{n}_D$, $\overline{x}_D$, $\overline{\eta}_D$ and $\overline{RD}_D$ be the means computed over private domestic firms. By subtracting the predicted values $\widehat{n}_F$ and $\widehat{n}_D$ we obtain the following decomposition

$$(\widehat{n}_F - \widehat{n}_D) = (\overline{x}_F - \overline{x}_D)' \widehat{\beta}_0 + \widehat{\beta}_4 (\overline{\eta}_F - \overline{\eta}_D) + \widehat{\beta}_5 \left(\overline{RD}_F - \overline{RD}_D\right). \tag{3.26}$$

The total contribution of differences in TFP to differences in the number of products between majority foreign-owned firms and private domestic firms is given by

$$\frac{\widehat{\beta}_4 (\overline{\eta}_F - \overline{\eta}_D)}{(\overline{x}_F - \overline{x}_D)' \widehat{\beta}_0 + \widehat{\beta}_4 (\overline{\eta}_F - \overline{\eta}_D) + \widehat{\beta}_5 \left(\overline{RD}_F - \overline{RD}_D\right)}. \tag{3.27}$$

The definition for the contribution of RD is analogous.

Consider now the Poisson case,

$$E\left[n_i | x_i, \eta_{i,} RD_i\right] = \exp\left(x_i' \beta_0 + \beta_4 \eta_i + \beta_5 RD_i\right) \tag{3.28}$$

The predicted number of products for foreign firms is given by the specification of the conditional mean: $\widehat{n}_F = \exp\left(\overline{x}_F{}' \widehat{\beta}_0 + \widehat{\beta}_4 \overline{\eta}_F + \widehat{\beta}_5 \overline{RD}_F\right)$, the definition is analogous for domestic firms. Because this expression is non-linear in the explanatory variables, it is convenient to consider incidence ratios. The predicted number of new varieties is $\frac{\widehat{n}_F}{\widehat{n}_D}$ times larger for foreign firms, and this ratio can be written as,

$$\frac{\widehat{n}_F}{\widehat{n}_D} = \exp\left[(\overline{x}_F - \overline{x}_D)' \widehat{\beta}_0 + \widehat{\beta}_4 (\overline{\eta}_F - \overline{\eta}_D) + \widehat{\beta}_5 \left(\overline{RD}_F - \overline{RD}_D\right)\right]. \tag{3.29}$$

In this non-linear case, there are different ways to define the contribution of a particular variable (for example η) to the difference in the number of products between foreign and domestic firms. I take the contribution to explain the index, given by

$$\frac{\widehat{\beta}_4 (\overline{\eta}_F - \overline{\eta}_D)}{(\overline{x}_F - \overline{x}_D)' \widehat{\beta}_0 + \widehat{\beta}_4 (\overline{\eta}_F - \overline{\eta}_D) + \widehat{\beta}_5 \left(\overline{RD}_F - \overline{RD}_D\right)}, \tag{3.30}$$

which is exactly the same as in the Least Squares case.

In Table 14, I construct the ratios in (3.27) and (3.30) for TFP, cost of innovation and exports using the estimates in Tables 12 and 13 (Table 13 includes exports as an explanatory variable). Differences in TFP between foreign and domestic firms explain between 13 percent and 31 percent of the predicted advantage of foreign firms in the introduction of new varieties, while differences in the cost of R&D and purchases of new technology explain between 0 percent and 2 percent of this advantage. The difference attributable to export share of sales lies between 0 and 7 percent. In the Least Squares case, the predicted difference in the number of new varieties is by construction equal to the observed difference. The total explanatory power of both factors of cost heterogeneity lies between 13 and 33 percent; when exports are included in the regression, the three factors together explain between 21 and 28 percent.

3.6 Conclusion

This paper describes some aspects of the introduction of new goods in the Chinese manufacturing sector by domestic and foreign firms, and provides empirical evidence on the effects of advantages in TFP and the cost of innovation of foreign firms.

Firms with more than 50 percent of foreign capital introduce twice the number of new products as privately-owned domestic firms; and firms fully owned by multinationals introduce three times as many new products. Differences in TFP and the cost of innovation are explored as possible explanations for the difference in the number of new varieties. The hypothesis is that foreign firms have already introduced the same or similar varieties in foreign markets and have already incurred development costs and gained experience in production; as a result, both the cost of innovation and of production are lower in China when compared to the cost of domestic firms (that operate only in the Chinese market) that have to set up the production of new varieties from scratch.

I find that majority foreign-owned firms are more efficient than domestic firms in the manufacturing of Electronics, Machinery and Appliances, but not in the production of Apparel, Textiles and Leather goods. They have an advantage in costs of innovation (measured as expenditure on R&D plus purchases of outside technology by Chinese subsidiaries per new variety introduced into the Chinese market), although it is not statistically significant. The advantage in TFP explains between 13 and 31 percent of the predicted difference in the number of new varieties between foreign and domestic firms; the lower cost of innovation explains only up to 2 percent of the difference.

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TABLE 1. Summary statistics by ownership type

Type of firm	Number of firms	Median number of workers	Average Output per worker	Average number of new products
	[1]	[2]	[3]	[4]
Private domestic	279	172	207	2.7
State-owned	171	602	70	2.8
Cooperative	139	286	97	1.1
Foreign 1%-50%	81	223	254	3.6
Foreign 50%-99%	148	306	483	4.5
Foreign 100%	41	165	470	4.8
All firms	859	269	226	3.0

FIGURE 1. Distribution of foreign ownership

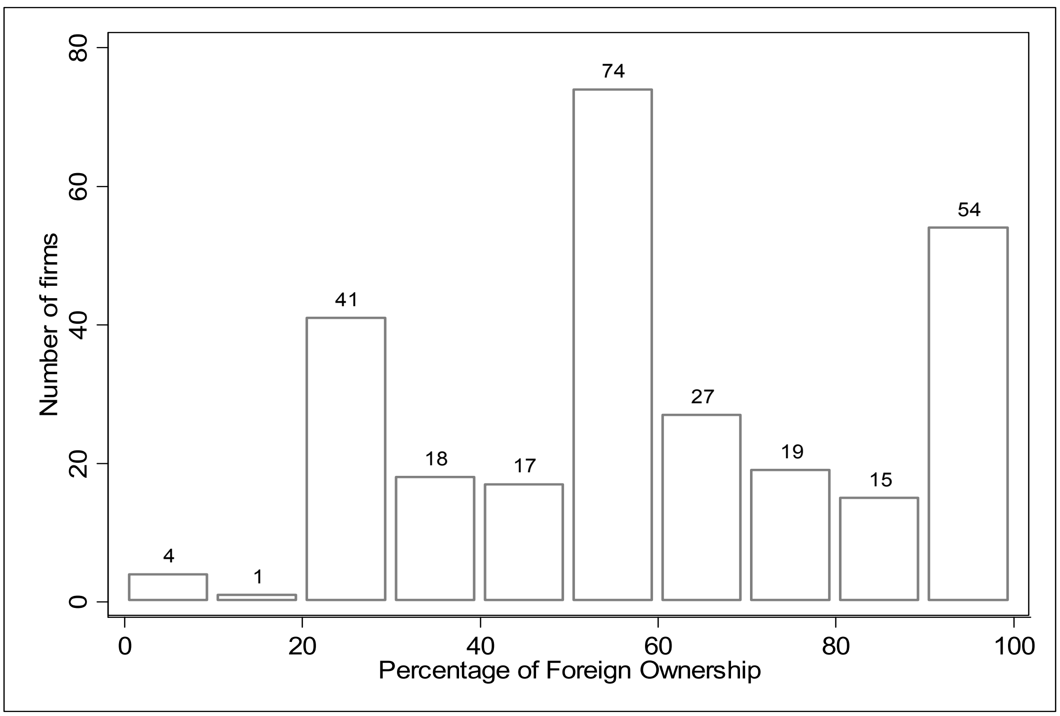

TABLE 2. Industrial sectors included in the survey

	INDUSTRY CODES
APPAREL AND LEATHER GOODS	
Apparel manufacturing	181, 1923, 1952
Leather tanning and finishing; product manufacturing	191, 192
Textiles	178
ELECTRONIC EQUIPMENT	
Computer and peripheral equipment manufacturing	414, 4171,4172
Communications equipment manufacturing	411
Audio and video equipment manufacturing	413
ELECTRONIC COMPONENTS	
Electron tube manufacturing	4151
Printed circuit manufacturing and assemble	4155
Semiconductor and related device manufacturing	4153, 3617
Electronic capacitors, resistors, coils, transformers, connectors	416, 4021, 4023, 4024
CONSUMER PRODUCTS	
Household cooking, refrigerating and laundry appliances	4066, 4069, 4063, 4061
Small electrical appliance manufacturing	4069
VEHICLES AND VECHICLE PARTS	
Motor vehicle manufacturing, including body and trailer	3721, 3725, 3726
Motor vehicle accessories	3727, 3512, 4222, 3727
Motorcycle, bicycle and parts manufacturing	373, 374

TABLE 3. Poisson regression of number of new varieties on foreign ownership

	Poisson [1]	[2]	[3]	2-Step Poisson [4]	[5]
Foreign 50%-100%	0.707***	0.607**	0.619**	0.797**	0.823***
	0.273	*0.269*	*0.285*	*0.325*	*0.313*
Foreign 1%-50%	-0.181	-0.213	-0.167	-0.117	-0.150
	0.257	*0.262*	*0.244*	*0.267*	*0.261*
Non-Private	-0.447**	-0.494**	-0.442*	-0.300	-0.350
	0.242	*0.245*	*0.247*	*0.258*	*0.237*
logWorkers	0.130**	0.152**	0.111**	0.156**	-
	0.064	*0.062*	*0.050*	*0.065*	
Market share	0.012***	0.011***	0.012***	0.007	0.009**
	0.003	*0.003*	*0.003*	*0.004*	*0.004*
logAge	0.133	0.175	0.123	0.083	0.185
	0.123	*0.119*	*0.121*	*0.135*	*0.130*
Initial Year dummies	Yes	Yes	Yes	Yes	Yes
City effects	Yes	-	-	Yes	Yes
Industry effects	Yes	Yes	-	Yes	Yes
INCIDENCE RATIOS					
Foreign	2.03	1.83	1.86	2.22	2.28
Foreign 1%-50%	0.83	0.81	0.85	0.89	0.86
Non-Private	0.64	0.61	0.64	0.74	0.70
logWorkers	3.67	4.57	3.03	4.76	-
Market share	1.13	1.12	1.13	1.07	1.09
logAge	3.77	5.73	3.44	2.30	6.36

Dependent variable: number of new varieties. Other controls: setup up year dummies. Standard errors in italics. ***, ** and * indicate significancy at the 1%, 5% and 10% level. Incidence ratios are computed for a discrete change in categorical variables and a 10% change in continuous variables.

TABLE 4. Poisson regression of number of new varieties on foreign ownership

	Foreign ownership dummy		Percentage of foreign ownership	
	Poisson [1]	2S-Poisson [2]	Poisson [3]	2S-Poisson [4]
Foreign	0.473**	0.554*	0.007**	0.010**
	0.246	*0.293*	*0.003*	*0.004*
Non-Private	-0.407*	-0.251	-0.440**	-0.265
	0.242	*0.268*	*0.218*	*0.238*
logWorkers	0.142**	0.162**	0.141**	0.163**
	0.065	*0.065*	*0.065*	*0.064*
Market share	0.012***	0.007	0.011***	0.006
	0.003	*0.005*	*0.003*	*0.004*
logAge	0.086	0.048	0.092	0.057
	0.125	*0.131*	*0.125*	*0.129*
INCIDENCE RATIOS				
Foreign	1.60	1.74	1.07	1.11
Non-Private	0.67	0.78	0.64	0.77
logWorkers	4.14	5.07	4.10	5.12
Market share	1.13	1.07	1.12	1.06
logAge	2.36	1.62	2.51	1.77

Dependent variable: number of new goods. The definition of the explanatory variable *Foreign* differs by column. In [1] and [2], *Foreign* is a dummy variable for firms with 1%-100% of foreign ownership. In [3] and [4], *Foreign* is a continuous variable defined over [0, 100] and indicates the percentage of foreign ownership. Incidence ratios are computed for a discrete change in categorical variables and a 10% change in continuous variables. Other controls: setup up year dummies, city and industry effects. Standard errors in italics. ***, ** and * indicate significancy at the 1%, 5% and 10% level.

TABLE 5. Fully foreign-owned firms

	Poisson		2-Step Poisson	
	[1]	[2]	[3]	[4]
Foreign 1%-50%	-0.182	-0.184	-0.137	-0.139
	0.255	*0.253*	*0.257*	*0.257*
Foreign 50%-99%	0.705**	0.702**	0.728**	0.726**
	0.307	*0.304*	*0.327*	*0.325*
Foreign 100%	0.712*	1.203**	1.025*	1.460**
	0.411	*0.488*	*0.597*	*0.723*
Foreign 100% - Investor	-	-0.252	-	-0.176
		0.429		*1.539*
INCIDENCE RATIOS				
Foreign 1%-50%	0.83	0.83	0.87	0.87
Foreign 50%-99%	2.02	2.02	2.07	2.07
Foreign 100%	2.04	3.33	2.79	4.31
Foreign 100% - Investor	-	0.78	-	0.84

Poisson regression of the number of new varieties. [1]: Foreign 100% includes all firms with no domestic participation. [2]: Foreign 100% includes firms with no domestic participation that are owned by a foreign firm, while Foreign 100% - Investor indicates that the firm is owned by a foreign investor, not a firm. Other controls: Non-Private, logWorkers, Market share, logAge, setup year dummies, industry effects, city effects. Standard errors in italics. ***, ** and * indicate significancy at the 1%, 5% and 10% level.

TABLE 6. Robustness to distributional assumptions

	Negative binomial	ZIP second step: Number of new goods	ZIP first step: Prob. of zero new goods	OLS
	[1]	[2]	[3]	[4]
Foreign 50%-100%	0.801***	0.667***	-0.226	2.617**
	0.259	*0.238*	*0.363*	*1.251*
Foreign 1%-50%	-0.135	-0.240	-0.968	-0.212
	0.208	*0.289*	*0.638*	*0.630*
Non-Private	-0.528***	-0.429*	0.080	-0.840
	0.194	*0.239*	*0.387*	*0.622*
logWorkers	0.245***	0.097	-0.467***	0.413**
	0.061	*0.069*	*0.177*	*0.174*
Market share	0.011***	0.004	-0.165***	0.044***
	0.003	*0.003*	*0.059*	*0.017*
logAge	0.141	0.132	-0.042	0.324
	0.110	*0.135*	*0.228*	*0.371*
INCIDENCE RATIOS				
Foreign 50%-100%	2.23	1.95		
Foreign 1%-50%	0.87	0.79		
Non-Private	0.59	0.65		

Dependent variable: number of new varieties. Standard errors in italics. ***, ** and * indicate significancy at the 1%, 5% and 10% level. Other controls: setup year dummies, industry fixed effects, city effects

TABLE 7. Production function coefficients

	Labor		Capital	
Leather	0.69	*0.09*	0.25	*0.44*
Apparel	0.67	*0.06*	0.27	*0.14*
Bare printed circuits	0.65	*0.38*	0.31	*0.43*
Semiconductor and related devices	0.56	*0.16*	0.28	*0.25*
Motor vehicles	0.68	*0.15*	0.34	*0.44*
Audio and video equipment	0.56	*0.21*	0.32	*0.11*
Computer equipment	0.49	*0.14*	0.28	*0.13*
Motor vehicles accessories	0.46	*0.07*	0.27	*0.14*
Motorcycles, bicycles and parts	0.51	*0.31*	0.32	*0.36*
Electronic capacitors, resistors and related	0.58	*0.15*	0.38	*0.19*
Small electrical appliances	0.54	*0.11*	0.39	*0.37*
Textiles	0.49	*0.24*	0.44	*0.24*
Large household appliances	0.55	*0.18*	0.53	*0.26*
Communications equipment	0.39	*0.15*	0.45	*0.21*
Electron tube manufacturing	0.32	*0.14*	0.59	*0.24*

Standard errors in italics

FIGURE 2. Distribution of TFP

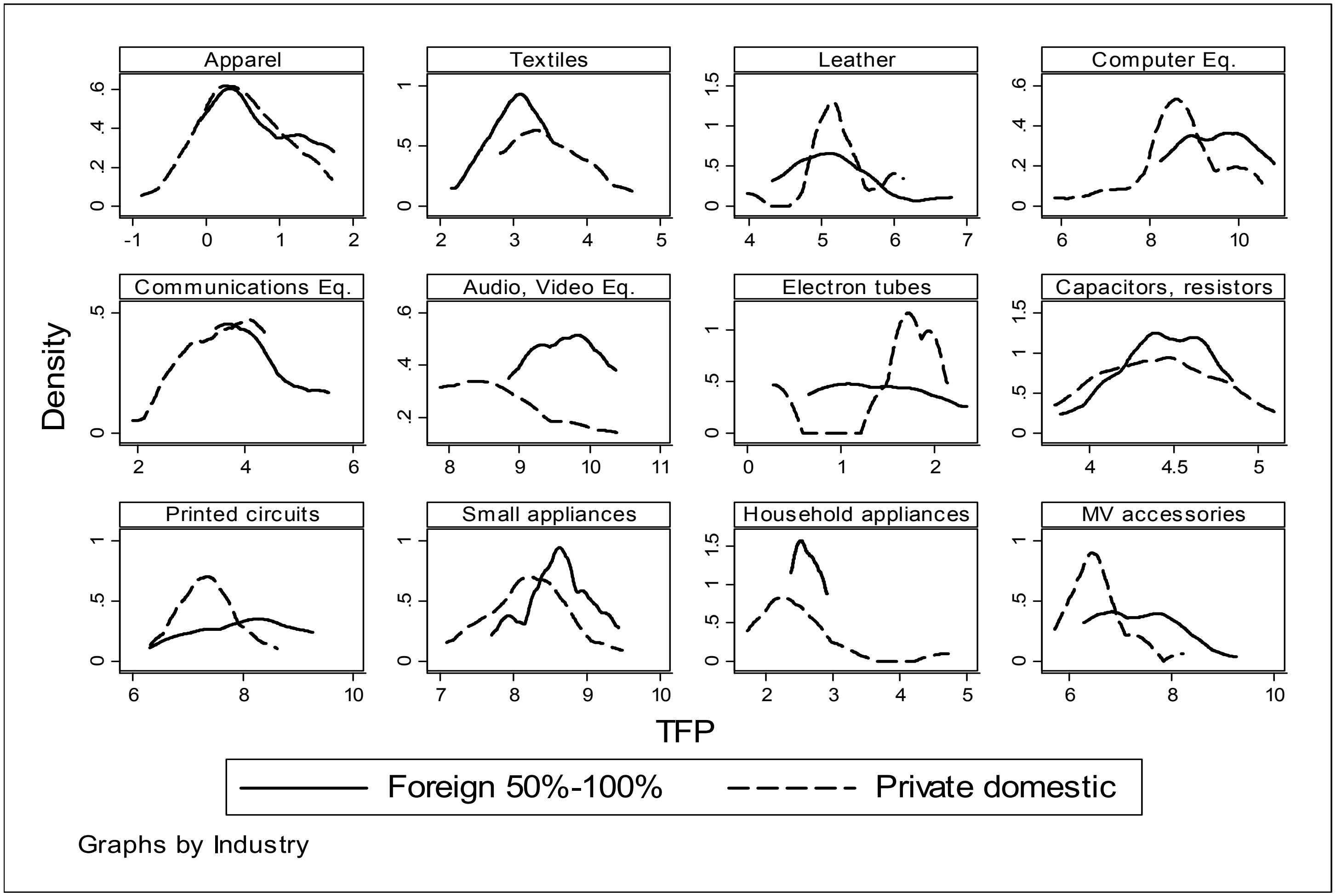

TABLE 8. Regression of average TFP on ownership structure

	Group 1		Group 2		Cutoff
	[1]	[2]	[3]	[4]	[5]
Foreign 50%-100%	-0.153	-0.181	0.226***	0.217***	0.196***
	0.133	*0.144*	*0.074*	*0.080*	*0.072*
Foreign 100% - Firms	-	0.045	-	0.314*	-
		0.156		*0.174*	
Foreign 100% - Investors	-	-0.074	-	0.221	-
		0.236		*0.178*	
Foreign 1%-50%	-0.305**	-0.305**	-0.012	-0.013	-0.009
	0.139	*0.141*	*0.087*	*0.087*	*0.086*
Non-Private	0.047	0.049	-0.084	-0.085	-0.099
	0.138	*0.139*	*0.075*	*0.075*	*0.075*
log Age	-0.301***	-0.302***	-0.004	-0.003	0.007
	0.072	*0.072*	*0.042*	*0.042*	*0.042*

Group 1: Textiles, apparel and leather. Group 2: Electronics, machinery and appliances. The definition of Foreign 50%-100% depends on the column; in columns [1], [3] and [5] it includes fully foreign-owned firms, while in columns [2] and [4], fully foreign-owned firms are included in two separate categories (Foreign100% - Firm, and Foreign 100% - Investors). Column [5] does not include firms below the estimated producitvity cutoff. Other controls: setup year dummies, industry and city effects. Standard errors in italics; *, ** and *** indicates significance at the 10%, 5% and 1% level.

TABLE 9. Difference in minimum estimated TFP levels between majority foreign-owned firms and private domestic firms

Apparel	0.69
Textiles	-0.67
Leather	0.35
Computer equipment	2.35
Communications equipment	1.68*
Audio and video equipment	1.14
Electron tube manufacturing	0.38
Semiconductors and related devices	0.35
Electronic capacitors, resistors and related	-0.06
Bare printed circuits	0.26
Small electrical appliances	0.67
Large household appliances	0.50
Motorcycle, bicycle and parts	0.84
Motor vehicles	2.80*
Motor vehicles accessories	0.60

* Indicates that it is significant at the 10% level. 90% confidence intervals constructed with 1,000 bootstrapped replications

TABLE 10. Ways in which firms introduce new varieties

	Transferred [1]	Licensed [2]	In-house [3]
Foreign 50%-100%	0.174***	0.379***	-0.189**
	0.073	*0.083*	*0.079*
Foreign 1%-50%	-0.014	-0.027	0.000
	0.065	*0.074*	*0.084*
Non-Private	-0.081	0.017	-0.064
	0.049	*0.073*	*0.062*

Probit regressions. Table displays incremental effect of regressors. Dependent variables: [1] Transferred at least one new good from company in same corporate group; [2] Purchased at least one license from a foreign source;[3] Developed a new good in house. Regressions only include firms that introduced new goods. Other controls: logWorkers, logAge, set-up year dummies, industry dummies, city effects. Standard errors in italics. ***, ** and * indicate significancy at the 1%, 5% and 10% level.

TABLE 11. Expenditure on technology

	OLS [1]	IV [2]	OLS [3]	IV [4]
Foreign 1%-50%	-0.385	-0.622	-0.583	-0.542
	0.441	*0.445*	*0.450*	*0.493*
Foreign 50%-100%	-0.838	-0.965*	-0.816	-0.711
	0.535	*0.572*	*0.585*	*0.628*
Foreign 100%	-	-	-1.655**	-1.246**
			0.737	*0.534*
Non-Private	-0.549*	-0.621**	-0.598*	-0.480
	0.306	*0.315*	*0.316*	*0.299*
Sales	0.0025***	0.0025***	0.0025***	0.0057***
	0.0007	*0.0007*	*0.0007*	*0.0016*
Market share	0.0029	0.0016	0.0021	0.0031
	0.0061	*0.0187*	*0.0189*	*0.0062*
logAge	-0.147	-0.192	-0.185	-0.133
	0.198	*0.203*	*0.204*	*0.200*

Robust standard errors in italics. ***, ** and * indicate significancy at the 1%, 5% and 10% level. Dependent variable is expenditure in R&D including purchases of technology from outside sources, measured in 1998 millions of dollars. Regressions only include firms that introduced new goods. Other controls: setup year dummies, industry and city effects.

TABLE 12. Number of new varieties

	Poisson	2-Step Poisson	Negative Binomial	2-Step Neg. Binomial	OLS	IV
	[1]	[2]	[3]	[4]	[5]	[6]
Foreign 50%-100%	0.498	0.499	0.431	0.441	3.477	5.811*
	0.318	*0.331*	*0.274*	*0.290*	*2.446*	*3.346*
Foreign 1%-50%	-0.362	-0.332	-0.334	-0.315	-1.923	0.948
	0.256	*0.261*	*0.243*	*0.261*	*1.489*	*2.828*
Non-Private	-0.529*	-0.407	-0.378	-0.279	-3.189**	-2.742
	0.277	*0.271*	*0.235*	*0.234*	*1.628*	*1.871*
TFP 1998	0.439**	0.430**	0.392**	0.382**	2.628**	2.704**
	0.189	*0.188*	*0.156*	*0.156*	*1.176*	*1.367*
R&D and Licenses	-0.075	-0.072	-0.029	-0.029	-0.233	-0.123
	0.053	*0.051*	*0.037*	*0.038*	*0.173*	*0.249*
logWorkers	0.086	0.063	0.105	0.090	0.624	-0.264
	0.079	*0.078*	*0.068*	*0.071*	*0.467*	*0.713*
Market share	0.011***	0.009*	0.008**	0.005	0.075**	0.369**
	0.003	*0.005*	*0.003*	*0.005*	*0.027*	*0.183*
logAge	0.156	0.123	0.089	0.071	1.041	2.303**
	0.118	*0.124*	*0.110*	*0.120*	*0.736*	*1.150*
INCIDENCE RATIOS						
Foreign 50%-100%	1.645	1.648	1.539	1.555		
Foreign 1%-50%	0.696	0.718	0.716	0.730		
TFP 1998	1.551	1.537	1.480	1.465		
R&D and Licenses	0.928	0.930	0.972	0.972		

Dependent variable: number of new goods. Incidence ratios computed for a change of one unit for continuous variables. Other controls: setup up year dummies, industry and city fixed effects. Standard errors in italics. ***, ** and * indicate significancy at the 1%, 5% and 10% level.

TABLE 13. Number of new varieties

	Poisson	2-Step Poisson	Negative Binomial	2-Step Neg. Binomial	OLS	IV
	[1]	[2]	[3]	[4]	[5]	[6]
Foreign 50%-100%	0.475	0.449	0.501	0.411	3.676	3.191
	0.544	*0.749*	*0.408*	*0.579*	*4.945*	*6.474*
Foreign 1%-50%	-0.210	-0.209	-0.149	-0.225	-0.730	0.660
	0.382	*0.654*	*0.323*	*0.604*	*3.027*	*4.997*
Non-Private	-0.714	-0.721	-0.610	-0.662	-3.656	-1.037
	0.484	*0.653*	*0.401*	*0.540*	*3.234*	*4.965*
TFP 1998	0.400	0.379	0.273	0.271	3.106	3.342
	0.296	*0.339*	*0.221*	*0.240*	*2.383*	*3.006*
R&D and Licenses	-0.059	-0.056	-0.030	-0.030	-0.388	-0.235
	0.083	*0.082*	*0.064*	*0.062*	*0.449*	*0.689*
logWorkers	0.155	0.141	0.132	0.112	1.186	0.028
	0.134	*0.213*	*0.105*	*0.178*	*1.149*	*1.885*
Market share	0.006	0.000	0.003	-0.003	0.039	0.337
	0.005	*0.042*	*0.004*	*0.037*	*0.035*	*0.393*
logAge	-0.038	-0.041	0.034	0.024	-0.154	0.778
	0.237	*0.335*	*0.181*	*0.281*	*1.582*	*2.442*
Exports	0.247	0.324	-0.009	0.061	1.708	5.160
	0.360	*0.488*	*0.302*	*0.427*	*2.358*	*4.202*
INCIDENCE RATIOS						
Foreign 50%-100%	1.608	1.567	1.650	1.508		
Foreign 1%-50%	0.811	0.811	0.862	0.799		
TFP 1998	1.492	1.460	1.314	1.311		
R&D and Licenses	0.943	0.945	0.970	0.970		
Exports	1.280	1.383	0.991	1.063		

Dependent variable: number of new goods. Incidence ratios computed for a change of one unit for continuous variables. Other controls: setup up year dummies, industry and city fixed effects. Standard errors in italics. ***, ** and * indicate significancy at the 1%, 5% and 10% level.

TABLE 14. Decomposition

	Poisson [1]	2-Step Poisson [2]	Negative Binomial [3]	2-Step Neg. Binomial [4]	OLS [5]	IV [6]
Coefficients from TABLE 12						
TFP 1998	23.4%	24.6%	28.3%	31.4%	19.4%	12.9%
R&D and Licenses	2.0%	2.1%	1.1%	1.2%	0.9%	0.3%
Coefficients from TABLE 13						
TFP 1998	21.3%	21.7%	19.7%	22.3%	22.9%	16.0%
R&D and Licenses	1.6%	1.7%	1.1%	1.3%	1.5%	0.6%
Exports	3.7%	5.3%	-0.2%	1.4%	3.6%	7.0%