Essays in International Trade

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Dedication

I dedicate my thesis to my late mother, Joyce Crystal Brooks, whose love for the world was matched only by her curiosity about it.

Abstract

This thesis is divided into three separate chapters. The first chapter, joint work with Alessandro Dovis, analyzes the effect of financial frictions on the gains from undergoing trade reform. Financial frictions may limit the ability of exporting firms to expand, or keep new firms from becoming exporters in response to a trade liberalization. The way that financial frictions are modeled crucially determines whether or not this happens. Empirical evidence from a trade liberalization shows that capital flows to new exporters efficiently in response to the liberalization, even though those firms are still financially constrained. This suggests that financial market inefficiency is not a barrier to realizing gains from international trade. The second chapter, joint with Pau Pujolas, examines contemporary and historical international trade data, and establishes new patterns of trade between countries of differing income levels. Existing trade models cannot simultaneously rationalize high intra-industry trade between countries of similar income levels, and low intra-industry trade between countries of different income levels. A model of non-homothetic preferences is consistent with these facts, and implies higher gains from trade than standard models. The third chapter considers the problem of a government that wants to use immigration policy as a source of fiscal revenue. Governments can allow highly productive immigrants to enter and then tax them to finance spending on their native population. Optimal policy is considered in the context of a fixed native population and pool of potential immigrants. Optimal immigration policy follows a cutoff rule in the productivity of the entering immigrant. When agents are privately informed about their own productivity, immigrants are taxed at a higher rate than natives and the effect on the native population of increased fiscal transfers may be very large.

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Chapter 1

Financial Frictions and Trade Liberalization

1.1 Introduction

Recent work has shown that credit market frictions can reduce gains from undertaking reform, because these frictions limit efficient reallocation. In this paper, we ask if the way that credit frictions are modeled is important for this result. In particular, we contrast two popular types of financial frictions: *limited enforcement*, following Albuquerque and Hopenhayn (2004), and *collateral constraints*, following Evans and Jovanovic (1989). To answer this question, we consider the special case of trade liberalization for two reasons. First, trade liberalization is a clear example of exactly the type of reform that requires reallocation among firms, as emphasized by the recent trade literature (see Melitz (2003) and Eaton and Kortum (2004)). Second, we show that trade liberalization provides a means of distinguishing between these two types of credit frictions. Typically these models are difficult to distinguish because they have similar implications for the behavior of firms. However, we show that they have different implications for economies undergoing reform. Looking at panel data from before and after a trade liberalization in Colombia, we show that the reallocation of capital among firms follows the pattern predicted by the limited enforcement model.

We extend a dynamic Melitz (2003) trade model to include credit market frictions. We consider two types of credit frictions: limited enforcement and collateral constraints.

With limited enforcement, the amount of debt that firms can sustain is limited by the value of continuing to operate the firm (that is, the discounted stream of income to the firm). With collateral constraints, the amount that firms can borrow is at most a fraction of their capital stock. The key difference between these specifications is how credit limits are affected by the firm's future profitability. With limited enforcement, higher future profits allow firms to sustain more debt. With collateral constraints, future profits have no direct effect on debt limits.

We show that both specifications of credit frictions are consistent with empirical regularities on the relationship between credit and export decisions at the firm level documented in a recent empirical literature surveyed in Manova (2010). In particular, both specifications can account for the fact that access to credit affects both export participation and the amount that firms export. Moreover, these specifications have similar predictions for the life cycle path of firms. In both models, young firms are small and grow over time until they reach their optimal scale. With collateral constraints, this is because it takes time to accumulate assets, while with limited enforcement it is because of the back-loading of incentives. In both models, firms do not find it optimal to enter export markets when their capital stocks are small. Because of their similarities these models are typically difficult to distinguish.

Despite these similarities, these specifications have different implications for gains from trade reform both on the aggregate and at the firm level. We show that the percentage increase in steady state consumption from a trade reform in the limited enforcement specification is *the same* as in a corresponding model with perfect credit markets. However, with collateral constraints, the percentage gains from trade are *lower* than with perfect credit markets. Looking at special cases, we show that the important difference is on the extensive margin of adjustment. In the limited enforcement model, future exporters are able to sustain higher debt after the trade liberalization than before, even in periods *before* they enter the export market. This allows young, productive firms to export. With collateral constraints, entering the export market requires asset accumulation. Non-exporters are less profitable after trade reform (due to increased wages) so they accumulate assets more slowly. Therefore, with collateral constraints productive, young (low net worth) firms are unable to enter export markets, while less productive, old (high net worth) firms are able to enter. This creates perverse selection into the export market that lowers the gains from trade reform.

Since we show that these two specifications have different implications for the gains from a reform, it is important to be able to distinguish between them. We show that this can be done using panel data from before and after a trade liberalization. Using panel data from Colombia from 1981-91, which includes a trade liberalization in the mid-1980s, we show that the increase in the fraction of exporting firms that follows the reform is accounted for mainly by young firms. This is suggestive evidence in favor of the limited enforcement model where the forward-looking nature of the debt limits allows firms to enter export markets more easily when the value of doing so increases. This is in contrast to collateral constraints, which requires firms to wait until they have accumulated sufficient assets to become exporters.

Second, we provide direct evidence of the mechanism of the limited enforcement model by showing that the amount of capital that firms can sustain is affected by future profitability. We perform a differences-in-differences exercise. We divide non-exporters into two groups: those that will be exporters in the future, and those that will not. We observe that future exporters use more capital than non-future exporters. What we take as informative is that this difference increases following the trade reform. That is, an increase in the value of a *future* activity allows firms to use more capital even before they are undertaking that activity. This is a prediction of the limited enforcement specification, where higher future profitability reduces the value of default allowing firms to sustain more capital. This is not a prediction of the collateral constraints model, where future profitability has no effect on the ability of firms to borrow.

The nature of these exercises show why looking at this in the context of international trade is relevant. Trade reforms affect different firms differently, and, because export status is observable, we can observe which firms are affected. Moreover, looking at panel data allows us to see what happens in a firm's future.

Therefore, we accept the implication of the limited enforcement model: credit market frictions are not a barrier to reallocation following trade reforms. Introducing credit market frictions into a trade model makes it consistent with the empirical relationship between export behavior and access to credit, but it is reasonable to abstract from credit frictions when computing the aggregate effects of a trade reform. However, we wish to stress that in general the existence of credit markets does matter for the level of aggregate output and consumption, even though we have shown that they do not matter for percentage gains from trade reform[1] .

Finally, we concentrate on a model of trade reform because it is a natural example of the type of reform that requires reallocation[2] , and because it provides a means of distinguishing between specifications of credit market frictions. However, we interpret our results as being applicable more generally.

Related Literature

This paper is related to several strands of the literature. We build on the seminal contribution of Melitz (2003) and subsequent work, such as Alessandria and Choi (2007), who analyze the gains from trade in a model with heterogeneous monopolistic competitive firms, which emphasize the role of reallocation and selection into the export market as a driver for the gains from trade. Chaney (2005) and Manova (2008) introduce credit market frictions into a Melitz (2003) framework. Both papers consider a static environment, and do not address how credit frictions affect the gains from trade, which is the central theme of our paper.

The model presented here is consistent with the growing empirical literature on the relationship between firm-level export behavior and access to credit (see Manova (2010) for a survey). This literature uses firm-level data from many different countries, and finds that access to credit is an important determinant of export participation (the extensive margin) and the scale of exports (the intensive margin). See Berman and Hericourt (2010), Minetti and Zhu (2011) and Gorodnichenko and Schnitzer (2010). This literature uses measures such as survey responses[3] and leverage ratios to proxy for access to credit. The models of trade and credit frictions developed in the next sections are consistent with both findings from this literature.

This paper is also related to the literature that studies how aggregate gains from a trade liberalization are affected by including institutional and technological details

[1] See Figure 7. As the quality of financial markets is decreased (moving to the right on the graph) the level of steady state consumption declines. However, the percentage increase in consumption following the reform (the gap between the blue and black lines) does not change.

[2] Most of the episodes of reform studied in Buera and Shin (2009) include trade liberalization as a major component.

[3] For instance, in Minetti and Zhu (2011) they use a firm-level Italian data set that includes answers to the question, "In 2000, would the firm have liked to obtain more credit at the market interest rate?"

in trade models. Arkolakis, Costinot and Rodriguez-Clare (2011) show that all of a large class of trade models have the same implications for welfare gains from trade given *ex post* realizations of changes in trade flows. We are interested in evaluating *ex ante* how a given reduction in tariffs affects welfare with and without credit market frictions. This is similar in spirit to Atkeson and Burstein (2010), who show that the modeling of innovation decisions has no effect on estimated aggregate gains from trade. Similarly, Kambourov (2009) shows that labor market frictions reduce gains from a trade liberalization.

We model credit market frictions following two specifications widely used in the literature. First, we consider debt limits arising from limited enforcement of debt contracts as in Kehoe and Levine (1993). This specification extends Albuquerque and Hopenhayn (2004) to a general equilibrium trade model. See Cooley, Marimon and Quadrini (2004) for an application in a closed economy context. Second, we analyze collateral constraints following Evans and Jovanovic (1989), which has been used in many applied papers.

Finally and most importantly, our paper contributes to the literature that analyzes how credit market frictions affect reallocation in economies undergoing reform. Buera and Shin (2009, 2010) show that collateral constraints slow down the reallocation process following a reform, because it takes time for productive but low net-worth firm to accumulate sufficient assets to start a business and operate at full scale[4] . Likewise, Song, Storesletten and Zilibotti (2011) consider a similar mechanism for the case of technological growth in China, showing that collateral constraints generate misallocation between constrained, productive private firms and unconstrained, less productive state-owned firms. These results all depend on the backward-looking nature of the financial constraints. If the debt limits have a forward-looking component, as in the specification that follows Albuquerque and Hopenhayn (2004), then productive firms can start a business and operate at a larger scale sooner after the reform or technological improvement, and they do not have to accumulate a large stock of assets to do so. Jermann and Quadrini (2007) consider a similar mechanism in the context of news shocks where they show that a signal of future productivity immediately relaxes the

[4] They show that this mechanism can account for several macro facts: the gradual, protracted transitions in growing economies following reforms, and the fact that rapidly growing economies run current account surpluses.

firms' enforcement constraints. The second contribution of our paper is to use micro-level evidence to tell these two formulations of credit market frictions apart, providing direct evidence that the limited enforcement specification of the debt limits is more in line with the data.

In Sections 2 and 3 we build and characterize a model of trade and consider credit frictions of two types. In Section 4 we discuss the difference in implications between these two specifications for trade reform both at the firm level and for aggregates. In Section 5 we provide a means of distinguishing between them and show that the data favors the limited enforcement specification.

1.2 Model

Time is discrete, denoted by $t = 0, 1, ...$ and there is no aggregate uncertainty. There are two symmetric countries, home and foreign. Variables for the foreign country are denoted with superscript f. Each country is populated by a unit measure of identical households, competitive final good producers, and monopolistic competitive firms producing an intermediate differentiated product. Each period a mass of monopolistic competitive firms is born, and existing firms face an exogenous exit probability. Firms are not born with sufficient wealth to operate at their efficient scale, so they must borrow to finance investment. Additionally, some firms are able to export and they must borrow to pay a fixed cost to do so.

1.2.1 Household Problem

The stand-in household in each country inelastically supplies 1 unit of labor each period. He chooses final good consumption c_t and bond holdings b_{t+1} to maximize his lifetime utility

$$\sum_{t=0}^{\infty} \beta^t u(c_t) \tag{1.1}$$

where $\beta \in (0, 1)$ is the discount factor and u has standard properties, subject to the sequence of budget constraints

$$c_t + q_t b_{t+1} \leq w_t + b_t + D_t + T_t \qquad \forall t \geq 0 \tag{1.2}$$

expressed in terms of the final good in each country. Here w_t is the wage, q_t is the intertemporal price. We assume that households are the recipients of the dividends paid by the firm, D_t. In particular, we assume that households are composed of workers, who supply labor, and of entrepreneurs who operate a representative cross-section of firms. Financial markets are anonymous, so entrepreneurs do not internalize losses to households from default[5] . Tariff revenue T_t is rebated lump sum to the households. The problem for the stand-in household in the foreign country is symmetric.

1.2.2 Final Good Producers

The final good in the home country is produced using the following CES aggregator:

$$y_t = \left[\omega \int_{I_t} y_{dt}(i)^{\frac{\sigma-1}{\sigma}} di + (1-\omega) \int_{I^f_{xt}} y^f_{xt}(i)^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}} \tag{1.3}$$

where I_t is the set of active domestic firms at time t, I^f_{xt} is the set of foreign firms that export at t, $y_{dt}(i)$ is the output of firm i in I_t, $y^f_{xt}(i)$ is the output of firm i in I^f_{xt}. The final good in the foreign country is produced analogously. The parameter ω can be either thought of as controlling for the home bias in consumption or as standing in for an iceberg transportation cost. The elasticity of substitution is $\sigma > 1$.

Final goods producers are competitive. A representative firm solves the following static problem:

$$\max_{y_t, y_{dt}, y_{xt}} y_t - \int_{I_t} p(i) y_{dt}(i) di - \int_{I^f_{xt}} (1+\tau_t) p(i) y^f_{xt}(i) di$$

subject to (1.3). One can then derive the inverse demand functions faced by domestic and foreign producers for the intermediated good i:

$$p_{dt}(y(i)) = \omega y_t^{\frac{1}{\sigma}} y(i)^{-\frac{1}{\sigma}} \tag{1.4}$$

$$p^f_{xt}(y(i)) = \frac{1-\omega}{1+\tau_t} y_t^{\frac{1}{\sigma}} y^f(i)^{-\frac{1}{\sigma}} \tag{1.5}$$

[5] This allows us to use aggregate consumption as a measure of welfare. Nothing in our analysis would be changed if firms were owned by risk-neutral entrepreneurs who are independent of the households, except welfare comparisons would be difficult.

1.2.3 Monopolistically Competitive Firms

In each country, in every period, a mass $\delta \in (0,1)$, of entrepreneurs is born. Each operates a firm and is endowed with a new variety of the intermediate good. At birth the entrepreneur draws a type (z, ϕ), where z is the firm's productivity and $\phi \in \{0,1\}$ indicates if the firm has the ability to export[6] . If $\phi = 1$ the firm can pay a fixed cost f_x in any period to enter the export market the following period, while if $\phi = 0$ the firm does not have that option. For simplicity, they are independently distributed. Productivity z is drawn from a distribution Γ, and the indicator ϕ is a Bernoulli random variable with parameter ρ. The type of the firm remains constant through time. Every period the firm's technology completely depreciates permenantly with probability δ. The firm can produce its variety using the following constant returns to scale technology:

$$y = zF(k,l) = zk^{\alpha}l^{1-\alpha}, \quad \alpha \in (0,1) \tag{1.6}$$

where l and k are the labor and capital employed by the firm, and y is total output produced, which the firm splits between domestic and export sales.

To operate the firm has to borrow to (i) finance its investment in capital stock k_t, and (ii) pay the export fixed cost f_x. All firms start with a_0 units of the final good, which are transferred to them by the household[7] . The budget constraint in period t of a new born firm is then

$$d_t + k_{t+1} + 1\{\eta_t = 0\}f_x \leq a_0 + (1-\delta)q_t b_{t,1} \tag{1.7}$$

where d_t are dividend payments to the entrepreneur, k_{t+1} is the capital invested for the production next period, η_t indicates after how many periods a firm born at time t decides to pay the sunk cost to start to export starting the following period, and b_t is the debt position. Firms trade bonds that are contingent on the firm's survival next period and they are priced accordingly. If a firm will never export (including if $\phi = 0$), we adopt the convention that $\eta_t = \infty$. In all the subsequent periods $t + s \geq t$, conditional

[6] This is a convenient way to model heterogeneity of export fixed costs. We include this feature so that there are firms in the model that are identical except for future export status. This is useful for the exercise described in the last section.

[7] We are assuming that a_0 is the maximum one-time transfer that the household can make to the firm not subject to the debt limit. Clearly if there was no bound on such transfers this channel would eliminate the credit friction.

on surviving, the budget constraint can be written as:

$$d_{t+s} + b_{t+s} + k_{t+s+1} + 1\{\eta_t = s\} f_x \leq \Pi_{t+s} + (1-\delta) q_{t+s} b_{t+s+1} \quad \forall s \geq 1 \tag{1.8}$$

where Π_{t+s} are the period profits of the firm defined as

$$\Pi_{t+s} \equiv p_{dt+s}(y_{dt+s}) y_{dt+s} + 1\{\eta_t < s\} p_{xt}(y_{xt+s}) y_{xt+s} - w_{t+s} l_{t+s} + (1-\delta_k) k_{t+s} \tag{1.9}$$

where l_{t+s} are the labor units employed by the firm, y_{dt+s} and y_{xt+s} are the production for the domestic and export market respectively, and $p_{dt+s}(.)$ and $p_{xt+s}(.)$ are the inverse demand functions defined in (1.4) and (1.5). Notice that a firm will have access to the foreign market in period $t+s$ only if it paid the export fixed cost f_x in a previous period, that is $\eta_t < s$.

A firm of age s in period t faces the following borrowing constraint:

$$\forall t, s, \; b_{t+s+1} \leq 1\{\eta_t \leq s\} \bar{B}_t^x(k_{t+s+1}; z, \phi) + 1\{\eta_t > s\} \bar{B}_t^{nx}(k_{t+s+1}; z, \phi) \tag{1.10}$$

That is, the amount that firms can borrow may depend on the amount of capital the firm operates next period, the firm's export status, and the type of the firm[8] . Faced with this general constraint, we can then write the problem of the firm recursively using capital and debt as the state of the firm: $s = (k, b)$. The problem of the firm that has already paid to enter the export market may be written as:

$$V_t^x(s, z, \phi) = \max_{d, b', k'} d + (1-\delta) q_t V_{t+1}^x(s', z, \phi) \tag{1.11}$$

subject to

$$\begin{aligned} d + k' &\leq \Pi_t^x(k, z) - b + (1-\delta) q_t b' \\ b' &\leq \bar{B}_t^x(k'; z, \phi) \\ d &\geq 0 \end{aligned}$$

where the last constraint simply states that the firm has no additional source of funds. $\Pi_t^x(k, z)$ is the period profit obtained from the static maximization problem

$$\Pi_t^x(k, z) = \max_{y_d, y_x, l} p_{dt}(y_d) y_d + p_{xt}(y_x) y_x - w_t l + (1-\delta_k) k \tag{1.12}$$

[8] Later we consider two types of borrowing constraints that are special cases of this.

subject to

$$y_d + y_x \leq zF(k,l)$$

For a firm that hasn't already paid the fixed cost to start to export, denoted with the superscript nx, the optimization problem is:

$$V_t^{nx}(s,z,\phi) = \max_{d,b',k',x\in\{0,1\}} d + (1-\delta)q_t\left[x\phi V_{t+1}^{x}(s',z,\phi) + (1-x)V_{t+1}^{nx}(s',z,\phi)\right] \quad (1.13)$$

subject to

$$\begin{aligned} d + k' + xf_x &\leq \Pi_t^{nx}(k,z) - b + (1-\delta)q_t b' \\ b' &\leq x\phi\bar{B}_t^{x}(k';z,\phi) + (1-x)\bar{B}_t^{nx}(k';z,\phi) \\ d &\geq 0 \end{aligned}$$

where $\Pi_t^{nx}(k,z)$ is given by the following static problem:

$$\Pi_t^{nx}(k,z) = \max_{y_d,y_x,l} p_{dt}(y_d)y_d - w_t l + (1-\delta_k)k \quad (1.14)$$

subject to

$$y_d \leq zF(k,l)$$

We will denote the policy functions of the firms associated with the above problems as $\{d_t^{nx}, b_t'^{nx}, k_t'^{nx}, y_{dt}^{nx}, l_t^{nx}, x_t\}_{t=0}^{\infty}$ for non-exporters and $\{d_t^{x}, b_t'^{x}, k_t'^{x}, y_{dt}^{x}, y_{xt}^{x}, l_t^{x}\}_{t=0}^{\infty}$ for exporters.

1.2.4 Equilibrium Conditions

We now report the feasibility conditions for the home country. Analogous relations must hold for the foreign country. To do so, we need to keep track of the evolution of the measure of operating firms over (s,z,ϕ) and export status. Denote by λ_t^{nx} and λ_t^{x} the measure of non-exporting and exporting firms at the beginning of the period over (s,z,ϕ) respectively, and let $\lambda_t = (\lambda_t^{nx}, \lambda_t^{x})$. The evolution over time for λ_t^{nx} and λ_t^{x} is given by: $\forall\ (S,Z,\Phi) \in \mathcal{B}(\mathbb{R}_+^2) \times \mathcal{B}(\mathbb{R}_+) \times P(\{0,1\})$:

$$\begin{aligned} \lambda_{t+1}^{x}(S,Z,\Phi) = (1-\delta)\int 1\left\{s_t'^{x}(s,z,\phi) \in S,\ z \in Z, \phi \in \Phi\right\} d\lambda_t^{x} + \quad (1.15) \\ + (1-\delta)\int 1\left\{x_t(s,z,\phi) = 1, s_t'^{nx}(s;z,\phi) \in S,\ z \in Z, \phi \in \Phi\right\} d\lambda_t^{nx} + \\ + \delta\rho\int_Z 1\left\{\ x_t((0,-a_0),z,\phi) = 1, s_t'^{nx}(0,-a_0,z,\phi) \in S\right\} d\Gamma \end{aligned}$$

$$\lambda_{t+1}^{nx}(S,Z,\Phi) = (1-\delta)\int 1\left\{x_t(s,z,\phi)=0, s'^{nx}(s,z,\phi)\in S,\ z\in Z,\phi\in\Phi\right\}d\lambda_t^{nx} \tag{1.16}$$

$$+\,\delta\int_Z 1\left\{\ x_t((0,-a_0),z,\phi)=0,\ \ s_t'^{nx}(0,-a_0,z,\phi)\in S\right\}d\Gamma$$

where $s'^i(s,z,\phi) = (k'^i(s,z,\phi), b'^i(s,z,\phi))$ for $i\in\{nx,x\}$.

Market clearing in the final good market requires that

$$y_t = c_t + K_{t+1} - (1-\delta_k)(1-\delta)K_t + y_{ft} \tag{1.17}$$

where D_t is aggregate dividend distributions, given by

$$D_t = \sum_{i\in\{nx,x\}}\int d_t^i(s,z,\phi)d\lambda_t^i + \delta\int_Z d_t^{nx}((0,-a_0),z,\phi)d\Gamma \tag{1.18}$$

and K_{t+1} is aggregate capital

$$K_{t+1} = \sum_{i\in\{nx,x\}}\int k_t'^i(s,z,\phi)d\lambda_t^i + \delta\int_Z k_t'^{nx}((0,-a_0),z,\phi)d\Gamma \tag{1.19}$$

and y_{ft} is the total investment in export units in period t:

$$y_{ft} = \int x_t(s,z,\phi)f_x d\lambda_t^{nx} + \rho\delta\int_Z \left[x_t((0,-a_0),z,\phi)f_x\right]d\Gamma \tag{1.20}$$

The labor market feasibility is given by

$$1 = \int l_t^x(s,z,\phi)d\lambda_t^x + \int l_t^{nx}(s,z,\phi)d\lambda_t^{nx} \tag{1.21}$$

For the bond market to clear, it must be that

$$b_t + b_t^f = B_t + B_t^f \tag{1.22}$$

where B_t is the aggregate amount of debt held by firms:

$$B_{t+1} = \delta\sum_{i\in\{nx,x\}}\int b_t'^i(s,z,\phi)d\lambda_t^i + (1-\delta)\int_Z b_t'^{nx}((0,-a_0),z,\phi)d\Gamma \tag{1.23}$$

Finally, lump-sum transfers are given by

$$T_t = \tau_t\int p_{xt}\left[y_{xt}^{xf}(s,z,\phi)\right]y_{xt}^{xf}(s,z,\phi)d\lambda^{xf} \tag{1.24}$$

We are now able to define a symmetric equilibrium for the economy in which the two countries start with the same initial distribution of firms, the same bond holding, the same capital stock, and with equal tariffs. In such an economy, prices will be equal in both countries.

Definition 1. *Given an initial symmetric distribution of firms $\lambda_0 = \lambda_0^f$, bonds holdings $b_0 = b_0^f$, and a sequence $\{\tau_t, \tau_t^f\}_{t=0}^{\infty}$ such that $\tau_t = \tau_t^f$, a symmetric equilibrium for the deterministic economy consists of (i) prices $\{p_t, w_t, q_t\}_{t=0}^{\infty}$, (ii) household's allocations $\{c_t, b_{t+1}\}_{t=0}^{\infty}$, (iii) firms decision rules $\{d_t^{nx}, b_t'^{nx}, k_t'^{nx}, y_{dt}^{nx}, l_t^{nx}, x_t\}_{t=0}^{\infty}$ and $\{d_t^{x}, b_t'^{x}, k_t'^{x}, y_{dt}^{x}, y_{xt}^{x}, l_t^{x}\}_{t=0}^{\infty}$, (iv) inverse demand functions $\{p_{xt}, p_{dt}\}_{t=0}^{\infty}$, (v) measure of firms $\{\lambda_t\}_{t=0}^{\infty}$, (vi) aggregate dividend distributions $\{D_t\}_{t=0}^{\infty}$, lump-sum transfers $\{T_t\}_{t=0}^{\infty}$, and $\{y_{ft}\}_{t=0}^{\infty}$ and analogous terms for the foreign country, such that:*

1. *Households' allocation solves the household's problem (1.1) subject to (1.2)*
2. *Firms' decision rules are optimal for (1.13) and (1.11)*
3. *Inverse demand functions are given by (1.4) and (1.5)*
4. *Final good, labor, bonds markets clear, that is (1.17), (1.21), (1.22) hold, where K_t by (1.19), y_{ft} by (1.20) and B_t by (1.23)*
5. *The measures of firms evolve according to (1.15) and (1.16)*
6. *Lump-sum transfers are given (1.24).*
7. *D_t is given by (1.18).*

In most of our analysis we will focus on a *symmetric stationary equilibrium* for the economy, or on a transition from one stationary equilibrium to another.

1.2.5 Credit Market Frictions

Limited Enforcement

In this paper we consider two forms of borrowing constraints corresponding to two definitions of the function $\bar{B}$. We refer to the first as *limited enforcement*, which follows Albuquerque and Hopenhayn (2004). Each firm is operated by an entrepreneur. In this specification entrepreneurs are born with no wealth ($a_0 = 0$) and credit contracts are not enforceable in the sense that every period they can choose to default on their outstanding debt. When it defaults the entrepreneur absconds with a fraction $\theta \in [0, 1]$ of the funds advanced for the next period's capital stock and, with probability $1 - \xi$, loses its production technology. If the technology survives the default, the entrepreneur is able to borrow to operate a new firm, but with no access to the capital it had accumulated before or to the capital with which it absconded. Therefore, a debt contract is enforceable only if firms can never borrow enough that default is more attractive than repayment. Hence, the following *enforcement constraint* must be satisfied in every period:

$$\sum_{r>t+s} (1-\delta)^{r-t+s} Q_{t+s,r} d_r \geq \theta k_{t+s} + \xi v_{0,t+s+1}(z,\phi) \tag{1.25}$$

where $v_{0,t+s+1}(z,\phi) = V^{nx}_{t+s+1}((0,0),z,\phi)$ is the value of starting a new firm with productivity z, and $Q_{t,t+s} = \prod_{r=0}^{s} q_{t+r}$ is the relevant discount factor. That is, the present discounted value of payments to the entrepreneur after $t+s$, $\sum_{r>t+s}(1-\delta)^{r-t+s}Q_{t+s,r}d_r$ (the inside equity value of the firm at t) must be no less than the value that the entrepreneur can obtain by defaulting. The parameters θ, ξ index the quality of the enforcement technology. The lower are θ and ξ, the more debt can be sustained. Perfect credit markets can be recovered as a special case with $\theta = \xi = 0$.

The debt limit $\bar{B}$ corresponding to (1.25) solves the following equality:

$$q_t(1-\delta)V^j_{t+1}\left(\left(k', \bar{B}^j_t(k';z,\phi)\right), z, \phi\right) = \theta k' + \xi v_0(z,\phi),\ j \in \{x, nx\} \tag{1.26}$$

The key feature of this specification is that debt limits depend on the future profitability of the firm. That is, the higher the present value of the firm, the more debt it can sustain from its first period of operation.

Collateral Constraints

Throughout this paper, we will contrast this with another popularly used specification of credit frictions: *collateral constraints.* In this specification the debt limit $\bar{B}$ is the following:

$$\forall j \in \{nx, x\}, \forall t,\ \bar{B}^j_t(k';z,\phi) = \theta k' \tag{1.27}$$

In this case, entrepreneurs may choose to not repay their debt in any period. The only punishment for doing so is the loss of a fraction $\theta \in [0,1]$ of their capital stock. In particular, default does not result in the destruction of the firm's technology nor in exclusion from credit markets[9] . In this case, new entrepreneurs must be endowed with

[9] This can be thought of as a version of the limited enforcement model in which there is no dynamic punishment for default. See Rampini and Viswanathan (2010).

some assets in order to begin operation. In contrast to limited enforcement, debt limits in this specification depend only on the amount of profits that the firm has reinvested in the past, and do not respond to any future profitability. In Section 5 we will exploit this difference to distinguish between these specifications.

1.3 Symmetric Stationary Equilibrium

We now characterize the symmetric stationary equilibrium for the economy with both specifications of credit frictions. For a given level of tariffs, we show that both specifications are able to account for the relationship between export behavior and access to credit documented in the empirical literature: (a) the probability that a firm is an exporter is decreasing with measures of firm-level financial constraints, (b) firms' sales and exports grow over time and are decreasing in the credit constraints it faces.

1.3.1 Firm's Problem Characterization

In a stationary equilibrium, all prices and aggregate quantities are constant over time. Therefore, we will drop the dependence on time in this section. First we consider a relaxed problem, dropping the borrowing constraint. It is easy to see that the production decisions are independent of the firm's debt level, and solve the following static problem:

$$\begin{aligned} \Pi^*(z,\phi) \quad = \quad & \max_{l,k,y_d,y_x,x} -\left[1-q(1-\delta_k)\right]k - x\phi(1-q(1-\delta))f_x + \\ & +q(1-\delta)\left[\omega y^{1/\sigma} y_d^{1-1/\sigma} + x\phi\frac{1-\omega}{1+\tau} y^{1/\sigma} y_x^{1-1/\sigma} - wl\right] \end{aligned} \tag{1.28}$$

subject to

$$y_d + x y_x \leq zF(k,l)$$

Given prices w, q, tariff τ and aggregate final output y, denote the solutions to this problem with $l^*(z,\phi), k^*(z,\phi), y_d^*(z,\phi), y_x^*(z,\phi), x^*(z,\phi)$. These would be the firms' decision rules in a standard Melitz (2003) model.

We define the state variable a to be "cash on hand", which is the firm's period profit less debt repayment

$$a = x\Pi^x(k) + (1-x)\Pi^{nx}(k) - b$$

This is the minimal state variable to characterize the firm's dynamic decision problem. The following proposition fully characterizes the evolution of a firm over time for a firm in the limited enforcement economy. The proof is relegated to the online appendix[10] .

Proposition 1. *(i) firms issue no dividends until they reach their optimal scale*[11] *;*

(ii) $\exists$ *cut-off productivity level* z_x *s.t. the firm will eventually export iff* $\phi = 1$ *and* $z \geq z_x$ *;*

(iii) $\forall z \geq z_x\ \exists \hat{a}(z, 1)$ *s.t. firms export iff* $\phi = 1$ *and* $a \geq \hat{a}(z, 1)$*;*

(iv) If $z' > z \geq z_x$ *and* $T(z)$ *is the age when a firm starts exporting, then* $T(z') \leq T(z)$*.*

Part (i) states a standard result for limited enforcement economies: payments to firms are back-loaded. Because the firm discounts at the equilibrium interest rate, the value of reducing their debt is always greater than the value of consumption whenever the enforcement constraint is binding. Therefore, the firm distributes no dividends so that it can reduce its external debt as quickly as possible. This allows the firm to grow over time until it reaches its unconstrained scale.

Part (ii) states that only more productive firms will export, as in Melitz (2003), but now with the qualification that they will *eventually* export. When a firm is constrained to operate at an inefficiently low scale it may be profitable to wait several periods to enter the export market. Part (iii) states that the firm's export status depends on both productivity and cash on hand, since cash on hand determines capital usage. Then firms whose enforcement constraints are binding are both less likely to be exporters and export at smaller scale. This is consistent with the empirical literature on the relationship between export behavior and access to credit discussed in Section 1.

Part (iv) states that more productive firms enter export markets younger. This is true for two reasons. First, the value of being an exporter is increasing in the productivity of the firm. Second, more productive firms are able to borrow more.

After the initial productivity draw there is no uncertainty (except for exogenous exit) and firms are fully characterized by their productivity and their age. The typical

[10] This characterization extends Albuquerque and Hopenhayn (2004) to an environment with a discrete choice of increasing the number of markets in which the firm operates.

[11] *This statement is minorly qualified. The period before the firm reaches its optimal scale it is only required to distribute a low enough level of dividends that it will still be able to operate at full scale in the next period. In that period, zero dividends is optimal, but not uniquely optimal.*

life-cycle path predicted by the model is as follows. The amount of capital that a firm can sustain is initially low, then increases over time as firms use period profits to pay down their debt. Likewise, labor usage and domestic sales (which are the static solutions to (1.14) above) grow over time with the capital stock. Some firms eventually find it optimal to pay the fixed cost to enter the export market. Then labor, domestic sales and export sales for a given capital stock are the solution to (1.12). In finite time, the firm is able to sustain its optimal capital stock, and labor, domestic sales and export sales are constant forever after that. After reaching optimal scale the dividend policy of the firm is arbitrary, so long as they maintain enough cash on hand to sustain their optimal scale of capital[12] .

Under the collateral constraints specification of credit frictions, exactly the same proposition is true. As with the limited enforcement specification, firms save all their period profits until they are able to operate at their efficient scale. Likewise, firms are delayed in entering the export market because their capital stock is too low to make it profitable to pay the fixed cost. The collateral constraints model is also consistent with the empirical literature discussed in Section 1. Constrained firms all have the same leverage ratio while unconstrained firms have a lower leverage ratio. The fact that the same characterization holds in both models highlights the difficulty of distinguishing between these two specifications. In Section 5 we show, however, that we are able to distinguish these models using data from a trade liberalization.

1.4 Effects of Trade Liberalization

In previous sections we have built a model with two possible specifications of borrowing constraints: limited enforcement and collateral constraints. We have shown that both are consistent with the empirical facts about the relationship between export behavior and access to credit. Under both specifications, financial frictions affect both the amount that firms export and export participation.

[12] Two extreme cases would be the following: 1) after reaching optimal scale, all firms maintain just enough cash on hand to sustain their optimal capital stock and always distribute the rest of its profit in dividends, or 2) all firms retain all of their earnings by saving in risk-free debt. Either of these dividend policies, or any intermediate case, is consistent with the same allocation within a stationary equilibrium. In the first case, the household receives the dividends directly from the firms, while in the second they receive them indirectly through increased borrowing.

In this section we are interested in evaluating if credit market imperfections reduce the welfare benefits from a bilateral tariff reduction. We will show that with limited enforcement the gains from trade are not affected by financial frictions, while with collateral constraints the gains from trade are reduced by financial frictions. We demonstrate these results first with special cases. With limited enforcement, if $f_x = 0$ the gains from trade are analytically independent of financial market quality. With collateral constraints, if $\theta = 0$ and $a_0 = 0$ the gains from trade are lower. We then demonstrate that these results are approximately maintained for a wide range of parameters in our quantitative model.

1.4.1 Special Case with Limited Enforcement: No Extensive Margin

First we consider a special case in which the extensive margin is not active by setting $f_x = 0$. All firms with $\phi = 1$ are exporters both before and after the trade liberaliztion. Then because the set of exporting firms is not affected by trade reform, the only margin of adjustment is the intensive margin. With perfect credit markets, trade liberalization causes factors of production to be moved from non-exporters to exporters. In principle, financial frictions could be a barrier to that reallocation. The following proposition shows *analytically* that this is not true with limited enforcement.

Proposition 2. *In the limited enforcement model with $f_x = 0$, for any change in tariffs the steady state percentage changes in aggregate output, and wages are independent of θ and ξ. Furthermore, firm-by-firm the percentage change in capital usage is independent of θ and ξ.*

Proof 1. *We include an outline of the proof here and leave the details to the online appendix. Consider a change in tariffs from τ to τ' in a corresponding economy with perfect credit markets. The proof proceeds as a guess and verify that the percentage changes in output and wages in that perfect credit markets economy are the same as in the limited enforcement economy. That is, if the percentage changes in output and wages in the full enforcement economy were Δ_y and Δ_w respectively, then wages and output in the limited enforcement economy change from (y, w) to $(\Delta_y y, \Delta_w w)$. In this special case a firm is an exporter if and only if $\phi = 1$.The key step is to show that all exporting firms increase their scale by exactly the same proportion in the limited enforcement economy* *as they do in the full enforcement economy. This is true because:*

$$\Delta_k V^x(k,b;z,p) = V^x(\Delta_k k, \Delta_k b; z, p')$$

where Δ_k *is the change in the capital stock of exporting firms in the economy with perfect credit markets,* $p = (y, w, \tau)$*, and* $p' = (\Delta_y y, \Delta_w w, \tau')$*. This change in capital satisfies the enforcement constraint because, noting that* $v_0(z,p) = V^x(0,0;z,p)$*:*

$$V^x(k,b;z,p) = \theta k + \xi v_0(z,p) \implies V^x(\Delta_k k, \Delta_k b; z, p') = \theta \Delta_k k + \xi v_0(z,p')$$

Hence, the borrowing constraint relaxes by exactly enough to allow exporting firms to increase their scale by the same proportion as with perfect credit markets. The opposite is true for non-exporters: they reduce their scale by exactly the same amount with limited enforcement as with perfect credit markets. It can be shown that markets clear by using the fact that Δ_y *and* Δ_w *cleared markets in the full enforcement economy and that the changes in policy functions were the same in both economies.* ∎

When tariffs are reduced exporting firms are more profitable, so for any debt level and capital stock, the value of not defaulting has increased. Therefore, the firm can sustain a higher debt level, meaning that borrowing constraints relax allowing the firm to operate at a greater scale. The opposite is true for non-exporters who, through general equilibrium effects, are less profitable after the tariff reduction than before. In this case, the relaxation of the borrowing constraints for exporters is such that all exporting firms increase their scale by exactly the same proportion for every age and every productivity level. Likewise, borrowing constraints for non-exporters tighten such that their scale is reduced by the same proportion across age and productivity. Hence, though credit frictions do create an inefficient allocation of inputs in the cross-section, they do not limit the reallocation of inputs following a trade reform[13] .

This example provides a useful benchmark for our quantitative results later in this section. There we find that gains from trade in the full and limited enforcement economies are approximately the same, which is analytical in this special case. The next special case illustrates why the collateral constraints model yields lower gains from trade than a perfect credit markets benchmark.

[13] This result also holds for other specifications of the enforcement constraint. The same result goes through if, instead of the capital stock, the firm was able to abscond with working capital, period revenues, period profits, or any linear combination of them.

1.4.2 Special Case with Collateral Constraints: Credit Frictions Only Affect Extensive Margin

Next, in the collateral constraint model we set $\theta = 0$, and $a_0 = 0$. Now in both cases all firms are able to operate at their efficient scale in each market they sell to, but young firms are not able to export.

Since capital is fully collateralized, the only thing that the firm has to finance is the fixed cost to export f_x. The value of a firm with $\phi = 1$ is maximized by entering the export market as soon as possible. Therefore the firm saves all its earnings until it has enough to pay to enter the export market. The period that occurs, $T(z)$, is the smallest value that satisfies the following inequality:

$$f_x \geq \Pi_{nx}(z) \sum_{s=0}^{T(z)} (q(1-\delta))^{-s}$$

where $\Pi_{nx}(z)$ is the period profit of an unconstrained non-exporter (the solution to (1.28) with $\phi = 0$). Solving this yields:

$$T(z) = \left\lceil \frac{\log\left(1 + f_x \frac{1-q(1-\delta)}{q(1-\delta)\Pi_{nx}(z)}\right)}{-\log(q(1-\delta))} \right\rceil$$

Then, since wages are higher following the trade liberalization, profits from only producing domestically are lower than before[14] . Hence $\Pi_{nx}(z)$ is smaller. Noting that $T(z)$ is decreasing in $\Pi_{nx}(z)$, this implies that firms take longer to enter export markets after the liberalization than before because it takes the firm longer to accumulate sufficient assets to pay the fixed cost. This generates a perverse reallocation effect where the cross-age distortion of export status gets worse after the reform. Hence, the gains from undergoing trade reform are reduced. With limited enforcement, the fact that borrowing constraints take into account future profitability makes it so that $T(z)$ always decreases after liberalization.

1.4.3 General Case: Quantitative Exercise

To evaluate the effects of a trade liberalization in general equilibrium, we conduct the following quantitative exercise: we calibrate both models and analyze the response to

[14] For this for be true, one needs to show that $yw^{\sigma-1}$ is decreasing in τ. It is sufficient for σ to be high relative to τ.

a bilateral, unforeseen reduction of tariffs. To calibrate our model we use the Colombian Survey of Manufactures from the years 1981-1991. A trade liberalization occured in 1985-86 in Colombia, so we calibrate our model to the 1981-84 data. A detailed description of the data is found in the next section. Table 1 lists the parameter values that are used. The parameters α (the Cobb-Douglas parameter), β (the discount factor), and δ_k (capital depreciation) are set to standard values. The survival probability is set to match the average age of operating firms in the data set during the pre-liberalization period, which is 14.7. Following Ruhl (2008), in our baseline calibration we set the elasticity of substitution in the CES aggregator σ to 2, which is necessary to match the elasticity of exports to changes in tariffs in this class of trade models. We assume that the ex-ante productivity distribution Γ is distributed log-normal(0,s). We estimate firm-level productivity in our data using the method of Levinsohn and Petrin (2003), using energy usage to control for the correlation between input usage and unobserved productivity. We choose s to match the standard deviation of these estimates of log-productivity in our data.

We set the post-liberalization tariff rate τ_L to 10%, which is the average effectively applied tariff rate[15] in Colombia in 1991 (the only year available). To get the pre-liberalization tariff rate, we calibrate the full enforcement model as follows. We calibrate the parameters f_x, ω, ρ, and τ_H to match exports as a fraction of GDP in the post-liberalization economy (the 1987-1991 data) and three moments in the pre-liberalization economy to the 1981-1984 data: exports as a fraction of GDP, the fraction of firms that export and the average log-productivity difference between exporters and non-exporters. This yields a pre-liberalization tariff rate τ_H of 38%. We then use this value of τ_H in the models with borrowing constraints.

Next we calibrate the two models with borrowing constraints. We have five parameters to calibrate in each model: f_x, ω, ρ, ξ, and θ in the limited enforcement model and f_x, ω, ρ, a_0, and θ in the collateral constraints model. They are set jointly to match five moments from Colombia in the years 1981-1984. These moments are: 1) the fraction of firms that export, 2) exports as a fraction of GDP, 3) the average difference in log-productivity between exporters and non-exporters, 4) the growth rate in labor

[15] This comes from UN TRAINS, and is the simple average of effectively applied tariff rates on Colombian exports of manufactured goods to the rest of the world.

usage from ages 1 to 15, and 5) the fraction of firms that export before age 5. The values of these moments in the data and both models can be found in Table 2.

We consider a bilateral, unforeseen tariff reduction. Our question is whether or not the *presence* of credit market frictions reduces the gains from trade liberalization. Therefore we always compare economies with credit market frictions to corresponding economies that are technologically identical, but with the credit friction removed. Table 3 summarizes the steady state change in aggregates induced by this tariff reduction in the calibrated models. The limited enforcement model has a slightly larger consumption gain than in the corresponding full enforcement model: 4.11% versus 4.00%. This is in contrast to the collateral constraint model, where the gains from trade are 20% lower than in the corresponding model with perfect credit markets: 3.55% versus 4.42%.

This result is not sensitive to our parameterization. We compare our results in both models as we vary the fixed cost f_x. Although the absolute gains from trade liberalization changes considerably as this parameter is moved, the gains from trade are always approximately the same in the limited enforcement economy and are smaller in the collateral constraints economy than in a benchmark economy with perfect credit markets.

Therefore we have two possible answers to our original question: do financial frictions limit gains from trade reform? In the collateral constraints model gains are limited by the presence of financial frictions. However, in the limited enforcement model, the difference in gains from trade is negligible. Furthermore, as discussed in Section 3, these models are difficult to distinguish. In the next section we will provide a means of distinguishing them using data from a trade reform. We will show that the evidence is in favor of the limited enforcement model.

1.5 Distinguishing Between Credit Market Frictions

In the previous sections we have shown that the model with collateral constraints and the model with limited enforcement have different implications for gains from trade and possibly other reforms. We now wish to distinguish between the two models using data from a trade reform in Colombia from the years 1981-1991. We find that the data favors the limited enforcement specification.

1.5.1 Colombian Survey of Manufactures

The data we use comes from the Colombian Survey of Manufactures (CSM), which is described in detail in Roberts and Tybout (1997). This dataset covers all manufacturing plants with ten or more employees[16] and provides data on items including sales, exports, input usage (employees, capital and energy), age, and subsidies at the plant level. Plants are classified by 3 digit SIC industry. There are 66,921 plant-year observations after removing observations that are inconsistently coded.

The major benefit of using this data is that there was major period of reform in the middle of sample. Through the early 1980s, Colombia had increasingly high tariff rates and quotas (see Roberts (1996)). This trend reversed in 1985, when Colombia agreed to a Trade Policy and Export Diversification Loan from the World Bank. Tariffs were reduced and trade subsequently increased (see Fernandes (2007)). Figure 3 shows large increases in exports at both the aggregate and firm level. Also, changes in exchange rate policy caused the real exchange rate to fall substantially (see Figure 4). We broadly interpret these events as leading to an increase in the value of exporting.

1.5.2 Direct Evidence: Effect of Future Profitability on Capital Stock

The most direct difference between these two models is how future profitability affects the amount of debt (and therefore capital) firms can sustain. We use future export status as a proxy for future profitability (since in the model, all else equal, a firm that is an exporter is more profitable than one that is not), and interpret trade liberalization as an increase in the profitability of exporting. We can then distinguish between the models by identifying the effect of increased future profitability. In the limited enforcement model, this effect is positive, while with collateral constraints the effect is zero.

In these two models, consider two firms that are identical except that, because of heterogeneous fixed costs to export, one will be an exporter in the future and the other will not. Hence, the future exporter has higher present value than does the non-exporter. In the limited enforcement model the future exporter will therefore be able to sustain more capital even before entering the export market. In the collateral constraints model both firms will sustain the same amount of capital because the constraint does not take

[16] Some years include some observations of firms with fewer than 10 employees. For consistency we drop these observations in our analysis.

into account future activity. This difference could in principle be used to distinguish the models in the cross-section, but the correlation between capital usage and future export status is prone to a variety of possible confounding factors.

Therefore, we exploit trade liberalization as exogenous variation in the profitability of future exporting. We show in the data that 1) future exporters are able to sustain more capital than non-future exporters, and 2) that this effect is amplified in the post-reform period even controlling for productivity, industry, size, age and subsidies[17] to the plant. We interpret the second result as saying that increased *future* profitability increases the ability of firms to sustain more capital, which is evidence in favor of the limited enforcement model. Figure 2 shows what happens following a trade reform in both models. The limited enforcement model predicts that increased future profitability increases the ability to sustain capital, while the collateral constraint model predicts no change in that difference.

Our result comes from the following regression, for firm i in industry j in year t:

$$\begin{aligned}\log(\text{Capital}_{ijt}) &= \alpha_{jt} + \beta_1 \text{Exporter}_{ijt} + \beta_2 \text{Exporter}_{ijt} \times \text{Reform}_t + \\ &\quad + \beta_3 \text{Future Exp.}_{ijt} + \beta_4 \text{Future Exp.}_{ijt} \times \text{Reform}_t + \\ &\quad + \text{Controls}_{ijt} + \varepsilon_{ijt}\end{aligned}$$

where Reform is an indicator variable for the post-reform period. Exporter is a dummy variable indicating export status. Future Exporter is a dummy variable indicating future export status. In the base case, this variable is one if the firm is not an exporter today but does export two periods in the future[18] . Controls are log of firm size (number of employees), age and its square, log of productivity and total subsidies as a fraction of plant sales. These controls most closely correspond to the determinants of capital usage in both models. Higher productivity plants use more capital than low productivity in both models. Because of heterogeneous fixed costs, there are plants in both models that are identical except for export status. Exporting firms use more capital than non-exporters, and this difference increases after the trade reform. Likewise, older firms use

[17] This is export subsidies plus production subsidies. Subsidies (such as export promotion) could confound our analysis if, for instance, the government subsidizes firms to get them to export in the future. Then those future exporters have more financing and can operate more capital. Including them as a control addresses this issue.

[18] We use this measure because it is consistent across years. We do two periods in advance to try to avoid "time to build" effects.

more capital than younger, and this effect is non-linear.

Table 4 shows the results of this regression for several combinations of controls. We see that the signs of the controls, as well as β_1 and β_2, are consistent with the predictions of both models of credit market frictions. To distinguish between them, we are most interested in β_4, which shows the increase in the effect of future export status on capital levels. This coefficient is positive and significant in each specification. This is consistent with the limited enforcement model, which predicts $\beta_4 > 0$ and is not consistent with the collateral constraints model, which predicts $\beta_4 = 0$. Not only is $\beta_4 > 0$, but it is also large. In every specification it is at least 60% as large as β_2, the increase in capital used by exporters.

This is true even though our measure of future export status is biased toward zero in two ways. First, the set of firms that we identify as future exporters is a strict subset of the true set of future exporters. Firms that expect to export in the future, but are three or more periods from doing so are counted as non-future exporters, which biases our estimates of the effects of future exporting toward zero. Likewise, our arguments assume that future export status is certain, when in reality it may not be. Ideally, here we would like to measure the effect of the expectation that a firm will be an exporter in the future. In our online appendix we develop an example to show that uncertainty in this respect also biases our results toward zero, since it shows up as classification error. Despite these sources of bias, we still find that the effect of future exporting is large. Hence, the fact that the effect we identify is large is evidence in favor of the effect of increased profitability on the ability of firms to use more capital, as predicted by the limited enforcement model.

We also show that this result is unchanged if $Future\ Exporter_{ijt}$ instead is equal to one if the firm is not an exporter at time t, but is an exporter at $t+1$. Table 4 displays the results. In each case, the coefficient of interest is positive.

Identification here comes from using trade reform as exogenous variation in future profitability. However, one may worry that trade reform is potentially correlated with other things, such as financial market reform. We argue that even if financial market reform did occur simultaneously it would not confound our exercise. Identification comes from the difference between future exporters and future non-exporters, so any confounding effect would have to affect those two groups differently. Reform in financial markets would make it easier for *all* firms to borrow. Then this effect would be accounted for by the industry-year fixed effects.

Lastly, the previous section was primarily concerned with comparisons between stationary equilibria (one with high tariffs and the other with low), while the data has so few years following the liberalization that it should be interpreted as being on a transition path. However, this is not important for our exercise. The collateral constraints model never distinguishes between future exporters and future non-exporters, either within a stationary equilibrium or on a transition path. In the limited enforcement model, debt limits are forward-looking, so they take changes in future profitability into account immediately on the transition path.

Year and Industry Analysis

We next examine whether or not this result is robust across industries and years within the sample. First we look at the evidence across years. We want to see if our results are driven by any particular year, and if the increase in the effect of being a future exporter coincides with the year of reform. We modify our regression by not specifying any particular year of reform and instead we estimate:

$$\log(\text{Capital}_{ijt}) = \alpha_{jt} + \beta_{1,t}\text{Exporter}_{ijt} + \beta_{2,t}\text{Future Exp.}_{ijt} + \text{Controls}_{ijt} + \varepsilon_{ijt}$$

Figure 5 shows β_2 across the sample years. We see that the effect of being a future exporter is declining in the 1981-84 period as the real exchange rate is rising and the government pursues protectionist policies. In 1985 we see a dramatic increase in this effect, and it stays high through the rest of the sample. This pattern is consistent with the limited enforcement model. The effect of being a future exporter is always positive, but it changes when the value of exporting changes. In the early period the value of being an exporter is declining (hence, the effect of being a future exporter falls), then after the reforms the value of being an exporter is higher, which amplifies the effect of being a future exporter. We interpret this as evidence in favor of the limited enforcement model.

Next we ask if the predictions of the limited enforcement model are borne out at the industry level. To do this, we estimate the following equation:

$$\begin{aligned}\log(\text{Capital}_{ijt}) &= \alpha_{jt} + \beta_{1,j}\text{Exporter}_{ijt} + \beta_{2,j}\text{Exporter}_{ijt} \times \text{Reform}_t + \\ &+\beta_{3,j}\text{Future Exp.}_{ijt} + \beta_{4,j}\text{Future Exp.}_{ijt} \times \text{Reform}_t + \\ &+\text{Controls}_{ijt} + \varepsilon_{ijt}\end{aligned}$$

We broadly interpret the reforms as being an increase in the value of exporting, but we do not expect this to be the case industry-by-industry. Indeed, we find that β_2 is negative for some industries (e.g., Clothing and Apparel). This could be for any number of reasons, such as an increase in international competition around the same time as the Colombian reforms. The limited enforcement model's prediction is that β_2 and β_4 have the same sign: an increase (decrease) in the profitability of exporting in a particular industry is associated with an increase (decrease) in the amount of capital that both exporters use and future exporters can sustain.

There are 27 industries and 1,183 Future Exporter observations in the post-reform period[19] . Of the 13 industries where the effect on exporters is significant, the signs of β_2 and β_4 are the same in every case. These industries represent 68.2% of exporting firms. In the remaining 14 industries where we should be less confident about the signs of these effects, we find that the signs of the point estimates of β_2 and β_4 are the same in 8 industries and different in 6 industries. Those industries where they are the same account for 23.5% of exporters, while those where they are different cover 8.3%.

Overall, the predictions of the limited enforcement model are borne out in industries covering 91.7% of exporting firms. Moreover, the only industries where its predictions fail are those with the most imprecise estimates of the effect of reform on exporters. We take this as evidence that the effects of reform on future exporters are broadly consistent with the limited enforcement model even at the industry level.

1.5.3 Indirect Evidence: Entry of Young Firms into Export Markets

We consider the entry into export markets (extensive margin) of young firms, which we showed is the key difference in implications for the two models that drives the difference in gains from trade reform. As demonstrated by the special case in the previous section,

[19] See Table A in the online appendix for complete results

gains from trade reform are lower in the collateral constraints model because the extensive margin is significantly dampened for young firms. Because of the forward-looking nature of financial constraints in the limited enforcement model, young firms are able to become exporters. Figure 4 shows the fraction of plants that export by age in the pre-liberalization period (1981-84) and the post-liberalization period (1987-1991). This figure shows that there was a very large increase in exporter participation among young firms. We take this as evidence that the extensive margin of trade is not significantly dampened for young firms. This is consistent with the limited enforcement model (where it is relatively easy for young firms to enter export markets following a reform), but not with the collateral constraints model (where export participation among young firms is not substantially affected by trade reform and may even be reduced).

1.6 Conclusion

This paper provides a means of distinguishing between two widely used specifications of borrowing constraints: limited enforcement and collateral constraints. We first show that these two models have importantly different predictions for the gains from undergoing a reform. We then show that trade reform provides a means for distinguishing between them. Our analysis provides evidence in favor of the limited enforcement specification. Although the model and data are related to a trade reform, we believe these results are more widely applicable.

We intrepret our results as demonstrating that models with fixed collateral constraints are inappropriate when analyzing economies undergoing reform or structural change. While a collateral constraint may be a good approximation to an underlying financial market imperfection in a stationary economy, it fails to address the endogenous response of financial markets in economies undergoing change. In many contexts this effect is important. Apart from this paper, the results in work by Buera and Shin (2009, 2010) may be significantly altered if borrowing constraints were forward-looking in the sense discussed in this paper. Reform causes the profitability of some firms to increase, and others to decrease. With enforcement frictions, this causes financing to be immediately reallocated from firms whose profitability is reduced toward firms whose profitability increased. This at least partially undoes the misallocation effect that is the key to their results.

In this paper, we abstracted from idiosyncratic productivity shocks to isolate the difference between these two financial environments. This abstraction is potentially important[20] , but introducing them would require one to specify whether or not debt is contingent on realizations of individual productivity. Typically, models with collateral constraints have only non-contingent debt[21] , while models with limited enforcement usually have contingent debt. In future work we plan to explore this distinction.

Parameter	Symbol	(a)	(b)	(c)
Discount Factor	β	0.96	0.96	0.96
Cobb-Douglas Parameter	α	0.3	0.3	0.3
Capital Depreciation	δ_k	0.05	0.05	0.05
Elasticity of Substitution	σ	2	2	2
Pre-Liberalization Tariffs	τ_H	0.38	0.38	0.38
Post-Liberalization Tariffs	τ_L	0.1	0.1	0.1
Survival Probability	δ	0.07	0.07	0.07
St. Dev. of Productivity	s	0.82	0.82	0.82
Export Fixed Cost	f_x	0.31	0.3	0.33
Home Bias	ω	0.51	0.51	0.51
% Firms that can Export	ϱ	0.23	0.27	0.22
Enforcement Parameter	θ	0.77	0.04	-
Prob. of Starting New Firm	ξ	0.99	-	-
Initial Assets	a_0	0	0.02	0

(a) Calibration for limited enforcement economy
(b) Calibration for collateral constraints economy
(c) Calibration for perfect credit markets economy

Table 1.1: Parameter Values

[20] Midrigan and Xu (2010) show that volatility in firm-level productivity can have large effects on the ability of firms to overcome their collateral constraints through self-financing, though they provide evidence that productivity is very persistent in the micro data.
[21] Rampini and Viswanathan (2010) is a notable exception.

Target	Data	Model (a)	Model (b)	Model (c)
Exports/GDP	8%	8%	8%	8%
% Firms Exporters	12%	12%	12%	12%
Exporter Prod. Premium	0.72	0.72	0.72	0.72
Firm Growth, 1 to 15	123%	123%	123%	-
% Age 1 to 5 Firms Export	6%	6%	6%	-

Data: Colombian Survey of Manufacturers, years 1981-1991

Table 1.2: Target Statistics: Model and Data

	% Change in c	% Change in y	% Change in w	% Change in Δ(x/y)
Limited Enforcement (a)	**4.11**	**4.68**	**6.49**	**5.51**
Perfect Credit Markets (a)	**4**	**4.56**	**6.42**	**5.5**
Difference	***+3%***	***+3%***	***+1%***	***+0%***
Collateral Constraints (b)	**3.55**	**4.04**	**5.87**	**5.32**
Perfect Credit Markets (b)	**4.42**	**5.03**	**7.22**	**6.16**
Difference	***-20%***	***-20%***	***-19%***	***-14%***
Perfect Credit Markets (c)	**4.15**	**4.75**	**6.55**	**5.53**

Δ(x/y) is the change in exports as a fraction of output.

Table 1.3: Steady State Comparison

OLS Regression: Log(Capital)

	(I)		(II)	
Exporter	0.331	0.343	0.326	0.336
	(0.075)	(0.075)	(0.076)	(0.075)
Exporter x Reform	0.269	0.269	0.272	0.267
	(0.086)	(0.099)	(0.088)	(0.100)
Future Exporter	0.308	0.289	0.247	0.228
	(0.069)	(0.067)	(0.075)	(0.076)
Future Exporter x Reform	0.151	0.157	0.190	0.214
	(0.056)	(0.055)	(0.083)	(0.088)
Log(Employees)	1.192	1.234	1.199	1.239
	(0.049)	(0.049)	(0.049)	(0.049)
Age		-0.027		-0.027
		(0.004)		(0.004)
Age ^{2}		0.0003		0.0003
		(0.00001)		(0.00001)
Subsidies		0.016		0.016
		(0.006)		(0.006)
Industry-Year Effects	YES	YES	YES	YES
R^2	0.414	0.421	0.413	0.420
N	52803	52803	52803	52803

Parentheses denote standard errors clustered by industry.

(I): Future Exporter is a non-exporter at t, and an exporter at t+2

(II): Future Exporter is a non-exporter at t, and an exporter at t+1

Table 1.4: Effect of Future Exporting on Capital

Industry	*Exporter*	*Fut. Exp.*	*N*	*Industry*	*Exporter*	*Fut. Exp.*	*N*
311 Food Products	1.021	0.737	833	355 Rubber Products	0.315	-0.220	145
	(0.114)*	(0.291)*	9.2%		(0.329)	(0.416)	1.6%
312 Other Food Products	-0.594	0.514	161	356 Plastic Products	0.354	0.317	524
	(0.162)*	(0.903)	1.8%		(0.100)*	(0.103)*	5.8%
313 Beverages	1.161	1.105	54	361 Pottery, China, Porc.	0.590	-0.553	100
	(0.466)*	(0.171)*	0.6%		(0.631)	(0.560)	1.1%
321 Textiles	0.225	0.190	682	362 Glass Products	0.186	-0.451	147
	(0.126)	(0.112)	7.6%		(0.174)	(0.441)	1.6%
322 Clothing and Apparel	-0.087	0.127	854	369 Other Non-Metal Prod.	-0.108	0.056	206
	(0.103)	(0.145)	9.5%		(0.193)	(0.260)	2.3%
323 Leather Products	0.266	0.367	377	371 Iron and Steel	-0.496	-2.213	77
	(0.140)*	(0.303)	4.2%		(0.371)	(0.474)*	0.9%
324 Leather Shoes	0.128	0.108	335	372 Non-Ferrous Metals	-0.456	-0.253	44
	(0.115)	(0.160)	3.7%		(0.226)*	(0.597)	0.5%
331 Lumber, Wood and Cork	0.445	0.654	132	381 Non-Mach. Metal Prod.	0.363	0.309	719
	(0.289)	(0.895)	1.5%		(0.125)*	(0.081)*	8.0%
332 Furniture	0.178	-0.527	96	382 Machinery	0.059	-0.008	630
	(0.152)	(0.191)*	1.1%		(0.080)	(0.227)	7.0%
341 Paper	0.459	0.155	226	383 Electronic Machinery	0.065	0.639	401
	(0.130)*	(0.360)	2.5%		(0.084)	(0.350)*	4.4%
342 Printing and Publishing	0.123	0.090	334	384 Transportation Eqmt	0.125	-0.089	298
	(0.104)	(0.454)	3.7%		(0.168)	(0.310)	3.3%
351 Industrial Chemicals	0.300	0.434	444	385 Professional/Sci. Eqmt	-0.109	-0.347	172
	(0.113)*	(0.438)	4.9%		(0.145)	(0.730)	1.9%
352 Other Chemicals	0.398	0.276	668	390 Misc. Manufacturing	0.634	0.368	346
	(0.086)*	(0.258)	7.4%		(0.157)*	(0.317)	3.8%
354 Petroleum and Coal	0.335	1.303	20				
	(0.182)*	(0.468)*	0.2%				

Parentheses contain standard errors clustered by year.

**** denotes significant at the 10% level.***

Table 1.5: Industry Analysis of Future Export Effect

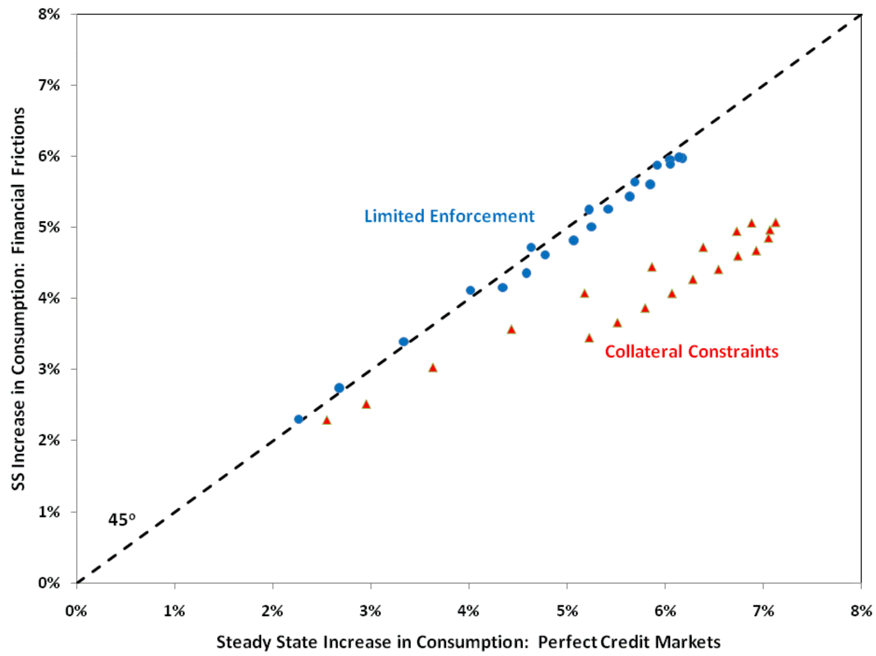


Figure 1.1: Gains from Trade, Varying Fixed Cost to Export

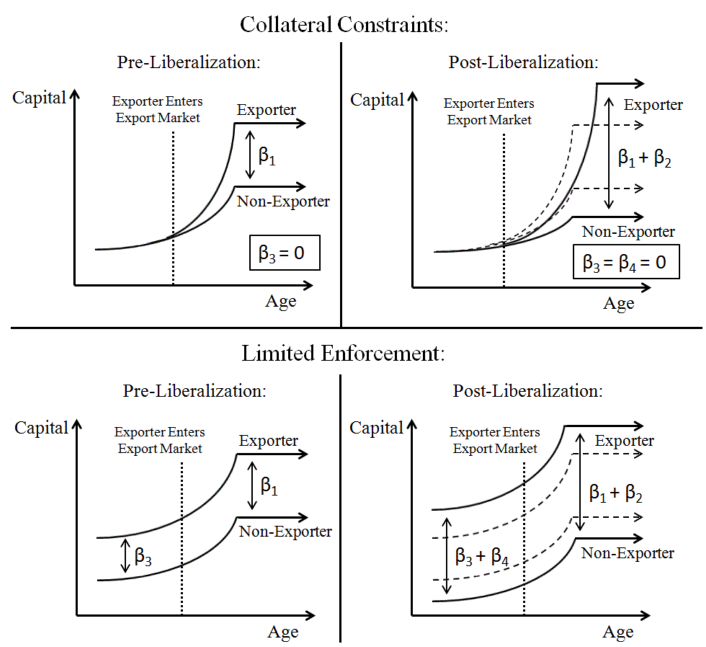


Figure 1.2: Predictions of Models for Trade Liberalization

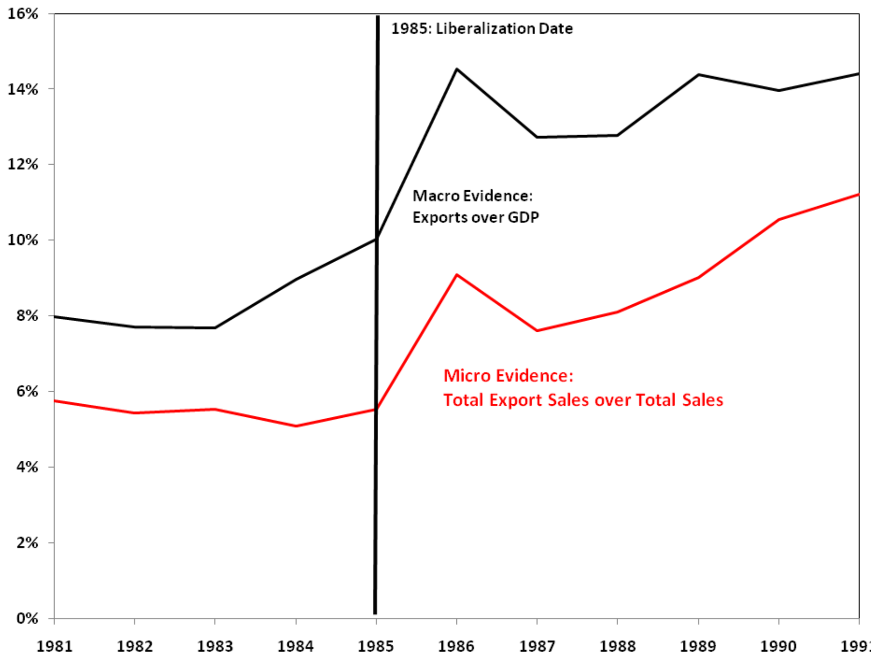


Figure 1.3: Evidence of Liberalization: Colombia 1981-1991 (Data)

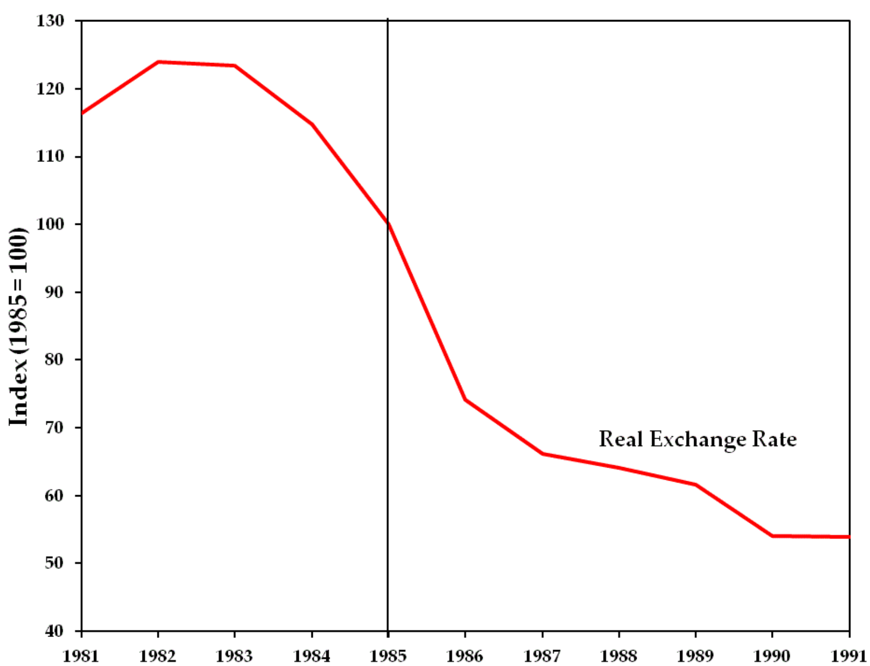


Figure 1.4: Real Exchange Rates (Data)

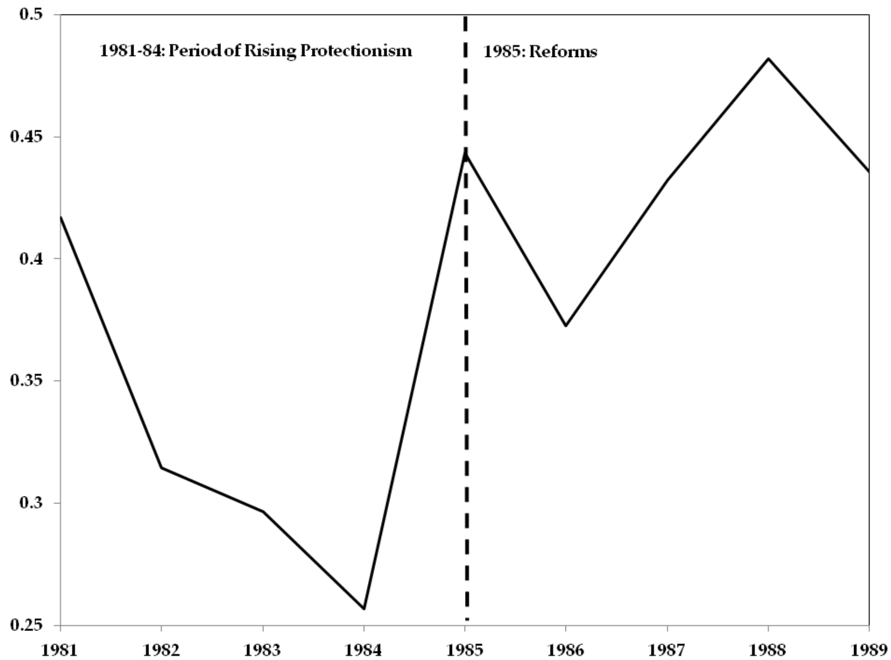


Figure 1.5: Year Analysis of Future Exporter Effect

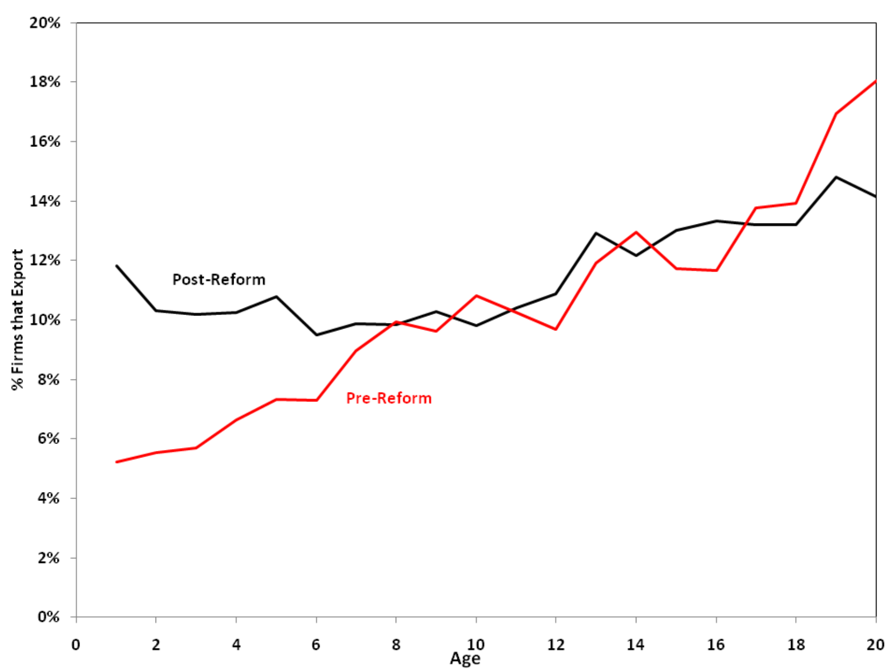


Figure 1.6: Trade Reform: Extensive Margin for Young Firms (Data)

Chapter 2

From Old to New Trade Theory

2.1 Introduction

Why do countries trade with each other? Trade theory is divided into two paradigms that provide very different answers to that question. The classical trade theories of Ricardo and Hecksher-Ohlin assume that countries trade because they are different. In Ricardian trade models, countries trade because they have different technologies, while in Hecksher-Ohlin they trade because they differ in factor endowments. This paradigm is very different from the new trade theories of Krugman (1979), Melitz (2003) and Eaton and Kortum (2002). These models focus on the industry or firm level, and assume that countries trade differentiated varieties even within given industries. In this paper we provide a unifying theory of these two paradigms that is consistent with patterns in the trade data.

First, we show that high income countries have patterns of trade consistent with the new trade theories, while low income countries have patterns consistent with classical trade theories. We look at disaggregated trade data from many countries. Our finding is that high income countries predominately import and export the same product categories. This suggests that their trade is not driven by industry-level comparative advantage. However, this relationship disappears for low income countries. That is, those product categories that they import most highly have no relation to those they export. This is more consistent with the paradigm of classical trade theory.

Second, we find this same relationship is true over time by looking at historical

Spanish trade data. In the nineteenth century, Spain exported very different products than it imported. This relationship diminished over time until now, when Spain exports and imports predominately the same products. We interpret this as a gradual transition over time from a pattern of trade consistent with classical trade theory to one consistent with new trade theory.

We then develop a model that encompasses both paradigms and is able to deliver this transition as countries increase in income levels. Countries trade differentiated agriculture and manufacturing goods. A non-homotheticity in agriculture consumption makes low productivity countries produce mainly in agriculture. Countries produce manufacturing varieties by paying fixed costs, and as they become wealthier they pay to produce more varieties.

We develop a case of our model, which is related to our empirical evidence from Spain. We consider a two country model in which the two countries are initially identical, then one begins to grow while the other does not. During this period, the growing country develops manufacturing varieties that it sells to the stagnant country. In turn, the stagnant country exports agriculture to the growing country. Then, the second country begins to an exogenous path of productivity improvement. It also develops manufacturing varieties, and the two countries begin to predominately trade manufacturing with each other. This is consistent with the pattern established in the Spanish data.

Understanding how patterns of trade differ across countries of different income levels is important for predicting the effects of trade reforms in different countries. Our results suggest that new trade theories would be appropriate for predicting patterns of trade in rich countries, while classical trade theories are appropriate in developing countries.

Furthermore, our model has implications for the gains from regional trade blocs. It predicts that high income countries gain the most from trade with close neighbors, making regional trade blocs highly beneficial. Meanwhile, low income countries have low gains from trade with their poor neighbors, making regional trade less beneficial. This suggests that the success of the EU or NAFTA is not evidence in favor of trade in regions composed mainly of developing economies.

2.1.1 Related Literature

Our paper unifies in a very stylized manner the three main theories of international trade that have been developed in economic theory. In this sense, we are related to the three of them.

First, it is related to Ricardian trade (after Ricardo (1817)) models that rely on trade being driven by countries having different technologies. This theory was initally formalized by Pasinetti (1960). A typical representation of Ricardian trade can be done by means of the production-possibility frontier: in a two country world, each country has a concave frontier, and the concavities of each country are different. This differentiation is what generates gains from trade. In our model we simplify this world: each country can only produce one of the goods, and not the other one. In a production-possibility frontier this is equivalent to letting the frontier of one country to only consist of a point in the x-axis, while the frontier in the other country only consists of a point in the y-axis. We make use of this simplification because the aim of our study is not to focus on the different properties of Ricardian trade, but to be able to modelize the trade structure that we observe in the data, which resembles Ricardian trade in the first half of the XIXth century, in a very stylized manner.

Second, our paper is related to Heckscher (1919) and Ohlin (1935) trade theory (hereinafter, H-O) later on formalized by Samuelson (1948, 1949), and extensively used in the literature. This theory relies on differences in endowments as the mechanics of international trade. It typically features two countries, two goods and two endowments required to produce these goods. The country relatively well endowed in one factor specializes in the production of the good that requires more of that endowment to be produced, and hence countries specialize in the production of the good that they are relatively better endowed with. Our model features two different H-O types of trade, which we refer to early-H-O and late-H-O trade.

Early-H-O trade involves two countries specializing on goods of different industries, for instance, agriculture and manufacturing. This is the more standard view of H-O trade, which has been extended in many different dimensions in the literature. Just to cite a few of them, Either (1972) has analyzed the role that non traded goods play in international markets, while Meyer (1984) has analyzed how tariffs are chosen optimally, precisely due to the losses that the relatively scarce sector faces when opening to trade.

In our model, there is a period of time in which trade flows behave as early-H-O trade in the following sense: the rich country has relatively more capital and produces very different goods than those produced by the poor country. Then, although the mechanism by which this pattern of trade arises is different than only relative endowment differences, the observed characteristics are equivalent. It is important to mention that, although dynamic, our model does not have the pattern of non-convergence pointed out in Atkenson and Kehoe (2000) and in Bajona and Kehoe (2006, 2010). They develop dynamic versions of the H-O model, showing that convergence does not necessarily happen in this framework, because the country relatively better endowed with capital remains richer than the one relatively better endowed with labor. The difference between our model and theirs is that in our model, although the pattern that arises looks like H-O, the driving force is not differences in relative endowments, but the level of development.

We also model another version of the same type of trade, which we label as late-H-O trade. This type of trade may arise due to the fragmentation of the production process in the luxury sector. That is, due to the vertical organizational structure of the production of one industry. We assume that the continuum of goods produced in the luxury sector are developed in two different stages. It starts producing an intermediate good which is labor-intensive to be used by the capital-intensive second stage of production, which produces the final good. This type of trade is closely related to Jones and Kierkowski (1990, 2001) and Yi (2003). The former models two stages of production, while the latter models three of them, which are sequentially ordered. We differ from the Jones and Kierkowski papers in that we use a modelization that is very close to theirs in order to explain the evolution of different trade regimes, while in their papers the main focus is the precise study of this trade structre. Yi tries to understand how much of the increase in world trade is driven by these vertical specialization forces. Our paper differs from this one in that we try to understand the patterns of trade that we observe between different countries of different stages of development. For a very detailed review of the literature on organizational structure of trade, see Antràs and Rossi-Hansberg (2009).

Third, it is related to the theory of New Trade goods, which relies on Dixit-Stiglity preferences (after Dixit and Stiglitz, 1977), and increasing returns due to a fixed cost of production, developed by Krugman (1979, 1980) and Helpman (1981). This theory has been extended in many directions, where probably the most notable one is the one developed after Melitz (2003) and Eaton and Kortum (1999, 2002) in which there is differentiation in the productivity of firms. In our model, when both countries are rich, the type of trade that arises is mainly due to New Trade theory. Interestingly, our model endogenously generates the pattern documented in Kehoe and Ruhl (2009), by which new trade is mainly due to new varieties being traded.

We are certainly not the first ones to put more than one trade theory together. Markusen (1986) develops a model of international trade in which three countries trade. Two of these countries are developed countries, while the third one is underdeveloped. With this setup, trade among developed countries is of the New Trade theory type, whereas trade between developed and underdeveloped countries is of the H-O type. His paper is very different than ours in two respects: first, our model is dynamic, which implies that the different trade theories naturally arise as there is economic growth. Second, in our paper we also encompass Ricardian trade, as the intial stage of trade and two different versions of H-O trade.

In spirit, our paper is very much related to the literature of unified growth theories, whose main contributions are Hansen and Prescott (2002), Jones (2001), Galor and Weil (1999) and Arifovic, Bullard and Duffy (1997). These papers put together the transition from Malthusian type of regime into modern economic growth based on the Solow model, and show that this mechanism provides an accurate description of the data. Our paper does a similar job, but instead of linking theories of economic growth, we link trade theories, and the data we provide is again regarding trade flows between countries.

Finally, our paper is also linked to the literature of economic history of Spain, providing a new explanation for the patter of trade observed in that country for the last 160 years. In order to obtain reliable data on Spanish trade, we have followed the Anuario Estadístico de España (for the years 1913-1986), the Estadística General del Comercio Exterior de España, con sus Provincias de Ultramar y Potencias Extranjeras (for the years 1885-1898), and the Cuadro General de Comercio Exterior de España (years 1853-1858). For the data on investment we have followed Carreras and Tafunell (2002) and for data on productivity we have followed Carreras (1984). In order to compare capital per person in Spain to that of the United Kingdom, we have followed Cubel and Palafox (2002). Finally, we follow Deane (1968) for the series of investment for the United Kingdom.

2.2 Empirical

This section is devided into two parts. In the first part we look at disaggregated trade data from a representative set of countries and see that the correlation between exports and imports is positive for rich countries and zero or even negative for poor countries, and that these correlations exhibit a hump-shaped pattern against the distance of country's GDP per capita and the average trading partner's GDP per capita. The second part consists of a historical analysis of the trade pattern of Spain for the period 1853-1986. In this analysis we again observe a similar pattern: very different goods were traded between Spain and the rest of the world during the XIXth century, and this pattern is slowly reversed until 1986.

2.2.1 Cross-country analaysis

We choose a set of representative countries[1] to analyse the relationship between imports and exports is at the 6 digit HS category for 2005.[2] Our finding is that high income countries predominately import and export the same product categories, while low income countries predominantly import and export in different categories. See Figure 1 for the examples of the Netherlands, the United States, South Africa and Bolivia. What we see is that, even at this very disaggregated level, those categories that wealthy countries export the most are also those that they import the most. Hence, their imports and exports are very closely related. This relationship is less clear for middle income countries and disappears completely for less developed countries. Figure 2 shows this pattern for all the countries in our sample. The cross-country correlation between GDP per capita of 2005 measured in US dollars and the correlation between exports and imports of that same year is 0.835.

[1] The list of countries is: Argentina, Australia, Austria, Azerbaijan, Bolivia, Bosnia, Brazil, Bulgaria, Burkina Faso, Cambodia, Cameroon, Canada, China, Colombia, France, Germany, Ghana, India, Italy, Jamaica, Japan, Kenya, Mexico, Morocco, Netherlands, New Zealand, Pakistan, Paraguay, Peru, Rep. Korea, Russian Federation, South Africa, Spain, Sweden, Tunisia, United Kingdom, United States, Uruguay, Vietnam, Zambia and Zimbawe

[2] In order to have a consistent analysis with the trade models on final goods, we have dropped all the categories about raw materials (25, 26, 27 and 44).

We next analyze how these correlations are compared to the income gap between a country and its trading partners. In order to proceed, we develop the following measure of GDP distance:

$$\begin{aligned} GDP_{ditsance,i} &= \frac{GDP_{pc,i} - \sum_j \omega_j^i GDP_{pc,j}}{\sum_j \omega_j^i GDP_{pc,j}} \\ \omega_j^i &= \frac{(X+I)_{i,j}}{\sum_k (X+I)_{i,k}} \end{aligned}$$

where ω_j^i is the weight of country i in trade with country j.

Figure 3 shows the pattern of trade for the set of countries. The relationship is hump-shaped: countries whose trade is mainly with countries with very different GDP per capita have correlations close to 0, whereas countries whose trade is mainly with partners of equal GDP per capita have very positive correlations. The trend line is a cubic polynomial.

We have documented two novel facts about trade patterns: First, as countries get richer, the correlation of imports and exports becomes larger. Second, the relationship of these correlations and GDP per capita is hump shaped, once we take into account the average GDP per capita of the partner with which the country trades this.

2.2.2 Spanish historical trade data

Spain has very detailed data on imports and exports since 1853 until 1986. This data can be found in the *Anuario Estadístico de España*, in the *Estadística General del Comercio Exterior de España, con sus Provincias de Ultramar y Potencias Extranjeras*, and in the *Cuadro General de Comercio Exterior de España.* The data is not as detailed as the HS 6 digit level, but the disaggregation level is still significant. This data has its own limitation on the period by which it is available: there is no data before 1849, and there is no yearly data before 1853, [3] and very little attempts have been done in order to recover some degree of disaggregation among them. [4]

Although we are facing these caveats, some very important findings appear after the examination of this data and the HS 6 digit data available for 2002-2010:

[3] As it is already noted in Prados de la Escosura (1984)

[4] See Prados de la Escosura (1986). To the best of our knowledge, this is the only attempt to recover some degree of disaggregation for before 1849, although their series are significatively different from those in the *Cuadro.*

1) We observe that imports were very different from exports in the second half of the XIX century

2) Imports and exports are very similar in the beginning of the XXI century

3) There is a slow convergence between the two points during the second half of the XIX century and the XX century

Imports were very different from exports in the second half of the XIX century

For instance, in 1853, there are 58 disaggregated categories in both, imports and exports, which represent 84% of total imports and 92% of total exports. Among the 116 distinct categories, only two appear with a very similar name in both, Eau-de-vie and salt, two appear with similar names, the textiles of silk and wool, and one more appears with similar names, iron (seven different categories in imports, only one in exports). In total, the reamining non-coincident categories represent 85% of detailed imports and 95% of exports. The same pattern is observed - although it declines - during the following 50 years. Table 1 shows this data.

In order to better understand trade, we should focus on the origins of it. For instance, by 1854, 58% of total Spanish imports were from France and from Engalnd, two countries that were undergoing the industrial revolution, and hence the main source of imported manufactures.

Years	Non-coincident Imp	Non-coincident Exp	% Imp+Exp England and France
1853-1856	76%	75%	58%
1867-1868	74%	68%	62%
1885-1898	63%	67%	53%

Table 2.1: Share of non-coincident imports and exports and imports from France and England.

Imports are very similar to exports in the beginning of the XXI century

We again use the 6 digit HS category for Spain for all the years it is available (2002-2010) in order to see how similar have been exports and imports in the beginning of the

XXI cenutry. The results are summarized in Table 2, together with GDP per capita of Spain and the share of trade that Spain was doing with developed countries (EU-15, US, Canada, Norway and Japan).

Year	Correlation	GDP per capita	%Trade from Developed Countries
2002	0.81	26095	71%
2003	0.81	26459	71%
2004	0.84	26881	69%
2005	0.84	27392	66%
2006	0.82	28075	63%
2007	0.81	28530	64%
2008	0.75	28329	60%
2009	0.75	27070	61%
2010	0.73	26967	58%

Table 2.2: Correlation of Imports and Exports, GDP per capita and trade with developed countries

The result is that Spanish correlation of imports and exports for all the period is really high (between 0.73 and 0.84) and total trade with developed countries is the most important one. Interestingly, we observe that the share of total trade with already developed countries and the correlation of imports and exports are both declining over time, suggesting that the empirical finding that we are discussing in this section is still observed in a span of 9 years difference.

Manufacturing and Agriculture 1853-1986

From the cross-country analysis we have shown that richer countries have higher correlation of imports and exports than poor countries. It is a well known fact that richer countries devote a larger part of their production to manufacturing than they do to agriculture.[5] In this part, in order to be able to compare all the data sources we have, we assume that, as suggested from the previous analysis, trade in agriculture is of very differentiated goods (e.g. olive oil is exported and tobacco is imported), while trade in mannufacturing is very similar (both exports and imports are predominated by cars, as noted in Kehoe and Ruhl, 2008).

[5] See, for instance, Herrendorf, Rogerson and Valentiny (2012)

Hence, we can analyse the relative importance of manufacturing versus agriculture for Spain during the period that we are interested in, since they are comparable magnitudes across sources. Figure 4 shows the pattern. There are three main findings in this pattern: 1) During the XIXth century, and consistent with the previous part, trade between Spain and the rest of the world was very different: Spain was mainly exporting agriculture and was importing many more manufatures. 2) By the end of the XXth century, Spain was mostly importing and exporting manufactures, and agriculture had a minor role. 3) The pattern of converging from 1) to 2) was more or less steady since 1890.

2.2.3 Capital levels in the XIX century

The last fact we want to show is not a novel fact, although it is really important to stress it in order to put all the pieces together. The fact we stress in this part is that capital per person in Spain was much smaller than that of the United Kingdom during the XIX century. We show the results in Figure 5. The series is constructed using the standard capital accumulation difference equation

$$K_{t+1} = K_t(1-\delta) + I_t$$

with paramenter $\delta = 0.07$, and intial capital level satisfying that $\frac{K_1}{K_0} = \sqrt[10]{\frac{K_{11}}{K_0}}$. The data on investment for the United Kingdom for 1830-1900 is taken from the estimates of Deane (1968) and for Spain from Carreras and Tafunell (2004). In order to have comparable magnitudes we use the estimate of Cubel and Palafox (2002) in that capital per person in 1900 for the UK was three times larger than that of Spain. The series for population are taken from Maddison (2003). The result is that capital per person in the United Kingdom remained much higher than that of Spain for the entire period. [6]

[6] This result is consistent with the data of Maddison (2003) on GDP per capita and the Kaldor stylized fact that $\frac{K}{Y}$ is constant over time and across countries, since a direct implication is that $\frac{K/L}{Y/L}$ is also constant, and hence $\frac{K_i/L_i}{K_j/L_j}$ has the same behavior as $\frac{Y_i/L_i}{Y_j/L_j}$, which, according to Maddison's estimates follows a very similar pattern as our calculation of capital per capita between the two countries.

2.3 Model

There are two countries that produce differentiated agricultural and manufacturing goods. Time is discrete and infinite. Each country has an endowment of labor and, at time 0, capital. Capital is accumulated endogenously over time. We will label one country as domestic and denote associated variables with d. The other country is foreign and has variables labeled with f. The domestic country has a representative household solves the following problem:

$$\max \sum_{t=0}^{\infty} \beta^t \left[\theta u(c_A^d) + (1-\theta)v(c_M^d)\right] \tag{2.1}$$

subject to

$$P_{A,t}^d c_{A,t}^d + P_{M,t}^d c_{M,t}^d + P_{x,t}^d (K_{t+1}^d - (1-\delta)K_t^d) \leq w_t^d + r_t^d K_t^d$$

The problem for the foreign country is analogous. Each country has technologies that produce agriculture, manufacturing and investment goods. Investment goods y_x^d are produced domestically by competitive firms solving the following problem:

$$\max P_{x,t}^d y_{x,t}^d - w_t^d L_{x,t}^d - r_t^d K_{x,t}^d \tag{2.2}$$

subject to

$$y_{x,t}^d = \gamma_{x,t} \left(K_{x,t}^d\right)^{\alpha} \left(L_{x,t}^d\right)^{1-\alpha}$$

Domestic agricultural goods are composed of intermediate goods from both countries. There is a minimum consumption requirement of both goods that captures a minimum amount of consumption from both countries. The intermediate goods y_A^d are produced by competitive firms:

$$\max q_{A,t}^d (x_{A,t}^d + m_{A,t}^d) - w_t^d L_{A,t}^d - r_t^d K_{A,t}^d \tag{2.3}$$

subject to

$$x_{A,t}^d + m_{A,t}^d = \gamma_{A,t} \left(K_{A,t}^d\right)^{\phi} \left(L_{A,t}^d\right)^{1-\phi}$$

The final consumption goods producers are competitive and solve the following problem:

$$\max P_{A,t}^d c_{A,t}^d - q_{A,t}^d x_{A,t}^d - \tau q_{A,t}^f m_{A,t}^f \tag{2.4}$$

subject to

$$c^d_{A,t} = (x^d_{A,t} - \bar{c})(m^f_{A,t} - \bar{c})$$

Manufacturing goods are produced by monopolistically competitive intermediate goods producers. Goods from the other country face an iceberg transportation cost $\tau - 1 > 0$. These goods are aggregated into the final manufacturing good in each country with the following CES aggregator by competitive final goods producers. They solve the following problem:

$$\max P^d_{M,t} c^d_{M,t} - \int q^d_{M,t}(i) x^d_{M,t}(i) di - \int q^d_{M,t}(i) m^f_{M,t}(i) di \tag{2.5}$$

subject to

$$c^d_{M,t} = \left(\int \left(x^d_{M,t}(i) \right)^\rho di + \int \left(m^f_{M,t}(i) \right)^\rho di \right)^{1/\rho}$$

Intermediate goods producers must use f units of capital to operate. The problem of a intermediate manufacturing goods producer in the domestic country is:

$$\max q^d_{M,t}(i) x^d_t(i) + q^f_{M,t}(i) m^d_t(i) - w^d_t L_{M,t}(i) - r^d_t f \tag{2.6}$$

subject to

$$x^d_t(i) + \tau m^d_t(i) = \gamma_{M,t} L^d_{M,t}(i)$$

In each period, there are an infinite number of potential producers. The mass of firms M^d that produce domestically are pinned down by a zero profit condition. Because all firms are identical, all manufacturing firms have no profits.

An equilibrium in this economy is a sequence of prices $\{\{P^i_{A,t}, P^i_{M,t}, P^i_{x,t}, q^i_{A,t}, w^i_t, r^i_t\}_{i \in \{d,f\}}\}^\infty_{t=0}$, inverse demand functions $\{\{q^i_{M,t}\}_{i \in \{d,f\}}\}^\infty_{t=0}$, and allocations $\{\{c^i_{A,t}, c^i_{M,t}, K^i_{t+1}, y^i_{x,t}, K^i_{x,t}, L^i_{x,t}, x^i_{A,t}, m^i_{A,t}, K^i_{A,t}, L^i_{A,t}, x^i_{M,t}, m^i_{M,t}, M^i_t, L^i_{M,t}\}_{i \in \{d,f\}}\}^\infty_{t=0}$ that solve:

1. Household problems (2.1)
2. Investment goods producer's problem: (2.2)
3. Market clearing for investment goods: $\forall i \in \{d,f\}, K^i_{t+1} - (1-\delta)K^i_t = y^i_{x,t}$
4. Agriculture intermediate goods producer's problem: (2.3)
5. Agriculture final goods producer's problem: (2.4)

6. Manufacturing intermediate goods producer's problem: (2.6)

7. Manufacturing final goods producer's problem: (2.5)

8. Initial capital is given: $\forall i \in \{d, f\}, K_0^i$

2.3.1 Example: Two countries with asymmetric growth

First we consider an example that is designed to replicate the historical pattern of trade in Spain. In this version of the model, we assume exogenous processes on $\{\{\gamma_{A,t}^i, \gamma_{M,t}^i, \gamma_{x,t}^i\}_{i\in\{d,f\}}\}_{t=0}^{\infty}$ as follows: $\forall i, t, \gamma_{A,t}^i = \gamma_{M,t}^i = \gamma_{x,t}^i = \gamma_t^i$. The two countries are identical at time 0. Then for the first T periods γ_t^d is fixed while γ_t^f grows. From period $T+1$ to $2T$, γ_t^d starts growing at a faster rate and at period $2T$ their productivities equalize again and grow at the same rate thereafter.

To summarize, the foreign country grows at a constant rate: $\gamma_t^f = \gamma_0^f e^{gt}$. The domestic country has the following pattern of growth:

$$\gamma_t^d = \begin{cases} \gamma_0^d & \text{if } t < T \\ \gamma_0^d e^{2g(t-T)} & \text{if } T \leq t < 2T \\ \gamma_0^d e^{gt} & \text{if } t \geq 2T \end{cases}$$

In this case, the pattern of trade follows the pattern over time in Spain, where Spain is the domestic country. Figure 5 illustrates the paths of production and trade in both countries over time. Due to the need to pay a fixed cost to operate, there is an increase in the number of manufacturing firms that operate in the foreign country. Therefore, the foreign country trades manufactures for increased agricultural goods in the domestic country. The domestic country specializes in agriculture, uses little capital and imports manufactures. Due to low investment, the domestic country is relatively labor abundant and specializes in the labor abundant good. Therefore, the pattern of trade appears classical, however trade is not driven by either comparative advantage (since both countries have the same underlying technology) nor by factor endowments (since both countries were ex-ante identical).

This pattern of trade continues until the domestic country also begins to grow. As the domestic country becomes wealthier, they also pay more fixed costs to develop manufacturing varieties. Eventually trade between the two countries is dominated by differentiated varieties of manufactures. Hence, once the countries have grown sufficiently, the pattern of trade is consistent with new trade theories.

The pattern of trade between the countries is determined by both the level of productivity and by the relative productivities between the countries. Patterns consistent with classical trade theory occur when countries are close to their subsistence requirement, and when countries differ sufficiently in their productivity levels.

2.4 Conclusion

This paper has two substantial contributions. First, we establish an empirical relationship between a country's pattern of trade and its level of development. We find that developed countries trade predominantly with one another, and their exported goods are very similar to their imported goods. Less developed countries trade predominantly with developed countries, and there is very little relationship between what they import and export. This pattern is true both across countries in the modern times, and across time in Spain. We summarize this as saying that developed countries follow a pattern of trade predicted by the new trade literature, while less developed countries follow that of the classical trade literature.

Our second contribution is to provide a modeling framework that unifies these observations. With non-homothetic preferences, the income level of a country in part determines the composition of what the country consumes. Hence, as a country grows it consumes a greater proportion of differentiated manufactured goods. In an example we show that this delivers a pattern of trade consistent with the growth experience of Spain.

We see these results as being important for predicting the effects of trade liberalization in developing and developed countries. These results suggest that the predictions of the new trade literature, such as Arkolakis, et al (2012), may not apply in developing economies. We see this work as having implications for the gains from regional trading blocs among developed and developing countries. Developed countries trade with one another and they import and export closely related goods, while less developed countries do not. Therefore, the experiences of regional trading blocs in developed regions may not be informative for the gains from developing such blocs in less developed regions.

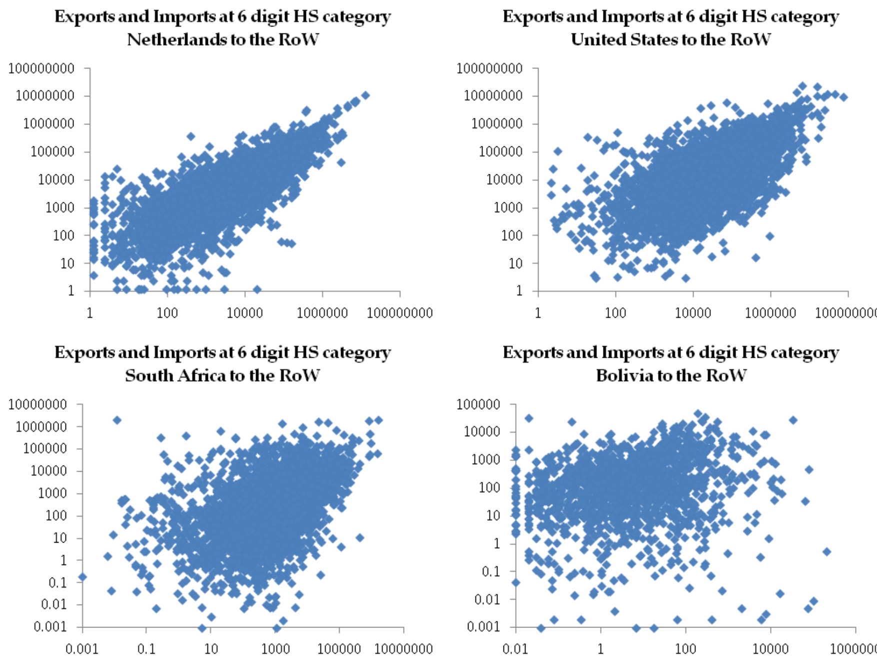


Figure 2.1: Intra-Industry Trade for Four Countries

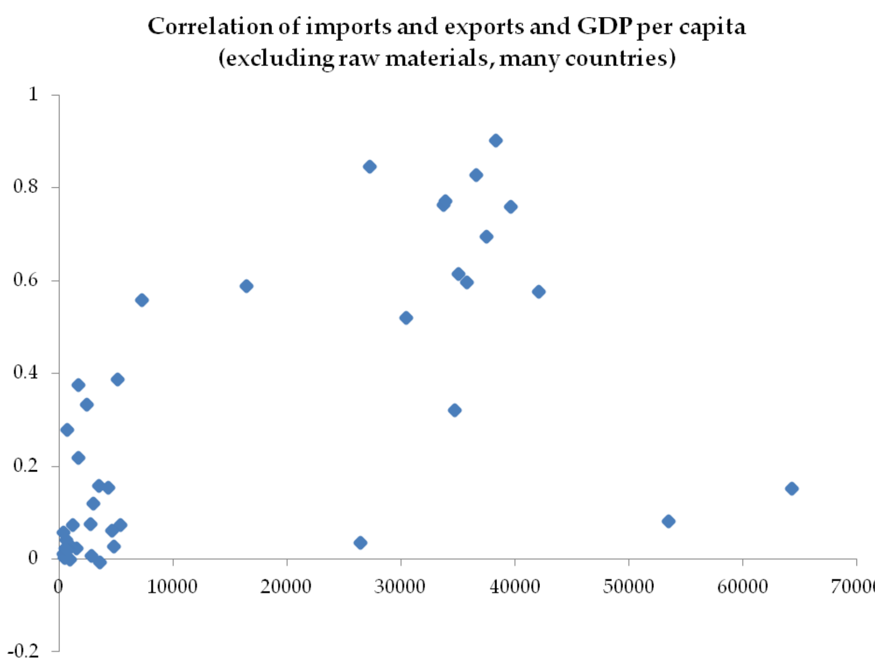


Figure 2.2: Relationship between Trade Correlation and Income

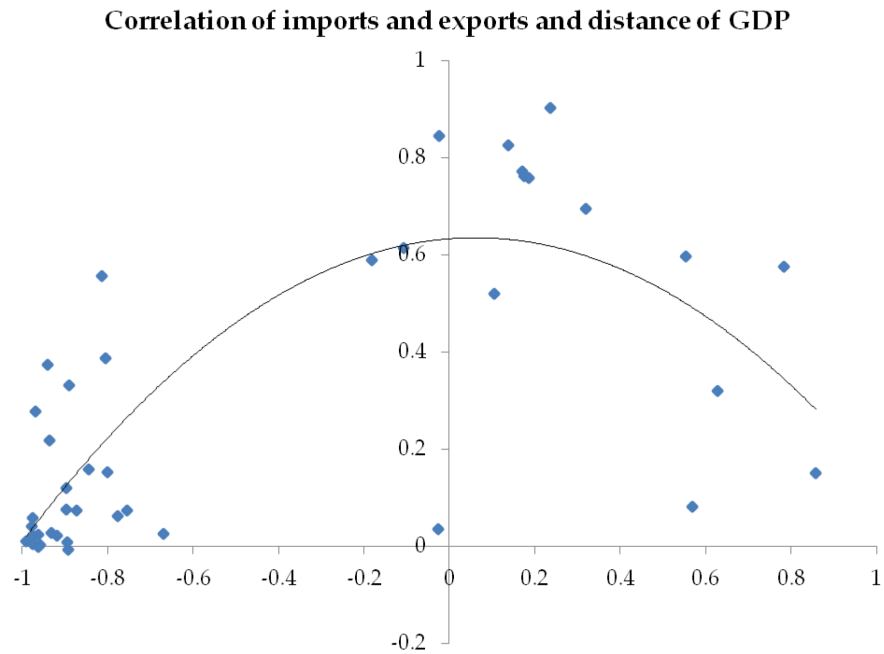


Figure 2.3: Trade Correlation and Income Relative to Trade Partners

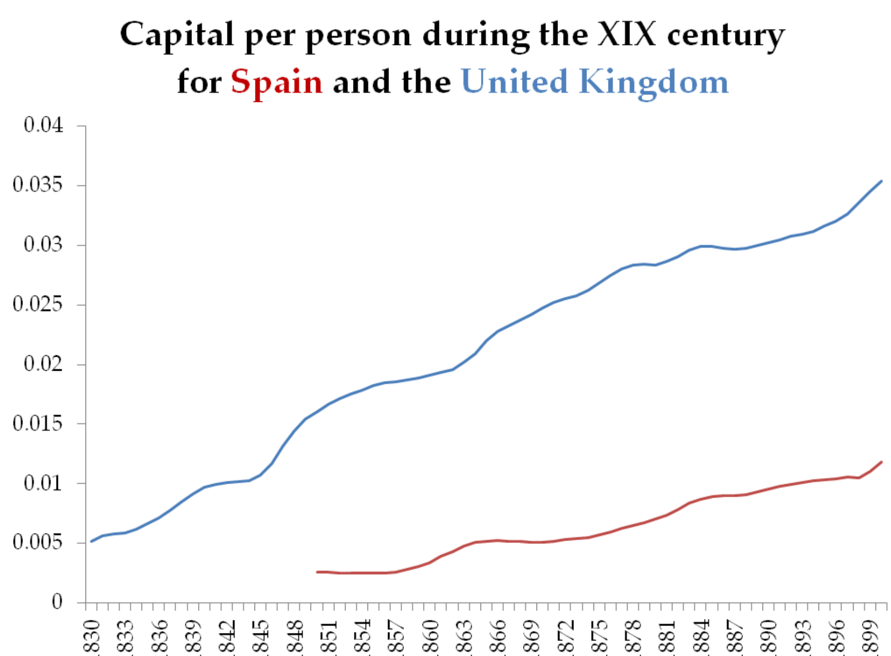


Figure 2.4: Capital Levels for Spain

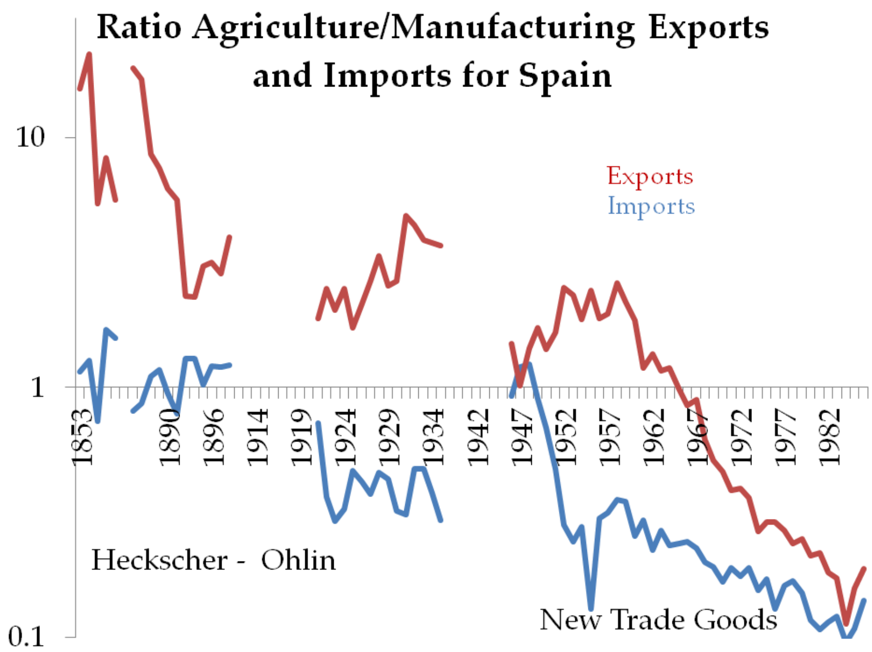


Figure 2.5: Spanish Trade in Agriculture and Manufacturing

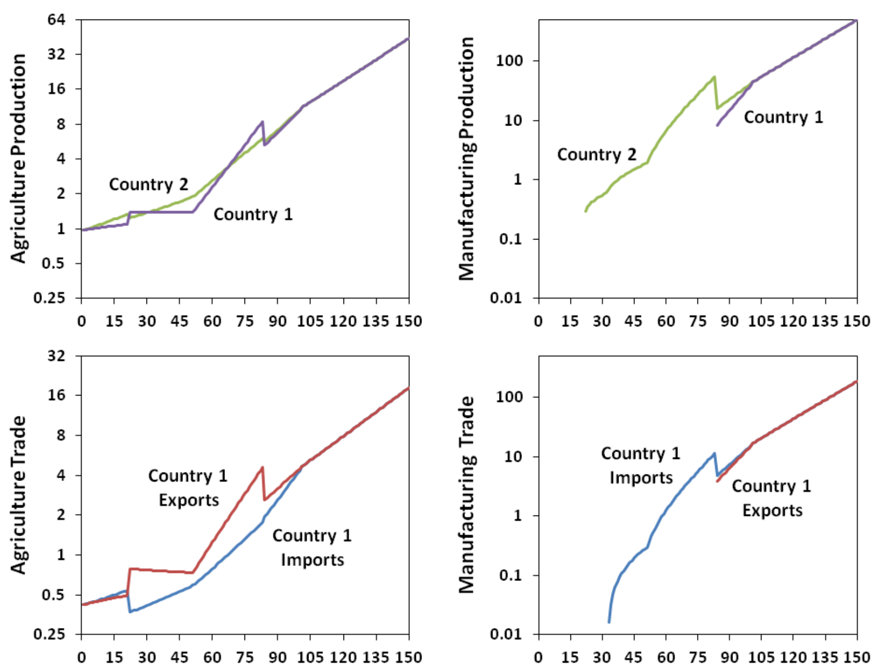


Figure 2.6: Production and Trade by Sector and Country (Model)

Chapter 3

Optimal Fiscal and Immigration Policy

3.1 Introduction

How can governments best use immigration policy to raise fiscal revenue? Governments determine whether or not potential immigrants may legally operate within their country. In many instances, the immigrant's productivity in the government's country may be higher than in their home country. Hence, there is positive surplus from their migration. Governments may collect part of that surplus as tax revenue, which raises fiscal revenue. The purpose of this paper is to study optimal immigration policy when the government's objective is to raise revenue, and to study optimal taxation of immigrants.

If governments have perfect information about immigrants, this problem is trivial. Any immigrant may enter who produces positive surplus, and all of that surplus is extracted by the government through lump sum taxation. Instead I consider the problem when the government cannot observe the productivity of the immigrant. This case seems particularly relevant for immigration policy, since governments have access to limited records on foreign nationals. Furthermore, the domestic government may have less information about the immigrant's prospects in their own country than does the immigrant.

I consider a static Mirrlees (1971) environment where there are two groups of agents: natives and foreigners. The planner knows the group that any individual agent belongs to, but does not know that agent's productivity type. The planner collects reports of productivity types from all natives and foreigners. Based on those reports, the planner transmits immigration decisions to foreigners (I assume that the planner can costlessly exclude immigrants from the country), and transmits production and consumption orders to all natives and immigrants. The planner observes consumption and output from each agent, but does not observe the effort that was required of agents to produce that output. Hence, it is possible for agents to transmit false reports of their true types and, potentially, be better off than they would by reporting the truth. The planner takes this into account when choosing production, consumption and immigration orders. Furthermore, all foreigners have a type-specific outside option that they can freely exercise. Hence, the planner faces participation constraints: if the planner would like a foreigner to immigrate, they must do at least as well as their outside option.

The solution to this problem has two interesting features. First, immigration policy follows a cutoff rule: all foreigners who report a type above a given threshold are allowed to immigrate. Second, not all immigrants who would produce positive surplus if admitted are allowed to do so. This is because there is a tradeoff between the number of immigrants admitted and the amount of surplus that can be extracted from each. When the productivity cutoff is reduced, that adds additional incentive constraints to the problem as there are more productivity type reports that can be transmitted that still allow for immigration. These additional incentive constraints reduce the ability of the planner to extract surplus from immigrants. I provide a numerical example to demonstrate that this can lead to a lower level of immigration than would be achieved with full information. That is, some immigrants that would produce positive surplus if admitted are not allowed to immigrate.

How immigration policy interacts with fiscal policy has previously received attention in the literature in the context of specific policy objectives. For example, Storesletten (2000) develops a model to ask if immigration policy could raise revenues sufficient to finance the U.S. social security system. Akin (2011) studies the effects of exogenous changes in the number of immigrants on taxes and pensions in Germany. Likewise, Bonin, et al (2000) show that immigration policy is capable of reducing (but not eliminating) the intergenerational fiscal imbalance in the German pension system. In contrast to these studies, this paper characterizes optimal immigration policy: the planner (or government) has no specific policy objective except to maximize welfare for the native population. Furthermore, unlike these studies I solve for optimal tax policy for immigrants and the native population. These other studies leave the tax rates fixed, or consider linear taxation.

In the next section I describe the economic environment. In Section 3 I prove that optimal immigration policy follows a cutoff rule, I describe the binding pattern of the constraints at the optimum and prove that there is a tradeoff between the immigration cutoff and the amount of surplus that may be extracted. In Section 4 I provide a numerical example and show that there may be foreigners who are not allowed to immigrate even if they would provide positive surplus. In Section 5 I conclude.

3.2 Model

There are two populations of workers called natives and foreigners. Within each population there is a publicly known distribution of types with finite support. The support of each population's distribution is the same, but the distributions of workers across types need not be the same. Individuals within each population are privately informed about their own type. The type θ of a worker is equal to the marginal value of a unit of that worker's effort when the worker operates.

I consider the problem of a planner that values the welfare of the native population. Here I consider the case when all natives have equal weight in the planner's problem, but that need not be the case in general. All individuals in both the native and foreign populations have the same preferences over consumption and effort represented by an additively separable utility function: $u(c)-v(l)$. I assume that u is concave and increasing, and v is strictly convex and increasing. Workers who operate produce output from effort with the linear production technology $y=\theta l$. The planner observes output from each worker, but does not observe effort.

The planner can costly keep foreigners from being able to operate[1] . Any foreigner that does not operate receives utility dependent on their true type $\bar{U}(\theta)$. Foreigners may choose to exercise their outside option even if the planner allows them to operate.

[1] I interpret this as immigration policy. The technology is domestic, and keeping the foreigner from operating it is like keeping them out of the country.

I solve the planner's problem as a mechanism design problem, which induces truthful revelation on the part of all agents. A mechanism is a function that maps agents' reports into allocations. The mechanism induces truthful revelation if no agent prefers to report a type other than their true type[2] . The timing is as follows: the planner announces a mechanism, all foreigners and natives observe their true types, then submit reports to the planner, then the planner gives operation orders to the foreigners, and production and consumption orders to natives and those foreigners who operate. Among operating workers, the planner is able to distinguish between natives and foreigners, and may treat them unequally.

I break the planner's problem into two parts. First, I consider the problem of the foreign population:

$$T = \max_{\{c,y,x\}} \sum_{i=1}^{M} x(\theta_i)[y(\theta_i) - c(\theta_i)] \tag{3.1}$$

subject to

$$(IC_{i,j}) : \text{if } x(\theta_i), x(\theta_j) > 0,\ u(c(\theta_i)) - v\left(\frac{y(\theta_i)}{\theta_i}\right) \geq u(c(\theta_j)) - v\left(\frac{y(\theta_j)}{\theta_i}\right) \tag{3.2}$$

$$(IR_i) : \text{if } x(\theta_i) > 0,\ \bar{U}(\theta_i) \leq u(c(\theta_i)) - v\left(\frac{y(\theta_i)}{\theta_i}\right) 0 \leq x(\theta_i) \leq g(\theta_i) \tag{3.3}$$

where the finite set of types of $\Theta = \{\theta_1, ..., \theta_M\}$ has, in the foreign population, density $g : \Theta \to \mathbb{R}_+$. The measure of foreigners of type θ that operate is given by $x(\theta)$. The (IC) constraints ensure that all agents truthfully reveal their types. The (IR) constraints ensure that any foreigner that is allowed to operate will choose to do so.

For a given solution to the problem of the foreigners, the equally weighted planner's problem of the native population is given by:

$$\max_{\{c^N, y^N\}} \sum_{i=1}^{M} f(\theta_i) \left[u(c^N(\theta_i)) - v\left(\frac{y^N(\theta_i)}{\theta_i}\right)\right] \tag{3.4}$$

subject to

$$(IC_{i,j}) : u(c^N(\theta_i)) - v\left(\frac{y^N(\theta_i)}{\theta_i}\right) \geq u(c^N(\theta_j)) - v\left(\frac{y^N(\theta_j)}{\theta_i}\right) \tag{3.5}$$

[2] Standard arguments (i.e., the Revelation Principle) imply that the restriction to revelation mechanisms is not restrictive. See Myerson (1979).

$$(RF) : T + \sum_{i=1}^{M} f(\theta_i)[y^N(\theta_i) - c^N(\theta_i)] \geq 0 \tag{3.6}$$

where $f : \Theta \to \mathbb{R}_+$ is the measure of natives of each productivity type. The problem of the natives differ in three ways. First, there is no operation decision, so natives may misreport their type to be any of the M productivity types. Second, natives have no outside option. Finally, the utility of natives enters the objective of the planner.

Writing the problem in this way emphasizes how the planner proceeds. The goal of the planner is to transfer as much as possible from foreigners to natives, subject to incentive and participation constraints. This makes the allocation for natives and foreigners qualitatively different, because the utility of foreigners does not directly enter the objective of the planner whereas that of natives does.

In general, the solution to this problem is difficult to characterize because the solution depends fundamentally on the shape of the $\bar{U}$ function. Therefore I will maintain the following assumption on the shape of this function:

Assumption 1. *The outside option $\bar{U} : \Theta \to \mathbb{R}$ satisfies the following property:*

$$\forall i \in \{1, ..., N-1\}, \bar{U}(\theta_{i+1}) - \bar{U}(\theta_i) \leq v\left(\frac{y(\theta_i)}{\theta_i}\right) - v\left(\frac{y(\theta_i)}{\theta_{i+1}}\right) \tag{3.7}$$

This is the least restrictive version of the assumption that will be maintained throughout the characterization. It is complicated by the presence of the endogenous objects $y(\theta)$. Some examples of primatives that satsify this assumption are the following: 1) $\bar{U}$ is constant, 2) for some $\alpha \in (0, 1)$, $\bar{U}(\theta)$ is the solution to an agent's problem producing in autarky with linear technology $y = \alpha\theta l$, and 3) $\bar{U}$ is the utility the agent would get in the foreign country if the planner puts all their Pareto weight on the lowest productivity type, $u(c) = c$ and the agents pays $f > 0$ consumption units to operate.

The benefit of this assumption is that it greatly simplifies the problem of the foreigners as illustrated by the following lemma:

Lemma 1. *In the problem of the foreigners, suppose $x(\theta_i), x(\theta_{i+1}) > 0$, (IR_i), and $(IC_{i+1,i})$ are satisfied. Then (IR_{i+1}) is satisfied.*

Proof. Adding (IR_i) and (3.7) yields

$$\bar{U}(\theta_{i+1}) \leq u(c(\theta_i)) - v\left(\frac{y(\theta_i)}{\theta_{i+1}}\right) \leq u(c(\theta_{i+1})) - v\left(\frac{y(\theta_{i+1})}{\theta_{i+1}}\right) \tag{3.8}$$

where the last inequality follows from $(IC_{i+1,i})$. Hence, (IR_{i+1}) is satisfied. $\square$

Hence, the participation constraints of the lowest operating types and the incentive constraints are sufficient to satisfy all other participation constraints. In the next section I demonstrate that this leads to a cutoff rule in immigration policy.

3.3 Immigration Policy: Cutoff Rule

In this section I will ignore the problem of the native population since, as I demonstrated in the previous section, the allocation of the foreign population can be solved without it. The first result is to demonstrate that the transfers from all operating types is positive.

Lemma 2. *Let* $t(\theta_i) \equiv y(\theta_i) - c(\theta_i)$. *Then* $x(\theta_i) > 0 \implies t(\theta_i) \geq 0$.

Proof. For contradiction, suppose the solution to the foreigner's problem is such that $\exists i : x(\theta_i) > 0$ and $t(\theta_i) < 0$. Then construct an alternative allocation that is the same, except that $x(\theta_i) = 0$. All constraints are satisfied given that they are in the original allocation. But the value of the objective is higher because $t(\theta_i) < 0$. Hence, the original allocation could not have been optimal. $\square$

Given this result we can prove that immigration policy follows a cutoff rule.

Proposition 3. *If* $i < N$, *and* $x(\theta_i) > 0$, *then without loss of generality* $x(\theta_{i+1}) = g(\theta_{i+1})$.

Proof. First, for contradiction, suppose $x(\theta_i) > 0$ and $x(\theta_{i+1}) = 0$. Consider an alternative allocation where $x(\theta_{i+1}) > 0$, $c(\theta_{i+1}) = c(\theta_i)$, and $y(\theta_{i+1}) = y(\theta_i)$. Then, given that the original allocation satisfies all (IC) constraints, the alternative allocation also satisfies them. Also, by Lemma 1, (IR_{i+1}) is satisfied. By Lemma 2, the alternative allocation gives a weakly higher value of the planner's objective (strictly higher if $t(\theta_i) > 0$). Hence, it is without loss that $x(\theta_{i+1}) > 0$.

Second, if $x(\theta_i) > 0$ and $x(\theta_{i+1}) \in (0, g(\theta_{i+1}))$, by Lemma 2 $t(\theta_{i+1}) \geq 0$. Then, if $t(\theta_{i+1}) > 0$ this allocation is dominated by one where $x(\theta_{i+1}) = g(\theta_{i+1})$. If $t(\theta_{i+1}) = 0$, this allocation has the same value of the objective when $x(\theta_{i+1}) = g(\theta_{i+1})$. $\square$

This result shows that the native problem can be reduced to one where the planner chooses a lower bound on productivity, and, by Lemma 1, only the (IR) constraint of the cutoff productivity is relevant. The next set of propositions shows that convexity of v is sufficient to simplify the binding pattern of constraints.

Proposition 4. *At the solution to the foreign problem, the only* (IC) *constraints that bind are of the form* $(IC_{i,i-1})$.

Proof. First I show that $t(\theta) \equiv y(\theta) - c(\theta)$ is strictly increasing in θ, which implies that no constraints of the form $(IC_{i,j})$ where $i < j$ are binding.

Lemma 3. *Let* $t(\theta) \equiv y(\theta) - c(\theta)$. *At the optimum,* $t(\theta), c(\theta)$ *and* $y(\theta)$ *are strictly increasing functions of* θ.

Proof. First I will prove that $t(\theta)$ is strictly increasing. The fact that $t(\theta)$ is weakly increasing is obvious. The only case that needs to be ruled out is of the form $t(\theta_i) = t(\theta_{i+1}) \implies c(\theta_i) = c(\theta_{i+1})$ by the (IC) constraints. To rule out this case, I look at the necessary first order conditions. Here, $\lambda_{i,j}$ is the Lagrange multiplier on constraint $(IC_{i,j})$. Then using the fact that $t(\theta_i) = t(\theta_{i+1})$ and $c(\theta_i) = c(\theta_{i+1})$, yields:

$$\sum_k \lambda_{i,k} = \sum_k (\lambda_{i+1,k} - \lambda_{i,k}) \frac{\left[\frac{v'(y(\theta_i)/\theta_k)}{\theta_k} - \frac{v'(y(\theta_i)/\theta_{i+1})}{\theta_{i+1}}\right]}{\left[\frac{v'(y(\theta_i)/\theta_i)}{\theta_i} - \frac{v'(y(\theta_i)/\theta_{i+1})}{\theta_{i+1}}\right]} \tag{3.9}$$

But the fact that $(c(\theta_i), y(\theta_i)) = (c(\theta_{i+1}), y(\theta_{i+1})) \implies \forall k, \lambda_{i+1,k} = \lambda_{i,k}$ so the right hand side is zero. The fact that at least one (IC) constraint is binding implies that $\exists k : \lambda_{i,k} > 0$. Finally, the term on the left cannot be zero. Hence, this is a contradiction. Therefore, $t(\theta)$ is strictly increasing. Rearranging $(IC_{i,i+1})$ and $(IC_{i+1,i})$ yields:

$$v(y(\theta_i)/\theta_{i+1}) - v(y(\theta_i)/\theta_i) \geq v(y(\theta_{i+1})/\theta_{i+1}) - v(y(\theta_{i+1})/\theta_i) \tag{3.10}$$

Let $F(y) \equiv v(y/\theta_{i+1}) - v(y/\theta_i)$. F is a decreasing function, so $y(\theta_{i+1}) \geq y(\theta_i)$. If $y(\theta_{i+1}) = y(\theta_i)$, then $t(\theta_{i+1}) > t(\theta_i) \implies c(\theta_i) > c(\theta_{i+1})$, which violates $(IC_{i+1,i})$. Hence $y(\theta_{i+1}) > y(\theta_i) \implies c(\theta_{i+1}) > c(\theta_i)$. This completes the proof. □

Also, notice that $\forall i \exists k$ such that $(IC_{i,k})$ is binding. I then prove the proposition by induction: suppose J is the lowest productivity index that operates. Then I show that $\forall i = J+1, ..., N$, $(IC_{i,i-1})$ is binding, and no other (IC) constraints bind.

I proceed by induction.The initial step is obvious: if only downward (IC) constraints bind and at least one (IC) must bind, then $(IC_{J+1,J})$ must be binding and no other constraints of the form $(IC_{J+1,i})$ are binding.

For the induction step, the induction hypothesis is that $\forall m > 0$, $u(c(\theta_{i-m})) - v(y(\theta_{i-m})/\theta_{i-m}) = u(c(\theta_{i-m-1})) - v(y(\theta_{i-m-1})/\theta_{i-m})$. Suppose for contradition that $\exists m \geq 1 : u(c(\theta_{i-m-1})) - v(y(\theta_{i-m-1})/\theta_i) = u(c(\theta_i)) - v(y(\theta_i)/\theta_i)$ and $u(c(\theta_{i-m})) - v(y(\theta_{i-m})/\theta_i) < u(c(\theta_i)) - v(y(\theta_i)/\theta_i)$. By the induction hypothesis, $u(c(\theta_{i-m-1})) - v(y(\theta_{i-m-1})/\theta_{i-m}) = u(c(\theta_{i-m})) - v(y(\theta_{i-m})/\theta_{i-m})$. Rearranging yields:

$$v(y(\theta_{i-m})/\theta_i) - v(y(\theta_{i-m})/\theta_{i-m}) > v(y(\theta_{i-m-1})/\theta_i) - v(y(\theta_{i-m-1})/\theta_{i-m}) \qquad (3.11)$$

As shown in the appendix, $y(\theta)$ is an increasing function. But if v is convex, $F(y) = v(y/\theta_i) - v(y/\theta_{i-m})$ is a decreasing function. This is a contradiction. □

For the next result it is convenient to define the following subproblem, which takes the cutoff productivity level as given:

$$T_J = \max_{\{c,y\}} \sum_{i=J}^{M} g(\theta_i)[y(\theta_i) - c(\theta_i)] \qquad (3.12)$$

subject to

$$(IC_i) \text{ for } i,j \in \{J+1,...,M\},\ u(c(\theta_i)) - v\left(\frac{y(\theta_i)}{\theta_i}\right) \geq u(c(\theta_j)) - v\left(\frac{y(\theta_j)}{\theta_i}\right) \qquad (3.13)$$

$$(IR)\bar{U}(\theta_J) \leq u(c(\theta_J)) - v\left(\frac{y(\theta_J)}{\theta_J}\right) \qquad (3.14)$$

So for every level of immigration, there is an associated level of transfers. Notice that this subproblem is essentially the dual of the problem of a planner who puts all weight on the lowest operating productivity type θ_J. The amount of transfers that can be gained for every level of the cutoff is characterized by:

Proposition 5. *Let $\{c(\theta_i), y(\theta_i)\}$ be the solution to the subproblem with cutoff J and $\{\tilde{c}(\theta_i), \tilde{y}(\theta_i)\}$ be the solution to the subproblem with cutoff K. If $K < J$, then*

$$\sum_{i=J}^{M} g(\theta_i)[y(\theta_i) - c(\theta_i)] \geq \sum_{i=J}^{M} g(\theta_i)[\tilde{y}(\theta_i) - \tilde{c}(\theta_i)] \qquad (3.15)$$

Proof. For contradiction, suppose the opposite were true. Given Lemma 1 and Proposition 2, the $\{\tilde{c}(\theta_i), \tilde{y}(\theta_i)\}$ allocation is feasible in the subproblem with cutoff J. Then $\{c(\theta_i), y(\theta_i)\}$ is not optimal, which is a contradiction. □

This demonstrated that there is a tradeoff between the number of foreigners allowed to operate and the level of transfers that can be attained. By lowering the productivity cutoff, more immigrants enter and may provide positive surplus. However, through the incentive constraints, this lowers the amount of surplus that can be extracted from the existing immigrants. This allows from the possibility that some foreigners are not allowed to operate even though they would provide positive transfers if they did enter.

3.4 Numerical Example

The previous section characterized immigration policy in this environment. In this section, we compare how immigrants and natives are taxed. The main conclusion is that natives face higher marginal taxes and lower average taxes than do foreigners. First I describe what I mean by taxation by considering the decentralized problem:

$$\max u(c) - v\left(\frac{y}{\theta}\right) \tag{3.16}$$

subject to

$$c \leq (1 - \tau)\, y \tag{3.17}$$

The marginal tax rate as a (non-linear) function of income is τ. The optimal income tax schedule is determined by first solving the planner's problem from the previous section, then solving for marginal tax rates using the first order condition:

$$\tau(\theta) = 1 - \frac{1}{\theta}\frac{v'(y(\theta)/\theta)}{u'(c(\theta))} \tag{3.18}$$

The average tax rate is given by:

$$ATR(\theta) = \frac{y(\theta) - c(\theta)}{y(\theta)} \tag{3.19}$$

To demonstrate the results for both taxation and immigration policy, I now present a numerical example. The preferences of both natives and foreigners are given by $u(c) = \log(c)$ and $v(l) = l^2$. The set of productivity types is the set of natural numbers from 1 to 25 with equal population weights across types in both the native and foreign populations. I assume that the outside option is constant with value $\forall \theta, \bar{U}(\theta) = 1$.

Figure 1 demonstrates the relationship between the lower bound on productivity and the total transfers T_J. For the parameter values used, the optimal cutoff is $\theta = 13$. This is true even though if the cutoff is reduced the marginal foreigners would contribute positive surplus. As discussed in the previous section, there is a tradeoff between the number of foreigners allowed to operate and the amount of consumption goods that can be extracted from the existing set of foreigners. So while reducing the cutoff would allows in workers that produce surplus, it would reduce the amount that could be extracted from all other workers.

For comparison, I will consider an alternative allocation where there is no immigration. Figure 2 shows three things: 1) marginal tax rates for immigrants in the optimal allocation, 2) marginal tax rates for natives in the optimal allocation and 3) marginal tax rates for natives when there is no immigration. There are two noteworthy features. First, marginal tax rates for natives are lower with immigration than without it. Second, the marginal tax rate for the cutoff productivity level drops sharply compared to the next highest productivity level. This is because the marginal productivity group must satisfy the (IR) constraint. Hence, cost minimization derives an additional benefit from not distorting the labor-consumption choice. Figure 3 shows the average tax rates of the same three groups. It is truncated on the left because low productivity agents get very large transfers relative to their output.

Figures 4 and 5 show how different productivity levels are affected by immigration. Lower productivity natives have the largest increase in consumption and the largest decrease in labor. This suggests that the additional resources from the immigrant population reduces inequality among natives.

Relative to the allocation with no immigration, optimal immigration policy generates very large welfare increases (especially for the lowest productivity workers) by reducing taxes (and increasing transfers) to natives with higher taxes on foreigners. The existence of private information, however, prevents this from occuring to the extent that it would with full information. This means that there will, at the optimum, always be potential immigrants that could produce positive surplus but are optimally kept from producing.

3.5 Conclusion

In this chapter I consider the problem of a planner that is trying to determine the size of the population to be admitted when there is private information over types. The main finding is that private information induces a tradeoff between the number of immigrants that may be admitted and the amount of fiscal revenue that can be raised from each immigrant.

Although the present exercise is motivated by the case of immigration, the findings may be applicable more broadly. For instance, the problem could describe a firm selecting a pool of customers of unknown types. Then, as in the present case, the firm attempts to minimize the cost of satisfying participation and incentive constraints for their customers. In such an environment, the results discussed here would go through with a slightly different interpretation: at the optimum, the firm serves fewer customers than would be willing to pay for its services so as not to increase the cost of providing its services to its existing customers. Such an environment would be a straightforward modification of that described here.

The next important (though complex) extension of the present exercise is to make the immigration problem dynamic. This could be implemented in many ways. For instance, if the immigration decision is one-shot (so that once an immigrant is admitted they never leave), one can study how the taxation of immigrants evolves over time. Alternatively, if the government can "deport" immigrants at any time, how does the probability of deportation evolve with the worker's innovations to productivity? Such a model could address important issues in immigration policy, such as guest worker programs, or provision and duration of work visas.

Figure 3.1: Transfers by Productivity Cutoff

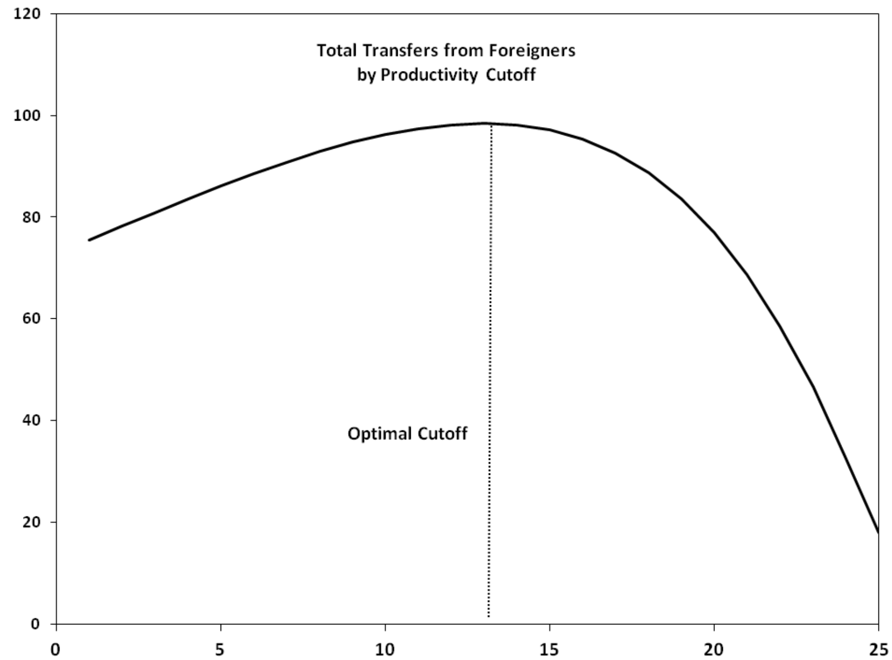


Figure 3.2: Marginal Tax Rates

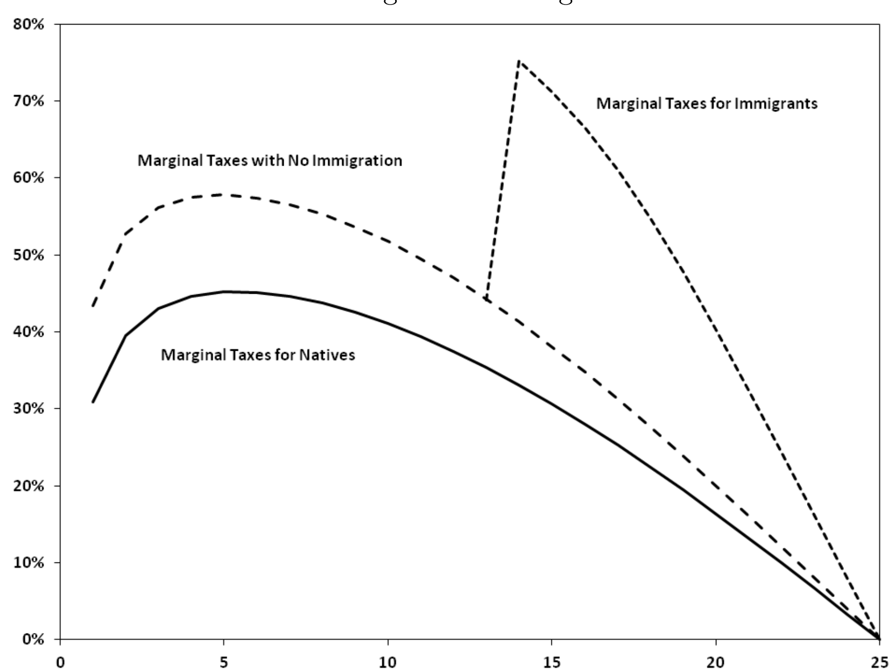


Figure 3.3: Average Tax Rates

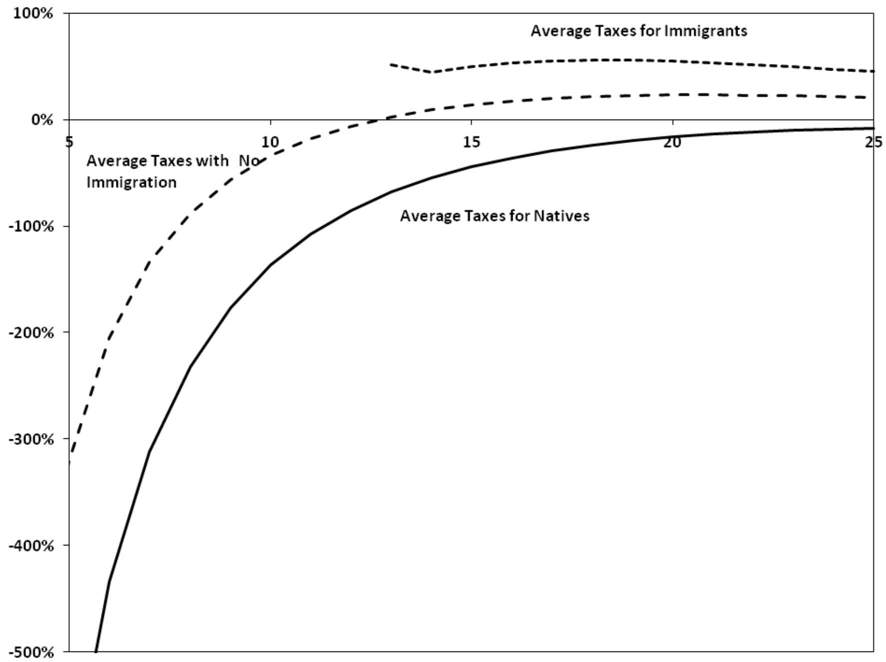


Figure 3.4: Consumption of Natives with Optimal Immigration

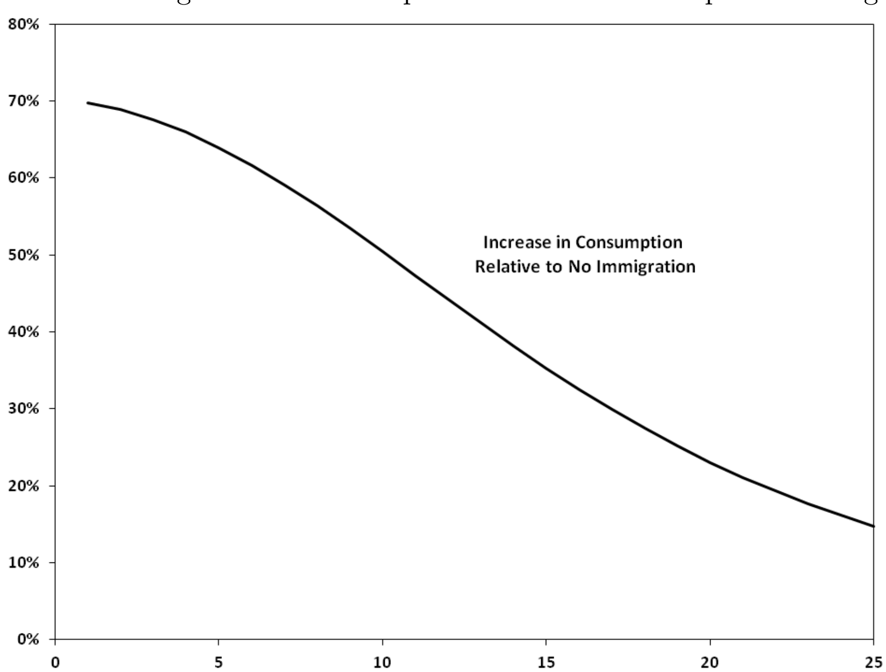
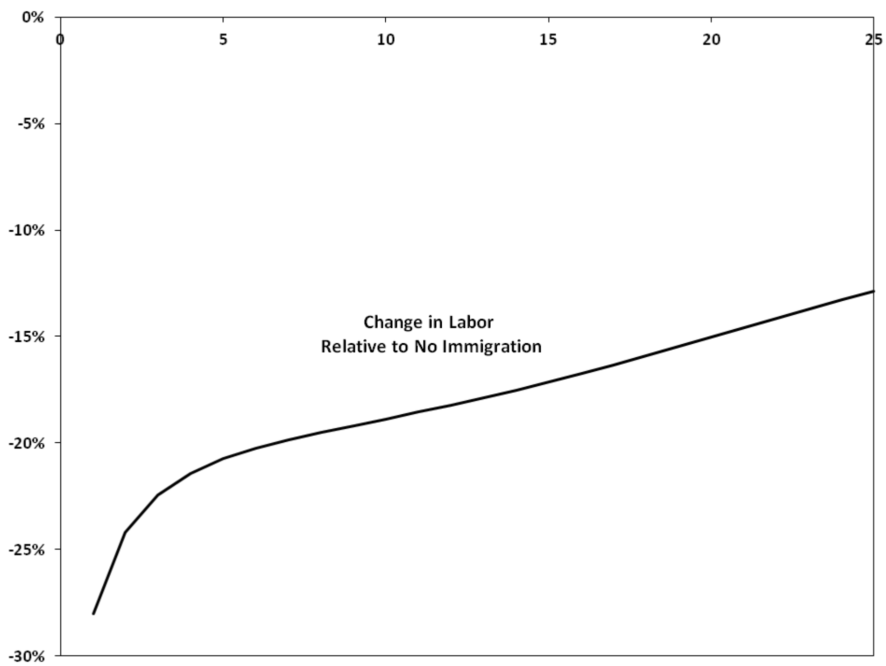


Figure 3.5: Labor of Natives with Optimal Immigration



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