Financial Development and International Trade

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ABSTRACT

This paper studies the industry-level and aggregate implications of financial development on international trade. I set up a multi-industry general equilibrium model of international trade with heterogeneous firms subject to export entry costs and financial frictions, in which industries differ in their dependence on external finance. The model is parametrized to match key features of plant-level data. I find that financial frictions have a large effect on the extent of international trade across industries, but a negligible impact at the aggregate-level. I show that these findings are consistent with estimates from cross-country industry- and aggregate-level data.

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1 Introduction

International trade costs are large, particularly in developing countries. While recent studies have estimated large gains from reducing these costs, identifying specific policies that may allow poor countries to reduce them remains an important challenge.[2]

Recent papers suggest that the development of financial markets may be one such policy. For instance, Beck (2003) and Manova (2013) find that better financial markets lead industries with higher dependence on external finance to export relatively more. Similarly, Minetti and Zhu (2011) and Amiti and Weinstein (2011), among others, have documented strong links between measures of access to external finance and international trade at the firm level, suggesting that firms' export decisions are significantly distorted by financial frictions.[3] Furthermore, recent quantitative studies, such as Kohn, Leibovici, and Szkup (forthcoming) and Gross and Verani (2013), find that financial frictions are a key driver of the dynamics of new exporters, implying that they constitute an important barrier to international trade.

There are, indeed, a number of features of international trade that make it a more finance-intensive activity than production for the domestic market. For instance, as Foley and Manova (2014) and others argue, entering foreign markets typically involves a variety of upfront investments, such as market research, product customization, or the development of distribution networks. To the extent that access to external finance is limited, low internal funds can prevent firms from making such investments. Similarly, foreign sales typically entail lower profit flows due to higher variable costs, such as transportation costs, duties, or freight insurance. Such costs can limit the extent to which firms are able to accumulate internal funds to finance the upfront investments.

[2] Anderson and van Wincoop (2004) show that international trade costs are large in developing countries. Waugh (2010) estimates large welfare gains from reducing them to the level of rich countries.

[3] Hur, Raj, and Riyanto (2006) and Svaleryd and Vlachos (2005) report similar findings at the industry level, while Bellone, Musso, Nesta, and Schiavo (2010) and Berman and Hericourt (2010) report related evidence at the firm level. For a more exhaustive review of the empirical evidence, see Contessi and de Nicola (2012).

The goal of this paper is to investigate the industry- and aggregate-level implications of these facts through the lens of a standard general equilibrium trade model with one key ingredient: frictions in financial markets. In particular, I study a multi-industry model that features firms that are heterogeneous in productivity and external-finance dependence, where international trade is a finance-intensive activity due to the existence of export entry and variable trade costs.[4] I parametrize the model to match key features of plant-level data and use it to quantify the impact of financial frictions on the share of output that is traded internationally at the industry and aggregate levels.[5]

I find that financial frictions can, indeed, account for the strong empirical relationship between financial development and international trade at the industry level. Relaxing the financial constraints increases the trade share in industries with high dependence on external finance, but decreases it in industries with low external-finance dependence. This reallocation of industry-level trade shares is driven by the higher equilibrium prices that result from the increased demand for factors of production due to financial development. These effects, along with the change in the share of aggregate output that each industry accounts for, offset each other almost exactly, leading to a negligible change in the aggregate trade share.

Financial frictions reduce industry-level and aggregate trade shares through two channels. First, financial frictions distort the production decisions of exporters relatively more than those of non-exporters, thereby reducing the share of output that is sold internationally. While financial frictions reduce the scale of production of all firms by limiting the capital expenditures that can be financed externally, exporters are distorted relatively more since they have a higher optimal scale: they face a larger market and are also typically more productive. Second, financial frictions distort export entry decisions since

[4]International trade is modeled following Melitz (2003) and Chaney (2008), with the dynamic features of Alessandria and Choi (2014). Financial frictions are modeled following Midrigan and Xu (2014) and Buera and Moll (2013). The approach to modeling the interaction between financial frictions and international trade builds on early theoretical work by Chaney (2013) and Manova (2013).

[5]I restrict attention to the trade share to study the extent to which international trade is relatively more distorted than production for the domestic market.

firms are led to delay export entry until they accumulate sufficient internal funds to make it profitable to undertake the export entry investment. This reduces the share of firms that export and, thus, the share of output sold internationally.

To study the quantitative impact of financial frictions on international trade, I choose the parameters of the model to match moments from Chilean plant-level data. In particular, I follow a Simulated Method of Moments (SMM) approach to target moments of the data that put discipline on firms' export decisions and the extent to which financial constraints distort production.

I use the calibrated economy as a laboratory to study the impact of financial frictions on international trade at the industry and aggregate levels. Specifically, I run an experiment that consists of contrasting its stationary equilibrium allocations with the stationary equilibria of economies featuring alternative levels of financial development. On the one hand, I contrast it with an economy in which entrepreneurs cannot borrow at all. On the other hand, I contrast it with an economy in which financial frictions are relaxed to resemble a financially developed economy.

I first study the effect of financial development on industry-level trade shares. I find that financial frictions have a significant effect on the extent of international trade at the industry level. Financial development has a heterogeneous impact across industries, which is driven by differences in their dependence on external finance. In industries in which external-finance dependence is high, relaxing the financial constraints increases the trade share since it allows more firms to finance the export entry investments and to increase their scale relative to non-exporters. In contrast, the trade share decreases in industries with low dependence on external finance since the increased incentives to trade and augment scale are offset by higher equilibrium factor prices that arise due to the increased demand for factors of production.

To contrast these findings with estimates from industry-level data, I construct an empirical counterpart to the model's quantitative implications. To do so, I first use the model to derive an empirical specification that explains an industry's trade share in a given country as a function of the country's level of financial development, the industry's degree of dependence on external finance, and the interaction between them. I then estimate the derived specification using the cross-country industry-level dataset previously used by Manova (2013), with financial development measured as the ratio of aggregate credit to GDP and external-finance dependence measured following Rajan and Zingales (1998). Finally, for industries with different degrees of external-finance dependence, I use the estimation results to compute the change in industry-level trade shares associated with the change in financial development featured by the quantitative experiment.

The empirical estimates are qualitatively and quantitatively consistent with the industry-level implications of the model. While higher financial development is associated with an increase of trade shares in industries with high dependence on external finance, it is associated with a decrease of trade shares in industries with low external-finance dependence. Moreover, I find that, in each of the industries, the model can account for more than 86% of the changes in trade shares associated with the development of financial markets.

I then study the effects of financial development on international trade at the aggregate level. In contrast to the strong relationship between trade and finance observed at the industry level, I find that financial frictions have a negligible impact on the extent of international trade at the aggregate level. The reallocation of industry-level trade shares that results from a relaxation of financial frictions and the change in the share of output that each industry accounts for, offset each other almost exactly, implying that the aggregate trade share remains largely unchanged.

Finally, I contrast the aggregate implications of the model with their empirical counterparts.[6] To do so, I first aggregate the cross-country industry-level

[6]Evidence of an aggregate relationship between trade and finance has been elusive, given the econometric challenge of identifying such estimates in a causal fashion. Amiti and Weinstein (2011) and Paravisini, Rappoport, Schnabl, and Wolfenzon (2015) overcome these difficulties by exploiting rich firm-level data that allow them to estimate the average response of trade-related outcomes across firms with differential exposure to banks affected by an aggregate shock.

dataset used by Manova (2013) to generate a country-level panel dataset. I then use it to examine the relationship between financial development and aggregate trade shares by estimating an empirical specification consistent with my quantitative model. I find that the relationship between financial development and aggregate trade shares is statistically insignificant,[7] which is consistent with the negligible link implied between them by the model.

This paper is closely related to previous empirical studies, such as Beck (2003) and Manova (2013), which have focused largely on the relationship between financial development and the *level* of international trade flows across industries. These studies have documented that, while better financial markets are typically associated with larger trade flows in all industries, they are relatively larger in finance-intensive industries. To the best of my knowledge, this is the first paper to document that such a finding hides a qualitatively different response of *trade shares* across industries: financial development is associated with higher trade shares in finance-intensive industries, but lower trade shares in non-finance-intensive ones. Moreover, I show that this heterogeneity across industries is crucial for understanding the extent to which international trade is relatively more distorted than domestic production at the aggregate level.

There is also a growing literature that studies the aggregate implications of financial frictions on international trade flows through the lens of equilibrium models. For instance, Wynne (2005), Matsuyama (2005), and Antras and Caballero (2009) study their qualitative impact on the pattern of comparative advantage. Brooks and Dovis (2013) and Caggese and Cuñat (2013) investigate their quantitative impact on the gains from reducing the barriers to international trade. My paper combines the quantitative approach of the latter with the multi-industry approach of the former to investigate the extent

[7]While Beck (2002) documents a strong link between trade and finance at the aggregate level, his measure of interest, the ratio of manufacturing exports to total GDP, is not directly comparable to the one I study. His measure confounds the impact of financial development on the magnitude of the manufacturing sector relative to total GDP, with its impact on the sectoral trade share. My findings suggest that his results are driven by the former rather than by the latter.

to which frictions in financial markets act as a barrier to international trade.

Finally, this paper is more broadly related to a large literature that investigates the role of domestic institutions as a potential barrier to international trade. In particular, frictions in product markets, labor markets, and financial markets, among others, have been documented to distort the pattern of comparative advantage across countries, suggesting they may have important implications at the aggregate level — for a review of this literature, see Nunn (2014). My paper examines whether this is indeed the case for frictions in financial markets.

The paper is organized as follows. Section 2 presents the model. Section 3 discusses the mechanism through which financial frictions distort aggregate trade flows. Section 4 presents the quantitative analysis of the model. Section 5 contrasts the quantitative findings with empirical evidence. Section 6 concludes.

2 Model

The model consists of an economy populated by a unit measure of entrepreneurs and final-good producers who trade with the rest of the world. There are three types of goods in the economy: final goods, domestic varieties, and foreign varieties. Final goods are produced by final-good producers and used by entrepreneurs for consumption and investment. Domestic varieties are produced by entrepreneurs and sold to final-good producers and the rest of the world. Finally, foreign varieties are produced by the rest of the world and sold to final-good producers. Only domestic and foreign varieties can be traded internationally.

2.1 Economic environment

2.1.1 Entrepreneurs

Preferences Entrepreneurs are risk-averse, with preferences over streams of consumption of final goods represented by the expected lifetime discounted sum of a constant relative risk-aversion period utility function. The utility function is given by $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\gamma}}{1-\gamma}$, where γ denotes the coefficient of relative risk aversion; β is the subjective discount factor; and $\mathbb{E}_0$ denotes the expectation operator taken over the realizations of a death shock that is described below, conditional on the information set in period zero.

Technology Entrepreneurs produce a differentiated variety by operating a constant returns-to-scale production technology $y_t = zk_t^{\alpha} n_t^{1-\alpha}$, where z denotes an idiosyncratic level of productivity; k_t is the capital stock; n_t is the amount of labor hired; and $\alpha \in (0, 1)$ is the capital share. Idiosyncratic productivity z is constant over the lifetime of entrepreneurs and is distributed log-normal with mean μ_z and standard deviation σ_z.

There are two types of entrepreneurs, which differ in the capital-intensity α of their production technology.[8] An exogenous share $\eta \in (0, 1)$ of entrepreneurs operate a capital-intensive technology, with $\alpha = \alpha_h$, while a share $1-\eta$ of them operate a non-capital-intensive technology, with $\alpha = \alpha_l$ such that $\alpha_l < \alpha_h$. The two types of entrepreneurs are otherwise identical.

Every period, entrepreneurs are endowed with a unit of labor that is supplied inelastically to other entrepreneurs through a competitive labor market. Capital is accumulated internally by transforming final goods invested in period t, x_t, into physical capital k_{t+1} in period $t+1$. Capital depreciates at rate δ after being used for production, leading to a law of motion for capital that is given by $k_{t+1} = (1 - \delta)k_t + x_t$.

International trade Entrepreneurs can trade internationally. To export, they need to pay export entry costs and variable trade costs. A firm's export status at time t is denoted by e_t and is equal to one if the firm can export in period t, and is zero otherwise. A firm that cannot export in period t has to pay a sunk export entry cost $F > 0$ in that period in order to start selling internationally in period $t + 1$. This cost is denominated in units of labor. A firm that exports in the current period can export in every subsequent period. Furthermore, exporters are subject to an ad-valorem trade cost $\tau > 1$, which requires firms to ship τ units for every unit that arrives and is sold at its

[8] In the quantitative analysis of the model, I interpret these two types of entrepreneurs as two industries that differ in the production technology that they operate.

destination.

Financial markets Entrepreneurs have access to an internationally integrated financial market, in which they can save or borrow from each other and the rest of the world by trading a one-period risk-free bond at interest rate r, denominated in units of the final good. Entrepreneurs face a borrowing constraint, that limits the amount that they can borrow to a fraction θ of the value of the capital stock at the time that the loan is due for repayment. Thus, while entrepreneurs can trade this bond to save as much as they desire, they can borrow an amount d_{t+1} that is limited by the borrowing constraint $d_{t+1} \leq \theta k_{t+1}$ and the natural borrowing limit.

Entry and exit At the end of every period, entrepreneurs die with probability ν. While constrained in their capacity to borrow, entrepreneurs have access to perfect annuity markets to insure themselves against the event of death.[9] Every period, after making financial and capital accumulation decisions, entrepreneurs purchase an annuity contract. The contract specifies that, upon death, their savings and capital are transferred to surviving entrepreneurs. Upon survival to the following period, the contract specifies that agents receive $\frac{\nu}{1-\nu}$ additional units of capital per unit of capital owned. Similarly, their savings are increased by $\frac{\nu}{1-\nu}$ units per unit of savings held.[10] Note that, given that entrepreneurs have no bequest motive, they always find it optimal to sign these contracts.

At the end of the period, dead entrepreneurs are replaced by a measure ν of newborn entrepreneurs. These newborn entrepreneurs begin life with an initial endowment of capital $\underline{k}$ that is financed via a lump-sum tax T levied by the government on all entrepreneurs, an idiosyncratic productivity level drawn from the stationary productivity distribution, a capital-intensity $\alpha \in \{\alpha_h, \alpha_l\}$, and zero debt.

[9]This assumption is made for convenience, to prevent wealth from being destroyed upon the death of entrepreneurs, while avoiding an explicit modeling of bequest decisions.

[10]If in debt, their stock of debt is increased by $\frac{\nu}{1-\nu}$ units per unit owed.

Market structure Entrepreneurs compete with each other under monopolistic competition and choose the quantities and prices at which to sell in each market, subject to their respective demand schedules. In the domestic market, the demand schedule is such that it solves the final-good producer's problem, while the demand schedule faced in the international market is the rest of the world's. These demand schedules are described in detail below. Denote the quantities and prices in the domestic (or "home") market by $y_{h,t}$ and $p_{h,t}$, and those corresponding to the rest of the world (or "foreign") by $y_{f,t}$ and $p_{f,t}$, respectively.

Timing protocol The timing of entrepreneurs' decisions is as follows. Entrepreneurs begin the period by hiring labor, producing their differentiated domestic variety, and then selling it in each of the markets in which they operate. Then, entrepreneurs simultaneously issue new debt, choose their level of investment, and repay their old debt. The remaining resources are used to pay the lump-sum tax, to consume, and to pay the export entry cost (if starting to export). At the end of the period, death shocks are realized, and the resources from dead entrepreneurs are transferred to surviving ones. At the beginning of the following period, dead entrepreneurs are replaced by newborn ones, who receive an initial endowment of capital from the taxes paid by entrepreneurs in the previous period.

Entrepreneurs' problem Given this setup, the entrepreneurs' problem at time zero consists of choosing sequences of consumption c_t, labor n_t, investment x_t, next period's export status e_{t+1}, and prices and quantities $y_{h,t}, p_{h,t}$, $y_{f,t}, p_{f,t}$ at which to sell their differentiated variety in each of the markets, in order to maximize lifetime expected utility. In addition to the borrowing constraint $d_{t+1} \leq \theta k_{t+1}$ described above and the market-specific demand schedules that are described below, their choices are subject to a sequence of period-by-period budget constraints, annuity-adjusted[11] law of motions of capital $k_{t+1} = \frac{1}{1-\nu}\left[(1-\delta)k_t + x_t\right]$, and the production technology $y_{h,t} + \tau y_{f,t} = z k_t^{\alpha} n_t^{1-\alpha}$. Their budget constraint in period t is given by

[11]Note that $1 + \frac{\nu}{1-\nu} = \frac{1}{1-\nu}$.

$p_t c_t + p_t x_t + p_t d_t + w_t F \mathbb{I}_{\{e_t=0, e_{t+1}=1\}} = w_t + p_{h,t} y_{h,t} + p_{f,t} y_{f,t} - w_t n_t + p_t d_{t+1} \frac{1-\nu}{1+r_t} - T$, where p_t denotes the price of the final good; w_t denotes the wage rate; $\mathbb{I}$ is an indicator function that is equal to one if its argument is true and zero otherwise; and the interest rate is adjusted by the annuity return.

2.1.2 Rest of the world

The rest of the world demands domestic varieties from entrepreneurs (the domestic economy's exports) and supplies foreign varieties to final-good producers (the domestic economy's imports). The demand for varieties produced by entrepreneurs is assumed to be given by a downward-sloping demand function with constant elasticity of substitution σ, $y_{f,t} = \left(\frac{p_{f,t}}{\bar{p}^*}\right)^{-\sigma} \bar{y}^*$, where $\bar{y}^*$ and $\bar{p}^*$ are parameters that denote the aggregate quantity and price indexes of the rest of the world. The supply of varieties from the rest of the world, imported by final-good producers, is assumed to be perfectly elastic at price $\bar{p}_m$, which is set to be the numeraire good.

Domestic entrepreneurs have access to international financial markets, where they face a perfectly elastic supply of funds at interest rate r.

2.1.3 Final-good producers

Final-good producers purchase differentiated varieties from entrepreneurs and the rest of the world and aggregate them to produce a final good. To do so, they operate a constant elasticity of substitution (CES) technology, with elasticity of substitution $\sigma > 1$. Let the set $[0,1]$ index the unit measure of entrepreneurs in the economy. Then, given prices $\{p_{h,t}(i)\}_{i\in[0,1]}$ and $\bar{p}_m$ charged by entrepreneurs and the rest of the world, respectively, final-good producers choose the bundle of inputs of domestic and imported varieties, $\{y_{h,t}(i)\}_{i\in[0,1]}$ and $y_{m,t}$, respectively, that maximizes their profits. Then, the problem of final-good producers is given by:

$$\max_{y_{h,t}(i),y_{m,t}} p_t y_t - \int_0^1 p_{h,t}(i) y_{h,t}(i) di - \bar{p}_m y_{m,t}$$

subject to

$$y_t = \left[\int_0^1 y_{h,t}(i)^{\frac{\sigma-1}{\sigma}} di + y_{m,t}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}},$$

where p_t and y_t denote the price and quantity of the final good, respectively.

Given prices $\{p_{h,t}(i)\}_{i\in[0,1]}$ and $\bar{p}_m$, the quantity of each variety demanded by final-good producers is given by the demand functions $y_{h,t}(i) = \left[\frac{p_{h,t}(i)}{p_t}\right]^{-\sigma} y_t$ and $y_{m,t} = \left(\frac{\bar{p}_m}{p_t}\right)^{-\sigma} y_t$, which are faced by entrepreneurs and the rest of the world, respectively.

2.2 Entrepreneurs' problem: Recursive formulation

Given the environment described above, the entrepreneur's problem can be represented by the following dynamic programming problem:

$$v(k,d,e;z,\alpha) = \max_{c,x,n,d',k',p_h,p_f,y_h,y_f,e'\in\{0,1\}} \frac{c^{1-\gamma}}{1-\gamma} + \beta(1-\nu) v(k',d',e';z,\alpha)$$

subject to

$$pc + px + pd + wn + wF\mathbb{I}_{\{e=0,e'=1\}} = w + p_h y_h + p_f y_f + pd' \frac{1-\nu}{1+r} - T$$

$$k' = \frac{1}{1-\nu}\left[(1-\delta)k + x\right], \quad d' \le \theta k'$$

$$y_h + \tau y_f = z k^\alpha n^{1-\alpha}, \quad y_h = \left(\frac{p_h}{p}\right)^{-\sigma} y, \quad y_f = \left(\frac{p_f}{\bar{p}^*}\right)^{-\sigma} \bar{y}^*,$$

where $v(k,d,e;z,\alpha)$ denotes the value function of an entrepreneur of productivity z and capital-intensity α, which begins the period with capital stock k, debt d, and export status e.

2.3 Equilibrium

Let $\mathcal{S} := \mathcal{K} \times \mathcal{D} \times \mathcal{E} \times \mathcal{Z} \times \mathcal{I}$ denote the state space of entrepreneurs, where $\mathcal{K} = \mathbb{R}^+$, $\mathcal{D} = \mathbb{R}$, $\mathcal{E} = \{0, 1\}$, $\mathcal{Z} = \mathbb{R}^+$, and $\mathcal{I} = \{\alpha_l, \alpha_h\}$ denote the set of possible values of capital, debt, export status, productivity, and capital intensity, respectively. Finally, let $s \in \mathcal{S}$ denote an element of the state space.

Then, a *recursive stationary competitive equilibrium* of this economy consists of prices $\{w, p\}$, policy functions $\{d', k', e', c, n, y_d, y_f, p_d, p_f, y, y_m, T\}$, a value function v, and a measure $\phi : \mathcal{S} \to [0, 1]$ over entrepreneurs' states such that:

1. Policy and value functions solve the entrepreneurs' problem
2. Policy functions solve the final-good producers' problem
3. Government's budget is balanced: $p\nu\underline{k} = T$
4. Labor market clears: $\int_{\mathcal{S}} \left[n(s) + F\mathbb{I}_{\{e=0,e'(s)=1\}}\right] \phi(s)ds = 1$
5. Markets for domestic varieties clear: $y_h(i) = y_h(s)$ if $s_i = s$
6. Final-goods market clears: $\int_{\mathcal{S}} [c(s) + x(s)] \phi(s)ds + \nu\underline{k} = y$
7. Measure ϕ is stationary

3 Mechanism

I now study the mechanism through which financial frictions distort international trade decisions in this economy. While a large literature has recently studied the extent to which financial frictions distort allocations in a closed economy (see, for instance, Midrigan and Xu (2014), Buera, Kaboski, and Shin (2011), and Buera and Moll (2013)), the extent to which international trade flows are relatively more distorted than production for the domestic market is much less understood. Therefore, I restrict attention to the effect of financial frictions on the industry- and aggregate-level trade shares — that is, the ratio of exports to domestic sales — rather than on the level of trade.[12] This allows me to focus on the relative impact of financial frictions across markets, while abstracting from their overall impact on allocations.[13]

The ratio of export sales to domestic sales across the set $j \in \{l, h, agg\}$ of entrepreneurs is given by:

$$\frac{\text{Exports}_j}{\text{Domestic sales}_j} = \frac{\bar{p^*}^{\sigma} \bar{y}^*}{p^{\sigma} y} \times \widehat{\tau}_j^{1-\sigma}, \tag{1}$$

where l and h denote the set of entrepreneurs that operate the technology with low and high capital intensity, respectively, while agg denotes the set the of all entrepreneurs. I refer to the endogenous object $\widehat{\tau}_j$ as a trade wedge, which I describe below in more detail. This trade wedge captures the impact of trade costs on firms' decisions and the trade share. Absent any trade costs, the trade wedge equals one, and the trade share is given by the ratio of the aggregate effective demand in the rest of the world relative to the aggregate effective demand in the domestic economy. In contrast, with export entry or variable trade costs, the trade wedge becomes larger than one, lowering the trade share, given that $\sigma > 1$.

Financial frictions affect the trade share through two channels. First, tighter financial frictions increase the relative effective foreign demand since domestic economic activity decreases, while the rest of the world remains unchanged.[14] This effect is captured by the first term in Equation (1): it increases the trade share by shrinking the domestic economy. The second

[12] While the ratio of exports to domestic sales is not literally the trade share (that is, the share of output that is exported), it is a monotonic function of it. Thus, I refer to them interchangeably.

[13] In addition, the response of the aggregate trade share is the key statistic determining the welfare gains from a reduction in trade costs for a large class of models of international trade (Arkolakis, Costinot, and Rodriguez-Clare, 2012). To the extent that estimates of trade costs based on these models capture distortions of international trade flows due to financial frictions, policies that relax these frictions can act as a reduction in the barriers to trade faced by poor countries, with potentially very large impacts on welfare (Waugh 2010).

[14] While this is an artifact of the small-open-economy nature of the model, multi-country extensions of this setup studied in earlier versions of the paper imply that a tightening of financial frictions in the domestic economy has a quantitatively negligible impact on the aggregate demand it faces from the rest of the world.

channel through which tighter financial frictions distort the ratio of exports to domestic sales is by increasing the trade wedge, as captured by the second term in Equation (1). Through this channel, industries and economies with tighter financial frictions may look as though they are subject to higher trade costs. To the extent that the latter effect is larger than the former, financial frictions reduce the ratio of exports to domestic sales.

The first channel reflects distortions of financial frictions on total production, which other papers have previously studied. I now examine the second channel in more detail, as this is the channel through which financial frictions may distort international trade flows relatively more than production for the domestic market, as suggested by previous empirical studies. To do so, I study the forces that determine the trade wedge across the set $j \in \{l, h, agg\}$ of entrepreneurs, which is given by:

$$\widehat{\tau}_j = \left[\frac{\int_{\mathcal{S}_j} \left[z \left(\frac{r+\delta}{r+\delta+\mu_\theta(s)} \right)^{\alpha} \right]^{\sigma-1} \phi(s) ds}{\frac{1}{E_j} \int_{\mathcal{X}_j} \left[z \left(\frac{r+\delta}{r+\delta+\mu_\theta(s)} \right)^{\alpha} \right]^{\sigma-1} \phi(s) ds} \right]^{\frac{1}{\sigma-1}} \times \left(\frac{1}{E_j} \right)^{\frac{1}{\sigma-1}} \times \tau, \qquad (2)$$

where μ_θ is the Lagrange multiplier on the entrepreneurs' borrowing constraint; $\mathcal{S}_j$ is the set of all entrepreneurs in j; $\mathcal{X}_j$ is the set of all firms that export across set j; and E_j denotes the share of exporters in set j of entrepreneurs.[15]

The first term captures the scale of production of all the domestic firms that sell in the domestic market relative to the scale of exporters. These measures of scale consist of the average productivity computed across firm-level productivities adjusted by a function of the Lagrange multipliers and the elasticity of demand, to capture the negative impact of financial frictions on production scale. That is, while their optimal scale is increasing in productivity, their scale of production is decreasing in the magnitude of the Lagrange multipliers. To the extent that financial frictions reduce the average scale of exporters (the denominator) relative to that of all firms that sell in the domestic market (the numerator), they increase the trade wedge $\hat{\tau}$ and, thus, reduce the trade share.

[15] $\mathcal{S}_l := \{s \in \mathcal{S} | \alpha = \alpha_l\}$, $\mathcal{S}_h := \{s \in \mathcal{S} | \alpha = \alpha_h\}$, and $\mathcal{S}_{agg} := \mathcal{S}$. $\mathcal{X}_j$ and E_j are given by $\mathcal{X}_j := \{s \in \mathcal{S}_j | e = 1\}$ and $E_j := \int_{\mathcal{S}_j} \mathbb{I}_{\{e=1\}} \phi(s) ds$, respectively.

The second term is a function of the share of firms that export. To the extent that financial frictions reduce the share of firms that export, they imply a higher trade wedge $\hat{\tau}$ and, thus, a lower trade share.

Finally, the last term is given by the variable trade cost τ and is, thus, unaffected by the extent of financial development. The impact of variable trade costs on equilibrium allocations, however, is affected by the extent of financial development: higher variable trade costs reduce the profit flows from exporting, reducing the extent to which firms can benefit from exporting to accumulate internal funds and relax their financial constraint.

3.1 Financial frictions reduce relative scale of exporters

I now argue that financial frictions indeed reduce the scale of exporters relative to firms that operate only in the domestic market, leading to an increase in the first term of Equation (2). To see this formally, it is useful to focus on the reformulation of the entrepreneurs' problem derived in the Appendix, which separates the dynamic decisions from the static ones and also casts the problem with net worth $a := k - \frac{d}{1+r}$ as an endogenous state variable in place of k and d.

Financial frictions distort entrepreneurs' production decisions by reducing the scale at which they operate the firm. If θ is low enough ($\theta < 1 + r$, specifically), an entrepreneur with net worth a can operate the firm with a capital stock that is, at most, as high as $\frac{1+r}{1+r-\theta}a$. As a result of these distortions, firms hold sub-optimal levels of capital, which lead to variation in the marginal product of capital across firms: $MPK(a, e; z, \alpha) = r + \delta + \mu_\theta$. In contrast, for high enough values of θ, the firm can operate with a capital stock that is as high as desired, regardless of its net worth a. In this case, the marginal product of capital is constant across firms since $\mu_\theta = 0$. The left panel of Figure 1 illustrates the relationship between net worth a and the total amount of output produced by exporters and non-exporters, conditional on states (z, α): the solid and dashed lines illustrate the case in which $\theta = 0$ and $\theta = \infty$, respectively, while keeping all aggregate prices and quantities fixed.

The extent to which financial constraints distort firms' production deci-

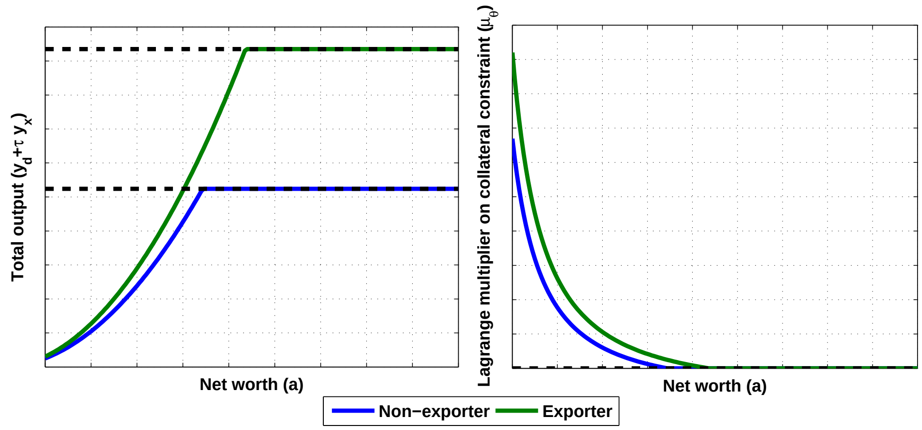

Figure 1: Total output and Lagrange multipliers

sions depends not only on their net worth, but also on their desired scale of operation, which is a function of the productivity level z and the effective demand faced in the markets served. In particular, productive firms that sell to multiple markets have a relatively higher optimal scale than unproductive ones that sell only in the domestic market. Therefore, conditional on a given level of net worth a and capital intensity α, the financial constraints of the former firms will be relatively more binding, as the gap between their effective scale of operation and their optimal scale is relatively larger. The right panel of Figure 1 indeed shows that, conditional on a level of net worth, exporters have higher Lagrange multipliers than non-exporters conditional on states (z, α).

3.2 Financial frictions reduce the share of exporters

I now show that financial frictions indeed reduce the share of firms that export, leading to an increase in the second term of Equation (2).

Whether or not entrepreneurs are subject to financial constraints, they choose to start exporting as long as the lifetime expected utility from starting to export is at least as high as that from remaining a non-exporter. Financial frictions affect firms' export entry decisions by distorting these relative values at different levels of net worth and productivity.

Financial frictions lower the value of exporting through three channels.

First, firms with sufficiently low net worth may not afford to finance the sunk export entry cost using the external and internal funds available. Second, firms with higher levels of net worth, which can actually afford this investment, may still have their decisions distorted. For these firms, financial frictions reduce the extent to which they can smooth out the payment of the sunk cost, forcing them to rely relatively more on internal funds and leading to a large drop in consumption upon entry. Therefore, such entrepreneurs choose to delay their export entry decision until they accumulate higher levels of net worth, reducing the impact of starting to export on consumption. The third channel is driven by the distortions to the firms' scale described above, which lower the expected returns from making the export entry investment. Firms without sufficient net worth, then, choose to delay their decision to enter the foreign market until they can operate at a scale that ensures that the returns to the export entry investment are high enough.

To illustrate the impact of these channels on firms' export entry decisions, Figure 2 contrasts the export entry policy functions with and without financial frictions. To make the comparison as sharp as possible, I contrast an environment in which firms cannot borrow at all ($\theta = 0$) with a frictionless economy ($\theta = \infty$), while keeping all aggregate prices and quantities fixed.

The left panel plots the export entry policy for the model without financial constraints. As in standard models, there is a threshold level of productivity such that only firms above it choose to export. Firms' profits in the foreign market are increasing in z, while the cost of entry to this market is independent of productivity. Thus, when productivity is sufficiently low, lifetime expected profits from starting to export are lower than the sunk export entry cost, and these firms do not export.

The right panel plots the export entry policy for the model with financial constraints. As in the frictionless model, there is a threshold level of productivity such that only firms above it choose to export. In addition, productive firms with sufficiently low net worth do not export – only those above a minimum level of net worth choose to do so. As discussed earlier, with financial constraints, firms with low net worth either cannot afford to finance the sunk

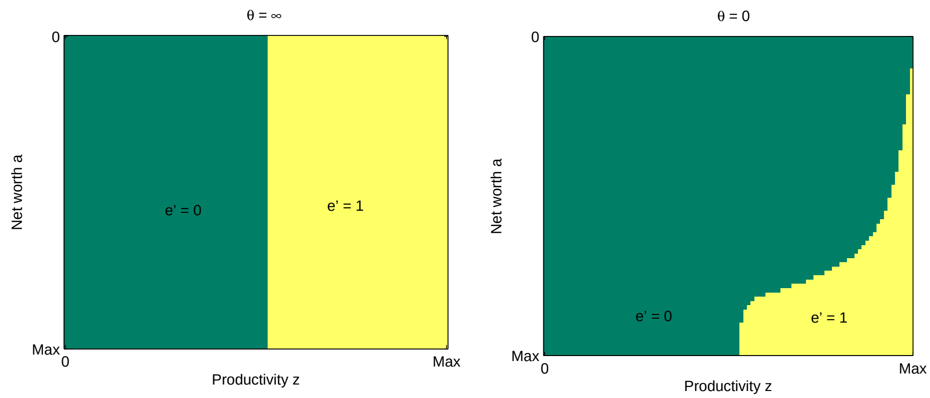

Figure 2: Export entry policy function

export entry cost, or they do not find it profitable to start exporting. Note that the minimum level of net worth at which these firms start exporting is decreasing in productivity: firms with higher productivity make relatively higher profits per unit of net worth and, thus, find it more profitable to pay the sunk cost (conditional on affording it) at lower levels of net worth.

4 Quantitative analysis

In this section, I quantify the extent to which financial frictions distort international trade flows in this economy. To do so, I begin by calibrating the model to match key features of plant-level data. I then use this calibrated economy as a laboratory to study the effect of financial frictions on international trade at both the industry and aggregate levels. In Section 5, I contrast my findings with estimates from the data.

4.1 Calibration

4.1.1 Data

I choose the parameters of the model to match salient features of data from Chilean manufacturing plants for the period 1995 to 2007. The data were collected by the Chilean National Institute of Statistics (INE) as part of its Annual Survey of Manufactures (ENIA). The survey collects longitudinal data on all plants with more than ten workers and provides information on foreign and domestic sales, as well as on the use of factor inputs, which constitute the main variables that I use to discipline the implications of the model.[16]

4.1.2 Parametrization

To choose the parameters of the model, I begin by partitioning the parameter space into two groups. The first group of parameters is set to standard values from the literature, as well as to values estimated directly using plant-level data and analytical implications of the model. The second group of parameters is chosen simultaneously through a simulated method of moments (SMM) approach to match key features of Chilean plants. The parameter values used are presented in Table 1, while the moments targeted and their model counterparts are presented in Table 2.[17]

The set of predetermined parameters consists of the preference parameters (γ, σ, and β), the technological parameters (α_h, α_l, and δ), and the interest rate r. The coefficient of relative risk aversion γ is set to 2, which implies an intertemporal elasticity of substitution $1/\gamma$ equal to 0.5. The discount factor β is set to 0.96; the elasticity of substitution across varieties σ is set to 4; and the rate of capital depreciation δ is set to 0.06. These values fall well within the range of values used previously in the literature to calibrate similar economic environments.[18] I set the interest rate to 6%, to match the average real interest rate in Chile over the period 1995-2007, as estimated by

[16]I exclude plants with negative or missing sales in the domestic or foreign markets, as well as those with zero or missing total sales. I also exclude observations from the following International Standard Industrial Classification (ISIC) Revision 3 categories, given their large dependence on natural resource extraction: category 2720 (manufactures of basic precious and non-ferrous metals) and category 2411 (manufactures of basic chemicals except for fertilizers and nitrogen compounds). The quantitative results are robust to the inclusion of these categories.

[17]The model is solved using an extension of the endogenous grid method from Carroll (2006) to account for the discrete nature of the export entry decision. The statistics of the model are calculated off the stationary distribution of entrepreneurs following the discretization approach in Heer and Maussner (2005).

[18]See Buera, Kaboski, and Shin (2011) and Midrigan and Xu (2014) for economic environments that use similar values of the coefficient of relative risk aversion, discount factor, and rate of capital depreciation. The intertemporal elasticity of substitution falls in the range estimated by Guvenen (2006) and Blundell, Meghir, and Neves (1993), while the elasticity of substitution across varieties is in the range estimated by Broda and Weinstein (2006) and Simonovska and Waugh (2014).

the International Monetary Fund in its International Financial Statistics.

The capital shares α_h and α_l that correspond to the two types of entrepreneurs in the economy are estimated directly by using plant-level data along with analytical implications of the model. For every entrepreneur of type $i \in \{h, l\}$, the optimality conditions of their decision problem imply that $\alpha_i = 1 - \left(\frac{\sigma}{\sigma-1}\right)\left(\frac{wn}{p_h y_h + p_f y_f}\right)$. I use plant-level data on the total wage bill and value added,[19] along with the predetermined value chosen for σ, to compute the capital share of every plant in the sample.[20] For each 3-digit ISIC rev. 3 industry category, I compute the median capital share across plants in the industry and then set α_h and α_l at the highest (0.69) and lowest median capital shares (0.13), respectively. Capital shares are set at these values to capture the range of technologies operated by plants across industries.[21] To ensure that the production technology implied by these shares is reasonable at the aggregate level, I choose the fraction of entrepreneurs of each type to match the aggregate capital-labor ratio.

The group of calibrated parameters consists of F, ν, τ, σ_z, η, θ, and the initial level of net worth $\underline{a}$.[22] I choose them simultaneously following the simulated method of moments, to match the following statistics from Chilean plant-level data: (1) the share of firms that export; (2) the exit rate (defined as the share of firms that operate in period t that do not do so in period $t+1$); (3) the ratio of aggregate exports to aggregate total sales; (4) the ratio between the average sales of exporters and the average sales of non-exporters; (5) the ratio between the average sales at age five and the average sales at age one, among new firms that survive for at least five years; (6) the ratio of aggregate credit to aggregate value added; and (7) the ratio between the aggregate capital stock[23]

[19] Value added is computed as total revenue net of spending on intermediate inputs.

[20] For the purposes of these calculations, I drop plants with negative value added, as well as plants with estimated capital shares below zero or above one.

[21] The average and median capital shares across industries are 0.39 and 0.38, respectively. Their respective standard deviations are 0.10 and 0.07.

[22] In the Appendix, I define net worth a as $k - \frac{d}{1+r}$ and show that the entrepreneurs' problem is equivalent to one with net worth as a state variable instead of k and d. I solve the model using this reformulation of the entrepreneur's problem and initialize newborn entrepreneurs with net worth $\underline{a}$.

[23] The capital stock at the plant level is computed by applying the perpetual inventory

Table 1: Parametrization

Predetermined parameters			*Calibrated parameters*		
Discount factor	β	0.96	Iceberg trade cost	τ	3.27
Risk aversion	γ	2	Death rate	ν	0.10
Substitution elasticity	σ	4	Productivity dispersion	σ_z	0.35
Depreciation rate	δ	0.06	Sunk export entry cost	F	1.43
High capital share	α_h	0.69	Collateral constraint	θ	0.18
Low capital share	α_l	0.13	Initial net worth	$\underline{a}$	1.80
Interest rate	r	0.06	Fraction of α_h firms	η	0.39

and the aggregate wage bill.[24] All target moments $(1)-(7)$ are computed using the Chilean plant-level dataset described above. To compute (6), I also use the total value of outstanding credit in the manufacturing sector, as reported by the Superintendencia de Bancos e Instituciones Financieras de Chile.

While all the calibrated parameters simultaneously affect all of the target moments, I now provide a heuristic argument to map the former with the latter. The dispersion of idiosyncratic productivity σ_z impacts the size of exporters relative to non-exporters since it affects the dispersion between high- and low-productivity firms and, hence, the gap between firms that choose to export and those that do not. The sunk export entry cost F affects the export entry threshold and, thus, the share of firms that export. The collateral constraint parameter θ determines the amount of credit taken in the economy, as reflected by the aggregate ratio of credit to value added, given that higher values of θ allow firms to borrow relatively more. The level of initial net worth of newborn firms $\underline{a}$ affects the extent to which these firms are constrained at birth and, thus, the gap between their scale in subsequent years and their scale at birth. The iceberg trade cost parameter τ plays a key role in determining the aggregate ratio of exports to total sales in the economy since it controls the extent to which sales abroad are more costly than domestic sales, conditional

method, using the value of δ chosen above and initializing each series with the book value of capital. For further details, see, for example, Caballero, Engel, and Haltiwanger (1995).

[24]The moments that I target and their quantitative implications are robust to aggregating the data across plants that belong to a common firm.

Table 2: Moments

Moment	*Data*	*Model*
A. Used to calibrate model		
Share of firms that export	0.21	0.21
Average sales (exporters/non-exporters)	7.18	7.18
Average sales (age 5/age 1)	1.52	1.52
Exit rate	0.10	0.10
Aggregate exports / Sales	0.25	0.25
Aggregate credit / Value added	0.33	0.33
Aggregate capital stock / Wage bill	5.40	5.40
B. Additional moments		
Std. dev. total sales	1.75	1.27
Std. dev. wage bill	1.47	1.05
Std. dev. capital	2.17	1.61
Avg. total sales growth	0.02	0.04
Avg. wage bill growth	0.05	0.04
Avg. capital growth	0.09	0.06
Share of total sales, ages 1-5	0.22	0.21
Share of wage bill, ages 1-5	0.21	0.26
Share of capital, ages 1-5	0.18	0.13

on exporting.[25] As mentioned above, the share of entrepreneurs of each type is chosen to match the aggregate capital-labor ratio in the economy since this ratio is increasing in the share of entrepreneurs that operate the capital-intensive technology. Finally, the death rate ν is chosen to match the exit rate of firms.

Finally, the price of imported goods p_m is set as the numeraire; the average level of productivity μ_z is normalized to 1; and the quantity $\bar{y}^*$ and price $\bar{p}^*$ of the final good in the rest of the world are normalized to 10 and 1, respectively.[26]

[25] I interpret τ broadly, as a residual that captures features not modeled explicitly that are required to reconcile the implications of the model with the amount of trade observed in the data. This parameter may capture more than technological costs to trade internationally. For instance, it may also reflect unmodeled policy distortions or demand-side factors that affect international trade, such as those studied by Fieler (2011).

[26] Note that, in this model, given the calibration approach described above, it is possible to normalize the size of the rest of the world. Specifically, conditional on a value of $\bar{y}$, the calibration approach adjusts τ to match the targeted level of trade without distorting other

4.1.3 Additional moments

In the bottom panel of Table 2, I report additional moments implied by the stationary equilibrium of the model, along with their empirical counterparts, which are not targeted directly in the calibration procedure.

A key ingredient of the model is firm heterogeneity, and I find that the degree to which firms are heterogeneous in the model is close to its empirical counterpart. Specifically, the degree of dispersion in total sales, wage bill, and capital implied is within the same order of magnitude as implied by the data, yet somewhat smaller.

Another key ingredient of the model is frictions in financial markets that distort young firms relative to older ones. I find that the contribution of young firms (less than five years old) to aggregate sales, the wage bill, and capital in the model is close to that observed in the data. This suggests that the extent to which young firms are distorted in the model is similar to that in the data.

However, I find mixed evidence on the extent to which the average growth of firms in the model, another important dimension affected by financial frictions, is consistent with the data. While the average growth of the wage bill is close to that in the data, the model implies total sales that grow faster, on average, while implying that capital grows considerably slower, on average.[27]

4.2 The experiment: Changes in financial development

To study the impact of financial development on international trade flows, I use the model to conduct the following experiment. I compute the stationary equilibrium of the calibrated economy and then contrast its allocations with those of two economies at different levels of financial development. In the first economy, to examine the allocations implied by the model in an environment in which firms have no access to external finance, I set θ to zero, while keeping all other parameters fixed. In the second economy, I set θ to match the highest ratio of credit to value added observed in cross-country data, which I interpret

outcomes in the economy.

[27] The slower average growth of the capital stock in the model shows that the extent to which firms can overcome financial frictions may be understated, suggesting that the quantitative results from the following sections may overstate the impact of financial frictions.

as an economy with highly developed financial markets.[28] Specifically, I choose θ to target Japan's average ratio of private credit to value added, equal to 1.63, as reported by Manova (2013), based on data from 1980-1997. The value of θ required to match this moment, while keeping all other parameters fixed, is 0.61.

4.3 Industry-level implications

I first ask: to what extent do financial frictions reduce the share of output that is traded internationally across industries that differ in their dependence on external finance?

I report the outcomes of the counterfactual experiment in Table 3. Each column of the table reports the equilibrium outcomes corresponding to the different economies under study. I label the economy with $\theta = 0$ as "No credit," the baseline calibration with $\theta = 0.18$ as "Baseline," and the economy with $\theta = 0.61$ as "High credit." Except for the bottom panel, which reports the equilibrium prices, the rows of the table separately report the equilibrium outcomes corresponding to each of the two types of entrepreneurs, or industries, in the economy. I label the entrepreneurs that operate the technology with capital share α_h as "High capital share" and those that operate the technology with capital share α_l as "Low capital share."

I find that, as the financial constraint is relaxed, the capital-intensive industry increases the share of output exported — from 0.36 in the economy with no credit, to 0.39 in the high-credit environment. While the increase is modest, it suggests that financial frictions distort firms' export decisions relatively more than their domestic market sales: as these frictions are relaxed, industry-level exports feature a relatively larger increase than domestic sales.

In contrast, I find that the trade share decreases sharply in the non-capital-intensive industry when financial frictions are relaxed — from 0.28 in the economy with no credit, to 0.09 in the economy with developed financial markets.

[28] While the allocations in a frictionless environment can be computed by setting $\theta = \infty$, I restrict attention to degrees of financial development feasible to the most advanced economies of the world. In this sense, I study the impact of improving financial markets to the level of developed economies, rather than to some abstract frictionless counterpart.

Table 3: Industry-level implications, model

		No credit	*Baseline*	*High credit*
$\frac{\text{Exports}}{\text{Domestic sales}}$	High capital share	0.36	0.37	0.39
	Low capital share	0.28	0.24	0.09
Share of exporters	High capital share	0.30	0.33	0.42
	Low capital share	0.17	0.13	0.04
Prices	w	0.62	0.65	0.81
	p	0.64	0.63	0.59

While apparently at odds with the earlier discussion in Section 3, the response of the trade share is driven by the impact of financial development on general equilibrium prices, which offset the mechanisms examined in the previous section. I discuss these forces in more detail below.

The response of industry-level trade shares to an increase in θ depends on the relative magnitude of two opposing forces. On the one hand, financial development increases the amount that firms can borrow, allowing them to operate at a higher scale and to afford the export entry costs, leading to a higher trade share, as discussed in Section 3. On the other hand, this increase in the scale of firms leads to an increased demand for labor that bids up the wage, thereby increasing firms' costs while reducing their profits and the returns to exporting. The overall effect on the trade share, then, depends on the relative magnitude of these two opposing forces: to the extent that the former dominates the latter, the trade share increases — and vice-versa.

The differential response of the trade share across industries is driven by differences in the relative importance of these forces. Production decisions are relatively more distorted by financial frictions in the capital-intensive industry, given that such firms have a higher optimal level of capital. These distortions reduce the internal and external funds available to finance the export entry investment, as well as the returns from doing so. Thus, capital-intensive firms experience a relatively larger increase in the incentives to trade when financial markets develop.

In contrast, the increase in labor costs with the development of financial markets impacts the non-capital-intensive industry relatively more, given its higher use of labor in production. Therefore, firms in the capital-intensive industry experience a relatively larger net increase in the incentives to trade than non-capital-intensive producers, which explains the differential response of industry-level trade shares across industries.

These findings show that financial development leads to a large reallocation of trade shares across industries. In Section 5, I study the extent to which the industry-level implications of the model are quantitatively consistent with empirical estimates of these effects.

4.4 Aggregate implications

Next, I ask: to what extent do financial frictions reduce the share of output that is traded internationally at the aggregate level?

To answer this question, I compute the aggregate trade share for each of the economies studied in the previous subsection. I report these results in Table 4. As before, each column reports the equilibrium outcomes corresponding to the various economies.

With a looser financial constraint, the aggregate ratio of credit to value added increases sharply, from 0.00 to 1.63, as firms increase the amount that they borrow. Less intuitively, however, I find that, even though the aggregate amount of credit increases as sharply as it does, the more relaxed financial constraints lead to a negligible increase in the aggregate trade share – it increases from 0.33 to 0.35 as we move from an economy without credit to its financially developed counterpart. These findings show that, while financial frictions lead to a strong reallocation of industry-level trade flows, these do not translate to strong effects on the extent of international trade at the aggregate level.

As reported in Table 4, financial development not only increases the capital-intensive industry's trade share, but the share of domestic output that it produces relative to the non-capital-intensive industry. Specifically, this share increases from 0.66 in the environment without credit, to 0.87 in its financially developed counterpart. These increases offset the sharp decrease of the trade share in the non-capital-intensive industry, leading to a negligible change

Table 4: Aggregate implications

	No credit	*Baseline*	*High credit*
Credit / Value added	0.00	0.33	1.63
Exports / Domestic Sales	0.33	0.33	0.35
Share of domestic output by α_h firms	0.66	0.71	0.87

in the aggregate trade share.[29]

The reallocation of domestic output towards the capital-intensive industry is driven by the same factors behind the reallocation of industry-level trade shares. As financial development leads firms in each industry to increase their scale, they increase their demand for labor and bid up the wage. This increases marginal costs and reduces profits, impacting non-capital-intensive firms relatively more, given their relative intensity in labor for production. Therefore, we observe an increase in the relative contribution of the capital-intensive industry to the total amount of output sold domestically.

These findings stand in sharp contrast to the strong industry-level relationship between trade and finance previously documented in the literature. While such an empirical relationship may suggest that financial frictions also distort international trade flows at the aggregate level, my findings imply that this need not be the case: the model implies that, while financial development can lead to a large reallocation of trade shares at the industry level, it can also lead to a negligible change in the share of output traded internationally at the aggregate level.

5 Empirical evidence

In this section, I contrast the model's quantitative implications at the industry and aggregate levels with estimates from cross-country industry-level data.

[29]Note that the aggregate trade share can be expressed as a weighted sum of the industry-level trade shares, with the weights given by the relative size of each industry in the domestic market: $\frac{X}{D} = \frac{D_l}{D_l+D_h} \times \frac{X_l}{D_l} + \frac{D_h}{D_l+D_h} \times \frac{X_h}{D_h}$ where, to simplify the notation, X and D denote aggregate exports and domestic sales, respectively, while X_i and D_i denote industry i's exports and domestic sales, respectively, for $i \in \{l, h\}$.

5.1 Industry-level estimates

I first ask: to what extent are the implications of the model consistent with the relationship between financial development and international trade observed in the data at the industry level?

To answer this question, I construct an empirical counterpart to the industry-level implications of the model. To do so, I use cross-country industry-level data to estimate the trade share of an industry in a given country as a function of two key variables: a measure of the country's level of financial development and its interaction with a measure of the industries' degree of dependence on external finance. Then, for industries with different degrees of dependence on external finance, I use the estimated specification to compute the change of industry-level trade shares associated with a change in the extent of financial development. Finally, I contrast these empirical estimates with the implications of the model presented above.

5.1.1 Empirical specification

Equations (1) and (2) of the model imply that the trade share of an industry that operates a production technology with capital-intensity $\alpha_j \in \{\alpha_l, \alpha_h\}$ is given, in logs, by:

$$\ln \frac{\text{Exports}_j}{\text{Domestic sales}_j} = \ln \left(\frac{\bar{p^*}^{\sigma} \bar{y}^*}{p^{\sigma} y} \right) + (1-\sigma) \ln \tau + \ln E_j + \ln \left[\frac{\frac{1}{E_j} \int_{\mathcal{X}_j} \left[z \left(\frac{r+\delta}{r+\delta+\mu_\theta(s)} \right)^{\alpha_j} \right]^{\sigma-1} \phi(s) ds}{\int_{\mathcal{S}_j} \left[z \left(\frac{r+\delta}{r+\delta+\mu_\theta(s)} \right)^{\alpha_j} \right]^{\sigma-1} \phi(s) ds} \right],$$

where, as above, $\mathcal{S}_j \subset \mathcal{S}$ denotes the set of all entrepreneurs that operate a technology with capital intensity α_j, and $\mathcal{X}_j \subset \mathcal{S}_j$ denotes the subset of these that export.

To obtain an empirical counterpart of this expression, I extend the empirical specification of Manova (2013) and Beck (2003) and estimate it using a cross-country panel of industry-level data. Notice that the first two terms in the expression above are only a function of country-level characteristics (such as the level of development of financial markets, the distribution of productivity across plants, and the variable trade cost) and, thus, are identical for all industries in a given economy. The third and fourth terms, however, are also a function of industry-specific features, such as the extent to which the industry depends on external finance.

Therefore, I estimate an industry's trade share as a function of both a country-level measure of financial development and its interaction with an industry-level measure of external-finance dependence. I also include country, industry, and year fixed effects to control for systematic differences in industry-level trade shares unrelated to financial development:

$$\ln \frac{\text{Exports}_{ijt}}{\text{Domestic sales}_{ijt}} = \alpha_i + \beta_j + \gamma_t + \frac{\text{Credit}_{it}}{\text{GDP}_{it}} \left[\omega_1 + \omega_2 \times \text{EFD}_j\right] + \varepsilon_{ijt},$$

where i, j, and t index countries, industries, and years, respectively; α_i, β_j, and γ_t are fixed effects corresponding to the different countries, industries, and years, respectively; $\frac{\text{Exports}_{ijt}}{\text{Domestic sales}_{ijt}}$ denotes the ratio of total exports to the rest of the world to total domestic sales in industry j, country i, and year t; $\frac{\text{Credit}_{it}}{\text{GDP}_{it}}$ denotes country i's ratio of credit to GDP, which is a widely-used outcome-based measure of financial development; EFD_j denotes a measure of industry j's external finance dependence; and, finally, ε_{ijt} is an error term.

Throughout the next subsection, I restrict attention to ω_1 and ω_2, which capture the empirical relationship between industry-level trade shares and both the country-level degree of financial development and the industries' need for external finance. These are the main objects that I use to construct an empirical counterpart of the model's industry-level implications.

5.1.2 Data

The data that I use in this section consist of the dataset constructed by Manova (2013), which I downloaded from the publisher's website and adjusted accordingly to estimate the empirical specification above. The dataset has a panel structure with 107 countries and 27 sectors at the 3-digit ISIC rev. 2 level, which are observed over the period 1985-1995.

To construct the industry-level trade shares, I compute the ratio between exports and domestic sales. Exports are obtained from Feenstra's *World Trade Database* and aggregated to the 3-digit ISIC rev. 2 level using Haveman's concordance tables. Domestic sales are computed by subtracting exports from total sales, as measured by the United Nations Industrial Development Organization (UNIDO) at the 3-digit ISIC rev. 2 level.[30]

Country-level credit-to-GDP is obtained from Beck, Demirguc-Kunt, and Levine (2010) and covers the total amount of credit issued by banks and other financial intermediaries to the private sector. This variable ranges from 0.04 in Guinea-Bissau in 1989, to 1.79 in Japan in 1995 (as mentioned above, Japan's average over the whole sample is 1.63). The mean of this variable is 0.40, and its standard deviation is 0.35.

External-finance dependence at the industry level is measured as the share of capital expenditures not financed with cash flows from operations, as defined by Rajan and Zingales (1998). I use the measure constructed by Braun (2003), based on data for all publicly-listed US-based companies from Compustat's annual industrial files. This variable ranges from -0.45 in the tobacco industry to 1.14 in the plastic products industry, with a mean value of 0.25 and a standard deviation of 0.33.

5.1.3 Regression estimates

Table 5 reports the ordinary least squares (OLS) estimates of the empirical specification above. Only the coefficients on the aggregate ratio of credit to GDP and its interaction with external finance dependence are reported since these are the main objects of interest. Note, however, that fixed effects for each country, industry, and year are included in the estimated regression.

To examine the implied relationship between financial development and international trade across industries with heterogeneous dependence on external finance, I compute the partial derivative of the trade share (in logs) with respect to the credit-to-GDP ratio, which is given by $\omega_1 + \omega_2 \times \text{EFD}_j$. The estimates of ω_1 and ω_2, both of which are statistically significant, imply that, in countries with more-developed financial markets, finance-intensive industries have relatively higher trade shares. These estimates are qualitatively consistent with the model's industry-level implications.

[30] Observations with negative industry-level domestic sales are dropped.

Table 5: Industry-level implications, regression estimates

	ln(Exports/Domestic sales)
Credit/GDP	-0.73
	(0.14)
Credit/GDP × EFD	0.68
	(0.10)
R^2	0.49
# of observations	15,945

Note: Fixed effects for each country, industry, and year are included. Heteroskedasticity-robust standard errors are reported in parentheses.

5.1.4 Model vs. empirical estimates

I now study the extent to which the model's industry-level implications are quantitatively consistent with the empirical estimates reported in the previous subsection.

To do so, I use the regression estimates reported above to compute the change in industry-level trade shares associated with a change in the aggregate credit-to-GDP ratio of the same magnitude implied by the model between the no-credit and high-financial-development economies — that is, an increase in this variable from 0.00 to 1.63.

To construct an empirical counterpart to the change in the trade shares featured by the model's capital-intensive and non-capital-intensive industries, I evaluate, respectively, the estimated regression at the highest and lowest levels of external-finance dependence observed in the data.[31] This choice is consistent with my calibration of the model's industry-level capital shares at the highest and lowest values estimated across industries: note that the model implies a monotonic relationship between the empirical measure of external finance dependence and industry-level capital shares.

Table 6 reports the results from this empirical exercise, along with their model counterparts (in log-changes). I find that the change in industry-level trade shares, implied by the model in response to the development of financial markets, is quantitatively consistent with the relationship between them

[31] I restrict attention to the set of industries observed in both datasets, which leads me to exclude ISIC rev. 2 code 314 (tobacco).

Table 6: Industry-level implications, model vs. data

External finance dependence	*Model*	*Data*
High	0.08	0.08
Low	-1.14	-1.31

Note: "High external-finance dependence" corresponds to the industry with high capital share in the model, and to the industry with the highest external finance dependence in the data. Similarly, "Low external-finance dependence" corresponds to the industry with low capital share in the model, and to the industry with the lowest external finance dependence in the data.

implied by the empirical specification estimated above.

I first find that the model, as well as its empirical counterpart, imply that financial development is associated with an increase in the trade share of the industry with high external finance dependence. Moreover, I find that they imply a modest increase in this share: by approximately 0.08 log-points in both the model and the data. On the other hand, I find that there is a very sharp decrease in the trade share of the industry with low dependence on external finance: by 1.14 and 1.31 log-points in the model and the data, respectively. Thus, the model can account for 98% and 86%, respectively, of the change in the trade shares of the capital- and non-capital-intensive industries, implied by the empirical specification estimated above.[32]

Therefore, I conclude that the model can quantitatively capture the empirical relationship between industry-level trade shares and financial development across industries that differ in their dependence on external finance. These findings provide further support to the industry-level and aggregate implications of the model, as well as to the importance of the mechanisms at play.

5.2 Aggregate-level estimates

Finally, I contrast the aggregate implications of the model with evidence from the data. Specifically, I ask: what is the empirical relationship between financial development and international trade at the aggregate level?

To answer this question, I aggregate the cross-country industry-level dataset across industries and estimate a country-level empirical specification

[32] These empirical estimates are robust to controlling for the measure of asset tangibility used by Manova (2013), GDP per capita, or the average distance from the country's trade partners.

that is consistent with my quantitative model. I then examine the statistical significance of the link between the development of financial markets and the extent of international trade at the aggregate level.

Note that the trade share expression from Section 3 can be used to derive an empirical specification analogous to that of the industry-level empirical analysis above. The only difference here is that industry-level fixed effects need to be excluded. Then, I estimate:

$$\ln \frac{\text{Exports}_{it}}{\text{Domestic sales}_{it}} = \alpha_i + \gamma_t + \omega \frac{\text{Credit}_{it}}{\text{GDP}_{it}} + \phi \ln \text{Distance}_{it} + \mu \ln \text{GDP per capita}_{it} + \varepsilon_{it},$$

where i and t index countries and years, respectively; α_i and γ_t are country and year fixed effects, respectively; $\frac{\text{Exports}_{it}}{\text{Domestic sales}_{it}}$ denotes the ratio of total exports to the rest of the world to total domestic sales in country i and year t; $\frac{\text{Credit}_{it}}{\text{GDP}_{it}}$ denotes country i's ratio of credit to GDP; Distance_{it} is the trade-weighted average distance between country i and its trade partners, while $\text{GDP per capita}_{it}$ denotes country i's GDP per capita in year t according to data from Penn World Tables 6.1; and, finally, ε_{it} is an error term. I include distance and GDP per capita to control for potential omitted variables bias through their simultaneous correlation with financial development and international trade. I report results with and without controlling for these variables.

Table 7 reports the estimation results. I find that the relationship between financial development and aggregate trade shares is not statistically significant, with and without controlling for distance and economic development. These estimates are consistent with the aggregate implications of the structural model examined above: they suggest that financial development has a negligible impact on the aggregate trade share, despite the strength of its effects at the industry level.

6 Conclusion

In this paper, I investigate the industry-level and aggregate implications of financial development on international trade. To do so, I study a general

Table 5: Aggregate-level implications, regression estimates

	ln(Exports/Domestic sales)	
Credit/GDP	0.18	-0.26
	(0.23)	(0.16)
GDP per capita and distance	No	Yes
R^2	0.83	0.86
# of observations	795	754

Note: Fixed effects for each country and year are included. GDP per capita and the average distance between the country and its export destinations are both in logs. Heteroskedasticity-robust standard errors are reported in parentheses.

equilibrium model with heterogeneous firms subject to borrowing constraints and export entry costs, estimated using Chilean plant-level data. I find that financial frictions have a large impact on the extent of international trade across industries with different degrees of dependence on external finance — an impact that is quantitatively consistent with empirical estimates of this relationship. However, I find that the model implies that financial frictions have a negligible effect on the extent of international trade at the aggregate level. I show that empirical estimates are also consistent with this finding. General equilibrium effects lead to a reallocation of trade shares and production across industries, offsetting the impact of financial development on the aggregate trade share.

Recent studies have documented a strong relationship between measures of access to external finance and the extent of international trade at both the firm and industry levels, suggesting that there may be large gains from financial development via international trade. My findings show that, while financial frictions may have a significant impact on the extent of international trade across industries, they need not have a large impact at the aggregate level. Thus, my findings point to the importance of general equilibrium effects in interpreting firm- or industry-level evidence. While some distortions can appear to play an important role when studying firms or industries in isolation, their importance at the aggregate level may sometimes be offset by changes in equilibrium prices.

Appendix

In this Appendix I derive a reformulation of the entrepreneurs' problem with one less endogenous state variable that is equivalent to the problem presented in the paper. This reformulation simplifies the analysis of the model and its numerical solution. Let $a := k - \frac{d}{1+r}$ denote the entrepreneurs' net worth at the beginning of the period, before interest is paid. I now show that the entrepreneurs' problem can be reformulated with a as a state variable, instead of k and d.

Starting from the recursive formulation of the entrepreneurs' problem, plug the law of motion for capital into the budget constraint and use the definition of a' to obtain:

$$pc + (1-\nu)pa' + pd + wn + wF\, \mathbb{I}_{\{e=0,e'=1\}} = w + p_h y_h + p_f y_f + (1-\delta)pk - T,$$

Next, note that the entrepreneur's problem can be rewritten as:

$$v\left(k,d,e;z,\alpha\right) = \max_{c,a',n,p_h,p_f,y_h,y_f,e'\in\{0,1\}} \frac{c^{1-\gamma}}{1-\gamma} + \beta(1-\nu)g\left(a',e';z,\alpha\right)$$

subject to

$$pc + (1-\nu)pa' + pd + wn + wF\, \mathbb{I}_{\{e=0,e'=1\}} = w + p_h y_h + p_f y_f + (1-\delta)pk - T$$

$$y_h + \tau y_f = zk^{\alpha}n^{1-\alpha}, \quad y_h = \left(\frac{p_h}{p}\right)^{-\sigma} y, \quad y_f = \left(\frac{p_f}{\bar{p}^*}\right)^{-\sigma} \bar{y}^*,$$

where $g(a,e;z,\alpha)$ is given by

$$g\left(a,e;z,\alpha\right) = \max_{k,d} v\left(k,d,e;z,\alpha\right)$$

subject to

$$a = k - \frac{d}{1+r}$$

$$pd \leq \theta pk.$$

Now, plugging $v\left(k,d,e;z,\alpha\right)$ into $g(a,e;z,\alpha)$, and $d = (1+r)\left(k-a\right)$ into both the budget constraint and borrowing constraint, we obtain:

$$g\left(a,e;z,\alpha\right)=\max_{c,a',n,k,p_h,p_f,y_h,y_f,e'\in\{0,1\}}\frac{c^{1-\gamma}}{1-\gamma}+\beta(1-\nu)g\left(a',e';z,\alpha\right)$$

subject to

$$pc+(1-\nu)pa'+(r+\delta)pk+wn+wF\,\mathbb{I}_{\{e=0,e'=1\}}=w+p_hy_h+p_fy_f+(1+r)pa-T$$

$$pk(1+r-\theta)\leq(1+r)pa$$

$$y_h+\tau y_h=zk^{\alpha}n^{1-\alpha},\quad y_h=\left(\frac{p_h}{p}\right)^{-\sigma}y,\quad y_f=\left(\frac{p_f}{\bar{p}^*}\right)^{-\sigma}\bar{y}^*,$$

I, then, redefine the state space of entrepreneurs $\mathcal{S}:=\mathcal{A}\times\mathcal{E}\times\mathcal{Z}\times\mathcal{I}$, where $\mathcal{A}$ denotes the set of possible values of net worth. For a related derivation, see Buera and Moll (2013).

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