ESSAYS ON INTERNATIONAL TRADE, PRODUCTIVITY, AND GROWTH

by

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Abstract

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This thesis investigates the role of institutions and firm behaviours in international trade.

Chapter 1 estimates a dynamic general equilibrium model of entry, exit, and endogenous productivity growth. Productivity is endogenous both at the industry level (firms enter and exit) and at the firm level (firms invest in productivity-enhancing activities). Three key findings emerge. First, there is no evidence of learning by exporting: the observed positive correlation between exporting and productivity operates entirely via the impact of exporting on productivity-enhancing investments. Restated, exporting decision raises productivity, but only indirectly by making investing in productivity more attractive. Second, there is evidence of learning by producing multiple products: product-mix raises productivity directly in addition to the investment channel. Third, there are strong complementarities among the product-mix, exporting and investment decisions. Finally, we simulate the effects of reductions in foreign tariffs. This increases exporting, investing, and wages. Productivity rises at the economy-wide level both because of the between firm reallocation effect and because of within firm increases in productivity.

Chapter 2 incorporates credit constraints into a model of global sourcing and heterogeneous firms. Following Antras and Helpman (2004), heterogeneous firms decide whether to source inputs at arms length or within the boundary of the firm. Financing of fixed organizational costs requires borrowing with credit constraints and collateral based on tangible assets. The party that controls intermediate inputs is responsible for these fi-
nancing costs. Sectors differ in their reliance on external finance and countries vary in their financial development. The model predicts that increased financial development increases the share of arms length transactions relative to integration in a country. The effect is most pronounced in sectors with a high reliance on external finance. Empirical examination of country-industry interaction effects confirms the predictions of the model.

Chapter 3 examines whether financial development facilitates economic growth by estimating the effect of financial development on reducing the costs of external finance to firms. The data reveal substantial evidence of decreasing returns to the benefit of financial development in industries that are more dependent on external finance and countries with less financial frictions.
Dedication

To my parents and my husband.
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Contents

1 Products, Exports, Investment and Growth .................................................. 1
  1.1 Introduction .......................................................................................... 2
  1.2 The Model ............................................................................................ 7
    1.2.1 Static Model ................................................................................. 7
    1.2.2 Dynamic Model ........................................................................... 15
  1.3 Equilibrium ............................................................................................ 21
  1.4 Empirical Analysis ................................................................................ 23
    1.4.1 Algorithm ...................................................................................... 24
  1.5 Data ........................................................................................................ 29
    1.5.1 Spanish Firm Level Data ............................................................... 29
    1.5.2 Empirical Transition Patterns for Entry/Exit, Investment, and Export .. 31
  1.6 Results .................................................................................................... 34
    1.6.1 Demand, Cost and Productivity Evolution ...................................... 34
    1.6.2 Dynamic Estimates ....................................................................... 37
    1.6.3 In-sample Model Performance ..................................................... 37
  1.7 Counterfactuals ....................................................................................... 38
    1.7.1 Within Firm Effect ....................................................................... 38
    1.7.2 Between Firm Effect ..................................................................... 40
  1.8 Conclusion .............................................................................................. 40
## 2 Global Sourcing and Credit Constraints

2.1 Introduction ........................................ 66
2.2 Relation to the literature .......................... 69
2.3 First glance at the data ............................ 70
2.4 The Model ........................................... 74
   2.4.1 Demand ........................................ 74
   2.4.2 Production ..................................... 75
   2.4.3 Credit Constraints .............................. 76
   2.4.4 Incomplete Contracts .......................... 77
   2.4.5 Equilibrium .................................... 78
2.5 Organizational Forms ............................... 83
   2.5.1 Headquarter Intensive Sector ............... 83
   2.5.2 Component Intensive Sector ................. 85
2.6 Empirical Analysis .................................. 87
   2.6.1 Headquarter Intensive Sector ............... 88
   2.6.2 Component Intensive Sector ................. 89
2.7 Data ................................................ 90
   2.7.1 Intra-firm and total U.S. imports data ...... 90
   2.7.2 Financial development data .................. 90
   2.7.3 External dependence on finance data ....... 91
2.8 Regression Results .................................. 91
   2.8.1 Headquarter Intensive Sector ............... 91
   2.8.2 Component Intensive Sector ................. 94
2.9 Conclusion .......................................... 98

## 3 Financial Dependence and Growth

3.1 Introduction ....................................... 123
3.2 Model and Data ...................................... 124
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3</td>
<td>Differencing Procedures</td>
<td>126</td>
</tr>
<tr>
<td>3.4</td>
<td>Empirical Results</td>
<td>127</td>
</tr>
<tr>
<td>3.5</td>
<td>Panel Data Analysis</td>
<td>129</td>
</tr>
<tr>
<td>3.5.1</td>
<td>Panel Data Setup</td>
<td>129</td>
</tr>
<tr>
<td>3.5.2</td>
<td>Empirical Results</td>
<td>130</td>
</tr>
<tr>
<td>3.6</td>
<td>Conclusions</td>
<td>131</td>
</tr>
</tbody>
</table>

**Bibliography**

137
Chapter 1

Product Restructuring, Exports, Investment, and Growth Dynamics
1.1 Introduction

Trade liberalization can increase productivity through intra-industry resource re-allocations or firms’ own investments in R&D and technology adoption. Pavcnik (2002), Melitz (2003) and Bernard et al. (2003) have emphasized the first channel: trade liberalization increases aggregate productivity by reallocating markets shares towards exporters who are the most productive firms and force the least productive firms to exit. More recently, several authors have begun to measure the potential role of the firms’ own investments in R&D or technology adoption as an important source of productivity increase (Lileeva and Trefler (2010), Aw, Roberts, and Xu (2011), and Bustos (2011)).

However, firms’ decisions to produce, invest and export are not only based on their own productivities but also on general equilibrium conditions. In this paper I build a tractable general equilibrium model of entry, exit and endogenous productivity growth. Productivity is endogenous both at the industry level and at the firm level. At the industry level, general equilibrium conditions determine the cut-off productivity for incumbent firms. Firms below the cut-off are forced to exit. At the firm level, surviving firms make production, investment and exporting decisions that lead to endogenous productivity growth. I focus on two activities that make productivity-enhancing investments more attractive, namely, exporting and product-mix choices. A firm that increases its exports and/or its number of products will have higher sales – and this makes investing in productivity more attractive because there are more units (sales) across which the productivity gains can be applied. This paper is most closely related to works by Aw, Roberts, and Xu (2011) and Aw, Roberts, and Xu (2008). Aw et al. estimate a dynamic model of firm’s decision to invest and export, allowing both choices to endogenously affect firm’s productivity. My model differs from Aw, Roberts, and Xu (2011) in three aspects. First, this is a general equilibrium model where firms’ entry and exit decisions are also endogenous whereas Aw, Roberts, and Xu (2008) assumed a fixed number of firms. Second, firms’ investment is a continuous choice instead of a discrete choice in-
volving a fixed cost. Third, I allow firms to produce more than one product and I call this product restructuring.

The empirical work presented in this paper also fits into the large empirical literature over the past decade trying to determine the causal relationship between productivity and exporting. Much of it documents the self-selection of more productive firms into the export market. The evidence that exporting raises productivity growth rates is less uniform, with some studies (Clerides, Lach, and Tybout (1998), Bernard and Jensen (1999), Bernard and Wagner (1997), Delgado, Fariñas, and Ruano (2002) and Bernard and Jensen (2004)) finding no such effect, and others finding varying degrees of support for a positive effect of exporting on productivity (Aw, Chung, and Roberts (2000), Baldwin and Gu (2003), Van Biesebroeck (2004), Lileeva (2004), Hallward-Driemeier, Iarossi, and Sokoloff (2005), Fernandes and Isgut (2006), Park et al. (2006), Aw, Roberts, and Winston (2007), Das, Roberts, and Tybout (2007), De Loecker (2011), and Schmmeiser (2012)). More recently, authors have looked at productivity and export link through firms’ investments in R&D or adoption of technology. Bustos (2011) find evidence of technology upgrading among exporters in Argentina after tariff reductions in Brazil. Lileeva and Trefler (2010) find that Canadian plants that start to export or export more under tariff reductions engaged in more product innovation and had higher adoption rates of advanced manufacturing technologies. Two theoretical papers, Atkeson and Burstein (2010) and Constantini and Melitz (2008), have formalized how trade liberalizations can increase the rate of return to a firm’s investment in new technology and thus lead to future endogenous productivity gains. Both papers share several common features: first, productivity is the underlying state variable that distinguishes heterogeneous producers; and second, productivity evolution is endogenous, affected by the firm’s investment decisions.

My model and empirical analysis demonstrate the importance of firm and industry endogenous productivity growth in response to trade liberalization. In every period,
firms make decisions about entry and exit, how much to invest, number of products to produce, how much to export, and compete in a monopolistically competitive product market. Following Bernard, Redding, and Schott (forthcoming) which builds on Melitz (2003), I allow firms to produce multiple products of varying profitability. I assume firm profitability in a particular product increases with two stochastic and independent draws in the first period in which the firm operates. The first is firm productivity, which is drawn stochastically after the firm enters and pays the sunk fixed entry cost. This governs the amount of labor that must be used to produce a unit of output. Firm productivity becomes a state variable in all subsequent periods and evolves over time based on firm investments, productivity, exporting and number of products. The second is firm-product consumer tastes drawn every period, which regulate the demand for a firm in a market. I assume both draws are revealed to firms after incurring a sunk cost of entry. If firms decide to enter after having observed these draws, they face fixed and variable costs for each good they choose to supply to a market as well as a fixed cost of serving each market that is independent of the number of goods supplied.

I assume consumers possess constant elasticity of substitution preferences on the demand side as in Dixit and Stiglitz (1977). Demand for product variety depends on the own-variety price, the price index for the product, and the price indices for all other products. If a firm is active in a product market, it manufactures one of a continuum of varieties and so is unable to influence the price index for the product. This implies the price of a firm’s variety in one product market influences only the demand for its varieties in other product markets through the price indices. Therefore, the firm’s inability to influence the price indices implies that its profit maximization problem reduces to choosing the price of each product variety separately to maximize the profits derived from that product variety. The structure of the model eliminates strategic interaction within or between firms.

In this paper I develop an algorithm for computing the Markov Perfect Equilibrium
(MPE) similar to Benkard, Roy, and Weintroub (2007) and Benkard, Roy, and Weintroub (2008). A nice feature of the algorithm is that, unlike existing methods, there is no need to place a priori restrictions on the number of firms in the industry or the number of allowable states per firm. These are determined by the algorithm as part of the equilibrium solution. In the past, for Ericson and Pakes (1995) type models, MPE are usually computed using iterative dynamic programming algorithms (e.g. Pakes and McGuire (1995)). However, computational requirements grow exponentially with the number of firms and possible firm productivity levels, making dynamic programming infeasible in many problems of practical interest. In this paper, I consider algorithms that can efficiently deal with any number of firms in a monopolistic competition setting. This is most closely related to Hopenhayn (1992) and Melitz (2003). As in Hopenhayn (1992), the analysis is restricted to stationary equilibria. Firms correctly anticipate this stable aggregate environment when making all relevant decisions. This becomes computationally feasible for MPE computation with common dynamic programming algorithms. I also use nested pseudo likelihood (NPL), a recursive extension of the two-step pseudo maximum likelihood (PML) proposed by Aguirregabiria and Mira (2007), that addresses inconsistent or very imprecise nonparametric estimate of choice probabilities to compute the MPE.

The reason to model the investment, multi-product and exporting decisions jointly is they are dependent on each other and on the general equilibrium conditions. A firm cannot export or produce multiple products if its productivity is below a certain cutoff, which is determined through the general equilibrium wage effect. Olley and Pakes (1996) show that ignoring endogenous market exit can generate significant biases in the estimation of production functions. The low-productivity firms need to invest and

\footnote{Benkard, Roy, and Weintroub (2008) define an oblivious equilibrium in which each firm is assumed to make decisions based only on its own state and knowledge of the long-run average industry state, but where firms ignore current information about competitors’ states. They show that as the market becomes large, if the equilibrium distribution of firm states obeys a certain “light-tail” condition, then the oblivious equilibrium closely approximates the MPE.}
increase their productivity in order to export and produce more products. The return to investment is higher for exporting and multi-product firms, which makes the probability that the firm will choose to invest and how much to invest dependent on the firm’s export status and the number of products produced.

I use the micro data collected by SEPI Foundation in Spain for the years 2002-2006. The data set is a collection of firms that operated in at least one of the five years between 2002–2006 and reported domestic and export revenue, investment, total variable costs, and number of products they are producing. The data do not provide firm-product-destination export information; therefore in the model I simplify the demand parameter in Bernard, Redding, and Schott (forthcoming) to firm-product level only. However, it is very simple to model the demand parameter at the firm-product-destination level.

The structural estimation of the model using the Spanish microdata yields a rich set of predictions about productivity, investing, product restructuring and exporting. First, a firm self-selects into exporting, investment, and product range based on its current productivity. Productivity evolves over time and is endogenous and positively impacted by both investment and the number of products produced. The direct positive impact on productivity from the number of products produced suggests the presence of learning by doing. However, there is no evidence of learning by exporting: the observed positive correlation between exporting and productivity operates entirely via the impact of exporting on productivity-enhancing investments. Past exporting is correlated with current productivity via past investing; that is, past exporting complements past investing which leads to current productivity gains. Second, there are strong complementarities between exporting, product range and investment decisions. A rise in the number of products raises productivity by making investment more attractive. (There is also a direct impact of the number of products on productivity, which captures unmeasured investments in new products). Finally, I simulate the effects of reductions in foreign tariffs. This increases exporting, investment and wages; and these wage increases cause a reduction in
the number of products per firm and force the least productive firms to exit. Productivity rises at the economy-wide level both because of the between firm reallocation effect and because of within firm increases in productivity.

The rest of paper is organized as follows. In Section 2, I outline the dynamic industry model. In Section 3, I define a MPE and solve for it. In Section 4, I discuss the algorithm to empirically estimate the model. In Section 5, I discuss the data used and the limitations to the data. In Section 6, I provide the main result, namely, the role that product differentiation, fixed costs of operating, sunk entry costs, cost of investment and trade liberalization play in explaining the observed firm heterogeneity. In Section 7, I discuss the counterfactuals. Finally, Section 8, presents conclusions, policies and a discussion of future research directions. All proofs and mathematical arguments are provided in the Appendix.

1.2 The Model

Consider a world consisting of many countries and many products. Firms decide whether to produce, what products to make, and where to export these products. Products are imperfectly substitutable, and within each product firms supply horizontally differentiated varieties. For simplicity, I develop the model for symmetric products and $n$ symmetric countries.

1.2.1 Static Model

Consumers

The world consists of a home country and a continuum of $n$ foreign countries, each of which is endowed with $L_n$ units of labor that are supplied inelastically with zero disutility. Consumers prefer more varieties to less and consume all differentiated varieties in a continuum of products that I normalize to the interval $[0,1]$. The utility function of a
Chapter 1. Products, Exports, Investment and Growth

representative consumer in country \( j \) is given by:

\[
U = \left[ \int_0^1 C_{jk}^\nu dk \right]^{1/\nu}, \quad 0 < \nu < 1,
\]  

(1.1)
as in the standard Dixit and Stiglitz (1977) form, where \( k \) indexes products. Within each product, a continuum of firms produce horizontally differentiated varieties of the product. \( C_{jk} \) is a consumption index for a representative consumer in country \( j \) for product \( k \) and is of the form:

\[
C_{jk} = \left[ \int_0^{n+1} \int_{\omega \in \Omega_{ijk}} [\lambda_{jk}(\omega) c_{ijk}(\omega)]^\rho d\omega di \right]^{1/\rho}, \quad 0 < \rho < 1,
\]  

(1.2)
where \( i \) and \( j \) index countries, \( \omega \) indexes varieties of product \( k \) supplied from country \( i \) to \( j \) and \( \Omega_{ijk} \) denotes the endogenous set of these varieties. Similar to Bernard, Redding, and Schott (forthcoming) the demand shifter \( \lambda_{jk}(\omega) \) captures the strength of the representative consumer’s tastes for firm variety \( \omega \) and is a source of demand heterogeneity. \( \lambda_{jk}(\omega) \) can also be interpreted as the quality of variety \( \omega \). I assume \( \sigma \equiv \frac{1}{1-\rho} > \kappa \equiv \frac{1}{1-\nu} \) or the elasticity of substitution across varieties within a product is greater than the elasticity of substitution across products. \( \sigma \) is assumed to be the same for all products. The corresponding price index for product \( k \) in country \( j \) is:

\[
P_{jk} = \left[ \int_0^{n+1} \int_{\omega \in \Omega_{ijk}} \left( \frac{p_{ijk}(\omega)}{\lambda_{ijk}(\omega)} \right)^{1-\sigma} d\omega di \right]^{\frac{1}{1-\sigma}}.
\]  

(1.3)

Furthermore, countries are symmetric and the only difference between the domestic market and each export market is that a common value of trade costs has to be incurred for each export market. Therefore, instead of indexing variables in terms of country of production, \( i \), and market of consumption, \( j \), I distinguish between the domestic market, \( d \), and each export market, \( x \), unless otherwise indicated.
Production

The only factor of production is labor as in Melitz (2003). The potential entrants are identical prior to entry. A potential entrant who decides to stay out of the market gets zero profits. The new entrant must incur a sunk entry cost $f_{EN,i} > 0$ units of labor in country $i$. Similar to Bernard, Redding, and Schott (forthcoming) I augment the model to allow firms to manufacture multiple products and to allow for demand heterogeneity across products. The new entrant is not active until the next period. Furthermore, the initial quality and the product attributes that influence demand (consumer tastes $\lambda$) of a new entrant are uncertain when the firm makes its entry decision, and they are not realized until the next period. The initial productivity $\varphi$ is common across products within a firm and is a random draw from the probability function $g(\varphi)$ with cumulative distribution function $G(\varphi)$. Consumer tastes for a firm’s varieties, $\lambda_k \in [0, \infty)$, vary across products $k$ and are drawn separately for each product from the probability function $z(\lambda)$ with cumulative distribution function $Z(\lambda)$. To make use of law of the large numbers, I make simplifying assumptions that productivity and consumer taste distributions are independent across firms and products, respectively, and independent of one another.

Once the sunk entry cost has been incurred in period $t - 1$, the potential entrant enters at the end of period $t - 1$ and becomes an incumbent in period $t$. An incumbent in period $t$ observes its sell-off value $\phi_t$ and makes exit and investment decisions. If the sell-off value (or the exit value) $\phi_t$ exceeds the value of continuing in the industry, then the firm chooses to exit, in which case it earns the sell-off value and then ceases operations permanently. If it decides to stay and invest, it faces fixed costs of supplying each market, which are $f_X > 0$ for any foreign market and $f_D > 0$ for the domestic market. These market-specific fixed costs capture, among other things, the costs of building distribution networks. In addition, I assume that the incumbent must pay the fixed costs of supplying each product to a market, which are $f_x > 0$ for each foreign market and $f_d > 0$ for the domestic market. These product- and market-specific fixed costs capture the costs of
market research, advertising, and conforming to foreign regulatory standards for each product. As more products are supplied to a market, total fixed costs rise, but average fixed costs fall. The firm can invest to improve its productivity for next period. A detailed modelling of the investment decision is given under the Investment subsection.

In addition to fixed costs, there is also a constant marginal cost for each product that depends on firm productivity, such that \( q_k(\varphi, \lambda_k)/\varphi \) units of labor are required to produce \( q_k(\varphi, \lambda_k) \) units of output of product \( k \). Finally, I allow for variable costs of trade, such as transportation costs, which take the standard iceberg cost form, where a fraction \( \tau > 1 \) of a variety must be shipped in order for one unit to arrive in a foreign country. I assume for simplicity that the fixed costs of serving each market are incurred in terms of labor in the country of production, although it is straightforward to instead consider the case where they are incurred in the market supplied.

**Firm-Product Profitability**

Demand for a product variety depends on the own-variety price, the price index for the product and the price indices for all other products. If a firm is active in a product market, it manufactures one of a continuum of varieties and so is unable to influence the price index for the product. At the same time, the price of a firm’s variety in one product market only influences the demand for its varieties in other product markets through the price indices. Therefore, the firm’s inability to influence the price indices implies that its profit-maximization problem reduces to choosing the price of each product variety separately to maximize the profits derived from that product variety. This optimization problem yields the standard result that the equilibrium price of a product variety is a constant mark-up over marginal cost:

\[
p_{d}(\varphi, \lambda_d) = \frac{1}{\rho \varphi}, \quad p_{x}(\varphi, \lambda_x) = \frac{1}{\rho \varphi},
\]  

(1.4)
where equilibrium prices in the export market are a constant multiple of those in the domestic market due to the trade costs; $\lambda_d$ varies across products and $\lambda_x$ varies across products and export markets. I choose the wage in one country as the numeraire, which together with country symmetry implies $w = 1$ for all countries.

Demand for a variety is:

\[
q_d(\varphi, \lambda_d) = Q\lambda_d^{\sigma - 1} \left[ \frac{p_d(\varphi, \lambda_d)}{P} \right]^{-\sigma}, \quad q_x(\varphi, \lambda_x) = Q\lambda_x^{\sigma - 1} \left[ \frac{p_x(\varphi, \lambda_x)}{P} \right]^{-\sigma}. \tag{1.5}
\]

Substituting for the pricing rule equation (4), the equilibrium revenue in each domestic and export market are respectively:

\[
r_d(\varphi, \lambda_d) = E(\rho P \varphi \lambda_d)^{\sigma - 1}, \quad r_x(\varphi, \lambda_x) = \tau^{1-\sigma} \left( \frac{\lambda_x}{\lambda_d} \right)^{\sigma - 1} r_d(\varphi, \lambda_d), \tag{1.6}
\]

where $E$ denotes aggregate expenditure on a product and $P$ denotes the price index for a product (subscript product $k$ is suppressed here). The equilibrium profits from a product in each domestic and export market are therefore:

\[
\pi_d(\varphi, \lambda_d) = \frac{r_d(\varphi, \lambda_d)}{\sigma} - \theta_d, \quad \pi_x(\varphi, \lambda_x) = \frac{r_x(\varphi, \lambda_x)}{\sigma} - \theta_x. \tag{1.7}
\]

Firm productivity and consumer tastes enter the equilibrium revenue and profit functions in the same way, because prices are a constant mark-up over marginal costs and demand exhibits a constant elasticity of substitution.

Relative revenue from two varieties of the same product within a given market depends solely on relative productivity and consumer tastes:

\[
r(\varphi', \lambda') = \left( \frac{\varphi'}{\varphi} \right)^{\sigma - 1} \left( \frac{\lambda'}{\lambda} \right)^{\sigma - 1} r(\varphi, \lambda). \tag{1.8}
\]

Similarly, as countries are symmetric, equation (6) implies that the relative revenue
derived from two varieties of the same product with the same values of productivity and consumer tastes in the export and domestic markets depends solely on variable trade costs: \( r_x(\varphi, \lambda)/r_d(\varphi, \lambda) = \tau^{1-\sigma} \).

A firm with a given productivity \( \varphi \) and consumer taste draw \( \lambda \) decides whether or not to supply a product to a market based on a comparison of revenue and fixed costs for the product. For each firm productivity \( \varphi \), there is a zero-profit cutoff for consumer tastes for the domestic market, \( \lambda^*_d(\varphi) \), such that a firm supplies the product domestically if it draws a value of \( \lambda_d \) equal to or greater than \( \lambda^*_d(\varphi) \). This value of \( \lambda^*_d(\varphi) \) is defined by:

\[
 r_d(\varphi, \lambda^*_d(\varphi)) = \sigma f_d. \quad (1.9)
\]

Similarly for the export market, \( \lambda^*_x(\varphi) \) is given by:

\[
 r_x(\varphi, \lambda^*_x(\varphi)) = \sigma f_x. \quad (1.10)
\]

I can write \( \lambda^*_d(\varphi) \) and \( \lambda^*_x(\varphi) \) as functions of their lowest-productivity supplier, \( \lambda^*_j(\varphi_j) \) for \( j \in \{d, x\} \), respectively:

\[
 \lambda^*_j(\varphi) = \left( \frac{\varphi^*_j}{\varphi} \right) \lambda^*_j(\varphi^*_j) \quad j \in \{d, x\} \quad (1.11)
\]

where \( \varphi^*_j \) for \( j \in \{d, x\} \) is the lowest productivity at which a firm supplies the domestic and the export market, respectively. As a firm’s own productivity increases, its zero-profit cutoff for consumer tastes falls because higher productivity ensures that sufficient revenue to cover product fixed costs is generated at a lower value of consumer tastes. In contrast, an increase in the lowest productivity at which a firm supplies the domestic market, \( \varphi^*_j \), or an increase in the zero-profit consumer tastes cutoff for the lowest productivity supplier \( \lambda^*_j(\varphi^*_j) \), raises a firm’s own zero-profit consumer tastes cutoff. The reason is that an increase in either \( \varphi^*_j \) or \( \lambda^*_j(\varphi^*_j) \) enhances the attractiveness of rival firms’ products, which
intensifies product market competition, and hence increases the value for consumer tastes at which sufficient revenue is generated to cover product fixed costs. Given $\tau^{\sigma-1}(f_x/f_d) > 1$, a firm is more likely to supply a product domestically than to export the product.

**Firm Profitability**

Having examined equilibrium revenue and profits from each product, I now turn to the firm’s equilibrium revenue and profits across the continuum of products as a whole. As consumer tastes are independently distributed across the unit continuum of symmetric products, the law of large numbers implies that the fraction of products supplied to the domestic market by a firm with a given productivity $\varphi$ equals the probability of drawing a consumer taste above $\lambda_{d}^*(\varphi)$, that is $[1 - Z(\lambda_{d}^*(\varphi))]$. As demand shocks are also independently and identically distributed across the continuum of countries, the law of large numbers implies that the fraction of foreign countries to which a given product is exported equals $[1 - Z(\lambda_{x}^*(\varphi))]$. A firm’s expected revenue across the unit continuum of products equals its expected revenue for each product. Expected revenue for each product is a function of firm productivity $\varphi$ and equals the probability of drawing a consumer taste above the cutoff, times expected revenue conditional on supplying the product. Therefore total firm revenue across the unit continuum of products in the domestic and export markets is:

$$ r_j(\varphi) = \int_{\lambda_{j}^*(\varphi)}^{\infty} r_j(\varphi, \lambda_j) z(\lambda_j) d\lambda_j \quad j \in \{d,x\}. \quad (1.12) $$

Total profits in the domestic and export market is:

$$ \pi_j(\varphi) = \int_{\lambda_{j}^*(\varphi)}^{\infty} \left[ \frac{r_j(\varphi, \lambda_j)}{\sigma} - f_j \right] z(\lambda_j) d\lambda_j - f_i \quad j \in \{d,x\}, i \in \{D,X\} \quad (1.13) $$

Total profit is:

$$ \pi(\varphi) = \pi_d(\varphi) + \pi_x(\varphi). \quad (1.14) $$
Equilibrium revenue from each product within the domestic market, \( r_j(\varphi, \lambda_j) \), is increasing in firm productivity and consumer tastes. Hence the lower a firm’s productivity, \( \varphi \), the higher its zero-profit consumer tastes cutoff, \( \lambda^*_d(\varphi) \), and the lower its probability of drawing a consumer tastes high enough for a product to be profitable. Therefore firms with lower productivities have lower expected profits from individual products and supply a smaller fraction of products to the domestic market, \( [1 - Z(\lambda^*_d(\varphi))] \). For sufficiently low firm productivity, the excess of domestic market revenue over product fixed costs in the small range of profitable products falls short of the fixed cost of supplying the domestic market, \( F_d \). The same is true for the export market.

The profit function satisfies the following properties:

1. Total profit for the domestic and export markets is increasing in \( \varphi \).
2. For all \( \varphi \in \mathbb{R}^+ \) and \( t \), \( \pi(\varphi) > 0 \) and \( \sup_{\varphi} \pi(\varphi) < \infty \).
3. \( \ln \pi(\varphi) \) is continuously differentiable.
4. Strengthened competition cannot result in increased profit due to competition for labor. The increased labor demand by the more productive firms and new entrants bids up the real wages and forces the least productive firms to exit. Work by Bernard and Jensen (1999) suggests that this channel substantially contributes to U.S. productivity increases within manufacturing industries.

### Aggregation and Market Clearing

Let \( M \) be a mass of firms. Let \( g(\varphi) \) be the distribution of productivity levels over a subset of \( [0, \infty) \). The weighted average productivity in the domestic and export market, respectively, is:

\[
\tilde{\varphi}_j = \left[ \int_0^\infty \left( \varphi \tilde{\lambda}_j(\varphi) \right)^{\frac{1}{\sigma-1}} g(\varphi)d\varphi \right]^{\frac{\sigma-1}{\sigma}}, \quad j \in \{d, x\},
\]

where \( \tilde{\lambda}_d(\varphi) \) denotes weighted-average consumer tastes in the domestic market for a firm
with productivity $\varphi$:

$$\tilde{\lambda}_j(\varphi) = \left[ \int_0^\infty (\lambda_j(\varphi))^{\frac{1}{\sigma-1}} z(\lambda_j)d\lambda_j \right]^{\frac{1}{\sigma-1}} \quad j \in \{d, x\}.$$  \hfill (1.16)

The weighted average productivity of all firms (domestic and foreign) competing in a single country is:

$$\tilde{\varphi} = \left\{ \frac{1}{M} \left[ M_d \tilde{\varphi}_d^{\sigma-1} + n M_x (\tau^{-1}\tilde{\varphi}_x)^{\sigma-1} \right] \right\}^{\frac{1}{\sigma-1}}.$$  \hfill (1.17)

where the productivity of exporters is adjusted by the trade cost $\tau$. As is well know in this class of models, all aggregate variables are linear functions of the $\tilde{\varphi}_j^{1-\sigma}$. The aggregate price index $P$ is then given by:

$$P = \left[ M_d \int_0^\infty p_d(\varphi)^{1-\sigma} g(\varphi)d\varphi + n M_x \int_0^\infty p_x(\varphi)^{1-\sigma} g(\varphi)d\varphi \right]^{\frac{1}{1-\sigma}}$$

$$= \left[ M_d \left( \frac{1}{\rho \tilde{\varphi}_d} \right)^{1-\sigma} + n M_x \left( \frac{1}{\rho \tilde{\varphi}_x} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}.$$  \hfill (1.18)

where $M_d$ and $M_x$ are the mass of firms in the domestic and export markets, respectively.

Thus the aggregate price index $P$ and revenue $R$ can be written as functions of only the productivity average $\tilde{\varphi}$ and $M$:

$$P = M^{\frac{1}{1-\sigma}} \frac{1}{\rho \tilde{\varphi}} \quad R = M r_d(\tilde{\varphi}).$$  \hfill (1.19)

1.2.2 Dynamic Model

In this section I formulate the static model discussed in the previous section into a dynamic model. The model evolves over discrete time periods and an infinite horizon. I index time periods with non-negative integers $t \in \mathbb{N}$ ($\mathbb{N} = \{0, 1, 2, ...\}$).

A firm’s state is its productivity level. At time $t$, the productivity level of firm $i$ is
I define the industry state $s_t$ to be the number of incumbent firms $M_t$ and the average productivity $\bar{\varphi}_t$ in period $t$. I define the state space $S = \{ s \in \mathbb{R}^2_+ | M \times \bar{\varphi} < \infty \}$.

In each period, each incumbent firm earns profits. As in the static model, a firm’s single period profit $\pi_t(\varphi_t, s_t)$ depends on its productivity $\varphi_t$ and the aggregate price index $P_t$, which can be written as a function of the productivity average $\bar{\varphi}_t$ and the mass of firms $M_t$ in period $t$.

The model also allows for entry and exit. In each period, each incumbent firm observes a positive real-valued sell-off value $\phi_{it}$ that is private information to the firm. If the sell-off value exceeds the value of continuing in the industry, then the firm chooses to exit, in which case it earns the sell-off value and then ceases operations permanently.

As noted before, in each period potential entrants can enter the industry by paying a fixed entry cost $f_{EN}$. Entrants do not earn profits in the period that they enter. They appear in the following period with productivity and consumer tastes drawn from $g(\varphi)$ and $z(\lambda)$ and earn profits thereafter. Each firm aims to maximize expected net present value. The interest rate is assumed to be positive and constant over time, resulting in a constant discount factor of $\beta \in (0, 1)$ per period.

In each period, events occur in the following order:

1. Each incumbent firm observes its sell-off value $\phi_{it}$, productivity at $t + 1$, and demand shocks.

2. The number of entering firms is determined and each entrant pays an entry cost of $f_{EN}$.

3. Incumbent firms choose price and quantity to maximize profit.

4. Incumbent firms choose investment, exporting, and number of products to maximize expected net present values.

4. Exiting firms exit and receive their sell-off values.

5. Productivity in $t + 1$ is realized and newentrants enter.

I assume that there are an asymptotically large number of potential entrants who
play a symmetric mixed entry strategy. This results in a Poisson-distributed number of entrants (see Weintraub, Benkard, and Van Roy (2008) for a derivation of this result). Assumptions are as follows:

Assumption:

1. The number of firms entering during period $t$ is a Poisson random variable that is conditionally independent of $\{\varphi_{it}, \lambda_{it}\}$ for all $i, t$, conditioned on $s_t$.

2. $f_{EN} < \beta \bar{\varphi}$, where $\bar{\varphi}$ is the expected net present value of entering the market, investing zero and earning zero profits each period, and then exiting at an optimal stopping time.

I denote the expected number of firms entering in period $t$, by $M_{EN,t}$. This state-dependent entry rate will be endogenously determined, and satisfies the zero expected discounted profits condition. Modeling the number of entrants as a Poisson random variable has the advantage that it leads to simpler dynamics. However, other entry processes can be used as well.

**Evolution of Productivity**

In order to model the firm’s dynamic optimization problem for exporting, investment, and product restructuring decisions I begin with a description of the evolution of the process for firm productivity $\varphi_{it}$. I assume that a firm’s productivity evolves over time as a Markov process that depends on the firm’s investment, its participation in the export market, the number of products the firm produces, and a random shock $\xi_{it}$:

$$\varphi_{it} = z(\varphi_{it-1}, I_{it-1}, X_{it-1}, N_{it-1}) + \xi_{it}$$

(1.20)

$I_{it-1}, X_{it-1}, N_{it-1}$ are, respectively, the firm’s investment, export market participation, and number of products produced in the previous period. Note that this specification is very general in that the function $z$ may take on either positive or negative values
(e.g., allowing for positive depreciation). The inclusion of $I_{it-1}$ captures the fact that the firm can affect the evolution of its productivity by investing. The inclusion of $X_{it-1}$ allows for the possibility of learning by exporting, i.e. that participation in the export market is a source of knowledge and expertise that can improve future productivity. The inclusion of $N_{it-1}$ allows for the possibility of learning by doing, i.e. that producing more products exposes the firm to a bigger pool of knowledge that can improve its future productivity. In the empirical section, I assess the strength of each of these decisions. The stochastic nature of productivity improvement is captured by $\xi_{it}$, which is treated as an i.i.d. shock with zero mean and variance $\sigma_\xi^2$. This stochastic component represents the role that randomness plays in the evolution of a firm's productivity. Uncertainty may arise, for example, due to the risk associated with a research and development endeavor or a marketing campaign.

Under perfect capital market, firms cannot invest more than their expected net present value.\footnote{I assume perfect capital market, firms investment decisions are constrained by the net present value of the firm, i.e. firms cannot borrow an infinite amount to increase their productivity. The role of imperfect capital market is left for future research.} $X_{it}$ is modeled as a discrete 0/1 variable in the empirical section. If modelled as a continuous variable, export volume is bounded by the consumer demand. Similarly, $N_{it}$ is also bounded by the consumer demand.

**Dynamic Decisions: Investing, Exporting, and Product Restructuring**

If the firm instead decides to remain in the industry, then it must choose the number of products to produce, whether to export, and how much to invest in improving its productivity. In this section I examine these dynamic decisions. Let $d$ denote the unit cost of investment. I assume that the firm decides whether to stay in operation after observing its scrap value $\phi_{it}$, and make production decisions if it decides to remain in operation. I model fixed costs as i.i.d. draws from a known joint distribution $G^f$. Firm
\( i \)'s value function in year \( t \) if it chooses to continue is:

\[
V^{\text{stay}}(\varphi_{it}, s_t) = \max \left\{ \int V^{D}_{\lambda_d}(\varphi_{it}, s_t) dG^{f}, \int V^{E}_{\lambda_d}(\varphi_{it}, s_t) dG^{f} \right\} 
\]

(1.21)

\( X_{it} \) is a binary variable identifying the firm's export choice in period \( t \), where \( V^{D}_{\lambda_d}(\varphi_{it}, s_t) \) is the current and expected future profit from producing products in the domestic market only:

\[
V^{D}_{\lambda_d}(\varphi_{it}, s_t) = \max_{\lambda_d} \int_{\lambda_d}^{\infty} \left[ \frac{r_d(\varphi, \lambda_d)}{\sigma} - f_d \right] z(\lambda_d) d\lambda_d - F_d + V^{D}(\varphi_{it}, s_t)
\]

where \( V^{D}(\varphi_{it}, s_t) \) is the value of a non-exporting firm after it makes its optimal investment decision:

\[
V^{D}(\varphi_{it}, s_t) = \int \left\{ \frac{\max_{I_{it}} \beta E_t V_{it+1}(\varphi_{it}, s_{t+1})}{1-X_{it}} | X_{it} = 0, N_{it} = [1 - Z(\lambda_d)], I_{it} = I_{it} \} \right. \\
\left. - dI_{it} - 1_{(I_{it} > 0)} f_I \right\} dG^{f}
\]

where if firm chooses to invest \( I_{it} \), it incurs the cost of investment \( dI_{it} \) and a fixed cost component of investment \( f_I \). It has an expected future return which depends on how investment affects future productivity. Similarly \( V^{E}_{\lambda_d}(\varphi_{it}, s_t) \) is the current and expected future profit from producing products in both domestic and export market:

\[
V^{E}_{\lambda_d}(\varphi_{it}, s_t) = \max_{\lambda_d} \int_{\lambda_d}^{\infty} \left[ \frac{r_d(\varphi, \lambda_d)}{\sigma} - f_d \right] z(\lambda_d) d\lambda_d - F_d + \max_{\lambda_x} \int_{\lambda_x}^{\infty} \left[ \frac{r_x(\varphi, \lambda_x)}{\sigma} - f_x \right] z(\lambda_x) d\lambda_x - F_x + V^{E}(\varphi_{it}, s_t)
\]

where \( V^{E}(\varphi_{it}, s_t) \) is the value of an exporting firm after it makes its optimal investment decision:

\[
V^{E}(\varphi_{it}, s_t) = \int \left\{ \frac{\max_{I_{it}} \beta E_t V_{it+1}(\varphi_{it}, s_{t+1})}{1-X_{it}} | X_{it} = 1, N_{it} = [1 - Z(\lambda_d)], I_{it} = I_{it} \} \right. \\
\left. - dI_{it} - 1_{(I_{it} > 0)} f_I \right\} dG^{f}
\]
This shows that the firm chooses to export in year $t$ when the current plus expected gain in future export profit exceeds the relevant fixed cost of exporting. Finally, to be specific, the expected future value conditional on different choices for $X_{it}, N_{it},$ and $I_{it}$ for firm staying in operation is:

$$E_t V^{stay}(\varphi_{it+1}, s_{t+1}|X_{it}, N_{it}, I_{it}) = \int \int V^{stay}(\varphi', s')dF(\varphi'|X_{it}, N_{it}, I_{it})dP(s'|s_t).$$

In this framework, the net benefit of product restructuring, exporting and investment are increasing in current productivity. This leads to the usual selection effect where high productivity firms are more likely to produce more products, export, and invest. By making future productivity endogenous this model recognizes that current choices lead to improvements in future productivity and thus more firms will self-select into, or remain in, multi-products, exporting and investment in the future.

After observing $\phi_{it}$, if the firm chooses to exit, its exiting value function is current period profit with optimized $X_{it}(\varphi_{it}, s_t), N_{it}(\varphi_{it}, s_t), I_{it}(\varphi_{it}, s_t)$ decisions plus the scrap value of exit:

$$V^{exit}(\varphi_{it}, s_t) = \int [\pi(\varphi_{it}, s_t, N_{it}(\varphi_{it}, s_t), X_{it}(\varphi_{it}, s_t), I_{it}(\varphi_{it}, s_t)) + \phi_{it}] dG^f$$

where

$$\max_{I_{it}} \beta \pi(\varphi_{it}, s_t, N_{it}(\varphi_{it}, s_t), X_{it}(\varphi_{it}, s_t), I_{it}(\varphi_{it}, s_t)) =$$

$$\pi_d(\varphi_{it}, s_t, N_{it}(\varphi_{it}, s_t)) + 1(\pi_{it}(\varphi_{it}, s_t) = 1) \pi_d(\varphi_{it}, s_t, N_{it}(\varphi_{it}, s_t)) - dI_{it}(\varphi_{it}, s_t) - 1(I_{it}(\varphi_{it}, s_t) > 0) f_I$$

Firm $i$ stays in operation in period $t$ if $V^{stay}(\varphi_{it}, s_t) \geq V^{exit}(\varphi_{it}, s_t)$. 
1.3 Equilibrium

As a model of industry behavior I focus on pure strategy Markov perfect equilibrium (MPE), in the sense of Maskin and Tirole (1988). I further assume that equilibrium is symmetric, such that all firms use a common stationary investment, export, product restructuring and exit strategy. In particular, there are functions $I, X, N$ such that at each time $t$, each incumbent firm $i$ invests an amount $I_{it} = I(\varphi_{it}, s_t)$, exports an amount $X_{it} = X(\varphi_{it}, s_t)$, and produces $N_{it} = N(\varphi_{it}, s_t)$ products. Similarly, each firm follows an exit strategy that takes the form of a cut-off rule: there is a real-valued function $\eta$ such that an incumbent firm $i$ exits at time $t$ if and only if $\phi_{it} \geq \eta(\varphi_{it}, s_t)$. Weintraub, Benkard, and Van Roy (2008) show that there always exists an optimal exit strategy of this form even among very general classes of exit strategies. Let $\Gamma$ denote the set of investment, export, product restructuring and exit strategies such that an element $\mu \in \Gamma$ is a set of functions $\mu = (I, X, N, \eta)$, where $I : \mathbb{R}^+ \times S \to \mathbb{R}^+$ is an investment strategy, $X : \mathbb{R}^+ \times S \to \mathbb{R}_{\geq 0}$ is an export strategy, $N : \mathbb{R}^+ \times S \to \mathbb{N}$ is a number of products to produce strategy, and $\eta : \mathbb{R}^+ \times S \to \mathbb{R}^+$ is an exit strategy. Similarly I denote the set of entry rate functions by $\Omega$, where an element of $\Omega$ is a function $\varpi : S \to \mathbb{R}^+.$

I define the value function $V(\varphi|\mu, \varpi)$ to be the expected net present value for a firm at state (productivity) $\varphi$ when its competitors’ state is $s$, given that its competitors each follow a common strategy $\mu \in \Gamma$, the entry rate function is $\varpi \in \Omega$, and the firm itself follows strategy $\mu \in \Gamma$. In particular,

$$V(\varphi, s|\mu, \varpi) = E_{\mu, \varpi} \left[ \sum_{k=t}^{T_i} \beta^{k-t} (\pi(\varphi_{ik}, s_k, \mu(\varphi_{ik}, s_k))) + \beta^{T_i-t} \phi_{iT_i} | \varphi_t = \varphi, s_t = s \right],$$

(1.22)

where $T_i$ is a random variable representing the time at which firm $i$ exits the industry, and the subscripts of the expectation indicate the strategy followed by firm $i$ and its competitors, and the entry rate function.

An equilibrium is a strategy $\mu = (I, X, N, \eta) \in \Gamma$ and an entry rate function $\varpi \in \Omega$
that satisfy the following conditions:

1. Incumbent firm strategies represent a MPE:

$$\sup_{\mu'} V(\varphi, s|\mu', \mu, \varpi) = V(\varphi, s|\mu, \varpi) \quad \forall \varphi \in R^+, \forall s \in S. \quad (1.23)$$

2. At each state, either the entrants have zero expected discounted profits or the entry rate is zero (or both):

$$\sum_{s \in S} \varpi(s) (\beta E_{\mu} [V(\varphi, s_{t+1}|\mu, \varpi)|s_t = s] - f_{EN}) = 0$$

$$\beta E_{\mu, \varpi} [V(\varphi, s_{t+1}|\mu, \varpi)|s_t = s] - f_{EN} \leq 0 \quad \forall s \in S$$

$$\varpi(s) \geq 0 \quad \forall s \in S.$$

and the labor market clears in each period. Weintraub, Benkard, and Van Roy (2008) showed that the supremum in part 1 of the definition above can always be attained simultaneously for all $\varphi$ and $s$ by a common strategy $\mu'$. Doraszelski and Satterhwaite (2007) establish existence of an equilibrium in pure strategies for a closely related model. I do not provide an existence proof here because it is long and cumbersome and would replicate this previous work. With respect to uniqueness, in general I presume the model may have multiple equilibria.$^3$

Dynamic programming algorithms can be used to optimize firm strategies and equilibria to the model can be computed via their iterative application without the curse of dimensionality problem commonly seen in the IO literature because $s_t$ can be completely characterized by $\check{\varphi}_t$. Stationary points of such iterations are MPE. An algorithm for computing the MPE is included under Empirical Analysis section.

$^3$Doraszelski and Satterthwaite (2007) also provide an example of multiple equilibria in their closely related model.
Market Clearing:

The feasibility constraint on is: $M_{EN,t}f_{EN} = L_{EN,t}$, where $L_{EN,t}$ is the total payments to labor used in entry, $M_{EN,t}$ is the mass of entering firms, and $f_{EN}$ is the sunk entry cost. Total payments to labor used in entry are equal to expected discounted profits $L_{EN,t} = M_t\bar{v}_t$, where $\bar{v}_t = \int V(\varphi, s_t)M_t(s_t)g(\varphi)d\varphi$. The evolution of the distribution of operating firms $M_t$ over time is given by the optimal strategy $\mu$ consisting of $I, X, N, \eta$ and entry rate $\varpi$. Total payments to labor used in production and investment, on the other hand, are equal to revenue minus expected discounted profits, $L_{p,t} + L_{I,t} = R - M_t\bar{v}_t$. Combining these two expressions, $L = R$. Thus the labor market clears: $L_{EN,t} + L_{I,t} + L_{p,t} = L$.

1.4 Empirical Analysis

I begin with a description of the evolution of the process for firm productivity $\varphi_{it}$. I assume that productivity in period $t$ evolves over time as a Markov process that depends on the firm’s investments $I_{it-1}$ in previous period, the export-market participation, $X_{it-1}$, the number of products $N_{it-1}$, and a random shock:

$$\ln \varphi_{it} = \alpha_0 + \alpha_1 \ln \varphi_{it-1} + \alpha_2 \ln \varphi_{it-1}^2 + \alpha_3 \ln \varphi_{it-1}^3 + \alpha_4 \ln I_{it-1} + \alpha_5 X_{it-1} + \alpha_6 N_{it-1} + \xi_{it}. \tag{1.24}$$

Investment $I_{it-1}$ is a continuous choice. The inclusion of $X_{it-1}$ recognizes that the firm may affect the evolution of its productivity through learning-by-exporting. The inclusion of $N_{it-1}$ allows the possibility of expanding into multiple products to have an effect on productivity. The stochastic nature of productivity improvement is captured by $\xi_{it}$ which is treated as an iid shock with zero mean and variance $\sigma^2_\xi$. This stochastic component represents the role that randomness plays in the evolution of a firm’s productivity. This is the change in the productivity process between $t-1$ and $t$ that is not anticipated.
by the firm and by construction is not correlated with $\phi_{it-1}, I_{it-1}, X_{it-1} \text{and } N_{it-1}$. This allows the stochastic shocks in period $t$ to be carried forward into productivity in future years.

1.4.1 Algorithm

To compute the MPE with the two-step PML method, the beliefs about transition, entry, investment, export and exit strategies are computed non-parametrically. The second step is to construct a likelihood function using those beliefs and estimate the structural parameters of interest. When consistent nonparametric estimates of choice probabilities either are not available or are very imprecise, I can use $k$-step PML, or also known as NPL, algorithm to compute the MPE (as in Aguirregabiria and Mira (2007)). NPL works as follows. Start with any set of beliefs/strategies and compute the structural parameters of interest, update strategies with the estimated structural parameters non-parametrically, then construct the likelihood function and update the structural parameters. Repeat this $k$ times until the strategies converge.

Demand and Cost Parameters

I begin by estimating the domestic demand, marginal cost and productivity-evolution parameters. The domestic revenue function for a single-product firm in log form with an iid error term $u_{it}$ that reflects measurement error in revenue or optimization errors in price choice is:

$$
\ln r_{d,it} = (\sigma_d - 1) \ln \left( \frac{\sigma_d - 1}{\sigma_d} \right) + (\sigma_d - 1) \ln \phi_{it} \\
+ \ln E_t + (\sigma_d - 1) \ln P_t + (\sigma_d - 1) \lambda_{it} + u_{it}
$$

where $\lambda_{it}$ is the unobserved demand shock for firm $i$ in the domestic market in time $t$. The composite error term $(\sigma - 1) \ln (\phi_{it}) + u_{it}$ contains firm productivity. Since the in-
puts are observed at the firm level, using the product-level information requires an extra step of aggregating the data at the product level to the firm level. From equation (25), I can aggregate the production function to the firm level by assuming identical production functions across products produced which is a standard assumption in empirical work. See, for instance, Bernard and Jensen (2008) and De Loecker (2011). Under this assumption, and given that I observe the number of products each firm produces, I can relate a firm’s average production of a given product $\bar{Q}_{ikt}$ to its total input use and the number of products produced. The production function for product $k$ of firm $i$ is then given by:

$$\bar{Q}_{ikt} = N_{it}^{-1}Q_{it}$$  \hfill (1.26)

where $N_{it}$ is the number of products produced. Introducing multi-product firms in this framework explicitly requires one to control for the number of products produced. Combining the production function and the expression for price from equation (4) leads to an expression for total revenue as a function of inputs, productivity, and the number of products:

$$\ln r_{d, it} = \ln N_{it} + (\sigma_d - 1) \ln \left( \frac{\sigma_d - 1}{\sigma_d} \right) + (\sigma_d - 1) \ln \varphi_{it}$$

$$+ \ln E_{it} + (\sigma_d - 1) \ln P_{it} + (\sigma_d - 1) \ln \bar{\lambda}_{it} + u_{it}$$  \hfill (1.27)

where $\bar{\lambda}_{it}$ is the average unobserved demand shock across all products for firm $i$ in time $t$ and $N$ is the number of products produced. For a single product firm, $\ln(1) = 0$, and therefore this extra term cancels out, whereas for multi-product firms an additional term is introduced.

I estimate firm productivity using the Olley and Pakes (1996) and Levinsohn and Petrin (2003) approach to rewrite the unobserved productivity in terms of expenditure on intermediate goods for each firm. In general, the firm’s choice of the variable inputs for materials, $m_{it}$, and electricity, $e_{it}$, will depend on the level of productivity and the
demand shocks (which are both observable to the firm). Under the model setting, the marginal cost of output is constant, the relative expenditures on all the variable inputs will not be a function of total output and thus will not depend on the demand shocks. In addition, differences in productivity will lead to variation across firms and time in the mix of variable inputs used. Thus, material and energy expenditures by the firm will contain information on the productivity level. I can write the level of productivity, conditional on the number of products produced, as a function of the variable input levels:

$$\varphi_{it} = \varphi_{it}(N_{it}, m_{it}, e_{it}).$$ (1.28)

I can rewrite (27) as follows:

$$\ln r_{d,it} = \gamma_0 + \sum_{t=1}^{T} \sum_{m=1}^{M} \gamma_{mt} D_mD_t + h(N_{it}, m_{it}, e_{it}) + v_{it}$$ (1.29)

where intercept $\gamma_0$ is the demand elasticity terms, $D_t$ is the time varying aggregate demand shock, $D_m$ is the market-level factor prices, $m_{it}$ is expenditure on intermediate goods, and $h(.)$ captures the effect of productivity on domestic revenue. I specify $h(.)$ as a cubic function of its arguments and estimate (28) with OLS. The fitted value of the $h(.)$ function, which I denote $\hat{h}_{it}$, is an estimate of $\ln N_{it} + (\sigma - 1) \ln \varphi_{it}$. Next, I can construct an estimate of productivity for each firm. Substituting $\ln \varphi_{it} = (\hat{h} - \ln N_{it}) / (\sigma - 1)$ into the productivity-evolution equation (24):

$$\hat{h}_{it} - \ln N_{it} = \alpha_0^* + \alpha_1 (\hat{h}_{it-1} - \ln N_{it-1}) + \alpha_2 (\hat{h}_{it-1} - \ln N_{it-1})^2 + \alpha_3 (\hat{h}_{it-1} - \ln N_{it-1})^3$$
$$+ \alpha_4^* \ln I_{it-1} + \alpha_5^* X_{it-1} + \alpha_6^* N_{it-1} + \xi_{it}$$ (1.30)

where $\alpha_i^* = \alpha_i (\sigma_d - 1), i = 1, ..., 6$. This equation can be estimated with nonlinear least squares and the underlying parameters $\alpha_i$ can be retrieved using an estimate of demand elasticities $\sigma_d$. I can estimate the demand elasticities using data on total variable cost.
Total variable cost is an elasticity-weighted combination of total revenue in each market:

\[ tvc_{it} = \rho_d * r_{d,it} + \rho_x * r_{x,it} + \varepsilon_{it} \] (1.31)

where \( \rho_j = 1 - 1/\sigma_j \) for \( j = d, x \). Finally given an estimate of \( \hat{\sigma}_d \), I can construct an estimate of productivity for each observation as:

\[ \ln \hat{\varphi}_{it} = (\hat{h} - \ln N_{it}) / (\hat{\sigma}_d - 1). \] (1.32)

Three aspects of this static empirical model are worth mentioning. First, because firm heterogeneity plays a crucial role in both the domestic and export markets, I utilize data on firm revenue to estimate firm productivity. Second, total variable costs were used to estimate demand elasticities in the both export and domestic markets. Third, estimation of the process for productivity evolution is important for a firm’s dynamic investment equation because the parameters from equation (30) are used directly to construct the value functions that underlie a firm’s investment, export, and number-of-products choice.

The Melitz (2003) framework assumes that the only factor of production is labor. For a Cobb-Douglas technology, the domestic revenue function becomes:

\[
\ln r_{d,it} = \ln N_{it} + (\sigma_d - 1) \ln \left( \frac{\sigma_d - 1}{\sigma_d} \right) + (\sigma_d - 1)(\beta_0 - \beta_k \ln k_{it} - \beta_\omega \ln \omega_t + \ln \varphi_{it}) \\
+ \ln E_t + (\sigma_d - 1) \ln P_t + (\sigma_d - 1) \ln \tilde{\lambda}_{it} + u_{it}
\] (1.33)

where \( k_{it} \) is a firm’s capital stock and \( \omega_t \) is a vector of variable input prices common to all firms. Productivity, conditional on the number of products produced and the capital stock, can be written as a function of the variable input levels: \( \varphi_{it} = \varphi_{it}(N_{it}, m_{it}, e_{it}) \).

Equation (29) becomes:

\[
\ln r_{d,it} = \gamma_0 + \sum_{t=1}^{T} \sum_{m=1}^{M} \gamma_{mt} D_mD_t + h(N_{it}, k_{it}, m_{it}, e_{it}) + v_{it}
\] (1.34)
The fitted value of the $h(.)$ function, denoted $\hat{h}_{it}$, is an estimate of $\ln N_{it} + (\sigma - 1) (-\beta_k \ln k_{it} + \ln \varphi_{it})$. Next, I can construct an estimate of productivity for each firm by substituting $\ln \varphi_{it} = (\hat{h} - \ln N_{it})/(\sigma - 1) + \beta_k \ln k_{it}$ into productivity evolution equation (24). The productivity evolution equation can be estimated with nonlinear least squares and the underlying $\beta_k$ parameter can be retrieved given an estimate of $\sigma_d$. Finally, given estimates of $\hat{\beta}_k$ and $\hat{\sigma}_d$, I can construct an estimate of productivity for each firm as:

$$\ln \hat{\varphi}_{it} = (\hat{h} - \ln N_{it})/(\hat{\sigma}_d - 1) + \hat{\beta}_k \ln k_{it}. \quad (1.35)$$

**Dynamic Parameters**

The algorithm in the Appendix is designed to compute the beliefs about transition, entry, investment, export, exit strategies and the value function associated with these strategies with a positive entry rate given some values of structural parameters. It starts with two extreme entry rates: $\bar{\omega} = 0$ and $\bar{\omega} = \frac{1}{\int_{E \cap N} \left( \sup_{\varphi, s} \pi(\varphi, s) \right) \left( \frac{1}{1 - \beta} \right) + \bar{\varphi}}$. Any equilibrium entry rate must lie in between these two extremes. The algorithm searches over entry rates between these two extremes for one that leads to the MPE strategies and the value function associated with these strategies given a set of structural parameters. For each candidate entry rate, an inner loop (step 6-10) computes an MPE firm strategy for that fixed entry rate. Strategies are updated smoothly (step 9). If the termination condition is satisfied with $\varepsilon_1 = \varepsilon_2 = 0$, I have a set of MPE beliefs given structural parameters.

The algorithm is easy to program and computationally efficient. In each iteration of the inner loop, the optimization problem to be solved is a one dimensional dynamic program. The state space in this dynamic program is the set of productivity levels a firm can achieve. In principle, productivity could be infinite. However, beyond a certain

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*Capital is not included as one of state variables in the estimation of dynamic parameters. To account for difference in capital size in addition to productivity, in the Appendix results are re-estimated by breaking the data into subgroups based on capital size.*

*See Appendix Computation of the Firm’s Dynamic Problem.*

*The parameters $\gamma$ and $N$ were set after some experimentation to speed up convergence.*
productivity level the optimal strategy for a firm is not to invest, so its productivity cannot increase to beyond that level.

1.5 Data

1.5.1 Spanish Firm Level Data

The model developed in the last section will be used to analyze the sources of productivity change of firms in Spain. The micro data used in estimation was collected by SEPI Foundation in Spain for the years 2002-2006. The products are classified into 20 manufacturing industries based on 3-figure CNAE-93 codes.

The data set I use is a collection of 3216 firms that operated in at least one of the five years between 2002–2006 and reported on domestic and export revenue, investment, total variable costs, and number of products they are producing. Only 848 of those firms operated in all five years between 2002–2006.

Table 1 provides summary measures of the size of the firms, measured in revenues and average employment. The top panel of the table provides the median firm size across operating firms in the sample in each year, while the bottom panel summarizes the average firm size. The first column shows that approximately 35 percent of the firms do not export in a given year. The median firm’s domestic revenue varies from 14.34 to 17.46 in hundred of thousands of Euros. Among the exporting firms, the median firm’s domestic revenue is approximately eight times as large, 10.5 to 12.9 million Euros. The export revenue of the median firm ranges from 3.4 to 5.5 million Euros. The median number of products for both exporters and non-exporters is 1, while the average number of products produced by non-exporters ranges from 1.07 to 1.14 and the 1.13 to 1.15 for exporters.

The distribution of firm revenue is highly skewed, particularly for firms that participate in the export market. Average domestic firm revenue is larger than the median
by a factor of approximately six for exporting firms and average export revenue is larger by a factor of approximately 10. The skewness in the revenue distributions can also be seen from the fact that the 100 largest firms in the sample in each year account for approximately 40 percent of total domestic revenue and 75 percent of export revenue. The skewness in revenues will lead to large differences in profits across firms and a heavy tail in the profit distribution. To fit the participation patterns of all the firms it is necessary to allow for the possibility that a firm has large fixed and/or sunk costs. I allow for this in the empirical model by assuming exponential distributions for the fixed and sunk costs. This assumption allows for substantial heterogeneity in these costs across plants.

The other important variable in the data is the number of products firms choose to produce. Number of products in the sample is defined as the number of products at 3 figures CNAE-93 that each firm produces. Even though in the sample only five percent of firms produce more than 1 product, they account for 20 percent of total domestic revenue and 25 percent of export revenue.

The last important variable in the data is the investment the firms make each year. Table 2 provides summary statistics for different measures of investment for exporters and non-exporters. I look at two measures of investment. The first one is capital investments which includes the purchases of information processing equipment, technical facilities, machinery and tools, rolling stock and furniture, office equipment and other tangible fixed assets. The second one is total expenditures on R&D, which is the sum of the salaries of R&D personnel (researchers and scientists), material purchases for R&D, and R&D capital (equipment and buildings) expenditures. The first column in Table 2 provides the percentage of firms with positive capital investment in each year. In the sample, approximately 70 percent of the non-exporters invest in capital, whereas close to 90 percent of the exporters invest in capital. Only 10 percent of non-exporters engage in R&D, whereas 50 percent of the exporters engage in R&D. The top panel of the second column provides the median of capital investments given positive investment
from operating firms, and the bottom panel provides the mean of the capital investment
given positive investment. The average positive investment in capital is approximately
ten times as large as the median positive capital investment for non-exporters and six
times for exporters. All numbers in the table are expressed in tens of thousands of Euros.
Median investment in capital for non-exporters ranges from 40 to 50 thousand Euros and
500-700 thousand Euros for exporters. Average investment in capital for exporters is
approximately seven times that of non-exporters. The average positive R&D expenses
are approximately 5 times the median positive R&D expenses for non-exporters, and ten
times of that for exporters. The difference in mean and median of the R&D expenses
between non-exporters and exporters is also approximately tenfold. Exporters are on
average ten times larger than non-exporters. They spend eight times more on capital, and
are slightly more likely to do so, suggesting that they invest disproportionately to size.
Exporters are five times more likely to engage in R&D and spend five times the amount,
again suggesting that they invest disproportionately to size.

1.5.2 Empirical Transition Patterns for Entry/Exit, Investment, and Export

In this section I summarize the patterns of entry, exit, R&D and exporting behavior in
the sample, with a focus on the transition patterns that are important to estimating the
fixed and sunk costs of entry, R&D, and exporting. Table 3 reports entry and exit rates
over the years for firms that operated in at least one year during 2002-2006. Operating
firms are defined as firms with positive revenue. The first column reports the number
of firms with positive revenue in each year. The second column reports the number of
non-operating firms in the sample. Column 3 and 4 report the number of new entrants
and exits in each year. New entrants are defined as firms that generated positive revenue
in time period \( t \) and zero revenue in time period \( t - 1 \). Similarly for exits, firms that
generated revenue in period \( t - 1 \) but stopped operating in period \( t \) are defined as exits.
In 2003, there were no new entrants and a high exit rate of 19 percent. This is the year following the technology bubble. In 2004 there was no entry and close to zero exits. In 2005 the entry rate shot up to 33 percent and the exit rate to 7 percent. In 2006 entry rate fell back to 15 percent and the exit rate went up to 10 percent. The average entry and exit rates for 2002–2006 are 14 and 9 percent, respectively. With significant entry and exit behaviors present, ignoring self selection into entry and exit will result in biased estimates of investment and export decisions.

Table 4 reports the proportion of firms that undertake each combination of the activities and the transition rates between pairs of activities over time. The top panel of Table 4 reports the average proportion of operating firms in both period \( t \) and \( t + 1 \) that undertake neither investment nor exporting, investment only, exporting only, and both investment and exporting and the transition rates between pairs of activities over time. The middle panel reports transition rates for new entrants in period \( t \) that continue to operate in \( t + 1 \). The bottom panel reports transition rates for firms that cease to produce in \( t + 2 \), but operate in both \( t + 1 \) and \( t \). The first row of each panel reports the cross-sectional distribution of exporting and investment averaged over all years. It shows that in each year, the proportion of operating firms undertaking neither of these activities is .11. This number is higher for new entrants and firms that will cease to produce. The proportion that invest but do not export is .25 for operating firms. This number is higher for new entrants and lower for firms that will cease production in the sample, suggesting that new entrants are more likely to invest to improve their productivity due to a bad productivity draw and firms that have a higher probability of exit are the ones with lower productivity and therefore don’t invest. The proportion that export only and do not invest .07 for operating firms, .08 for new entrants and .11 for firms that will exit. The proportion that do both for operating firms is .57, which is higher than the number for new entrants and firms that will exit. Overall, 82% of operating firms engage
in investments and 64% of operating firms export. One explanation for the difference in export and investment participation is that differences in productivity as well as the export demand shocks affect the return of each activity and firms self select into each activity based on underlying profits.

The transition patterns among investment and exporting are important for the model estimation. The last four rows in each panel of the table report the transition rate from each activity in year $t$ to each activity in year $t+1$. Several patterns are clear. First, there is significant persistence in the status over time for all three panels. This may reflect a high degree of persistence in the underlying sources of profit heterogeneity, which in the model, are productivity and export-market shocks. Of the operating firms that did neither activity in year $t$, .67 of them are in the same category in year $t+1$. This number is .88 for firms that will exit and only .49 for new entrants. This suggests that even though there is persistence in status over time, different kind of firms have different levels of persistence. New entrants that did not invest or export are more likely to invest than incumbent firms and firms that will exit soon are less likely to invest than incumbent firms. The probability of remaining in the same category over adjacent years is .79, .49, and .92 for invest only, export only, and both for incumbent firms. These numbers are similar for new entrants and firms that will soon exit, except for invest only. Firms that will soon exit with positive investment in period $t$ are less likely to invest in $t+1$ when they decide to exit at the end of period $t+1$. This difference in persistence reflect the importance of modeling self selection into entry and exit.

Second, firms that undertake one of the activities in year $t$ are more likely to start the other activity than a firm that does neither. This is true for all firms. If the firm does neither activity in year $t$, it has a probability of .03 of entering the export market and .31 of investing in the next period for operating firms. These number are .07 and

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7The Spanish export participation rate is comparable to that of France. The export participation rate of French firms (with 20 employees or above) was 69.4% in 1990 and 74.8% in 2004.
.85 for firms that only invest in period t, .93 and .47 for firms that only export in period t, and .98 and .94 for firms that do both in period t. Third, firms that conduct both activities in year t are less likely to abandon one of the activities than firms that only conduct one of them. Operating firms that conduct both activities have a .06 probability of abandoning investment and a .02 probability of leaving the export market. Operating firms that only do investment have a .15 probability of stopping in investment while firms that only export have a .07 probability of stopping in export. Exiting firms that only do investment have a .44 probability of stopping and those who only do export have a .03 probability of stopping. Fourth, export only firms are much more likely to do both (.44 probability) than investment only firms (only .06 probability).

The transition patterns reported in Table 4 illustrate the need to model the investment and exporting decision jointly. In the model, firms cannot export below a certain productivity cut-off. Therefore firms need to invest and increase their productivity in order to export. The return to investment can be higher or lower for exporting versus non-exporting firms, which makes the probability that the firm will choose to invest dependent on the firm’s export status. Table 5 illustrates the average productivity constructed from equation 30 in each year for operating firms, new entrants, firms that exit, and firms that operated in all 5 years. Firms that survived in all five year are on average more productive than firms that exit. New entrants enter with productivity below the average.

1.6 Results

1.6.1 Demand, Cost and Productivity Evolution

The parameter estimates from the estimation of equation (31) and (20) are reported in Table 6. In Panel A, \( \rho_j = 1 - 1/\sigma_j \) for \( j = d, x \). The elasticity of substitution for domestic and export markets are 7.7 and 2.1, respectively.
In Panel B, the first column reports the estimates using investment in capital, which I also use in the dynamic model. The second column reports estimates using investment in R&D. Focusing on the first column, the implied value of the demand elasticity for domestic and export markets are 7.55 and 2.11. These elasticity estimates imply markups of price over marginal cost of 15.3 percent for domestic market sales and 89.7 percent for foreign sales. The effect of lagged productivity on current productivity and it is positive and significant. The effect of capital investments on current productivity is positive and significant. Firms that increase their investment by 1% increase their productivity by .03%. The effect of past exporting measures of the impact of learning by exporting on productivity and is not significant, suggesting very little learning by exporting. The last coefficient measures the impact of product restructuring on productivity. Producing one more product increases firm’s productivity by 6%. This suggests learning by doing.\(^8\)

Relative to a firm that neither invests nor exports, a firm that invests an amount equal to the average investment in capital goods and export will have mean productivity that is 111% higher. A firm that does not export but able to invest the average investment is 104% higher in productivity. A firm that only exports is 8% higher in productivity. A firm that produces one additional product is 4.1% lower. While this provides a summary of the technology linkages between exporting, investing, diversifying, and productivity, it does not recognize the impact of this process on the firm’s choice to enter into operation and exporting. This behavioral response is the focus of the second stage estimation. Given the estimates in Table 6, I construct estimate of firm productivity from equation (32). The mean of the productivity estimates is 2.36 among operating firms and the (.05, .95) percentiles of the distribution are (1.97, 2.78). The mean of the productivity estimates including firms that exit in one of the five periods is 1.47 with (.05, .95) percentiles of the distribution (0, 2.7). The variation in productivity will be important in explaining...

\(^8\)The second column repeats the estimation using log of R&D expenditure rather than log of investment on capital goods. This does not change any sign nor significance of the coefficients in the model.
which firms self-select into entry/exit, exporting and diversifying.

I can assess how well the productivity measure correlates with the firm’s entry/exit, export and product restructuring choices. In the top panel of Table 7 I report estimates of a probit regression of exporting on the firm’s productivity, lagged investment on capital goods, lagged export dummy, lagged number of products, and a set of time, industry, and time cross industry dummies. The export demand shocks are not included explicitly but rather captured in the error terms. In the probit model, only past productivity and lagged export status play a positive and significant role in determining the current export status. The coefficients on investment and product restructuring are insignificant. In the second and third row of the top panel I report OLS regression of export revenue on productivity with and without fixed effects. The explanatory variables are productivity and a set of dummies (industry, time, and industry cross time effects). The lagged export dummy and investment choice do not affect the volume once the firm is in the export market. Since the Spanish firm data does not provide information on how many products firms export, the number of products choice is also not included. The R square term for the regression without fixed effects is .66 and .69 for the regression without fixed effects, suggesting export demand heterogeneity is not a source of size and profit differences in the export market.

The first row of the second panel in Table 7 reports estimates of a probit regression of firm exit. Firm is defined as exit in period t if it has zero total revenue (domestic plus export) in the period t+1. This definition of firm exit is consistent with the way I model firm entry/exit where I assumed in each period firms make their production decisions, produce, and decide if they want to exit and receive a scrap value at the end of the period. Firms with higher productivity are less likely to exit the market. This is both economically and statistically significant. The parameter on investment is positive and significant, suggesting firms that invest in their future are less likely to exit. Multi-product firms are also less likely to exit the market. Being an exporter in the past does
not affect firm’s probability to exit.

The last panel in Table 7 reports estimates of an OLS regression of firm’s product choices. The dependent variable is the number of products firm chooses to produce. Firms with higher productivity will produce more products.

Overall, it is clear from these reduced form regressions that the productivity variable I have constructed is measuring an important plant characteristic that is correlated with export and entry/exit decisions and the firm’s export and domestic revenue once they choose to participate in the market. I report the estimates of the dynamic investment equations in the next section.

1.6.2 Dynamic Estimates

The remaining cost, export demand parameters, entry and exit rates are estimated in the second stage of the empirical model using the likelihood function that is the product over the firm-specific joint probability of the data. The coefficients reported in Table 8 are the means and standard deviations of the parameters for the fixed and sunk cost of operation. The estimated fixed cost parameter is less than the sunk cost parameter, indicating that the firm entry cost is substantially larger than the per-period costs of maintaining operation.

1.6.3 In-sample Model Performance

To assess the overall fit of the model, I use the estimated parameters to simulate patterns of firm entry and survival, investment, exporting and product restructuring decision, transition patterns between the choices, and productivity trajectories for the firms in the sample and compare the simulated patterns with the actual data. Since each firm’s productivity evolves according to equation (24), I need to simulate each firm’s trajectory of productivity jointly with its dynamic decisions. In Table 9 I report the actual and predicted percentage of entry, exit, investment, export, product restructuring and the
mean productivity. Overall, the simulations do a good job of replicating these average data patterns for all three variables.

1.7 Counterfactuals

1.7.1 Within Firm Effect

In the model, the determinants of a firm’s entry, exit, export, investment and product restructuring choices are its current productivity and cost draws. I will isolate the role of current productivity and the cost shocks on these activities. I do this by calculating the marginal benefit to each activity. Table 10 reports the partial equilibrium marginal benefits of exporting with different combinations of productivity and investment with entry and exit rate for calculated for firms optimal strategies. The first column in the top panel reports the logged values of $V(\phi, X, I, N)$ with the optimal investment, export, product restructuring, entry and exit strategy for each productivity level. The second column reports the logged values of $V(\phi, X, I = 0, N)$, forcing investment to be zero, allowing optimal export and product restructuring strategies every period, but take entry and exit rate as given when I calculated for $V(\phi, X, I, N)$ . The third column reports the logged values of $V(\phi, X = 0, I, N)$, forcing profit to be consistent of domestic revenue only and the optimal investment and product restructuring strategy are recalculated based on domestic profit only. The fourth column reports the logged value of $V(\phi, X = 0, I = 0, N)$ forcing both export and investment to be zero. All the values in the four columns are increasing, reflecting the increase in profits with higher productivity.

The fifth column reports the marginal benefit of exporting for a firm that is allowed to invest in its future productivity and choose number of products to produce with entry and exit rate as given. It is positive, reflecting the fact that a firm that does both activities has a higher future productivity trajectory, and is increasing in current productivity implying that a high productivity producer is more likely to self select into the export market. The
benefit of exporting for a firm that is not allowed to invest in its future productivity is reported in the sixth column and it is also positive and increasing in the level of current productivity. Comparing the fifth and sixth column, I see that the difference between the marginal benefits of exporting with investment and without investment is positive, implying that the investment decision has important impact on the return to exporting. This is what I call the market size effect or complementarity in export and investment.

From Figure 3, the return to exporting is greatest for middle productivity firms because both low and high productivity firms investment rate (investment/profit) are less than the middle productivity investment rate.

Table 11 looks at the marginal benefit of exporting with different combinations of productivity and product restructuring strategy with entry and exit as given. The third column reports the logged values of $V(\phi, X, I, N = 1)$, forcing all firms to produce only one product with optimal investment and export strategy but taking entry and exit as given before. The fourth column reports the logged values of $V(\phi, X = 0, I, N = 1)$, not allowing firms to export nor to produce more than one product. Again, all the values in the first four columns are increasing reflecting higher profits with higher productivity. The fifth column is still the marginal benefit of exporting for firms with optimal strategies in investment and product restructuring. The sixth column is the marginal benefit of exporting for firms that are only allowed to produce one product. This is positive and increasing in productivity. The last column in the second panel is the difference between the marginal benefits of exporting for multi-product firms and firms that are allowed to produce only one product. This number is positive for middle productivity firms and negative for high productivity firms. From Figure 4, firms with higher productivity and higher profits, when opening up to trade, tend to reduce the number of products produced to better focus on their core competency groups to grab bigger market shares through exporting.

Table 12 looks at the marginal benefit of investment with different combinations of
productivity and product restructuring strategy with entry and exit as given. Column five reports the marginal benefit of investment for firms with optimal product restructuring and export strategies. Column six reports the marginal benefit of investment for firms that are not allowed to produce more than one product. The last column reports the difference between the marginal benefits of investment for multi-product firms and firms that produce only one product. From Figure 5, the market size effect or complementarity in investment and product restructuring present because the difference in marginal benefit is positive for all productivity levels but is greatest for the middle productivity firms.

### 1.7.2 Between Firm Effect

I looked at the above counterfactuals with entry and exit rate as given in the previous section, in this next section, I recompute entry and exit condition for each scenario and look at the general equilibrium marginal benefits of these activities.

### 1.8 Conclusion

This paper estimates a dynamic structural model that captures the relationship between investment, exporting and productivity for multi-product firms in the presence of endogenous entry and exit. It characterizes a firm’s joint dynamic decision process for entry, exit, investment, exporting and number of products as depending on its productivity, and fixed and sunk costs. It also describes how a firm’s decisions on investment, exporting and product restructuring endogenously affect its future productivity.

There are five broad conclusions I draw about the sources of productivity evolution among Spanish firms. First, firm productivity evolves endogenously in response to the firm’s choice to invest and diversify, but not to the choice to export. An one percent increase in investment raises future productivity by three percent, and increasing the number of products produced by one raises future productivity by 6 percent. Second,
the marginal benefits of exporting vs. non-exporting increase with firm’s productivity. The marginal benefits of investment versus zero investment is positive; however it is greater for the middle productivity firms than for both low and high productivity firms. The marginal benefits of multi-product versus single product reveals a similar pattern. This leads to the self-selection of high productivity firms into exporting, investment, and multi-products. When combined with the fact that decisions to diversify and invest lead to endogenous productivity improvements, this further reinforces the importance of self-selection based on current productivity as the major factor driving the decision to export, invest and produce multiple products. Third, the cross-partial between exporting and investment, and investment and product restructuring are positive for all firms. This suggests that both exporting and investment and product restructuring augment each other and further reinforce the self-selection through the complementarity effect. However, the cross partial between exporting and product restructuring is positive only for low and middle productivity firms and is negative for high productivity firms. This suggests that when opening up to trade, high productivity firms should decrease the number of products produced in order to focus on their core competency products and grab a greater market share through exporting. Fourth, the fixed cost of investment is smaller than the fixed costs of exporting, which results in a larger proportion of firms choosing to invest than to export. The larger proportion of firms choosing to invest is also a result of investment having a larger direct effect on future productivity. Finally, the counterfactual exercises show that a reduction in trade costs will have a significant positive effect on both the probability and the amount that a firm exports and invests, while the number of products produced is reduced. These three effects lead to an overall increase in mean productivity. The combination of larger export markets, and the firm’s ability to invest and change the number of products they produce to take the advantage of larger export markets contributes to larger productivity gains.

Overall, empirical results emphasize the important role of heterogeneity in produc-
tivity as the driving force in determining a firm's total revenue and decision to export, invest and produce multiple products. This is further reinforced by the fact that investment and product restructuring decisions result in future productivity gains. The model can be extended in several ways. I can include the distinction between different types of investment and determine the return to each type of investment. The Spanish firm data includes investment expenditures on R&D, information computing technologies, industrial machinery, land, building and furniture. I will be able to look at whether one of the investment tools had a more substantial impact on the productivity. In addition, I assumed perfect capital markets in this paper. I can explore the role of imperfect capital market on the return to investment and therefore productivity for different sectors. Firms in some sectors need to finance a greater share of their costs externally and sectors differ in their endowment of tangible assets that can serve as collateral.
This table provides summary statistics for firm size as measured by revenues (in 100,000 Euros), average employment and number of products produced. The top two panels report median and average measures for non-exporters. The bottom two panels report median and average measures for exporters.
This table provides summary statistics for firm investment and R&D expenditures (in 10,000 Euros) for exporters and non-exporters. The top panel is for non-exporter; the bottom panel is for exporters.
This table reports the number of entrants, exits and operating firms in each year.

<table>
<thead>
<tr>
<th>Year</th>
<th>N of firms w/ positive Revenue</th>
<th>N of non-operating firms</th>
<th>N of New Entrants</th>
<th>N of Exits</th>
<th>Entry Rate</th>
<th>Exit Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>1707</td>
<td>941</td>
<td>327</td>
<td></td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>1380</td>
<td>1268</td>
<td>0</td>
<td>6</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2004</td>
<td>1374</td>
<td>1274</td>
<td>0</td>
<td>97</td>
<td>0.00</td>
<td>0.07</td>
</tr>
<tr>
<td>2005</td>
<td>1911</td>
<td>737</td>
<td>634</td>
<td>195</td>
<td>0.33</td>
<td>0.10</td>
</tr>
<tr>
<td>2006</td>
<td>2023</td>
<td>625</td>
<td>307</td>
<td></td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>1679</td>
<td>969</td>
<td>235.25</td>
<td>156.25</td>
<td>0.14</td>
<td>0.09</td>
</tr>
</tbody>
</table>
This table reports the average annual transition rates for incumbent firms, new entrants and exiting firms in four possible activities: only invest, only export, both, and neither.
<table>
<thead>
<tr>
<th>Table 5 Average Productivity (logs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean / Std. Dev.</td>
</tr>
<tr>
<td>All Firms</td>
</tr>
<tr>
<td>New Entrants</td>
</tr>
<tr>
<td>Firms that Exit</td>
</tr>
<tr>
<td>Firms in all 5 Years</td>
</tr>
</tbody>
</table>

This table provides the average log productivity for new entrants, exiting firms, and incumbent firms in each year. The productivity measure is constructed using Levinsohn and Petrin (2003) approach.
The top panel provides the estimates for the elasticity of substitution for the domestic and export markets, respectively (equation (31)). The bottom panel provides the estimates of the productivity-evolution (equation (20)). * indicates significance at 1%.


### Table 7

**Reduced Form Export Participation and Revenue**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>( \varphi_{it} )</th>
<th>( I_{it-1} )</th>
<th>( X_{it-1} )</th>
<th>( N_{it-1} )</th>
<th>Fixed Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A. Export Decision</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export</td>
<td>2.60*</td>
<td>0.00</td>
<td>3.33*</td>
<td>-0.08</td>
<td>Yes</td>
</tr>
<tr>
<td>(0.12)</td>
<td>(0.02)</td>
<td>(0.09)</td>
<td>(0.09)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \ln R^x )</td>
<td>9.01*</td>
<td></td>
<td></td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>(.10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \ln R^x )</td>
<td>8.98*</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>(.11)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Panel B. Exit Decision</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exit</td>
<td>-1.64*</td>
<td>0.11*</td>
<td>0.10</td>
<td>-0.26*</td>
<td>Yes</td>
</tr>
<tr>
<td>(.09)</td>
<td>(.01)</td>
<td>(.08)</td>
<td>(.10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \ln R^x )</td>
<td>6.62*</td>
<td></td>
<td></td>
<td></td>
<td>No</td>
</tr>
<tr>
<td>(.03)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \ln R^x )</td>
<td>6.58*</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>(.03)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Panel C. Number of Products</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( N )</td>
<td>0.13*</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>(.02)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This table provides the reduced form estimates for firm’s production decisions. Panel A provides estimates for export decisions using productivity measures constructed from before. Panel B provides estimates for exit decisions. Panel C provides estimates for the number of products firms produce. * indicates significance at 1%.
### Table 8
Dynamic Parameter Estimates

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>St. Dev.</th>
<th>In Euros</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry sunk cost</td>
<td>19.7</td>
<td>2.25</td>
<td>359 million</td>
</tr>
<tr>
<td>Domestic fixed cost</td>
<td>12</td>
<td>0.41</td>
<td>.16 million</td>
</tr>
<tr>
<td>Product fixed cost</td>
<td>11</td>
<td>0.36</td>
<td>59 thousand</td>
</tr>
<tr>
<td>Export fixed cost</td>
<td>13.5</td>
<td>0.45</td>
<td>.73 million</td>
</tr>
<tr>
<td>Investment Fixed Cost</td>
<td>10.4</td>
<td>0.32</td>
<td>32 thousand</td>
</tr>
<tr>
<td>d (investment cost)</td>
<td>1</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>avg sell-off value</td>
<td>16</td>
<td>0.92</td>
<td>8.9 million</td>
</tr>
</tbody>
</table>

This table provides the estimated coefficients for the dynamic parameters in the model and the corresponding dollar values for these estimates.
Chapter 1. Products, Exports, Investment and Growth

Table 9

<table>
<thead>
<tr>
<th>In-Sample Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>export participation</td>
</tr>
<tr>
<td>actual</td>
</tr>
<tr>
<td>predicted</td>
</tr>
<tr>
<td>Investment</td>
</tr>
<tr>
<td>Actual</td>
</tr>
<tr>
<td>Predicted</td>
</tr>
<tr>
<td>Entry rate</td>
</tr>
<tr>
<td>Actual</td>
</tr>
<tr>
<td>Predicted</td>
</tr>
</tbody>
</table>

This table shows the in-sample performance for estimated static and dynamic parameters.
<table>
<thead>
<tr>
<th>productivity</th>
<th>V(X,I,N)</th>
<th>V(X,I=0,N)</th>
<th>V(X=0,I,N)</th>
<th>V(X=0,I=0,N)</th>
<th>MBE</th>
<th>MBE (I=0)</th>
<th>MBE - MBE(I=0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.9</td>
<td>16.44</td>
<td>16.44</td>
<td>16.44</td>
<td>16.44</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>16.73</td>
<td>16.48</td>
<td>16.66</td>
<td>16.48</td>
<td>0.08</td>
<td>0.00</td>
<td>0.08</td>
</tr>
<tr>
<td>2.1</td>
<td>16.96</td>
<td>16.53</td>
<td>16.80</td>
<td>16.53</td>
<td>0.16</td>
<td>0.00</td>
<td>0.16</td>
</tr>
<tr>
<td>2.2</td>
<td>17.27</td>
<td>16.57</td>
<td>16.98</td>
<td>16.57</td>
<td>0.29</td>
<td>0.00</td>
<td>0.29</td>
</tr>
<tr>
<td>2.3</td>
<td>17.65</td>
<td>16.66</td>
<td>17.21</td>
<td>16.66</td>
<td>0.43</td>
<td>0.00</td>
<td>0.43</td>
</tr>
<tr>
<td>2.4</td>
<td>18.08</td>
<td>16.84</td>
<td>17.49</td>
<td>16.80</td>
<td>0.59</td>
<td>0.04</td>
<td>0.55</td>
</tr>
<tr>
<td>2.5</td>
<td>18.53</td>
<td>17.14</td>
<td>17.79</td>
<td>17.02</td>
<td>0.74</td>
<td>0.11</td>
<td>0.62</td>
</tr>
<tr>
<td>2.6</td>
<td>18.98</td>
<td>17.55</td>
<td>18.11</td>
<td>17.32</td>
<td>0.87</td>
<td>0.23</td>
<td>0.64</td>
</tr>
<tr>
<td>2.7</td>
<td>19.43</td>
<td>18.13</td>
<td>18.49</td>
<td>17.76</td>
<td>0.94</td>
<td>0.37</td>
<td>0.57</td>
</tr>
<tr>
<td>2.8</td>
<td>19.77</td>
<td>18.81</td>
<td>19.00</td>
<td>18.29</td>
<td>0.77</td>
<td>0.51</td>
<td>0.26</td>
</tr>
<tr>
<td>2.9</td>
<td>20.40</td>
<td>19.53</td>
<td>19.57</td>
<td>18.87</td>
<td>0.84</td>
<td>0.66</td>
<td>0.18</td>
</tr>
<tr>
<td>3</td>
<td>21.10</td>
<td>20.30</td>
<td>20.16</td>
<td>19.50</td>
<td>0.94</td>
<td>0.80</td>
<td>0.14</td>
</tr>
</tbody>
</table>

This table shows the investment and export complementarity. All values are in logs. MBE is marginal benefit of exporting and is defined as \( V(X,I,N) - V(X=0,I,N) \), where \( V(X,I,N) \) is the value function when all three choices, X, I, and N are chosen optimally and the dynamic parameters are computed using maximum likelihood estimator. \( V(X=0,I,N) \) is the value function when export is restricted to 0 and I and N are chosen optimally with entry and exit rate fixed as in \( V(X,I,N) \). MBE (I=0) is the marginal benefit of exporting when investment is restricted to 0 and is defined as \( V(X,I=0,N) - V(X=0, I=0, N) \). The cross partial between I and X is defined as MBE - MBE (I=0).
### Table 11 Multi-Product and Export Complementarity

<table>
<thead>
<tr>
<th>Productivity</th>
<th>V(X,I,N)</th>
<th>V(X=0,I,N=1)</th>
<th>V(X,I,N=1)</th>
<th>V(X=0,I,N=1)</th>
<th>MBE (N=0)</th>
<th>MBE (N=0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.9</td>
<td>16.44</td>
<td>16.44</td>
<td>16.44</td>
<td>16.44</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2</td>
<td>16.73</td>
<td>16.67</td>
<td>16.63</td>
<td>0.08</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>2.1</td>
<td>16.96</td>
<td>16.83</td>
<td>16.73</td>
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<td>0.09</td>
<td>0.07</td>
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<tr>
<td>2.2</td>
<td>17.27</td>
<td>17.04</td>
<td>16.86</td>
<td>0.29</td>
<td>0.18</td>
<td>0.11</td>
</tr>
<tr>
<td>2.3</td>
<td>17.65</td>
<td>17.32</td>
<td>17.01</td>
<td>0.43</td>
<td>0.30</td>
<td>0.13</td>
</tr>
<tr>
<td>2.4</td>
<td>18.08</td>
<td>17.67</td>
<td>17.19</td>
<td>0.59</td>
<td>0.48</td>
<td>0.11</td>
</tr>
<tr>
<td>2.5</td>
<td>18.53</td>
<td>18.06</td>
<td>17.39</td>
<td>0.74</td>
<td>0.66</td>
<td>0.07</td>
</tr>
<tr>
<td>2.6</td>
<td>18.98</td>
<td>18.47</td>
<td>17.75</td>
<td>0.87</td>
<td>0.71</td>
<td>0.16</td>
</tr>
<tr>
<td>2.7</td>
<td>19.43</td>
<td>18.86</td>
<td>18.20</td>
<td>0.94</td>
<td>0.66</td>
<td>0.28</td>
</tr>
<tr>
<td>2.8</td>
<td>19.77</td>
<td>19.49</td>
<td>18.72</td>
<td>0.77</td>
<td>0.77</td>
<td>0.00</td>
</tr>
<tr>
<td>2.9</td>
<td>20.40</td>
<td>20.18</td>
<td>19.27</td>
<td>0.84</td>
<td>0.91</td>
<td>-0.07</td>
</tr>
<tr>
<td>3</td>
<td>21.10</td>
<td>20.93</td>
<td>19.82</td>
<td>0.94</td>
<td>1.11</td>
<td>-0.17</td>
</tr>
</tbody>
</table>

This table shows the multi-product and export complementarity. All values are in logs. MBE is marginal benefit of exporting and is defined as \( V(X,I,N) - V(X=0,I,N) \), where \( V(X,I,N) \) is the value function when all three choices, \( X, I, \) and \( N \) are chosen optimally and the dynamic parameters are computed using maximum likelihood estimator. \( V(X=0,I,N) \) is the value function when export is restricted to 0 and \( I \) and \( N \) are chosen optimally with entry and exit rate fixed as in \( V(X,I,N) \). MBE (N=0) is the marginal benefit of exporting when number of products is restricted to 1 and is defined as \( V(X,I,N=1) - V(X=0, I, N=1) \). The cross partial between \( N \) and \( X \) is defined as MBE - MBE (N=1).
Table 12 Investment and Multi-Product Complementarity

<table>
<thead>
<tr>
<th>productivity</th>
<th>V(X,I,N)</th>
<th>V(X,I=0,N)</th>
<th>V(X,I,N=1)</th>
<th>V(X,I=0,N=1)</th>
<th>MBI</th>
<th>MBI (N=1)</th>
<th>MBI - MBI(N=1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.9</td>
<td>16.44</td>
<td>16.44</td>
<td>16.44</td>
<td>16.44</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>2.0</td>
<td>16.73</td>
<td>16.48</td>
<td>16.67</td>
<td>16.48</td>
<td>0.25</td>
<td>0.19</td>
<td>0.06</td>
</tr>
<tr>
<td>2.1</td>
<td>16.96</td>
<td>16.53</td>
<td>16.83</td>
<td>16.52</td>
<td>0.43</td>
<td>0.30</td>
<td>0.13</td>
</tr>
<tr>
<td>2.2</td>
<td>17.27</td>
<td>16.57</td>
<td>17.04</td>
<td>16.56</td>
<td>0.70</td>
<td>0.48</td>
<td>0.22</td>
</tr>
<tr>
<td>2.3</td>
<td>17.65</td>
<td>16.66</td>
<td>17.32</td>
<td>16.64</td>
<td>0.99</td>
<td>0.67</td>
<td>0.31</td>
</tr>
<tr>
<td>2.4</td>
<td>18.08</td>
<td>16.84</td>
<td>17.67</td>
<td>16.81</td>
<td>1.24</td>
<td>0.86</td>
<td>0.38</td>
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<tr>
<td>2.5</td>
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<td>17.14</td>
<td>18.06</td>
<td>17.07</td>
<td>1.39</td>
<td>0.99</td>
<td>0.40</td>
</tr>
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<td>18.47</td>
<td>17.48</td>
<td>1.43</td>
<td>0.99</td>
<td>0.44</td>
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<tr>
<td>2.7</td>
<td>19.43</td>
<td>18.13</td>
<td>18.86</td>
<td>18.04</td>
<td>1.30</td>
<td>0.82</td>
<td>0.48</td>
</tr>
<tr>
<td>2.8</td>
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<td>18.81</td>
<td>19.49</td>
<td>18.71</td>
<td>0.97</td>
<td>0.78</td>
<td>0.19</td>
</tr>
<tr>
<td>2.9</td>
<td>20.40</td>
<td>19.53</td>
<td>20.18</td>
<td>19.44</td>
<td>0.87</td>
<td>0.74</td>
<td>0.13</td>
</tr>
<tr>
<td>3.0</td>
<td>21.10</td>
<td>20.30</td>
<td>20.93</td>
<td>20.22</td>
<td>0.80</td>
<td>0.72</td>
<td>0.08</td>
</tr>
</tbody>
</table>

This table shows the investment and multi-product complementarity. All values are in logs. MBI is marginal benefit of investment and is defined as V(X,I,N)-V(X,I=0,N), where V(X,I,N) is the value function when all three choices, X, I, and N are chosen optimally and the dynamic parameters are computed using maximum likelihood estimator. V(X,I=0,N) is the value function when investment is restricted to 0 and X and N are chosen optimally with entry and exit rate fixed as in V(X,I,N). MBI (N=1) is the marginal benefit of investment when number of products is restricted to 1 and is defined as V(X,I,N=1) - V(X, I=0, N=1). The cross partial between I and N is defined as MBI - MBI (N=1).
This graphs shows that investment, export and productivity are all correlated.
This graph shows how the investment, export, and profits change when a country is opening up to trade. The top panel shows the change in profits when a country is opening up to trade. The bottom panel shows the change in investment profile when a country is opening up to trade. $\varphi_{it}$ is the productivity. $\varphi_{it}^{A^*}$ is the productivity cut-off in autarky below which firms cannot operate. $\varphi_{ix}^{CT^*}$ is the productivity cut-off when a country goes from autarky to trading, below which firms cannot operate. $\varphi_{ix}^{CT^*}$ is the productivity cut-off for exporting firms, below which firms cannot export.
Figure 3 Investment and Export Complementarity

This graph shows the investment and export complementarity. The thin continuous line plots the MBE defined before, the dotted line plots the MBE (I=0), and the dashed line plots the cross partial between investment and export, or what we call investment complementarity.
This graph shows the multi-product and export complementarity. The thin continuous line plots the MBE defined before, the dotted line plots the MBE (N=1), and the dashed line plots the cross partial between multi-product and export, or what we call multi-product complimentarity.
This graph shows the investment and multi-product complementarity. The thin continuous line plots the MBI defined before, the dotted line plots the MBI (N=1), and the dashed line plots the cross partial between investment and multi-product, or what we call investment-multi-product complementarity.
Appendix

Capital Size

Capital in the Spanish survey is defined as the value of the technical facilities, machinery, tools, other facilities, furniture, information processing equipment, rolling stock and other tangible fixed assets (land and buildings excluded). Capital and Investment have a correlation coefficient of 0.63.

I break the Spanish data into two subgroups based on capital size in the year 2002. For simplicity, I’m assuming firms cannot move from the low capital group to the high capital group within the sample period. For the high capital group, the export participation rate is 88% and the investment participation rate is 91%. For the low capital group, the export participation rate is 40% and the investment participation rate is 68%. The average export and investment volumes for the high capital group are 58 million and 49 million euros, respectively. For the low capital group, they are 350 thousand and 640 thousand, respectively.

I estimate the dynamic parameters for the two subgroups and find that the investment and export complementarity effect is smaller for the high capital group and the investment and export complementarity effect is bigger for the low capital group than if I estimate the whole sample without accounting for capital size. This is because in the high capital group, most firms already export, the marginal benefit of exporting with zero investment is higher for these firms with high capital which are also of high productivity. As a result, the cross partial between investment and export is reduced. Similarly, for the low capital group, most firms do not export, the marginal benefit of exporting with zero investment is very low for these firms with low capital which are also of low productivity. As a result, the difference between the marginal benefit of exporting with optimal investment and zero investment becomes bigger.
Sample Coverage and Data Collection

The ESEE’s population of reference is made up by the firms with 10 or more employees and which belong to what is usually known as the manufacturing industry. The geographical scope of reference is all the Spanish territory, and the variables have a yearly temporal dimension.

One of the most relevant characteristics of the ESEE is its representativeness. The initial selection was carried out combining exhaustiveness and random sampling criteria. In the first category were included those firms which have over 200 employees, and whose participation was required. The second category was composed by the firms which employ between 10 and 200 workers, which were selected through a stratified, proportional, restricted and systematic sampling, with a random start. Each year, all the newly incorporated firms which employ over 200 workers, as well as a randomly selected sample which represents around 5% of the newly incorporated firms which have between 10 and 200 employees enter into the sample.
Computation of the Firm’s Dynamic Problem

Algorithm: MPE solver

1. \( \bar{\omega} = 0 \) and \( \bar{\omega} = \frac{1}{\theta_{EN}} \left( \sup_{\phi, s} \pi(\phi, s) \right) \frac{1}{1 - \beta} + \bar{\phi} \)

2. \( \mu(\phi) = 0 \) for all \( \phi \)

3. \( n = 0 \)

4. Loop

5. \( \bar{\omega} = (\bar{\omega} + \bar{\omega}) / 2 \)

6. Loop

7. Choose \( \mu^* \) to maximize \( V(\phi, s|\mu, \bar{\omega}) \) for all \( \phi \)

8. \( \Delta = ||\mu^* - \mu||_{\infty} \quad n = n + 1 \)

9. \( \mu = \mu + (\mu^* - \mu)/(n^\gamma + N) \)

10. until \( \Delta \leq \varepsilon_1 \)

11. if \( \beta E_{\mu} [V(\phi, s_{t+1}|\mu, \bar{\omega})|s_t = s] - \theta_{EN} \geq 0 \) then

12. \( \bar{\omega} = \bar{\omega} \)

13. else

14. \( \bar{\omega} = \bar{\omega} \)

15. until \( |\beta E_{\mu} [V(\phi, s_{t+1}|\mu, \bar{\omega})|s_t = s] - \theta_{EN}| \leq \varepsilon_2 \)
The table shows the evolution of the sampled firms during the period 1990-2007.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<td>1898</td>
<td>1768</td>
<td>1721</td>
<td>1693</td>
<td>1584</td>
<td>1596</td>
<td>1764</td>
<td>1631</td>
<td>1634</td>
<td>1693</td>
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<td>1380</td>
<td>1374</td>
<td>1277</td>
<td>1716</td>
<td>1892</td>
<td>1855</td>
</tr>
<tr>
<td>1.2 Disappear¹</td>
<td>62</td>
<td>52</td>
<td>72</td>
<td>53</td>
<td>51</td>
<td>28</td>
<td>35</td>
<td>18</td>
<td>45</td>
<td>38</td>
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<td>18</td>
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<td>4</td>
<td>17</td>
<td>35</td>
<td>30</td>
<td>57</td>
</tr>
<tr>
<td>1.3 Do not collaborate</td>
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<td>62</td>
<td>124</td>
<td>45</td>
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<td>33</td>
<td>54</td>
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<td>10</td>
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<td>47</td>
<td>13</td>
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<td>77</td>
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<td>31</td>
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<td>58</td>
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<td>59</td>
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<td>2</td>
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<td>146</td>
<td>83</td>
<td>93</td>
</tr>
<tr>
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<td>99</td>
<td>99</td>
<td>132</td>
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<td>12</td>
<td>123</td>
<td>236</td>
<td>31</td>
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<td>0</td>
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<td>307</td>
<td>118</td>
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<td></td>
</tr>
<tr>
<td>3. Entries in the current year</td>
<td>42</td>
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<td>101</td>
<td>56</td>
<td>9</td>
<td>132</td>
<td>324</td>
<td>12</td>
<td>123</td>
<td>236</td>
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<td>0</td>
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<td>0</td>
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<td>307</td>
<td>118</td>
<td>154</td>
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<td>3431</td>
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<td>4475</td>
<td>4629</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. Closures, firms in liquidation, change to a non-manufacturing activity, disappearance through merger or acquisition.
2. Cannot be found, provisional close-up.
3. In 1991 they are large-sized firms to which the questionnaire was already submitted in 1990, but which did not answer it. In 1994 it is made up of large-sized firms which had filled the questionnaire before but which at some time they stopped doing it.

* Includes a company which did not collaborated in 1995 but which collaborated in 1996.
## SAMPLE COVERAGE ESEE 2005*

<table>
<thead>
<tr>
<th>Industry</th>
<th>Less than 20</th>
<th>21 to 50</th>
<th>51 to 100</th>
<th>101 to 200</th>
<th>More than 200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat-processing industry</td>
<td>1.54%</td>
<td>3.03%</td>
<td>2.04%</td>
<td>14.29%</td>
<td>32.00%</td>
</tr>
<tr>
<td>Foodstuffs and tobacco</td>
<td>2.42%</td>
<td>3.10%</td>
<td>3.97%</td>
<td>5.32%</td>
<td>38.75%</td>
</tr>
<tr>
<td>Drinks</td>
<td>3.32%</td>
<td>3.40%</td>
<td>7.41%</td>
<td>23.81%</td>
<td>41.03%</td>
</tr>
<tr>
<td>Textiles</td>
<td>3.06%</td>
<td>3.75%</td>
<td>6.98%</td>
<td>16.04%</td>
<td>42.62%</td>
</tr>
<tr>
<td>Leather and footwear</td>
<td>3.03%</td>
<td>4.67%</td>
<td>5.63%</td>
<td>14.81%</td>
<td>14.29%</td>
</tr>
<tr>
<td>Wood industry</td>
<td>1.37%</td>
<td>3.25%</td>
<td>7.69%</td>
<td>16.67%</td>
<td>50.00%</td>
</tr>
<tr>
<td>Paper</td>
<td>3.53%</td>
<td>3.38%</td>
<td>6.82%</td>
<td>14.29%</td>
<td>60.53%</td>
</tr>
<tr>
<td>Editing and printing</td>
<td>1.98%</td>
<td>2.96%</td>
<td>6.67%</td>
<td>7.08%</td>
<td>40.32%</td>
</tr>
<tr>
<td>Chemical industry</td>
<td>2.25%</td>
<td>4.28%</td>
<td>6.61%</td>
<td>11.03%</td>
<td>39.16%</td>
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<tr>
<td>Rubber and plastics</td>
<td>3.09%</td>
<td>2.95%</td>
<td>5.79%</td>
<td>12.90%</td>
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<td>Iron and steel</td>
<td>2.12%</td>
<td>3.02%</td>
<td>5.65%</td>
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<td>Metallic products</td>
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<td>2.88%</td>
<td>5.31%</td>
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<tr>
<td>Machinery and mechanical goods</td>
<td>2.41%</td>
<td>3.27%</td>
<td>5.42%</td>
<td>12.84%</td>
<td>51.95%</td>
</tr>
<tr>
<td>Office machinery, computers, processing, optical and similar</td>
<td>1.54%</td>
<td>5.63%</td>
<td>13.64%</td>
<td>4.55%</td>
<td>45.45%</td>
</tr>
<tr>
<td>Electrical and electronic machinery and material</td>
<td>3.06%</td>
<td>3.95%</td>
<td>4.81%</td>
<td>11.70%</td>
<td>45.83%</td>
</tr>
<tr>
<td>Motor vehicles</td>
<td>2.74%</td>
<td>3.85%</td>
<td>6.19%</td>
<td>12.66%</td>
<td>44.85%</td>
</tr>
<tr>
<td>Other transport material</td>
<td>1.57%</td>
<td>6.15%</td>
<td>13.04%</td>
<td>44.00%</td>
<td>31.58%</td>
</tr>
<tr>
<td>Furniture</td>
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<td>3.31%</td>
<td>4.86%</td>
<td>12.00%</td>
<td>50.00%</td>
</tr>
<tr>
<td>Other manufacturing</td>
<td>3.06%</td>
<td>2.73%</td>
<td>2.70%</td>
<td>9.38%</td>
<td>40.00%</td>
</tr>
<tr>
<td>Total</td>
<td>2.36%</td>
<td>3.37%</td>
<td>5.44%</td>
<td>11.40%</td>
<td>42.95%</td>
</tr>
</tbody>
</table>

* Sample coverage, calculated with respect to the Spanish Social Security Census

The table shows the sample coverage.
Chapter 2

Global Sourcing and Credit Constraints
2.1 Introduction

A growing literature in international economics has emphasized the importance of financial development in facilitating trade. This literature has addressed questions including but not limited to how financial development promotes increased exports of finance intensive industries (e.g. Manova (2008) and Manova and Chor (2012)) and the importance of financial development in providing trade financing (e.g. Amiti and Weinstein (2009)). Within global supply chains, one of the implications of this literature is that international supply chain operations necessitate confidence in global suppliers to deliver their share of valued-added and to have the necessary financial means to produce and export it in a timely manner.\footnote{To meet liquidity needs, firms often obtain trade finance from banks and other financial institutions. These financial arrangements are backed by collateral in the form of tangible assets. Therefore, there is a very active market that operates for the financing and insurance of international transactions, reportedly worth $10–12 trillion – that is roughly 80% of 2008 trade flows valued at $15 trillion. Up to 90% of world trade has been estimated to rely on some form of finance (Auboin (2009)).} This paper examines in detail how differences in financial depth across countries and credit constraints across industries affect the organization of global supply chains.

To do so, this paper extends the work of Antras and Helpman (2004) to explain how the disruption in the ability of the financial sector to provide working capital leads to a shift in the global supply chain from arm’s length transactions to vertical integration and contraction in trade. It also shows how the magnitude of this relationship depends crucially on credit constraints in an industry due to how well industry assets can serve as collateral. In addition, firms of varying productivity levels within an industry chose different organizational structures. Finally, the model generates predictions that can be easily verified in the data. First, it generates classic comparative advantage predictions regarding country-industry level patterns of specialization depending on country-level financial depth and industry-level credit constraints. Second, it incorporates firm heterogeneity and can therefore analyze how firms of varying productivity levels in an industry
choose different organizational structures and how this sorting depends on financial depth and credit constraints. Third, it takes patterns of industrial specialization and can analyze what proportion of trade occurs within the boundary of the firm. While most prior studies focus on export volumes, I explore the patterns of multinational firm activity. This allows me to study how credit constraints explain not only export volumes but also how firms choose to produce intermediate inputs.

More precisely, I develop a multi-sector model of credit-constrained heterogeneous firms financing their fixed organizational costs, countries at different levels of financial development, and sectors of varying financial dependence. Production of a final good requires two inputs, headquarter services, and intermediate inputs. Headquarter services are only provided in the North. As in AH, a fixed organizational cost depends on whether the supplier of intermediate inputs resides in the North or the South and whether exchange occurs at arm’s length or within the boundary of the firm. I assume that under vertical integration, the final good producer provides financing for these fixed costs. While under outsourcing, the intermediate supplier is responsible. Intuitively, in the case of establishing subsidiaries, parent firms often must incur the upfront fixed costs that cannot be financed out of retained earnings or internal cash flows from operations. With independent intermediate input suppliers, the burden lies on the independent intermediate input suppliers to finance such costs. Finally, the firm that is responsible for financing the costs faces the credit constraint of the country in which it is located and parties choose the organizational structure that maximizes ex-post surplus.

As shown in Rajan and Zingales (1998), financial dependence and credit constraints vary dramatically across both countries and industries. For example, sectors differ in their endowment of tangible assets that can serve as collateral (Braun (2003)). Final-good producers in some sectors find it easier to operate because they can more easily raise outside finance because they possess more tangible assets that can serve as collateral. Credit constraints vary across countries because financial contracts between firms and
investors are more likely to be enforced at higher levels of financial development. If the financial contract is enforced, the financing firm makes a payment to the investor; otherwise the financing firm defaults and the investor claims the collateral. Financing firms then find it easier to raise external finance in countries with high levels of financial contractibility. The need to rely on external finance is common across firms. Firms often rely on external capital to finance upfront fixed costs, such as investment in fixed capital equipment, expenditures on R&D and product development, marketing research and advertising. When production requires the use of intermediate inputs, the final good producers can choose to open their own subsidiaries or find independent suppliers to produce them.

In the absence of credit constraints, all final-good producers above a certain cut-off level operate and sort to different type and location of organizational forms according to their productivity level. With credit constraints in the South, more Northern firms choose to integrate with Southern firms relative to arm’s length transactions. This is because the Northern firms can cover the fixed costs of production using the well developed Northern financial system more easily than if fixed costs were covered using the Southern financial system. For similar reasons, integration with other Northern input suppliers (using the Northern financial system) becomes more attractive relative to arm’s length transactions with Southern input suppliers.

The empirical section of the paper examines two of the core predictions of the theoretical model. First, improvements in financial contractibility in the South increases the proportion of arm’s length trade between the North and the South. Second, this effect is most pronounced in the sectors that depend more on external finance and have less tangible assets. I find strong support for the model’s predictions in a sample of intra-firm U.S. imports from 90 exporting countries and 429 4-digit SIC manufacturing sectors in 1996-2005. I show how the interaction of country level financial development and industry level external dependence on finance and asset tangibility predict the choice of
organizational forms. I use credit extended to the private sector as a share of GDP as my measure of financial development, and show consistent results with indices of accounting standards, risk appropriation, contract repudiation, and stock capitalization. I measure sector-level financial dependence in two ways. First, a sector relies more on external finance if it possesses a high share of investment not financed from internal cash flows. Second, asset tangibility for collateral purposes is constructed as the share of structures and equipment in total assets.

The rest of the paper is organized as follows. Section 2 describes the relation to the literature. Section 3 provides an overview of trade patterns in the data. Section 4 develops the model. Section 5 shows how firms with different productivity sort into different organizational forms and the role credit constraint plays on the firms’ sourcing decisions. Section 6 provides the empirical specification to test. Section 7 discusses the data. Section 8 provides the regression results. Section 9 concludes.

## 2.2 Relation to the literature

Prior theoretical and empirical work has focused on the effect of financial development on industry-level outcomes and on factors that determine the boundary of the firm, but rarely the two together. A number of studies have proposed that financial development becomes a source of comparative advantage and affects aggregate growth and volatility (Rajan and Zingales (1998), Braun (2003), Aghion et al. (2010)). There has been robust empirical evidence that financially developed countries export relatively more in financially dependent sectors.\(^2\) In addition, there has also been evidence that host country financial development has implications for patterns of multinational firm activity and foreign direct investment flows (Antras, Desai, and Foley (2009)). Using Chinese transaction-level data, Manova, Wei, and Zhang (2011) show that foreign-owned affiliates

and joint ventures have better export performance than private domestic firms, and that this advantage is systematically greater in sectors that require more external finance. Manova (2008) show that financial liberalizations increase exports disproportionately more in financially dependent sectors that require more outside finance or employ fewer assets that can be collateralized.

More generally, this paper contributes to a line of research that examines institutional frictions as a source of comparative advantage in international trade. For example, Nunn (2007) develops an incomplete-contracts model of relationship specific investments and finds that countries with better contract enforcement have a comparative advantage in industries intensive in such investments. Claessens and Laeven (2003) and Levchenko (2007) also show that property rights protection and the rule of law affect international trade. Antras and Foley (2011) show that transactions are more likely to occur on cash in advance or letter of credit terms when the importer is located in a country with weak contractual enforcement and in a country that is further from the exporter. Whereas these prior studies on institutions and trade focus on export volume, I explore the impact of financial institutions on the patterns of multinational firm activity.

2.3 First glance at the data

This section presents basic summary statistics and highlights simple correlations in the data that motivate the theoretical model and empirical analysis. The data set is assembled by the U.S. Census Bureau captures all U.S. international trade between 1996-2005. This dataset records the product classification, the value and quantity, the destination (or source) country, the transport mode, and whether the transaction takes place at arms length or between related parties. Related-party, or intra-firm, trade are shipments between U.S. companies and their foreign subsidiaries as well as trade between U.S. sub-
sidiaries of foreign companies and their affiliates abroad. Following Antras (2003), I take the share of intra-firm U.S. imports to be an indicator for prevalence of vertical integration.

Table 1 demonstrates substantial variation in the organizational behavior of 90 exporting countries in 429 4-digit SIC manufacturing sectors. In panel A, the average share of related-party trade across countries and sectors is 22% with standard deviation of .31%, and conditional on positive party-related trade, the mean rises to 36% and standard deviation is .32%. Across all industries, the U.S. imports from an average of 60 countries with a standard deviation of 30. With party-related trade, this number drops to 35 countries with a standard deviation of 19. The large number of countries the U.S. firms are trading with allows us to explore the cross country variation in their financial development on the organizational structures of multinational firms. Panel B shows the difference in capital-labor ratio and trade volumes for industries that have zero related-party trade and positive related-party trade. In Antras (2003) and Antras and Helpman (2004), those sectors with zero related-party trade are component intensive and those with positive related-party trade are headquarter intensive. Conditional on positive trade volume, 37% of the exporter-sector cells show no intra-firm trade. The average and trade weighted capital-labor ratios for exporter-sector cells show no significant difference between industries with zero and strictly positive intra-firm trade. From panel C, the average trade volume is higher conditional on strictly positive intra-firm trade. This is consistent with Antras and Helpman (2004)’s model in which the firms with positive related-party trade tend to have higher revenues.

The first measure of financial development I use is the ratio of credit from banks and

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3For imports, firms are related if they either own, control or hold voting power equivalent to 6 percent of the outstanding voting stock or shares of the other organization (see Section 402(e) of the Tariff Act of 1930).

4The capital-labor ratio for each sector is defined as log of the U.S. capital stock in over the number of production workers in 1994.
other financial intermediaries to the private sector as a share of GDP.\(^5\) In the panel of 90 countries, private credit over GDP ratio varies significantly across countries and over time. Table 2 summarizes the cross sectional variation for private credit over GDP ratio. The countries listed are listed in descending order of the average private credit over GDP ratio over the years. Excluding the U.S., Switzerland, Hong Kong, and Great Britain are the top three countries that extend most private credit as a share of GDP. Vietnam and Denmark experienced greatest change in this measure of financial development over the years.

Sector-level measures of external dependence on finance and asset tangibility are constructed based on data for all publicly traded U.S. based companies from Compustat. A firm’s external dependence on finance is defined as capital expenditures minus cash flow from operations divided by capital expenditures. A sector’s level’s measure of external dependence on finance is the median firm’s external dependence on finance in a sector, as proposed by Rajan and Zingales (1998). Asset tangibility is similarly defined as the share of net property, plant and equipment in total book-value assets for the median firm in a given sector. Both measures are constructed as averages for the 1996-2005 period. For comparison reasons, after aggregating these measures to 3-digit SIC industry classification, they appear very similar to those constructed by Braun (2003). In Table 3 panel B, the mean and standard deviation of external dependence on finance across all sectors are \(-1.25\) and \(2.04\), respectively. The mean and standard deviation of asset tangibility are \(.74\) and \(.73\).\(^6\)\(^7\)

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\(^5\)I obtain this measure from Beck et al. (2000).

\(^6\)The sectors in greatest need for outside capital tend to be intensive in up-front investments, such as professional and scientific equipment and electrical machinery. Apparel and beverages are the sectors that require the least amount of outside capital. Sectors with highest level of asset tangibility are petroleum refineries, paper and products, iron and steel, and industrial chemicals. Sectors with lowest level of asset tangibility are toys, electric machinery, and professional equipments.

\(^7\)As in Rajan and Zingales (1998), using the U.S. as the reference country is convenient due to the limited data for many other countries. It’s also reasonable to assume the U.S. measures reflect firms true demand for external finance and tangible assets because U.S. has the most sophisticated and advanced financial systems. Using U.S. measure also eliminates the potential bias for an industry’s external dependence on finance to endogenously respond to a country’s financial development.
In addition, sectors in greatest need for outside capital tend to have more affiliated trade with the U.S; and the opposite is true for sectors with greatest assets. Figure 1 shows shares of related-party (intra-firm) trade is computed by aggregating the data to 3-digit SIC classification. It is clear that industries that are more dependent on external finance are associated with a greater share of U.S. intra-firm trade. Figure 2 illustrates the opposite relationship for asset tangibility and share of U.S. intra-firm trade. This relationship persists for all years.

The Asian financial crisis of 1997-1999 provides additional motivation. During an episode of diminished financial depth, I expect an increase in the share of intra-firm trade and that this effect is more pronounced in sectors with the most binding credit constraints. Financial frictions rose during this period as international investors were reluctant to lend to developing countries. In Figure 3, for each country \( c \) and year \( t \), I calculate the average external finance dependence and asset tangibility for the share of intra-firm trade as \( \sum_i (\text{FinDep}_i \times R_{ict} / T_{ict}) \) and \( \sum_i (\text{Tang}_i \times R_{ict} / T_{ict}) \) respectively, where \( R_{ict} / T_{ict} \) is the share of intra-firm trade in sector \( i \) in country \( c \) in year \( t \). I plot both measures for the 12 countries with the largest growth in the credit extended to private sector as a share of GDP between 1996 and 2004. I expect the average external finance dependence measure to be higher during financial crunches because the share of intra-firm trade will be higher, and this is especially true in the sectors that require greater outside finance. I expect the average asset tangibility measure to be lower during financial crunches because for sectors that have the greatest tangible assets for collateral, the share of intra-firm trade will be small. From Figure 3, I see that the average external finance dependence weighted by the share of intra-firm trade increased in 1997 for most countries. After year 1999, these values decreased. The opposite is true using the average asset tangibility weighted by the share of intra-firm trade, because the more tangible assets firms have, the less financially dependent they are. I also see another spike in 2001, this is likely due to the events of 9-11 and the bursting of the technology bubble,
where credit tightened around the world and firms became more financially dependent. The 12 graphs are ordered by the standard deviation of the change in private credit to GDP ratio over this period as indicated in the graph headings.

The variation in the share of intra-firm trade in the data across countries, sectors and time are not random. I proceed with the following model to better understand the mechanisms behind these features.

2.4 The Model

Consider a world consisting of two countries: North (N) and South (S). There are $J + 1$ sectors consisting of $J$ CES aggregates described below and a single homogenous goods sector. As described below, firms decide whether to produce, from where to source intermediate inputs, and the boundaries of the firm.

This section starts by describing consumer preferences and the production technology of firms. It then describes the incomplete contracting setting and credit constraints that are at the core of the model. I then derive the profit functions under arm’s length and integrated sourcing with both Northern and Southern suppliers of intermediate inputs. Finally, I derive the equilibrium choice of firm boundaries and location of intermediate input suppliers as a function of credit constraints, financial depth, and firm productivity.

2.4.1 Demand

The utility function of a representative consumer is given by:

$$U = x_0 + \frac{1}{\mu} \sum_{j=1}^{J} X_j^\mu, \quad 0 < \mu < 1$$  \hspace{1cm} (2.1)

$$X_j = \left[ \int x_j(i)^\alpha di \right]^{1/\alpha}, \quad 0 < \alpha < 1$$  \hspace{1cm} (2.2)
where $x_0$ is the consumption of a homogeneous good, and $X_j$ is the CES aggregate consumption index in sector $j$. Each firm produces an imperfectly substitutable variety $x_j(i)$ such that $i$ indexes both firms and varieties. The constant elasticity of substitution in a sector is given by $\varepsilon = 1/(1-\alpha) > 1$. Assume $\alpha > \mu$, so that varieties within a sector are more substitutable within than across. Inverse demand for variety $i$ in sector $j$ is:

$$p_j(i) = X_j^{\mu-\alpha} x_j(i)^{\alpha-1}$$

and the revenue function for a given firm is

$$R_j(i) = X_j^{\mu-\alpha} x_j(i)^\alpha.$$  

### 2.4.2 Production

The only factor of production is labor. Producers face a perfectly elastic supply of labor in each country. I assume that the wage rate is fixed in the North and the South and $w^N > w^S$. As in Antras and Helpman (2004), only the North produces the final-good variety. The production of the final good requires two inputs, headquarter services $h_j(i)$, and intermediate inputs, $m_j(i)$ using a Cobb-Douglas production function,

$$x_j(i) = \theta \left[ \frac{h_j(i)}{\eta_j} \right]^{\eta_j} \left[ \frac{m_j(i)}{1-\eta_j} \right]^{1-\eta_j}, \quad 0 < \eta_j < 1$$

where $\theta$ is the productivity of final good producer $H$ of variety $i$ in sector $j$. $\theta$ is drawn from a known distribution $G(\theta)$ after $H$ pays a fixed cost of entry $w^N f_E$. $\eta_j$ is sector specific, with higher $\eta_j$ indicating greater intensity of headquarter services. Headquarter services must be produced in the North, whereas intermediate inputs can be produced in

---

8The assumption of a higher wage in the North can be justified by assuming that labor supply is large enough in each country so that both countries produce $x_0$ and that $x_0$ is produced with constant returns to scale, but with higher productivity in the North.
either the North or the South. $H$ makes two decisions: whether to source intermediate inputs in the North or in the South, and whether to vertically integrate the supplier ($V$) or to outsource ($O$). The first is the location decision ($l \in \{N, S\}$) and the second is the organizational-structure decision ($k \in \{V, O\}$). Following Antras and Helpman (2004), the fixed organizational costs are assumed to be ranked in the following order:

$$f^S_V > f^S_O > f^N_V > f^N_O.$$ (2.6)

That is, in either location, the costs of vertical integration are higher than the costs of outsourcing and, for either ownership structure, costs are higher in the South than in the North.

### 2.4.3 Credit Constraints

Final good producers and intermediate suppliers face credit constraints in the financing of fixed costs associated with organizational choice depending on both reliance on external finance and the tangibility of assets that can serve as collateral. Following Manova (2006), I begin by assuming all firms can finance their variable costs internally, but they need to raise outside capital to finance for a fraction $d_j$ of the fixed organizational costs. Consequently, production requires that $H$ or the $M$ borrow $d_j w^n f^l_k$. Firms experience liquidity constraints because of up-front costs which they can cover after revenues are realized but not internally in advance. As argues by Rajan and Zingales (1998) I assume that the reliance on external finance $d_j$ varies across industries. To obtain external finance, firms must use tangible assets as collateral. If the firm fails to pay back its loan, the creditor receives ownership of the collateral. $t_j$ corresponds

\[0 < d_j < 1.\]

\[10\] BRIEFLY SUMMARIZE THIS ARGUMENT.

\[11\] Examples of tangible assets include structures and equipment whereas an example of an intangible asset is human capital.
to the measure of asset tangibility in my empirical analysis and is also innate to each industry, as in Braun (2003). A fraction $t_j$ of the sunk costs must be provided as collateral to obtain external finance such that the total collateral that must be posted is $t_j w^N f_E$.\textsuperscript{12}

The North and the South varies in their level of financial contractibility. Investors can be expected to be repaid with probability $\lambda^l$.\textsuperscript{13} I assume that $\lambda^N > \lambda^S$. A final goods producer located in the North defaults with probability $(1 - \lambda^N)$, and intermediate supplier who is located in the North or South defaults with probability $(1 - \lambda^l)$, and the investors claim $t_j w^N f_E$. $\lambda^l$ is exogenous in the model and corresponds to the strength of country $l$’s financial institutions in my empirical analysis.

### 2.4.4 Incomplete Contracts

As in Antras (2003), final good producers and intermediate input suppliers cannot sign ex ante enforceable contracts specifying the purchase of specialized intermediate inputs for a certain price nor a contract contingent on the amount of labor hired or the volume of sales after the final good is sold.\textsuperscript{14} Therefore, surplus is split between the final goods producer and intermediate supplier in generalized Nash bargaining such that the final good producer obtains a fraction $\beta \in (0, 1)$ of the ex post gains from the relationship.

Ex post bargaining takes place both under vertical integration and outsourcing. Under outsourcing, the outside option of both parties is assumed to be zero because the inputs are relationship specific and have no outside value. Under vertical integration, failure to reach an agreement on the distribution of surplus leaves $M$ with no outside value; however, $H$ can appropriate a fraction $\delta^l$ of the intermediate inputs produced because $H$ cannot use the intermediate inputs as effectively in an outside relationship as it can with $M$.\textsuperscript{15} I assume $\delta^N \geq \delta^S$, as in Antras and Helpman (2004), because a contractual breach

\textsuperscript{12}$0 < t_j < 1$
\textsuperscript{13}$0 < \lambda^l < 1$.
\textsuperscript{14}This can be justified as in Hart and Moore (1999) where the precise nature of the intermediate input is revealed ex post only and is not verifiable by a third party.
\textsuperscript{15}$0 < \delta^l < 1$ and $\delta^l \neq 1$ because if $H$ were able to appropriate all intermediate inputs, $H$ would
is more costly to \( H \) when \( M \) is located in the South. This also reflects more corruption and lack legal protection in the South.

There is infinitely elastic supply of \( M \) in each country. Because of this \( M \)'s profits from the relationship are equal to its outside option, which is assumed to be 0 here. Consequently, to ensure the relationship is at minimum costs to \( H \), \( M \) pays a fee \( T \) for that makes its participation constraint binding.

### 2.4.5 Equilibrium

**Ex-Post Revenue Shares**

Looking at a particular sector \( j \) and dropping the industry subscript, if \( H \) and \( M \) agree in the bargaining, revenue from the sale of the final good is:

\[
R(i) = X^{\mu - \alpha \theta^\alpha} \left[ \frac{h(i)}{\eta} \right]^{\alpha \eta} \left[ \frac{m(i)}{1 - \eta} \right]^{\alpha(1 - \eta)}.
\]  
(2.7)

If they fail to agree, the outside option for \( M \) is always zero. The outside option for \( H \) varies with ownership structure and the location of \( M \).

When \( H \) outsources the intermediate inputs, its outside option is zero. Consequently, each party obtains a share of ex-post gains from trade \( R(i) \) corresponding to their Nash bargaining weight. Therefore, \( H \) obtains \( \beta R(i) \) and \( M \) receives \((1 - \beta)R(i)\).

With vertical integration, if Nash bargaining breaks down, \( H \) can sell \( \delta l x(i) \) of output when \( M \) is in country \( l \), which yields revenue \((\delta l)^\alpha R(i)\). In the bargaining, \( H \) receives its outside option plus a fraction \( \beta \) of the ex post gains from the relationship. Consequently, \( H \) receives \( [(\delta l)^\alpha + \beta(1 - (\delta l)^\alpha)] R(i) \) and \( M \) receives \((1 - \beta)(1 - (\delta l)^\alpha)R(i)\).

Using this information, I can order the shares of revenue that accrue to \( H \) under the always have an incentive to seize all inputs, and this would lead \( M \) to choose \( m_j(i) = 0 \) which leaves \( x_j(i) = 0 \).
four organizational forms. Let $\beta_{ikl}^l R(i)$ denotes the payoff of $H$ under ownership structure $k$ and the location of $M$ in country $l$, then:

$$\beta_{V}^N = (\delta^N)^{\alpha} + \beta(1 - (\delta^N)^{\alpha}) \geq \beta_{V}^S = (\delta^S)^{\alpha} + \beta(1 - (\delta^S)^{\alpha}) > \beta_{O}^N = \beta_{O}^S = \beta$$ \hspace{2cm} (2.8)

As in Grossman and Hart (1986), integration gives $H$ the right to ex post use the inputs produced by $M$, which in turn enhances $H$’s bargaining position ($\beta_{V}^l > \beta_{O}^l$).

### Ex-Ante Investments and Financing

Since final good producers and intermediate input suppliers cannot sign ex ante enforceable contracts, the parties choose their quantities non-cooperatively. In absence of credit constraint, $H$ provides an amount of headquarter services that maximizes $\beta_{k}^l R(i) - w^N h(i)$ subject and $M$ provides the intermediate input that maximizes $(1 - \beta_{k}^l)R(i) - w^m m(i)$ each subject to (7). Combining the two first-order conditions, the total operating profit is

$$\pi_{k}^l (\theta, X, \eta) = X^{(\mu - a)/(1 - \alpha)} \theta^{a/(1 - \alpha)} \psi_{k}^l (\eta) - w^N f_{k}^l$$ \hspace{2cm} (2.9)

where

$$\psi_{k}^l (\eta) = \frac{1 - \alpha \left[ \beta_{k}^l \eta + (1 - \beta_{k}^l)(1 - \eta) \right]}{(1/\alpha) \left( w^N / n_{k}^l \right)^{\eta} \left( \eta / (1 - \beta_{k}^l) \right)^{1 - \alpha}} \eta^{\alpha/(1 - \alpha)}.$$

Under credit constraints, two additional conditions must be satisfied.

### Vertical Integration

If $H$ chooses vertical integration, no matter where the supplier is located, $H$ faces the financial friction in the North and chooses an amount of headquarter services that maximizes

$$\max_{h, F(a)} \beta_{V}^l R(i) - w^N h(i) - (1 - d)w^N f_{V}^l - \lambda^N F(i) - (1 - \lambda^N)tw^N f_E + T$$ \hspace{2cm} (2.10)
subject to \( (1) \ R(i) = X^{\mu-\alpha} \theta^\alpha \left[ \frac{h(i)}{\eta} \right]^{\alpha \eta} \left[ \frac{m(i)}{1-\eta} \right]^{\alpha(1-\eta)} \)

(2) \( A(i) \equiv \beta_V^l R(i) - w^N h(i) - (1-d)w^N f^l_V + T \geq F(i) \)

(3) \( B(i) \equiv -dw^N f^l_V + \lambda^N F(i) + (1-\lambda^N)tw^N f_E \geq 0. \)

I describe each expression in turn. \( H \) maximizes its profits by financing all its variable costs and a fraction \((1-d)\) of its fixed costs internally. With probability \( \lambda^l \) the contract is enforced and the investor receives \( F(i) \). With probability \( 1-\lambda^l \) there is default and the investor receives the collateral \( tw^N f_E \). \( T \) is the ex-ante transfer payment \( M \) has to pay to \( H \) that makes \( M \)'s participation constraint binding such that

\[
T = (1-\beta_V^l)R(i) - w^l m(i). \tag{2.11}
\]

Consider next the financial constraint (2). When financial contract is enforced, \( H \) can offer at most \( A(i) \), its net revenue, to the investor. Thus the firm cannot borrow more than \( A(i) \) such that \( A(i) \geq F(i) \). Finally, consider the participation constraint (3). Investors only lend to \( H \) if they expect to at least break even. \( B(i) \) represents the expected return to the investor taking into account the possibility default. With competitive credit markets, investors break even, \( H \) adjusts \( F(i) \) to bring investors’ net return to 0, and \( B(i) = 0 \). Therefore, \( F(i) = \frac{dw^N f^l_V - (1-\lambda^N)tw^N f_E}{\lambda^N} \).

Using equation (11) and the expression for \( F(i) \), profits for \( H \) under vertical integration are

\[
\max_m \pi^l_{HV} = R(i) - w^N h(i) - w^l m(i) - (1-d + \frac{d}{\lambda^N})w^N f^l_V + \frac{(1-\lambda^N)}{\lambda^N}tw^N f_E \tag{2.12}
\]

subject to \( R(i) = X^{\mu-\alpha} \theta^\alpha \left[ \frac{h(i)}{\eta} \right]^{\alpha \eta} \left[ \frac{m(i)}{1-\eta} \right]^{\alpha(1-\eta)} \).

The profit function for \( H \) then becomes

\[
\pi^l_{HV} = X^{(\mu-\alpha)/(1-\alpha)} \theta^\alpha/(1-\alpha) \psi^l_V(\eta) - (1-d + \frac{d}{\lambda^N})w^N f^l_V + \frac{(1-\lambda^N)}{\lambda^N}tw^N f_E. \]
Chapter 2. Global Sourcing and Credit Constraints

Outsourcing

If $H$ chooses to outsource the intermediate inputs, $M$ raises outside capital to finance fixed cost. Under outsourcing $M$ chooses intermediate inputs that maximizes

$$\max_m (1 - \beta^O) R(i) - w^l m(i) - (1 - d + \frac{d}{\chi^l}) w^N f^l_k + \frac{(1 - \lambda^l)}{\chi^l} t w^N f_E - T$$

subject to $R(i) = X^{\mu - \alpha} \theta^\alpha \left[ \frac{h(i)}{\eta} \right]^{\alpha\eta} \left[ \frac{m(i)}{1 - \eta} \right]^{\alpha(1 - \eta)}$.

Using the expression for $T$ from equation (11), the resulting profit function for $H$ is

$$\pi^l_{HO} = X^{(\mu - \alpha)/(1 - \alpha)} \theta^{\alpha/(1 - \alpha)} \psi^l_O(\eta) - (1 - d + \frac{d}{\chi^l}) w^N f^l_k + \frac{(1 - \lambda^l)}{\chi^l} t w^N f_E.$$ 

Productivity Cutoffs

In absence of credit constraints, the total operating profit function defines a productivity cutoff $(\theta^*)^{\alpha/(1 - \alpha)}$ above which $H$ finds it profitable to operate. Since profits are increasing in productivity $\theta$, firms with productivity below this level do not operate. When final good producers face credit constraints, more productive firms can offer investors greater returns when financial contract is enforced and repayment occurs. Consequently, higher borrowing costs will cause the least productive firms to earn lower profits with credit constraints than they would in a world with frictionless credit markets.

As a result, in the presence of credit constraint, a new and higher productivity cut-off for firms operating under vertical integration is $(\theta^*_{V,C})^{\alpha/(1 - \alpha)}$. This productivity cutoff is the level of productivity that solves the condition $A(\theta^*_{V,C}) = F(\theta^*_{V,C})$ such that

$$X^{(\mu - \alpha)/(1 - \alpha)} (\theta^*_{V,C})^{\alpha/(1 - \alpha)} \psi^l_k(\eta) = (1 - d + \frac{d}{\chi^N}) w^N f^l_k + \frac{(1 - \lambda^N)}{\chi^N} t w^N f_E.$$  

(2.13)

---

16This cutoff is given by the level of $\theta$ that solves $X^{(\mu - \alpha)/(1 - \alpha)} (\theta^*)^{\alpha/(1 - \alpha)} \psi^l_k(\eta) = w^N f^l_k$. 

The productivity cut-off for firms operating under outsourcing is

$$X^{(\mu-\alpha)/(1-\alpha)} (\theta^*_O, \theta^*_c)^{\alpha/(1-\alpha)} \psi^l_k(\eta) = (1 - d) w^N f^l_O + \frac{(1 - \lambda^l)}{\lambda^l} tw^N f^l_E. \quad (2.14)$$

Regardless of organizational structure, there is a higher productivity cut-off under credit constraint than without. This can be seen by noting that the right hand side of each of the expressions is increasing as $\lambda$ falls. Consequently, with lower financial development, there are higher productivity cutoffs. Without financial frictions ($\lambda^l = 1$), the model reduces to original Antras and Helpman (2004) formulation. In addition, note that reliance on external funding ($d_j$) only has an impact when financial contracts are not perfectly enforced.

Also, note that the payment to investors $F(i)$ is decreasing in financial development. As financial development falls ($\lambda \downarrow$), intermediate suppliers in the South face a higher interest rates on loans. This then reduces the transfer payment $T$ they can make to H, and thus H that choose to outsource in the South in essence need to pay a higher repayment on loans.

Regardless of ownership, Final good producers cannot operate with productivity lower than $\min(\theta^*_V, \theta^*_O, \theta^*_c)$ when they face credit constraints. $\min(\theta^*_V, \theta^*_O, \theta^*_c) > \theta^*$ whenever $df^l_k > t f^l_E$, which means credit constraints bind when firms need to borrow more than they can offer in collateral.\footnote{(Manova (2006), Greenaway et al. (2005), Becker and Greenberg (2005), Beck (2002), and Beck (2003))}. Consequently, I make the following assumption on the magnitude of fixed costs to ensure that all four organizational forms can exist in equilibrium:

**Assumption 1** $df^S_O > t f^l_E$. Since $df^S_O$ is the smallest, $df^l_k > t f^l_E$.

I assume this condition holds for the rest of the analysis. In addition, notice that $\theta^*_V > \theta^*_O$ because $f^l_V > f^l_O$. Figure 4 illustrates the productivity cut-offs between credit constrained and unconstrained final good producers.
To summarize, after observing its productivity level \( \theta \), a final good producer \( H \) chooses the ownership structure and the location of \( M \) that maximizes \( \pi_{Hk}^{l} \), or exits the industry and forfeits the fixed cost of entry \( w_{EF} \). \( \pi_{Hk}^{l}(\theta, X, \eta) \) is decreasing in \( w_{k}^{l} \) and \( f_{k}^{l} \). Looking at variable costs, producing intermediate inputs in the South is preferred to producing intermediates in the North regardless of ownership structure because \( w_{S}^{V} < w_{N}^{V} \). Looking at fixed costs, \( f_{V}^{S} > f_{O}^{S} > f_{V}^{N} > f_{O}^{N} \), ranking of profits is the reverse order of the fixed costs.

As shown in Antras and Helpman (2004), if final good producer \( H \) could freely choose \( \beta \), \( \frac{\partial \beta_{k}^{l}}{\partial \eta} > 0 \). This means the more intensive a sector is in headquarter services, the higher \( \beta_{k}^{l} \) \( H \) would prefer. Following Grossman and Hart (1986), \( \beta \) cannot be chosen freely, so the choice of \( \beta_{k}^{l} \) is constrained to the set \( \{ \beta_{V}^{N}, \beta_{V}^{S}, \beta_{O}^{N}, \beta_{O}^{S} \} \).

### 2.5 Organizational Forms

**2.5.1 Headquarter Intensive Sector**

First consider a sector with high headquarter intensity \( \eta \), such that profits are increasing in \( \beta_{k}^{l} \). In a headquarter intensive sector, the marginal product of headquarter services is high, making underinvestment in headquarter services more costly and integration more attractive. Because \( \psi_{V}^{l} > \psi_{O}^{l} \), \( \pi_{V}^{l} \) is steeper than \( \pi_{O}^{l} \) such that the slope of the profit function for vertical integration is greater than the slope for outsourcing within a country. However, the slope of \( \pi_{O}^{S} \) can be steeper than the slope of \( \pi_{V}^{S} \) when the variable costs in the South are very low, or flatter than the slope of \( \pi_{V}^{S} \) because integration gives higher the final good producer a larger fraction of the revenue. Figure 5 reflects the benchmark case when slope of \( \pi_{O}^{S} \) is steeper than the slope of \( \pi_{V}^{S} \). Unlike the case of the component intensive sector, all four forms of organization are now possible. The productivity cut-offs with credit constraints \( (\theta_{c}^{*}, \theta_{V,c}^{N}, \theta_{O,c}^{S}, \theta_{V,c}^{S}) \) and without credit constraints...
Proposition 1 For headquarter intensive sectors, firms tend to choose outsourcing in more financially developed country \( (\frac{\partial \theta_{SV,c}}{\partial \lambda_S} > 0, \frac{\partial \theta_{SO,c}}{\partial \lambda_S} < 0) \). This effect is more pronounced in financially dependent sectors \( (\frac{\partial \theta_{SV,c}}{\partial d} \frac{\partial \lambda_S}{\partial \lambda_N} > 0, \frac{\partial \theta_{SO,c}}{\partial d} \frac{\partial \lambda_S}{\partial \lambda_N} < 0, \frac{\partial \theta_{SV,c}}{\partial t} \frac{\partial \lambda_N}{\partial \lambda_N} < 0, \frac{\partial \theta_{SO,c}}{\partial t} \frac{\partial \lambda_N}{\partial \lambda_N} > 0, \frac{\partial \theta_{SV,c}}{\partial d} \frac{\partial \lambda_N}{\partial \lambda_S} < 0, \frac{\partial \theta_{SO,c}}{\partial d} \frac{\partial \lambda_N}{\partial \lambda_S} > 0, \frac{\partial \theta_{SV,c}}{\partial t} \frac{\partial \lambda_N}{\partial \lambda_S} > 0) \). In sectors with higher headquarter intensity, integration is favored relative to outsourcing \( (\frac{\partial \psi_{SV}^l(\eta)}{\partial \psi_{SO}^l(\eta)} > 0 \text{ for } l = N, S) \).

For an improvement in the financial development in the South \( (\lambda_S \uparrow) \), the most productive firms that were vertically integrated in the North now outsource in the South. The least productive firms firms that integrated in the South now switch to arm’s length transactions with suppliers in the South. Overall, the proportion of firms conducting sourcing with suppliers in the South relative to the North increases and revenue of firms that were both initially and currently sourcing from the South increase. In addition, the share of vertically integrated firms in the South relative to total firms firms sourcing from the south will decrease, as depicted in Figure 6. This effect is strongest in sectors that require more outside capital or possess fewer tangible assets.

For an increase in financial development in the North \( (\lambda_N \uparrow) \), the most productive firms that initially chose to exit now outsource in the North. The most productive firms that previously outsourced in the North will now vertically integrate and realize higher revenues. Firms that previously operated in the North continue to operate in the North and realize higher revenue. Increased financial development in the North lead to fewer firms conducting sourcing with suppliers in the South through two channels. First, the least productive firms that were outsourcing in the South now vertically integrate in the North. Second, the most productive firms that were outsourcing in the South now

\(^{18}\text{Figure 5 plots the productivity cut-offs without credit constraints. With credit constraints, productivity cut-offs are increased.}\)
vertically integrate in the South to take advantage of the improved financial depth in the North. Overall, increase in financial development in the North leads to higher share of vertically integrated firms in the South relative to total firms sourcing from the South.

The share of firms and trade that occur via vertical integration relative to at arm’s length (regardless of location), is increasing in the headquarters intensity of the industry \( \eta_j \). This result is also found in Antras (2003). Notice that any of the first three organizational forms (outsourcing in North, vertical integration in North, and outsourcing in South) may not exist in equilibrium but vertical integration with Southern suppliers always exists due to the absence of an upper bound on support of \( G(\theta) \). See Figure 6 for illustration. Organizational forms that survive in equilibrium have firms sorted according to the order in Figure 6 depending on their productivities.

### 2.5.2 Component Intensive Sector

Next, consider a sector with sufficiently low headquarter intensity \( \eta \) that \( H \) prefers outsourcing to integration in every country \( l \). This is because outsourcing has lower fixed costs and \( H \) prefers \( \beta^l_k \) to be as low as possible, or \( \beta^l_k = \beta^l_O = \beta \). \( H \) trades off between lower variable cost in the South against the lower organizational costs in the North. If wage differential is small relative to the fixed cost differential, \( w^N/w^S < (f^S_O/f^N_O)^{(1-\alpha)/\alpha(1-\eta)} \).

The top panel in Figure 7 depicts the choice of location of \( M \) depending on productivity level \( \theta \) without credit constraints. As in Antras and Helpman (2004), the cutoffs \( \theta^* \) and \( \theta^S_O \) are given by:

\[
\theta^* = X^{(\alpha-\kappa)/\alpha} \left[ \frac{w^N f^N_O^{\alpha}}{\psi^N_O(\eta)} \right]^{(1-\alpha)/\alpha},
\]

\[
\theta^S_O = X^{(\alpha-\kappa)/\alpha} \left[ \frac{w^N (f^N_O - f^N_S)}{\psi^S_O(\eta) - \psi^N_O(\eta)} \right]^{(1-\alpha)/\alpha}.
\]

As is clear from Figure 7, firms do not operate with productivity lower than \( \theta^* \) and can only outsource in the South if their productivity level is above \( \theta^S_O \). The bottom panel in
Figure 7 provides analogous cutoffs when there are credit constraints

\[ \theta^*_c = X^{(\alpha-\kappa)/\alpha} \left[ \frac{(1 - d + d/\lambda^N) w^N f_O^N - \frac{1-\lambda^N}{\lambda^N} t w^N f_E}{\psi_O^N(\eta)} \right]^{(1-\alpha)/\alpha}, \]

\[ \theta^S_{O,c} = X^{(\alpha-\kappa)/\alpha} \left[ \frac{(1 - d + d/\lambda^S) w^N f_O^S - \frac{1-\lambda^S}{\lambda^S} t w^N f_E - \left[ (1 - d + d/\lambda^N) w^N f_O^N - \frac{1-\lambda^N}{\lambda^N} t w^N f_E \right]}{\psi_O^S(\eta) - \psi_O^N(\eta)} \right]^{(1-\alpha)/\alpha}. \]

H firms with productivity lower \( \theta^*_c \) do operate. H outsources in the North when its productivity is between \( \theta^*_c \) and \( \theta^S_{O,c} \), and outsource in the South when its productivity is above \( \theta^S_{O,c} \). Proposition 2 provides comparative statics on these cut-offs.

**Proposition 2** In component intensive sectors, firms do not integrate. An increase in financial development in the South leads to more outsourcing in the South (\( \frac{\partial \theta^S_{O,c}}{\partial \lambda^S} < 0 \) and \( \frac{\partial \theta^*_c}{\partial \lambda^S} = 0 \)). An increase in financial development in the North leads to less outsourcing in the South (\( \frac{\partial \theta^S_{O,c}}{\partial \lambda^N} > 0 \) and \( \frac{\partial \theta^*_c}{\partial \lambda^N} < 0 \)). This effect is stronger in the sectors that require more outside capital (\( \frac{\partial \theta^S_{O,c}}{\partial d} < 0 \) and \( \frac{\partial \theta^*_c}{\partial d} = 0 \) for the South, \( \frac{\partial \theta^S_{O,c}}{\partial d} > 0 \) and \( \frac{\partial \theta^*_c}{\partial d} < 0 \) for the North) and less tangible assets (\( \frac{\partial \theta^S_{O,c}}{\partial t} > 0 \) and \( \frac{\partial \theta^*_c}{\partial t} = 0 \) for the South, \( \frac{\partial \theta^S_{O,c}}{\partial t} < 0 \) and \( \frac{\partial \theta^*_c}{\partial t} > 0 \) for the North).

An increase in financial development in the South (\( \lambda^S \uparrow \)) leads to a lower cut-off productivity \( \theta^S_{O,c} \) for outsourcing firms in the South as depicted in figure 8. The most productive firms initially outsourcing in the North now switch to outsourcing in the South to take the advantage of better financial institutions in the South. The profits of the firms already outsourcing in the South also increase. This is because with less financial frictions, a smaller repayment is required when the financial contract is enforced. This effect is stronger for sectors that require more outside capital (\( d \) higher) or possess fewer tangible assets (\( t \) lower) as firms in those sectors find it cheaper to outsource from suppliers located in the South with a more developed financial system.

An increase in the financial development in the North (\( \lambda^N \uparrow \)) leads to a lower cut-off
productivity $\theta^*_c$ for outsourcing firms in the North and a higher cut-off productivity $\theta^S_{O,c}$ for outsourcing firms in the South. The most productive firms that initially exited now find it profitable to outsource in the North. Firms that were initially outsourcing in the North now enjoy higher profits. The least productive firms that were outsourcing in the South now outsource in the North. By choosing to outsource in the North, the intermediate suppliers have smaller payments to investors ($F(I) \downarrow$) and possess higher profits than before. Overall, a higher proportion of operating firms choose to outsource in the North than the South relative to before the improvement in financial development. As with the case of increased financial development in the South, this effect is strongest in sectors that require more outside capital or possess fewer tangible assets.

Finally, regardless of headquarter intensity,

**Proposition 3** An increase in financial development in the South leads to higher firm revenues in the South regardless of whether sourcing is done through vertical integration or at arm’s length. This effect is strongest in sectors that require more outside capital or possess fewer tangible assets.

### 2.6 Empirical Analysis

The model presented above predicts that the share of intra-firm imports should be 0 for industries with headquarter intensity $\eta$ below a certain threshold. After grouping the share of intra-firm U.S. imports into SIC 4 digit category, there is 37% of the sample that contains 0 share of intra-firm trade. First, I consider the sectors with 0 intra-firm trade to be the component intensive sectors and the rest to be headquarter intensive sectors. I then test the three propositions outlined in the previous section. Later on, I will relax this assumption and consider different capital-labor ratio cut-offs to divide the data into component and headquarter intensive sectors.
Chapter 2. Global Sourcing and Credit Constraints

2.6.1 Headquarter Intensive Sector

Under Proposition 1, in headquarter-intensive sector, with higher headquarter intensity $\eta$, outsourcing in the North is favored relative to outsourcing in the South, and integration is favored relative to outsourcing regardless of location. The more financially developed the South is, the more prevalent outsourcing is in the South, i.e. the less vertical integration there is in the South. This effect is strengthened in sectors that require more external capital and have less tangible assets.

Since the dependent variable share of U.S. intra-firm imports is a variable between 0 and 1, the effect of any particular explanatory variable cannot be constant throughout the range of the explanatory variables. This problem can be overcome by augmenting a linear model with non-linear functions of the explanatory variable.\(^{19}\)

I report estimates from regression of the form:

\[
\ln \left( \frac{S^l_j}{(1 - S^l_j)} \right) = \beta_1 + \beta_2 \ln(K/L_j) + \beta_3 \text{FinDev}^l \ast \text{ExtFin}_j + \beta_4 \text{FinDev}^l \ast \text{Tang}_j + \beta_5 \text{FinDev}^l + \beta_6 X^l_j + \varepsilon^l_j
\]

where $S^l_j$ is the industry $j$’s share of U.S. intra-firm imports from country $l$, $K/L_j$ is the capital-labor ratio in industry $j$. I test the first hypothesis that $\beta_2 > 0$, $\beta_3 < 0$, $\beta_4 > 0$, and $\beta_5 < 0$. Log-odds transformation is applied to the share of intra-firm imports instead of using a linear regression for two reasons. First, the predicted values can be greater than one and less than zero under linear regression and such values are theoretically inadmissible. Second, the significance testing of the coefficients rest upon the assumption that errors are normally distributed which is not the case when the dependent variable is between zero and one.

\(^{19}\)This most common approach is to model the log-odds ratio of the dependent variable share of U.S. intra-firm imports as a linear function. This requires the dependent variable to be strictly between 0 and 1. Since in headquarter intensive sectors, integration from the South always exists in the absence of an upper bound on support of $G(\theta)$, the dependent variable is always bigger than 0. About 3% of the data is lost using this log-odds transformation approach from 100% of vertical integration in the South.
Next, under Proposition 3, there are more imports from the South the more financially developed the South is, and this effect is stronger in the financially dependent sectors. I run the regression of the following form:

$$\ln(M^l_j) = \zeta_1 + \zeta_2 \ln(K/L_j) + \zeta_3 \text{FinDev}^l \ast \text{ExtFin}_j + \zeta_4 \text{FinDev}^l \ast \text{Tang}_j + \zeta_5 \text{FinDev}^l + \zeta_6 X^l_j + \varepsilon^l_j$$ (2.16)

where $M^l_j$ is the total imports from country $l$ in sector $j$. The theory predicts that $\zeta_2 > 0$, $\zeta_3 > 0$, $\zeta_4 < 0$, and $\zeta_5 > 0$. The effect of financial development and its interaction with financial dependence on the total imports from the South should be stronger in the headquarter intensive sectors than in the component intensive sectors.

### 2.6.2 Component Intensive Sector

Under Proposition 2, there are more imports from the South the more financially developed the South is, and this effect is stronger in the financially dependent sectors. I report estimates from regression of the form:

$$\ln(M^l_j) = \delta_1 + \delta_2 \text{FinDev}^l \ast \text{ExtFin}_j + \delta_3 \text{FinDev}^l \ast \text{Tang}_j + \delta_4 \text{FinDev}^l + \delta_7 X^l_j + \varepsilon^l_j$$ (2.17)

where $M^l_j$ is the total US imports from country $l$ and sector $j$, $j \in$ component intensive sectors, or share of intra-firm trade is zero. I assume the terms in $d$, $\lambda$, and $t$ can be expressed as the observed measures of country level financial development $\text{FinDev}$, sectoral indicators of external finance dependence $\text{ExtFin}$ and asset tangibility $\text{Tang}$. $\text{FinDev}^l \ast \text{ExtFin}_j$ is the interaction of financial development in country $l$ and industry $j$’s external dependence on finance, $\text{FinDev}^l \ast \text{Tang}_j$ is the interaction of financial development in country $l$ and industry’s asset tangibility, and $X^l_j$ is a vector of controls. The theory predicts that $\delta_2 > 0$, $\delta_3 < 0$, $\delta_4 > 0$. 
2.7 Data

In this section I use data on intra-firm and total U.S. imports from 90 countries and 429 sectors over the 1996-2005 period. I have also confirmed my results in a cross section for each year. I evaluate the impact of credit constraints on the choice of organizational form and location of supplier by regressing intra-firm trade variables on the interaction of country level measure of financial development and industry level measure of dependence on external finance and asset tangibility.\textsuperscript{20}

2.7.1 Intra-firm and total U.S. imports data

A sector is defined as a 4-digit SIC industry. The share of intra-firm U.S. imports

\[ S_j^l = \frac{\text{Related}_{lj}}{\text{Total}_{lj}}, \]

where Related\textsubscript{lj} is the U.S. reported import value from country \( l \) in sector \( j \) that is from a related party, and Total\textsubscript{lj} is the total U.S. import from country \( l \) in sector \( j \).

2.7.2 Financial development data

The first measure of financial development I use is the ratio of credit banks and other financial intermediaries to the private sector as a share of GDP, which I obtain from Beck et al. (2000). Domestic credit has been used extensively in the finance and growth literature (Rajan and Zingales, 1998; Braun 2003; Aghion et al. 2004). Stock market capitalization and stock traded are also used for robustness checks, which I obtain from the IMF.

In additional robustness checks, I use measures of the accounting standards, the risk of expropriation, and the repudiation of contracts from Porta et al. (1998). Even though these indices are not direct measures of the probability that financial contracts will be

\textsuperscript{20}Firm-level data are not available. As a result, I cannot estimate firm productivities and interact them with external finance dependence and financial development.
enforced, they are good measures for the contracting environment in a country, which allies to financial contracting as well. These indices are available for a subset of countries and do not vary over time. Table 3, panel A summaries the cross sectional variation in these measures.

### 2.7.3 External dependence on finance data

Industry-level measures of external dependence on finance and asset tangibility are constructed based on data for all publicly traded U.S. based companies from Compustat’s annual industrial files based on usSIC 1987 classification. It is then converted to the SIC 4-digit industry classification system based on the concordance table provided by Jon Haveman. A firm’s external dependence on finance is defined as capital expenditures minus cash flow from operations divided by capital expenditures. An industry level’s measure of external dependence on finance is the median firm’s external dependance on finance in an industry, as proposed by Rajan and Zingales (1998). Asset tangibility is similarly defined as the share of net property, plant and equipment in total book-value assets for the median firm in a given industry. Both measures are constructed as averages for the 1996-2005 period, and appear very stable over time compared to indices for 1986-1995, 1980-1989, or 1966-1975 period.

### 2.8 Regression Results

#### 2.8.1 Headquarter Intensive Sector

*The Effect of Credit Constraints on the Multinationals’ Sourcing Decisions*

The capital to labor ratio is used to measure the headquarter intensity of a sector. Earlier papers on the role of capital labor ratios on the choice of organizational forms also have documented that the share of intra-firm imports is significantly higher, the
higher the capital intensity of the exporting industry \( j \) in country \( i \) (Antras (2003)). Table 4 column 1 re-establishes this basic pattern between 90 countries and 375 sectors in the period 1996-2005. Since capital labor ratio, external dependence on finance, and asset tangibility do not have a time dimension, sector dummies are not included for all subsequent analysis. Industry dummies at 3-digit classification level are included. The results for the interaction terms are similar if sector dummies are used instead of the measures on external finance and asset tangibility.

Column 2 is the regression results of equation (15) using the ratio of private credit to GDP for each country as a measure of financial development. The interaction of financial development and external finance dependence enters negatively into the equation and the interaction of financial development and asset tangibility enters positively into the equation as predicted by the theory. This implies that North chooses more outsourcing than integration in financially developed countries when the sectors are in need of more external finance and have less tangible assets. Column 3-7 are the same regression results but using different measures of financial development for robustness checks. Those include the ratio of stock capitalization to GDP, ratio of stock traded to GDP, accounting standards, risk of expropriation, and contract repudiation. One might argue that degree of a country’s financial development is an endogenous outcome of a country’s history, origin of law, or some other endowment factors. Column 8 provides the IV estimation result using the colonial origin of a country’s legal system as reported in Porta et al. (1998) to instrument for the private credit to GDP ratio.

Table 9 Column 2 examines the economic significance of the effects of credit constraints on the share of intra-firm trade in the headquarter intensive sectors. Each cell reports on the odds-ratio of the share of intra-firm trade to the share of outsourcing for one standard deviation increase in the measure of financial development of the exporting country in the sector at the 75th percentile of the distribution by external finance dependence and asset tangibility, respectively, relative to the sector at the 25th percentile.
The odds-ratio for the share of intra-firm trade to the share of outsourcing is 44% for one standard-deviation increase in the private credit to GDP ratio in the more financially dependent sectors (3rd quartile) than in the sectors are less financially dependent (1st quartile). With the odds-ratio less than 100%, this implies the share of intra-firm trade has decreased. More firms choose to outsource rather than vertically integrate when the foreign country is more financially developed in sectors that are more dependent on finance. The opposite is true for the interaction between financial development and asset tangibility. The odds-ratio is above 100% the interaction with asset tangibility. This indicates that more firms choose integration over outsourcing when the foreign country is more financially developed in sectors that have more tangible assets, and thus less dependent on finance. These results confirm the first part of Proposition 1: the North tends to choose more outsourcing instead of vertical integration when the South is more financially developed and the sector is more financially dependent.

Table 5 provides additional robustness checks by including additional measures of headquarter intensity and the interaction of headquarter intensity with financial development of a country to isolate the effect of financial development and its interaction with the financial dependence of a sector. Those include the U.S. industry research and development at 3 digit NAICS from NS R&D in industry in 2004, the Rauch Index\textsuperscript{21}, and Lall Index\textsuperscript{22}. By including additional measures of headquarter intensity and their interaction with a country’s financial development measure, the results provided are in Table 5 are not changed.

\textsuperscript{21}Rauch (1999) classified products traded on an organized exchange as homogeneous goods. Products not sold on exchanges but whose benchmark prices exist were classified as reference priced; all other products were deemed differentiated.

\textsuperscript{22}Lall (2000) classified products by technology at the 3-digit SITC level. Low technology products tend to have stable and slow-changing technologies. High technology products tend to have advanced and fast-changing technologies, normally associated with high R&D investments. Middle technology products lie somewhere in between.
The Effect of Credit Constraints on Total U.S. Imports

Column 1 in Table 6 re-establishes the positive relationship between the capital labor ratio and total U.S. imports as shown in Antras(2003). Under Proposition 3, there are more imports from the South the more financially developed the South is, and this effect is stronger in the financially dependent sectors. I test Proposition 3 by looking at the OLS regression results of equation (16). Column 2-8 in Table 6 provide the results using different measures of financial development. Those measures include private credit to GDP ratio, ratio of stock capitalization to GDP, ratio of stock traded to GDP, accounting standards, risk of expropriation, and contract repudiation. The last three measures are time invariant and therefore are not included by themselves in the regression due to multicollinearity with country dummies in the regression. Table 9 Column 3 examines the economic significance of the effects of credit constraints on the total U.S. imports in the headquarter intensive sectors. Each cell reports on how much bigger the effect of one standard deviation increase in the measure of financial development of the exporting country on the total U.S. imports in the sector at the 75th percentile of the distribution by external finance dependence and asset tangibility, respectively, relative to the sector at the 25th percentile. All results confirm the statement in Proposition 3 that the North imports more from the South when the South becomes more financially developed, and especially so in the financially dependent sector.

2.8.2 Component Intensive Sector

Next, I consider the sectors with zero intra-firm trade to be the component intensive sectors. I test proposition 2 by estimating equation (17) for the effect of financial development and its interaction with financial dependence in the component intensive sectors using OLS specification. Later on, I will relax this assumption and consider different $K/L$ cut-offs to divide the data into component and headquarter intensive sectors. Table
Chapter 2. Global Sourcing and Credit Constraints

7 provides the regression results. The sample is limited to sector and country pairs that have no intra-firm trade. The dependent variable is log of the total U.S. imports from a country sector pair. According to Proposition 2, in the component intensive sectors, increased financial development in the South leads to more outsourcing in the South and this effect is stronger in the financially dependent sector.

Table 7 presents empirical support for proposition 2. There is more U.S. imports from a country that is more financially developed when the sector is more dependent on outside finance and has less tangible assets. The effect of the financial development is not significant by itself; however, the sign works in the right direction. The second part of the Proposition 2 regarding the financial development of the North cannot be tested due to lack of domestic U.S. intra-firm trade data. Table 7 column 1 uses the ratio of the private credit to GDP as a measure of the financial development of a country. Subsequent columns use accounting standards, risk of expropriation, contract repudiation, and stock capitalization as different measures of the financial development as reported in Porta et al. (1998).23 Last column includes the IV estimation using the colonial origin of a country’s legal system instrument for financial development. This set of the results confirm the results presented in Manova (2006) and Manova (2008) regarding exporting and credit constraint24. In the last column I instrument for private credit with the country’s legal origin, both the interaction of financial development with external dependence on finance and asset tangibility are strongly significant, whereas in the previous columns only the interaction with asset tangibility is strongly significant.

Table 9 Column (1) examines the economic significance of the effects of credit constraints on the share of intra-firm trade in the component intensive sectors. Each cell.

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23Financial development measured using accounting standards, risk of expropriation, contract repudiation, and stock capitalization do not have a time dimension.

24Manova (2006) and Manova (2008) uses bilateral export data to test the effect of financial development and its interaction with financial dependence of a sector using Heckman’s selection to correct for the selection into exporting. Here the OLS and IV did not correct for selection into exporting and the data is limited to U.S. imports only.
reports on the effect of one standard deviation increase in the measure of financial development of the exporting country on its exports in the sector at the 75th percentile of the distribution by external finance dependence and asset tangibility, respectively, relative to the sector at the 25th percentile. The U.S. will increase its imports by 10% to 18% more from countries that experience an one standard deviation increase in their financial development in the sectors that have little tangible assets for collateral (1st quartile) than in the sectors that have a lot of tangible assets (3rd quartile). The U.S. will increase its imports by 34% more from countries that have one standard deviation growth in their financial development in the sectors that are very dependent on external finance (3rd quartile) than in the sectors that are not too dependent on external finance (1st quartile).

Establishing causality has typically been difficult in the trade literature. Reverse causality could arise when an increase in demand for sectors that are heavily dependent on external funds to lead to both higher outsourcing and higher borrowing from the outsourcing country, as measured by the private credit to GDP ratio. This mechanism could generate the result that firms increase their outsourcing from financially developed countries in more external capital dependent sectors. However, the significant effect of the interaction between private credit and asset tangibility does suggest a causal effect of credit constraints on outsourcing patterns. If capital markets were frictionless, the availability of collaterals would not affect a sector’s ability to raise outside capital. The increase in demand would not affect the private credit holding the financial dependence constant. The result that firms outsource less from the financially developed countries in sectors with more tangible assets is thus strong evidence of presence of credit constraints. Finally, using time-invariant measures of contract repudiation, accounting standards and the risk of expropriation further helps with establishing causality as these variables do not respond to variation in demand as the way private credit might.\footnote{Prior researchers have instrumented for private credit with legal origin to establish causality. The}
Difference in Difference Method

One of the biggest concerns of estimating the effect of financial development is determining causality. Countries that have higher export volumes have higher GDP levels, which in turn could affect the financial institutions in those countries. In addition to implementing the IV estimator using the colonial origin of a country’s legal system, here I take the advantage of an exogenous event taking place that directly affects a country’s financial development. In the year 1997, the Asian financial crisis was a period of financial crisis that gripped much of Asia and raised fears of a worldwide economic meltdown due to financial contagion, where small shocks which initially affect only a particular region of an economy, spread to the rest of financial sectors and other countries whose economies were previously healthy. The crisis started in Thailand with the financial collapse of the Thai baht caused by the decision of the Thai government to float the exchange rate for baht. Thailand became effectively bankrupt and as the crisis spread, most of Southeast Asia and Japan saw a devalued stock market. International investors were reluctant to lend to developing countries, leading to economic slowdowns in developing countries in many parts of the world. By 1999, the economies of Asia were beginning to recover. I implement the difference in difference methods before and after the Asian financial crisis to avoid reverse causality. During the Asian financial crisis, the financial development measures for each country falls. Table 8 shows the estimates for the interaction between financial development and external finance dependence using the 3 years before the Asian financial crisis and the 3 years after (the dependent variable is \((S_{j1999} - S_{j1997}) - (S_{j1996} - S_{j1994})\)). Here, I took the difference between share of intra-firm trade instead of the difference between the logs because it is easier to in-

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interaction between external finance dependence and asset tangibility are strongly significant. However, it has been argued that legal origin may impact institution formation and the economy more broadly, which in turn are likely to affect trade through channels other than its effect on the financial development. For robustness checks, I use difference in difference methods around the Asian financial crisis as an exogenous source of variation in financial development.
interpret the difference in shares instead of the difference in logs. Using the difference in
difference method, financial contractibility in that country decreases the market share of
vertically integrated firms in that country and this effect is again more pronounced in
the financially dependent sectors.

The bottom panel in Table 9 shows the effect of countries’ financial development and
sectors’ financial dependence on firms’ sourcing decisions. During the Asian financial
crisis, the share of intra-firm trade increased by 29% in sectors that are heavily dependent
on external finance (3rd quartile) than in sectors that are less dependent on external
finance (1st quartile).

Component vs. Headquarter Intensive Sectors

As an additional robustness check, I consider different $K/L$ cut-offs to divide the data
into component and headquarter intensive sectors. Column 1 in Table 10 provides the
regression results for equation (17) under different $K/L$ cut-offs. Column 2 and 3 provide
the regression results for equation (15) and (16), respectively, under those $K/L$ cut-offs.
Table 10 confirms my previous results. In addition, the magnitude of the interaction
effect between a country’s financial development and the sector’s financial dependence
are increasing as I increase the $K/L$ cut-offs for the headquarter intensive sectors. Propo-
sition 1 states that integration is favored relative to outsourcing in sectors with higher
headquarter intensity. If $K/L$ ratio is an accurate measure of headquarter intensity, the
reduction in the share of integration in the financially dependent sectors should be greater
when the country improved its financial development, as Column 2 in Table 10 suggests.

2.9 Conclusion

In this paper I have extended the global sourcing model of Antras and Helpman (2004)
to incorporate the role of credit constraints. In the model, a continuum of firms with
heterogeneous productivities decide whether to integrate or outsource the intermediate inputs and in which countries to source the inputs. By choosing an organizational structure, the firm (final good producer or intermediate supplier depending on the choice of organizational structure) faces a fixed cost, part of which cannot be financed internally and needs to raise outside capital to finance it. When the financial contract is enforced, the firms needs to make a payment to the investor; when the financial contract is not enforced, the investors claim the collaterals of the firms. By competing for investors’ capital, some firms that could operate without credit constraint are now forced to exit the market with credit constraint because they cannot make enough repayment to the investors when the financial contract is enforced. The productivity cut-off level is raised for all forms of organization under credit constraint.

This model generates equilibria in which firms with different productivity levels choose different ownership structure and suppliers location. In the model, credit constraints affect firms in different countries and sectors differently. Final-good producers in some sectors find it easier to operate because they need to raise less outside finance and have more tangible assets. Credit constraints vary across countries because contracts between firms and investors are more likely to be enforced at higher levels of financial development. In particular, I study the effect of improvements in financial contractibility on relative prevalence of these organizational forms. I have shown that an improvement in financial contractibility in the South decreases the market share of vertically integrated final-good producers, this effect is more pronounced in the financially dependent sector, i.e. the interaction of financial development and external dependence on finance has a negative effect on the market share of vertically integrated firms, and the interaction of financial development and asset tangibility has a positive effect on the market share of vertically integrate firms.
Figure 1. U.S. Intra-Firm Imports and External Financial Dependence

This graph shows the relationship between the share of U.S. intra-firm imports in sector j and the sector’s external dependence on finance. The share of U.S. intra-firm imports in sector j is defined as sum of all party-related U.S. imports in sector j divided by the sum of all U.S. imports in sector j. A firm’s external dependence on finance is defined as capital expenditures minus cash flow from operations divided by capital expenditures. A sector’s external dependence on finance is defined as the median firm’s external dependence on finance in that sector. All data is for year 2000.
Figure 2. U.S. Intra-Firm Imports and Asset Tangibility

This graph shows the relationship between the share of U.S. intra-firm imports in sector j and the sector’s asset tangibility. The share of U.S. intra-firm imports in sector j is defined as sum of all party-related U.S. imports in sector j divided by the sum of all U.S. imports in sector j. A sector’s asset tangibility is defined as the median firm’s share of net property, plant and equipment in total book-value assets. All data is for year 2000.
Figure 3. Average Financial Vulnerability of Intra-firm Trade

This figure shows the average financial vulnerability of share of intra-firm trade overtime for 12 countries that have improved their financial development by the measurement of private credit to GDP ratio by at least 20% of their 1996 level. For each year the average intensity of intra-firm trade with respect to external finance dependence (Avg Fin Dep of S) is calculated as \( \sum_j \text{FinDep}_j \times \text{Intra}_{j,t}^l \), where \( \text{Intra}_{j,t}^l \) is the share of U.S. intra-firm imports in sector \( j \) from country \( l \) in time \( t \). The average intensity of intra-firm trade with respect to asset tangibility (Avg Tang of S) is similarly constructed. Each country graph plots Avg Fin Dep of S (Avg Tang of S) on the left (right) vertical axis. Each graph’s title indicates the difference between the log private credit in 1996 and 2004. The graphs are sorted by the degree of change in the financial development of a country.
Figure 4. Productivity Cut-off with and without Credit Constraints

This graph plots the profit as a function of productivity and shows the wedge between the productivity cut-offs for operating with and without credit constraints in the financing of the fixed costs.
Figure 5. Productivity Cut-offs in Headquarter Intensive Sector without Credit Constraints

This graph plots the profit as a function of productivity in the Headquarter Intensive Sector and shows the productivity cut-offs for outsourcing in the North, vertical integration in the North, outsourcing in the South, and vertical integration in the South without credit constraints in the financing of the fixed costs.
This graph shows that different subsets of firm organizational firms may exist in the equilibrium; however, vertical integration in the South will always exist due to lack of the upper bound on the productivity. The arrows show how the productivity cut-offs will change for a financial improvement in the South.
Figure 7. Productivity Cut-off with and without Credit Constraints in Component Intensive Sector

This graph plots the profit as a function of productivity in the Component Intensive Sector and shows the wedge between the productivity cut-offs for outsourcing in the North and South with and without credit constraints in the financing of the fixed costs.
Figure 8. Financial Improvement in the South

This graph shows the change in the productivity cut-offs for outsourcing in the North and the South with credit constraints in the financing of the fixed costs when the South becomes more financially developed.
Table 1. Summary Statistics

This table summarizes the variation in the U.S. intra-firm imports from 90 countries and 429 4-digit SIC sectors in the period 1996-2005.

<table>
<thead>
<tr>
<th>Panel A. Trading Partners</th>
<th>N of Partners</th>
<th>Sample</th>
<th>Avg Share of Party-related Trade</th>
<th>Standard Deviation</th>
<th>Avg Number of Trade Partners</th>
<th>Standard Deviation</th>
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<td>0.32</td>
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</table>

<table>
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<tr>
<th>Panel B. Vertical Integration v. Outsourcing</th>
<th>Share of Positive Trade</th>
<th>KL</th>
<th>Standard Deviation</th>
<th>Weighted KL</th>
<th>Standard Deviation</th>
<th>Trade Volume (logs)</th>
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<td>0.92</td>
<td>5.01</td>
<td>1.10</td>
<td>10.49</td>
</tr>
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</table>
Table 2. Measurements of Financial Development

This table summarizes the variation a country’s financial development variation over the timer period 1996–2005. The financial development is defined as the ratio of private credit to GDP.

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<th>ISO</th>
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<th>St Dev</th>
<th>ISO</th>
<th>Mean</th>
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<th>ISO</th>
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<td>0.03</td>
<td>AGO</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>EGY</td>
<td>0.46</td>
<td>0.07</td>
<td>SEN</td>
<td>0.17</td>
<td>0.02</td>
<td>SLE</td>
<td>0.02</td>
<td>0.01</td>
</tr>
</tbody>
</table>
### Table 3. Measurements of Financial Development and Financial Vulnerability

Panel A provides the summary statistics for other financial development measures: risk of expropriation, risk of contract repudiation, accounting standard, and whether a country is of English origin. On a scale from 1 to 10, a higher score implies less risk of expropriation and contract repudiation. A higher score on accounting standard also implies better financial development. Panel B provides the summary statistics for a sector's external dependence on finance and asset tangibility.

<table>
<thead>
<tr>
<th>Panel A. Measures of Financial Development</th>
<th>Sample</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk of Expropriation</td>
<td>41</td>
<td>7.83</td>
<td>1.53</td>
</tr>
<tr>
<td>Risk of Contract Repudiation</td>
<td>41</td>
<td>7.34</td>
<td>1.74</td>
</tr>
<tr>
<td>Accounting Standards</td>
<td>34</td>
<td>60</td>
<td>14</td>
</tr>
<tr>
<td>English Origin</td>
<td>41</td>
<td>0.39</td>
<td>0.49</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B. Measures of Financial Vulnerability</th>
<th>Sample</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Finance</td>
<td>172225</td>
<td>-1.25</td>
<td>2.04</td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>172225</td>
<td>0.74</td>
<td>0.73</td>
</tr>
</tbody>
</table>
Table 4. Financial Development and Sourcing Decisions

This table examines the effect of credit constraints on the choice of organizational forms. The dependent variable is \( \log \left[ \frac{S_{jt}}{1-S_{jt}} \right] \), where \( S_{jt} \) is the share of intra-firm U.S. imports in a 4-digit SIC sector \( j \) from country \( l \) in year \( t \). There are 375 4-digit sectors, 122 3-digit industries, and the data spans from year 1996 to 2005. Financial development is measured by private credit. External finance dependence \( \text{Ext fin dep} \) and asset tangibility \( \text{Tang} \) are defined in the text. Log of capital to labor ratio is \( K/L \) in the table. IV estimation uses whether the exporting country is of English origin as the instrument. ***, ** and * indicate significance at 1%, 5% and 10% level.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Log R/(1-R)</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Development</td>
<td>-0.20</td>
<td>(0.07) ***</td>
<td>-0.06</td>
<td>(0.06) ***</td>
<td>-0.09</td>
<td>(0.04) ***</td>
<td>1.32</td>
<td>1.32</td>
<td>2.00</td>
</tr>
<tr>
<td>Financial Development x External Finance</td>
<td>0.05</td>
<td>0.05</td>
<td>0.10</td>
<td>0.13</td>
<td>0.03</td>
<td>0.13</td>
<td>0.03</td>
<td>0.15</td>
<td>2.00</td>
</tr>
<tr>
<td>Financial Development x Asset Tangibility</td>
<td>-0.40</td>
<td>-0.40</td>
<td>(0.15) ***</td>
<td>-0.02</td>
<td>(0.12) ***</td>
<td>-0.15</td>
<td>(0.07) ***</td>
<td>-0.13</td>
<td>-0.13</td>
</tr>
<tr>
<td>K/L</td>
<td>0.14</td>
<td>0.14</td>
<td>0.17</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
<td>0.19</td>
<td>0.19</td>
<td>0.20</td>
</tr>
<tr>
<td>External Finance Dependence</td>
<td>0.68</td>
<td>0.68</td>
<td>0.84</td>
<td>1.46</td>
<td>0.77</td>
<td>1.46</td>
<td>2.28</td>
<td>2.40</td>
<td>1.53</td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>-0.71</td>
<td>-0.71</td>
<td>-0.68</td>
<td>-1.58</td>
<td>-0.71</td>
<td>-1.58</td>
<td>-1.84</td>
<td>-2.05</td>
<td>-2.15</td>
</tr>
<tr>
<td>Country Dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry Dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year Dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>28,195</td>
<td>28,195</td>
<td>26,971</td>
<td>26,843</td>
<td>20,488</td>
<td>22,172</td>
<td>22,172</td>
<td>22,172</td>
<td>22,172</td>
</tr>
</tbody>
</table>
This table examines the robustness of the effect of credit constraints on the choice of organizational forms. The dependent variable is $\log \left( \frac{S_{jt}}{(1-S_{jt})} \right)$, where $S_{jt}$ is the share of intra-firm U.S. imports in a 4-digit SIC sector $j$ from country $l$ in year $t$. There are 375 4-digit sectors, 122 3-digit industries, and the data spans from year 1996 to 2005. Financial development is measured by private credit. External finance dependence Ext fi dep and asset tangibility Tang are defined in the text. Log of capital to labor ratio is K/L in the table. R & D is log R&D from U.S.; Lall index is equal to one for high- and medium-tech products, zero for low-tech products (Lall, 2000); and Rauch Index is equal to one if it’s traded on integrated market or referenced priced (Rauch, 1999), see detail discussion in text. ***, ** and * indicate significance at 1%, 5% and 10% level.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Log R/(1-R)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>Financial Development</td>
<td>-0.18</td>
</tr>
<tr>
<td>x External Finance</td>
<td>-0.07</td>
</tr>
<tr>
<td>Financial Development</td>
<td>-0.11</td>
</tr>
<tr>
<td>x Asset Tang</td>
<td>-0.06</td>
</tr>
<tr>
<td>Financial Development x R &amp; D</td>
<td>0.05</td>
</tr>
<tr>
<td>x Lall Index</td>
<td>0.12</td>
</tr>
<tr>
<td>Financial Development x Rauch Index</td>
<td>0.15</td>
</tr>
<tr>
<td>R &amp; D</td>
<td>0.11</td>
</tr>
<tr>
<td>Lall Index</td>
<td>0.15</td>
</tr>
<tr>
<td>Rauch Index</td>
<td>0.15</td>
</tr>
<tr>
<td>K/L</td>
<td>0.06</td>
</tr>
<tr>
<td>External Finance</td>
<td>0.09</td>
</tr>
<tr>
<td>Dependence</td>
<td>0.86</td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>0.29</td>
</tr>
<tr>
<td>Country Dummies</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry Dummies</td>
<td>Yes</td>
</tr>
<tr>
<td>Year Dummies</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>28,183</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>.13</td>
</tr>
</tbody>
</table>
Table 6. Financial Development and Total U.S. Imports in Headquarter Intensive Sectors

This table examines the effect of credit constraints on the total U.S. imports. The dependent variable is log $M_{jt}^l$, where $M_{jt}^l$ is the total U.S. imports in a 4-digit SIC sector $j$ from country $l$ in year $t$. There are 375 4-digit sectors, 122 3-digit industries, and the data spans from year 1996 to 2005. Financial development is measured by private credit. External finance dependence Ext fin dep and asset tangibility Tang are defined in the text. Log of capital to labor ratio is $K/L$ in the table. IV estimation uses whether the exporting country is of English origin as the instrument. ***, ** and * indicate significance at 1%, 5% and 10% level.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Log Total U.S. Imports</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>PC/GDP</td>
</tr>
<tr>
<td>Financial Development</td>
<td>0.31 ***</td>
</tr>
<tr>
<td>x External Finance</td>
<td>(0.08) ***</td>
</tr>
<tr>
<td>Financial Development</td>
<td>(0.14) ***</td>
</tr>
<tr>
<td>x Asset Tangibility</td>
<td>(0.05) ***</td>
</tr>
<tr>
<td>Financial Development</td>
<td>(0.02) ***</td>
</tr>
<tr>
<td>K/L</td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td>(0.02) ***</td>
</tr>
<tr>
<td>External Finance</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>(0.02) ***</td>
</tr>
<tr>
<td>Dependence</td>
<td>(0.11) ***</td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>-1.62</td>
</tr>
<tr>
<td></td>
<td>(0.08) ***</td>
</tr>
<tr>
<td>Country Dummies</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry Dummies</td>
<td>Yes</td>
</tr>
<tr>
<td>Year Dummies</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>29,612</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>.39</td>
</tr>
</tbody>
</table>

Dependent Variable

<table>
<thead>
<tr>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock Cap</td>
<td>0.14</td>
<td>0.12</td>
<td>3.52</td>
<td>0.32</td>
<td>0.30</td>
<td>0.73</td>
</tr>
<tr>
<td>Stock Traded</td>
<td>(0.07) ***</td>
<td>(0.04) ***</td>
<td>(0.67) ***</td>
<td>(0.05) ***</td>
<td>(0.05) ***</td>
<td>(0.12) ***</td>
</tr>
<tr>
<td>Accounting</td>
<td>-0.82</td>
<td>-0.56</td>
<td>-7.26</td>
<td>-0.62</td>
<td>-0.61</td>
<td>-1.19</td>
</tr>
<tr>
<td>Contract</td>
<td>(0.05) ***</td>
<td>(0.02) ***</td>
<td>(0.44) ***</td>
<td>(0.03) ***</td>
<td>(0.04) ***</td>
<td>(0.09) ***</td>
</tr>
<tr>
<td>Expropriation</td>
<td>0.02</td>
<td>0.06</td>
<td>0.02</td>
<td>(0.16)</td>
<td>(0.14)</td>
<td>(0.08) ***</td>
</tr>
<tr>
<td>IV Estimation</td>
<td>0.28</td>
<td>0.28</td>
<td>0.29</td>
<td>0.31</td>
<td>0.31</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td>(0.02) ***</td>
<td>(0.02) ***</td>
<td>(0.02) ***</td>
<td>(0.02) ***</td>
<td>(0.02) ***</td>
<td>(0.02) ***</td>
</tr>
<tr>
<td></td>
<td>0.58</td>
<td>0.62</td>
<td>-1.81</td>
<td>-2.19</td>
<td>-2.19</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td>(0.07) ***</td>
<td>(0.08) ***</td>
<td>(0.44) ***</td>
<td>(0.40) ***</td>
<td>(0.48) ***</td>
<td>(0.14) ***</td>
</tr>
<tr>
<td></td>
<td>-0.43</td>
<td>-0.71</td>
<td>4.75</td>
<td>5.16</td>
<td>5.37</td>
<td>-1.66</td>
</tr>
<tr>
<td></td>
<td>(0.06) ***</td>
<td>(0.06) ***</td>
<td>(0.29) ***</td>
<td>(0.28) ***</td>
<td>(0.33) ***</td>
<td>(0.12) ***</td>
</tr>
</tbody>
</table>

Adjusted R-squared
| 0.39 | 0.40 | 0.36 | 0.39 | 0.037 | 0.30 | 0.32 | 0.33 |
Table 7. Financial Development and Total U.S. Imports in Component Intensive Sectors

This table examines the effect of credit constraints on the total U.S. imports. The dependent variable is log $M_{jl}^t$, where $M_{jl}^t$ is the total U.S. imports in a 4-digit SIC sector $j$ from country $l$ in year $t$. There are 54 4-digit sectors, 7 3-digit industries, and the data spans from year 1996 to 2005. Financial development is measured by private credit. External finance dependence Ext fin dep and asset tangibility Tang are defined in the text. Log of capital to labor ratio is $K/L$ in the table. IV estimation uses whether the exporting country is of English origin as the instrument. ***, ** and * indicate significance at 1%, 5% and 10% level.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Log U.S. Imports</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>Financial Development x Private Credit/GDP</td>
<td>0.06</td>
</tr>
<tr>
<td>Financial Development x Accounting Standards</td>
<td>(0.06)</td>
</tr>
<tr>
<td>Financial Development x Risk of Expropriation</td>
<td>-0.27</td>
</tr>
<tr>
<td>Financial Development x Contract Repudiation</td>
<td>(0.04) ***</td>
</tr>
<tr>
<td>Financial Development x Stock Capitalization</td>
<td>0.12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>IV Estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Development x Private Credit/GDP</td>
<td></td>
</tr>
<tr>
<td>Financial Development x Accounting Standards</td>
<td></td>
</tr>
<tr>
<td>Financial Development x Risk of Expropriation</td>
<td></td>
</tr>
<tr>
<td>Financial Development x Contract Repudiation</td>
<td></td>
</tr>
<tr>
<td>Financial Development x Stock Capitalization</td>
<td></td>
</tr>
<tr>
<td>Country Dummies</td>
<td>Yes</td>
</tr>
<tr>
<td>Product Dummies</td>
<td>Yes</td>
</tr>
<tr>
<td>Year Dummies</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>16,099</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>.28</td>
</tr>
</tbody>
</table>
Table 8. Difference in Difference for Financial Development and Sourcing Decisions

This table examines the effect of credit constraints on the total U.S. imports using difference in difference method. The dependent variable is \((S_{j1999} - S_{j1997}) - (S_{j1996} - S_{j1994})\), where \(R_{jt}\) is the share of intra-firm U.S. imports in a 4-digit SIC sector \(j\) from country \(l\) in year \(t\). There are 375 4-digit sectors, 122 3-digit industries. Because the data for the year 1995 are not available, the data used in all previous tables only begin from 1996. However, the data are available for 1994. Difference in difference method is applied here to look at the effect of an exogenous event on multinational firms’ export behaviors, namely the Asian financial crisis in the year 1997. Financial development is measured by private credit. External finance dependence Ext fin dep and asset tangibility Tang are defined in the text. Log of capital to labor ratio is \(K/L\) in the table. IV estimation uses whether the exporting country is of English origin as the instrument. ***, ** and * indicate significance at 1%, 5% and 10% level.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Difference in Difference of Share of Intra-firm Trade</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PC/GDP</td>
<td>Stock Cap</td>
</tr>
<tr>
<td>Financial Development x</td>
<td>-0.07</td>
<td>-0.07</td>
<td>-0.02</td>
</tr>
<tr>
<td>External Finance</td>
<td>(0.03) ***</td>
<td>(0.03) **</td>
<td>(0.01) ***</td>
</tr>
<tr>
<td>Financial Development x</td>
<td>0.06</td>
<td>0.05</td>
<td>0.00</td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>(0.04)</td>
<td>(0.04)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Financial Development</td>
<td>-0.24</td>
<td>-0.05</td>
<td></td>
</tr>
<tr>
<td>K/L</td>
<td>(0.10) **</td>
<td>(0.03) *</td>
<td></td>
</tr>
<tr>
<td>External Finance</td>
<td>0.07</td>
<td>0.08</td>
<td>0.07</td>
</tr>
<tr>
<td>Dependence</td>
<td>(0.02) ***</td>
<td>(0.02) ***</td>
<td>(0.02) ***</td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Industry Dummies</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td></td>
</tr>
<tr>
<td>Number of Observations</td>
<td>5,087</td>
<td>5,087</td>
<td>4,657</td>
</tr>
<tr>
<td>R-squared</td>
<td>.0053</td>
<td>.0792</td>
<td>.0063</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>.0041</td>
<td>.0338</td>
<td>.0050</td>
</tr>
</tbody>
</table>
**Table 9. Economic Significance**

This table examines the economic significance of the effects of credit constraints on the share of intra-firm trade in the component intensive sectors. Each column reports the effect of one standard deviation increase in the measure of financial development of the exporting country in the sector at the 75th percentile of the distribution by external finance dependence and asset tangibility, respectively, relative to the sector at the 25th percentile. Insignificant results are not reported.

<table>
<thead>
<tr>
<th>One Standard Deviation Increase in the Financial Development</th>
<th>Component Intensive Sectors</th>
<th>Headquarter Intensive Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total U.S. Imports</td>
<td>Share of Intra-firm Trade (odds ratio)</td>
</tr>
<tr>
<td>Private Credit</td>
<td>Total U.S. Imports</td>
<td>Share of Intra-firm Trade (odds ratio)</td>
</tr>
<tr>
<td>External Finance Dependence</td>
<td>44%</td>
<td>22%</td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>-11%</td>
<td>-57%</td>
</tr>
<tr>
<td>Accounting Standards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External Finance Dependence</td>
<td>58%</td>
<td>33%</td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>-10%</td>
<td>205%</td>
</tr>
<tr>
<td>Risk of Expropriation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External Finance Dependence</td>
<td>33%</td>
<td>32%</td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>-12%</td>
<td>250%</td>
</tr>
<tr>
<td>Contract Repudiation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External Finance Dependence</td>
<td>30%</td>
<td>38%</td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>-11%</td>
<td>247%</td>
</tr>
<tr>
<td>Stock Capitalization</td>
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<td></td>
</tr>
<tr>
<td>External Finance Dependence</td>
<td>13%</td>
<td></td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>-14%</td>
<td>170%</td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td></td>
</tr>
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<td>External Finance Dependence</td>
<td>34%</td>
<td>27%</td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>-18%</td>
<td>360%</td>
</tr>
<tr>
<td>Difference in Difference</td>
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<td></td>
</tr>
<tr>
<td>External Finance Dependence</td>
<td>-</td>
<td>29%</td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Share of Intra-firm Trade</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 10. K/L Cut-offs for Component and Headquarter Intensive Sectors

This table provides the regressions results for equation (5.1) (5.2) and (5.3) using prive credit to GDP ratio as the financial development measure under different K/L cut-offs for Component and Headquarter Intensive Sectors. Column (1) reports the results in Table 4 (1) using different K/L cut-offs. Column (2) reports Table 5 (2) using different K/L cut-offs. Column (3) reports Table 7 (2) using different K/L cut-offs.

<table>
<thead>
<tr>
<th></th>
<th>Component Intensive Sectors</th>
<th>Headquarter Intensive Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>K/L bottom 10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private Credit x</td>
<td>0.07</td>
<td>-0.05</td>
</tr>
<tr>
<td>External Finance</td>
<td>(0.04)</td>
<td>(0.02) ***</td>
</tr>
<tr>
<td>Private Credit x</td>
<td>-0.07</td>
<td>0.20</td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>(0.06)</td>
<td>(0.03) ***</td>
</tr>
<tr>
<td>Financial Development</td>
<td>0.01</td>
<td>-0.19</td>
</tr>
<tr>
<td></td>
<td>(0.24)</td>
<td>(0.08) ***</td>
</tr>
<tr>
<td>K/L top 90%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private Credit x</td>
<td>0.12</td>
<td>-0.15</td>
</tr>
<tr>
<td>External Finance</td>
<td>(0.03) ***</td>
<td>(0.02) ***</td>
</tr>
<tr>
<td>Private Credit x</td>
<td>-0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>(0.05) ***</td>
<td>(0.03) ***</td>
</tr>
<tr>
<td>Financial Development</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>(0.15)</td>
<td>(.08)</td>
</tr>
<tr>
<td>K/L bottom 25%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private Credit x</td>
<td>0.04</td>
<td>-0.20</td>
</tr>
<tr>
<td>External Finance</td>
<td>(0.02) ***</td>
<td>(.02) ***</td>
</tr>
<tr>
<td>Private Credit x</td>
<td>-0.20</td>
<td>0.25</td>
</tr>
<tr>
<td>Asset Tangibility</td>
<td>(.02) ***</td>
<td>(.05) ***</td>
</tr>
<tr>
<td>Financial Development</td>
<td>0.19</td>
<td>-0.28</td>
</tr>
<tr>
<td></td>
<td>(0.10) **</td>
<td>(0.11) ***</td>
</tr>
</tbody>
</table>
Appendix

Cut-off Productivities for Headquarter Intensive Sectors

As in Antras and Helpman (2004), the cutoffs without credit contraint are given by:

\[ \theta^* = X^{(\alpha - \kappa) / \alpha} \left[ \frac{w^N f_O^N}{\psi_O^N(\eta)} \right]^{(1-\alpha) / \alpha}, \]

\[ \theta^N_V = X^{(\alpha - \kappa) / \alpha} \left[ \frac{w^N (f_V^N - f_O^N)}{\psi_V^N(\eta) - \psi_O^N(\eta)} \right]^{(1-\alpha) / \alpha}, \]

\[ \theta^S_O = X^{(\alpha - \kappa) / \alpha} \left[ \frac{w^N (f_O^S - f_O^N)}{\psi_O^S(\eta) - \psi_O^N(\eta)} \right]^{(1-\alpha) / \alpha}, \]

\[ \theta^S_V = X^{(\alpha - \kappa) / \alpha} \left[ \frac{w^N (f_V^S - f_O^S)}{\psi_V^S(\eta) - \psi_V^N(\eta)} \right]^{(1-\alpha) / \alpha}. \]

With credit constraints, the new cutoffs are given by equation (3.13):

\[ \theta^*_c = X^{(\alpha - \kappa) / \alpha} \left[ \frac{1 - d + d / \lambda^N w^N f_O^N - \frac{1 - \lambda^N}{\lambda^N} tw^N f_E}{\psi_O^N(\eta)} \right]^{(1-\alpha) / \alpha}, \]

\[ \theta^N_{V,c} = X^{(\alpha - \kappa) / \alpha} \left[ \frac{(1 - d + d / \lambda^N) w^N (f_V^N - f_O^N)}{\psi_V^N(\eta) - \psi_O^N(\eta)} \right]^{(1-\alpha) / \alpha}, \]

\[ \theta^S_{O,c} = X^{(\alpha - \kappa) / \alpha} \left[ \frac{1 - d + d / \lambda^S w^N f_O^S - \frac{1 - \lambda^S}{\lambda^S} tw^N f_E}{\psi_O^S(\eta) - \psi_V^S(\eta)} \right]^{(1-\alpha) / \alpha}, \]

\[ \theta^S_{V,c} = X^{(\alpha - \kappa) / \alpha} \left[ \frac{(1 - d + d / \lambda^S) w^N f_V^S - \frac{1 - \lambda^S}{\lambda^S} tw^N f_E}{\psi_V^S(\eta) - \psi_O^S(\eta)} \right]^{(1-\alpha) / \alpha}. \]
Proof of Proposition 1

In component intensive sectors, firms do not integrate. An increase in financial development in the South leads to more outsourcing in the South \( \left( \frac{\partial \theta^S_{O,c}}{\partial \lambda^N} < 0 \right) \) and less tangible assets \( \left( \frac{\partial \theta^S_{O,c}}{\partial t} < 0 \right) \) for the South, \( \left( \frac{\partial \theta^S_{O,c}}{\partial \lambda^S} > 0 \right) \) and more outside capital \( \left( \frac{\partial \theta^S_{O,c}}{\partial d} > 0 \right) \) for the North.

An increase in financial development in the North leads to less outsourcing in the South \( \left( \frac{\partial \theta^S_{O,c}}{\partial \lambda^N} > 0 \right) \) and more tangible assets \( \left( \frac{\partial \theta^S_{O,c}}{\partial t} > 0 \right) \) for the North.

Since \( X \) and \( \psi^l_k(\eta) \) is not a function of \( \lambda, d, \) and \( t \), the productivity cut-off increases if the partial derivative sign is positive, and decreases if it is negative:

\[
\frac{\partial \theta^*_{c}}{\partial \lambda^N} \propto \left( \frac{t f_E - d f^N_O}{\lambda^N} \right) w^N / \psi^N_O < 0, \quad \frac{\partial \theta^*_{c}}{\partial \lambda^S} = 0
\]

\[
\frac{\partial \theta^S_{O,c}}{\partial \lambda^N} \propto - \frac{\partial \theta^*_{c}}{\partial \lambda^N} > 0, \quad \frac{\partial \theta^S_{O,c}}{\partial \lambda^S} \propto \left( \frac{t f_E - d f^S_O}{\lambda^S} \right) w^N / (\psi^S_O(\eta) - \psi^N_O(\eta)) < 0.
\]

\[
\frac{\partial \theta^*_{c}}{\partial t} \propto \frac{1}{\lambda^N} w^N f^N_O / \psi^N_O < 0, \quad \frac{\partial \theta^*_{c}}{\partial d} = 0
\]

\[
\frac{\partial \theta^S_{O,c}}{\partial t} \propto \frac{1}{\lambda^N} w^N f^S_O / \psi^S_O > 0, \quad \frac{\partial \theta^S_{O,c}}{\partial d} = 0
\]

and the opposite for tangible assets:

\[
\frac{\partial \theta^*_{c}}{\partial \lambda^N} \propto \frac{1}{\lambda^S} w^N f^S_O / \psi^S_O > 0, \quad \frac{\partial \theta^*_{c}}{\partial d} = 0
\]

\[
\frac{\partial \theta^S_{O,c}}{\partial \lambda^N} < 0, \quad \frac{\partial \theta^S_{O,c}}{\partial d} \propto \frac{1}{\lambda^S} w^N f^S_O / \psi^S_O > 0.
\]
Proof of Proposition 2

For headquarter intensive sectors, firms tend to choose outsourcing in more financially developed country ($\frac{\partial \theta^S_{V,c}}{\partial \lambda^N} > 0$, $\frac{\partial \theta^S_{O,c}}{\partial \lambda^N} < 0$ and $\frac{\partial \theta^S_{V,c}}{\partial \lambda^S} < 0$, $\frac{\partial \theta^S_{O,c}}{\partial \lambda^S} > 0$). This effect is more pronounced in financially vulnerable sectors ($\frac{\partial \theta^S_{V,c}}{\partial \lambda^N} < 0$, $\frac{\partial \theta^S_{O,c}}{\partial \lambda^N} > 0$, $\frac{\partial \theta^S_{V,c}}{\partial \lambda^S} > 0$, $\frac{\partial \theta^S_{O,c}}{\partial \lambda^S} < 0$). In sectors with higher headquarter intensity, integration is favored relative to outsourcing ($\frac{\partial \psi^l_N(\eta)}{\partial \theta(\eta)} > 0$ for $l = N, S$).

Productivity cut-offs without credit constraints in headquarter intensive sectors are the following:

$$\theta^* = X^{(\alpha-\kappa)/\alpha} \left[ \frac{w^N f^N_O}{\psi^N_V(\eta)} \right]^{(1-\alpha)/\alpha},$$

$$\theta^N_V = X^{(\alpha-\kappa)/\alpha} \left[ \frac{w^N(f^N_V - f^N_O)}{\psi^N_V(\eta) - \psi^N_O(\eta)} \right]^{(1-\alpha)/\alpha},$$

$$\theta^S_O = X^{(\alpha-\kappa)/\alpha} \left[ \frac{w^N(f^S_O - f^S_V)}{\psi^S_O(\eta) - \psi^S_V(\eta)} \right]^{(1-\alpha)/\alpha},$$

$$\theta^S_V = X^{(\alpha-\kappa)/\alpha} \left[ \frac{w^N(f^S_V - f^S_O)}{\psi^S_V(\eta) - \psi^S_O(\eta)} \right]^{(1-\alpha)/\alpha}.$$

With credit constraints, the new cutoffs are given by:

$$\theta^* = X^{(\alpha-\kappa)/\alpha} \left[ \frac{(1 - d + d/\lambda^N)w^N f^N_O - \frac{1 - \lambda^N}{\lambda^N} tw^N f_E}{\psi^N_V(\eta)} \right]^{(1-\alpha)/\alpha},$$

$$\theta^N_{V,c} = X^{(\alpha-\kappa)/\alpha} \left[ \frac{(1 - d + d/\lambda^N)w^N(f^N_V - f^N_O)}{\psi^N_V(\eta) - \psi^N_O(\eta)} \right]^{(1-\alpha)/\alpha},$$

$$\theta^S_{O,c} = X^{(\alpha-\kappa)/\alpha} \left[ \frac{(1 - d + d/\lambda^S)w^N f^S_O - \frac{1 - \lambda^S}{\lambda^S} tw^N f_E - (1 - d + d/\lambda^N)w^N f^S_V - \frac{1 - \lambda^N}{\lambda^N} tw^N f_E}{\psi^S_O(\eta) - \psi^S_V(\eta)} \right]^{(1-\alpha)/\alpha},$$

$$\theta^S_{V,c} = X^{(\alpha-\kappa)/\alpha} \left[ \frac{(1 - d + d/\lambda^N)w^N f^S_V - \frac{1 - \lambda^N}{\lambda^N} tw^N f_E - (1 - d + d/\lambda^S)w^N f^S_O - \frac{1 - \lambda^S}{\lambda^S} tw^N f_E}{\psi^S_V(\eta) - \psi^S_O(\eta)} \right]^{(1-\alpha)/\alpha}.$$
Comparative Statics:

\[ \frac{\partial \theta^*_e}{\partial \lambda^N} \propto \left( \frac{t_f E - d f^N_O}{\lambda^{N^2}} \right) w^N / \psi^N_O < 0, \quad \frac{\partial \theta^*_e}{\partial \lambda^S} = 0 \]

\[ \frac{\partial \theta^N_{V,e}}{\partial \lambda^N} \propto -\frac{d f^N_V}{\lambda^{N^2}} w^N \left( f^N_V - f^N_O \right) / \left( \psi^N_V(\eta) - \psi^N_O(\eta) \right) < 0, \quad \frac{\partial \theta^N_{V,e}}{\partial \lambda^S} = 0 \]

\[ \frac{\partial \theta^S_{V,e}}{\partial \lambda^N} \propto \left( \frac{t_f E - d f^S_O}{\lambda^{S^2}} \right) w^N / \left( \psi^S_O(\eta) - \psi^S_V(\eta) \right) > 0, \quad \frac{\partial \theta^S_{V,e}}{\partial \lambda^S} \propto \left( \frac{t_f E - d f^S_O}{\lambda^{S^2}} \right) w^N / \left( \psi^S_V(\eta) - \psi^S_O(\eta) \right) < 0, \]

\[ \frac{\partial \theta^S_{V,e}}{\partial \lambda^N} \propto \left( \frac{t_f E - d f^S_O}{\lambda^{S^2}} \right) w^N / \left( \psi^S_V(\eta) - \psi^S_O(\eta) \right) > 0, \]

\[ \frac{\partial \theta^S_{V,e}}{\partial \lambda^S} \propto -\left( \frac{t_f E - d f^S_O}{\lambda^{S^2}} \right) w^N / \left( \psi^S_V(\eta) - \psi^S_O(\eta) \right) > 0 \]
Chapter 3

Financial Dependence and Growth
3.1 Introduction

There has been a growing literature on financial institutions and growth. Dating as far back as Schumpeter (1911), development of a country’s financial institutions has a positive influence on the rate of growth of its per capita income. In addition, Rajan and Zingales (1998) show that this effect is more pronounced in the financially dependent industries.

The basic specification in this paper is a semiparametric growth rate function where the interaction between external financial dependence of an industry and financial development of a country enters non-parametrically and the remaining variables are parametric. This paper provides evidence that the effect of financial development and external dependence on finance is non-linear and increasing at decreasing rate. In other words, parametric estimation of this interaction effect significantly underestimates the effect of financial improvement for countries starting out with low financial development and industries that depend on less external finance, and overestimates the effect of financial improvement for countries that are already financially developed and industries that depend on more external finance.

This non-linear effect of financial development and external finance dependence on industry growth rates is evident in the case of China. China’s measures of financial development, such as private credit to GDP ratio and market capitalization ratio, have grown over the years but initially started from a low point. The fastest expanding industries in China are the apparel and footwear industries, which are less dependent on external finance. China’s story confirms the result that financially underdeveloped countries should focus on producing products that are less dependent on external finance while they are improving their financial institutions. Countries that are financially underdeveloped tend to be low and middle income countries. Sutton and Trefler (2011) also find that low and middle income countries can achieve higher GDP growth by improving on what they are already producing (i.e. low-tech products like footwear and textiles that tend to be not
dependent on external finance) instead of copying what the rich countries are producing (high-tech products).

This paper also shows that welfare effects of positive shocks to the economy are substantially different if one estimates this financial development and external finance dependence effect non-parametrically rather than parametrically.

Finally, this paper considers the possibility that measures of financial development for a country are endogenous. Countries that have higher growth rates are more likely to have better financial institutions in place. One might therefore expect the measures of financial development to be positively correlated with the residual in an equation where the dependent variable is growth rates or value added. In the concluding section this paper conducts a simple test of the endogeneity hypothesis.

In summary, I have two main objectives: to estimate a semiparametric model of growth rate in value added using the Industrial Statistics Yearbook database put together by the United Nations Statistical Division (1993); and to test whether our measure of financial development is endogenous. Section 2 describes the model and provides additional details about the data. Section 3 uses single-equation differencing techniques (Yatchew (1997), Yatchew (1998), and Yatchew (1999)) to analyze the effect of external financial dependence and financial development on growth rates. Section 4 reports results. Section 5 utilizes the panel data and reports semiparametric results using time changing measurements of financial development and external finance, and the concluding Section 5 compares the results in this paper to those of previous studies.

### 3.2 Model and Data

This paper uses the dataset provided by Rajan and Zingales (1998). Growth in value added for an industry is defined as the change in the log of real value added in that industry between 1980 and 1990. External financial dependence of an industry is mea-
sured as the median firms capital expenditures minus cash flow from operations divided by capital expenditures in that industry. There are several measures available for financial development of a country. The first measure this paper uses is fairly traditional—the ratio of domestic credit plus stock market capitalization to GDP. The second proxy for financial development used in this paper is the accounting standards in a country. A higher score in the accounting standards indicates more disclosure.

The main empirical objective of this paper is to estimate the effect of external financial dependence on financial development on the growth rates. A priori, the relationship between growth rates and external financial dependence interacted with financial development maybe flat, increasing, decreasing or U-shaped; it may be concave or it may have multiple inflection points. I propose therefore to estimate the effect using a semiparametric model.

In addition to an industry’s external financial dependence and a country’s financial development, a number of variables may influence growth rates and therefore need to be incorporated into the model. These covariates include the conventional arguments of growth rate function—an industry’s share of manufacturing in a country, country indicators and industry indicators.

The basic econometric specification is given by:

$$\text{Growth}_{jk} = f(\text{ExtFinDep}_j \times \text{FinDev}_k) + \beta_1 \text{ShareofManufacturing}_{jk} + \beta_2 \text{CountryIndicators} + \beta_3 \text{IndustryIndicators} + \text{constant} + \epsilon_{jk} \quad (3.1)$$

I assume little about the function beyond smoothness, thus equation (1) is a growth rate function with the interaction between external financial dependence and financial development entering both non-parametrically (through \(f\)) and parametrically (through the country and industry indicators). The model has a partial linear structure \(y = \)
Chapter 3. Financial Dependence and Growth

\[ f(x) + z\beta + v \] where the non-parametric variable is the interaction term and the vector is composed of the industry share and other variables which enter parametrically. Summary statistics are contained in Appendix 1.

Because the parametric and non-parametric portions of the model are additively separable, the simple differencing techniques can be applied to the partial linear structure easily. The essential idea is to reorder the data so that the values of the non-parametric variable are close to each other, then to take first- or higher-order differences to remove the non-parametric effect. This differencing technique is explained in details in Yatchew (2000).

3.3 Differencing Procedures

The model maybe written in the form:

\[ y_{jk} = f(x_{jk}) + z_{jk}\beta + v_{jk} \] (3.2)

where \( j \) indexes the industry and \( k \) indexes the country. Throughout the paper, the non-parametric variable \( x_{jk} \) is a scalar.

Let \( y \) be the column vector of the values of the dependent variable. Define \( x \) and \( v \) in a similar fashion. I assume the residuals are distributed independently and homoscedastically across industry-country pairs. For each industry-country pair, the \( jk \)-dimensional row vector \( z_{jk} \) contains data on the parametric variables. Data must be ordered so that within each year, the \( x \)s are in increasing order, i.e. \( x_{11} \leq ... \leq x_{JK} \). In matrix notation, this model is written as:

\[ y = f(x) + Z\beta + v. \] (3.3)

Let \( m \) be the order of differencing and \( d_0, d_1, ..., d_m \), the optimal differencing weights.
The weights satisfy the conditions:

$$\sum_{j=0}^{m} d_j = 0, \sum_{j=0}^{m} d_j^2 = 1$$ (3.4)

To estimate the parametric effects using differencing, I reorder the data so that the values of the nonparametric variable are close. I then difference the data to remove the effect of the nonparametric variable and run ordinary least squares regressions of the differenced dependent variable on the differenced parametric explanatory variables. For details on these techniques see Yatchew (1997) and Yatchew (1999).

### 3.4 Empirical Results

Differencing estimates of the parametric component of equation (1) are presented in Table 1 (throughout the paper I use third-order differencing \((m = 3)\). Results for other orders of differencing were similar.) Since I use U.S. data to identify the external dependence, I drop the United States in all regressions. I start with private credit to GDP ratio as the proxy for financial development. The estimated industry share effect is negative and significant. The rest of the columns of the table include different measures of financial development.

For comparison purposes I provide estimates of the parametric analogues of the models in Table 2. These are the different measures of financial development where the interaction term external finance dependence and financial development is modeled using a quadratic. Estimates for different specifications of financial development do not differ substantially between parametric and semiparametric versions. The \(R^2\), which is defined as \(R^2 = 1 - \frac{s_v^2}{s_y^2}\) is higher in the semiparametric specifications relative to the pure parametric ones.

Returning to the semiparametric specification, I remove the estimated parametric effect from the dependent variable and analyze the non-parametric effect. I use the
estimates from the private credit to GDP ratio to remove the parametric effect. Figure 1 displays the ordered pairs \((y_{jk} - z_{jk}\hat{\beta}, x_{jk})\) as well as kernel estimates of \(f\) bordered by 95% uniform hypotheses may be tested against non-parametric alternatives using the statistic:

\[
(mN)^{1/2} \frac{s_{res}^2 - s_u^2}{s_v^2} \rightarrow N(0, 1)
\]  

under \(H_0\), where \(s_{res}^2\) is the estimate of the residual variance from the parametric regression. When I insert a constant function for \(f\) equation (5) constitutes a test of significance of the scale variable against a non-parametric alternative. The resulting test statistic is 10.89 indicating a strong scale effect of external finance dependence and financial development on growth. Next I test a quadratic model for the interaction term. The resulting statistics is 5.80, suggesting that the quadratic model is still inadequate.

For robustness I repeated my estimation and inference procedures using various orders of differencing. Parameter estimates changed little and tests of significance and specification were consistent with the conclusions above.

It is possible that measures of financial development for a country are endogenous. Countries that have higher growth rates are more likely to have better financial institutions in place. One might therefore expect the measures of financial development to be positively correlated with the residual in an equation where the dependent variable is growth rates or value added. This in turn would lead to underestimation of the effect of external financial dependence and financial development. Porta et al. (1998) suggests that the origin of a country's legal system has an effect on the development of a domestic capital market and on the nature of the accounting system. Countries colonized by the British tend to have sophisticated accounting system while countries colonized by the French tend to have poor standards. This suggests using colonial origin of a country's legal system as one instrument. The second instrument I use is rule of law, an index of efficiency and integrity of legal system produced by Business International Corporation, a country-risk rating agency. I modify the specification in equation (1) to allow for a
simple form of endogeneity as follows:

$$y = f(Ext\text{FinDep} \ast FinDev) + \eta \gamma + z\beta + v \quad (3.6)$$

where $\eta$ is defined by the instrumental variable equation $FinDev = Instrument \ast \pi + \eta$ and $E(v|Ext\text{FinDep} \ast FinDev, \eta, z) = 0$ (See Blundell and Duncan (1998) and Newey, Powell, and Vella (1999)). After estimating $\eta$ from an OLS regression, equation (6) is estimated using differencing. The coefficient of $\eta$ is 0.0893 with a standard error of 0.1151, which would not result in the rejection of the null hypothesis that financial development is exogenous. Using instrumental variable in the pure parametric estimation resulted little change in the coefficient for the interaction between the external finance dependence and financial development and the Hausman (1978) test statistic ($\chi^2_1 = 0.66$) was also insignificant.

### 3.5 Panel Data Analysis

#### 3.5.1 Panel Data Setup

The availability of several years of data permits me to assess the stability of parametric effects over time as well as the stability of non-parametric scale effect. The testing of these hypotheses will be the two main objectives of the panel data analysis. The basic model is given by $y_{jkt} = f_t(x_{jkt}) + z_{jkt}\beta_t + v_{jkt}$. Now the residual is:

$$v_{jkt} = u_{jk} + \varepsilon_{jkt} \quad (3.7)$$

where, conditional on $x$’s, $E(u_{jk}) = 0$, $Var(u_{jk}) = \sigma_u^2$, $E(\varepsilon_{jkt}) = 0$, $Var(\varepsilon_{jkt}) = \sigma^2_\varepsilon$, $Cov(\varepsilon_{jkt}, \varepsilon_{jks}) = 0$ for all $t$.

The presence of country-industry specific effects requires keeping track of how data
have been reordered. Data are ordered so that the $x$s are in increasing order in period 1. Data in all subsequent periods are initially in the same order as the data in the first period. This only ensures that the corresponding country-specific effects are in the same position in each year, but it's not longer the case that the corresponding $x$s are close. Permutation matrices are used to reorder data and quadratic forms to estimate variances, see details in Yatchew (2000). The permutation matrix reorders the data stacked across all periods so that corresponding $x$s are close within each period. The OLS estimator applied to the stacked, reordered and differenced data is identical to the estimator applied year by year. However, its asymptotic covariance matrix must account for correlations between residuals over time arising out of the individual specific effect. This requires consistent estimation of $\sigma^2_u$ and $\sigma^2_\varepsilon$. Estimates of $\sigma^2_u$ and $\sigma^2_\varepsilon$ will be used to test the stability of the non-parametric effect.

3.5.2 Empirical Results

Figure 2 shows the estimation of the non-parametric component using the pooled data where the estimated parametric effects have been removed using private credit to GDP ratio as the measurement of financial development. After getting an estimate of $\beta$ from the stacked, reordered and differenced data, I obtain $s^2_v = 0.21$, $s^2_u = 0.18$ and by subtraction $s^2_\varepsilon = 0.11$. Thus, about 86% of the variance of the residual is attributable to the country-industry specific effect. To test constancy of parametric effects over time, the estimated covariance matrix is used in the conventional asymptotic chi-square statistics for testing linear restrictions. The test statistic is 14.76, indicating rejection. Casual comparison of year by year estimation would suggest that they are not too different. However, since the residuals are dominated by a country-specific effect and the explanatory variables are highly correlated over time, coefficient estimates are also highly correlated over time. Therefore, even small differences are statistically significant. I also test the equality of non-parametric regression functions. The standardized statistic has a standard normal
distribution under the null hypothesis. The test statistic is 0.48, indicating that the null cannot be rejected.

3.6 Conclusions

The central objective of this paper is to estimate the effect of external finance dependence and financial development under relatively weak functional form assumptions. Formal testing rejects the parametric function in favor of its semiparametric counterpart. The results indicate that the interaction between external finance dependence and financial development has a non-linear effect on growth rates, and exhibits decreasing returns to scale.

It may be useful to compare this paper’s findings to those of other studies. Rajan and Zingales (1998) use the same data averaged over ten year period. Looking at the industry at the 75th percentile of external finance dependence, Machinery, and the 25th percentile, Beverages, and the country at the 75th percentile of financial dependence, Italy, and the 25th percentile, Philippines, Rajan and Zingales (1998, p. 574) state that Machinery should grow 1.3 percent faster than Beverages annually, in real terms, in Italy as compared to the Philippines; the annual growth rate is, on average, 3.4 percent per year. So a differential of 1.3 percent is a large number. Using semiparametric estimation approach, this paper finds that Machinery should grow 2.5 percent faster than Beverages annually in Italy as compared to the Philippines. The difference between the two numbers is significant. The parametric estimation of financial development significantly underestimates the returns to financial development when the interaction between financial development and external finance is low and overestimates the returns to financial development when the interaction term is high.

Apart from using the new semiparametric methodology, this paper’s findings suggest that the change in financial institutions that leads to better financial development has
the greatest influence on the rate of economic growth for countries starting with low financial development, by reducing the cost of external finance to financially dependent firms, or put simply, the cost of external finance to financially dependent firms is greatest for countries with more financial frictions. However, further financial development for already financially developed countries will only lead to smaller increases on the rate of economic growth for the financially dependent firms. The interaction effect of external finance dependence and financial development on growth rates exhibits a decreasing return to scale relationship.

Finally, the findings in this paper suggest a fresh explanation for the pattern of industry specialization and growth across countries. For a country starting out with a lot of financial frictions, it is easier to increase its growth rates in the industries that are not financially dependent when it chooses to improve its financial development. Therefore, for the financially underdeveloped countries, it is in their best interest to improve their financial institutions and focus on producing products that are least dependent external finance in order to speed up the process of catching up to the developed countries.
Table 1 Parametric Components of Equation 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Financial development measured as</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Private Credit</td>
</tr>
<tr>
<td>Industry's share of total value added in 1980</td>
<td>-0.89</td>
</tr>
<tr>
<td></td>
<td>(0.15)</td>
</tr>
<tr>
<td>Country fixed effects</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry fixed effects</td>
<td>Yes</td>
</tr>
<tr>
<td>R²</td>
<td>0.31</td>
</tr>
<tr>
<td>Number of observations</td>
<td>1253</td>
</tr>
</tbody>
</table>

The dependent variable is the 3rd order differenced annual compounded growth rate in real value added for the period 1980-1990 for each ISIC industry in each country after the data is sorted by the interaction between financial development and external finance dependence. External finance dependence is the fraction of capital expenditures not financed with internal funds for U.S. firms in the same industry between 1980-1990. The interaction variable is the product of external finance dependence and financial development. Financial development is private credit to GDP ratio in the first column, total capitalization in the second column, accounting standards in 1990 in the third column, and accounting standards in 1983 in the fourth column.
### Table 2: Parametric Analogues of Equation 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Financial development measured as</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Private Credit</td>
</tr>
<tr>
<td>Industry's share of total value added in manufacturing in 1980</td>
<td>-0.90</td>
</tr>
<tr>
<td></td>
<td>(0.14)</td>
</tr>
<tr>
<td>Interaction (external dependence x financial dependence)</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
</tr>
<tr>
<td>Interaction (external dependence x financial dependence)²</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
</tr>
<tr>
<td>Country fixed effects</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry fixed effects</td>
<td>Yes</td>
</tr>
<tr>
<td>R²</td>
<td>0.29</td>
</tr>
<tr>
<td>Number of observations</td>
<td>1253</td>
</tr>
</tbody>
</table>

The dependent variable is the differenced annual compounded growth rate in real value added for the period 1980-1990 for each ISIC industry in each country. External finance dependence is the fraction of capital expenditures not financed with internal funds for U.S. firms in the same industry between 1980-1990. The interaction variable is the product of external dependence and financial development. Financial development is private credit to GDP ratio in the first two columns, total capitalization in the third and fourth column, accounting standards in 1990 in the fifth and sixth column, and accounting standards in 1983 in the seventh and eighth column. The interaction variable is the product of external dependence and financial development. Interaction term alone is the linear parametric analogue of equation 1. Interaction and interaction term squared are the quadratic parametric analogue of equation 1.
Figure 1 Single-equation analysis of averaged growth rates over ten years non-parametric component

The y-axis is the average annual compounded growth rate in real value added for the period 1980-1990 for each ISIC industry in each country after differencing with order m=3. External finance dependence is the fraction of capital expenditures not financed with internal funds by firms in the same industry during the 1980s. This ratio is set to 0 if it is negative. Financial development is private credit to GDP ratio. This ratio is positive for all countries. The negative external finance dependence is set to zero for ease of interpretation. The following picture becomes V-shaped if negative external finance dependence is not set to zero, with the bottom part of V pointing around 0 and linear fitted line does not change much. A V-shaped curve still implies that for financially underdeveloped countries, an improvement in their financial institutions will lead to higher increases in growth rates in industries that are least dependent on finance. It is also possible to make the fraction of capital expenditures not financed with internal funds positive by adding the absolute value of the minimum to all values.
Figure 2 Panel data analysis growth rates 1980-1991 non-parametric component

The y-axis is the average annual compounded growth rate in value added for every four years during 1980-1991 for each ISIC industry in each country after differencing with order $m=3$. The annual growth rate itself exhibits too much noise and therefore I look at the panel data in the averages of every four years. The results are similar if I used three or five years. External finance dependence is the fraction of capital expenditures not financed with internal funds by firms in the same industry during the 1980s. This ratio is set to 0 if it is negative. Financial development is private credit to GDP ratio. This ratio is positive for all countries. The negative external finance dependence is set to zero for ease of interpretation.
Bibliography


