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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 input-output linkages and heterogeneous firms subject to financial frictions. Industries differ in capital-intensity, which leads to differences in external finance dependence. The model is parameterized to match key features of firm-level data. Financial development leads to substantial reallocation of international trade shares from labor- to capital-intensive industries, with minor effects at the aggregate-level. These findings are consistent with estimates from cross-country industry-level and aggregate data.

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1 Introduction

International trade barriers are large, particularly in developing countries. While recent studies estimate large gains from reducing them, identifying specific policies that may allow poor countries to do so remains an important challenge.[2]

Several studies 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, document 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 (2016) and Gross and Verani (2013), find that financial frictions are a key driver of the dynamics of new exporters, suggesting they are an important barrier to international trade.

Several features of international trade indeed make it a more finance-intensive activity than production for the domestic market. For instance, entering a foreign market typically involves a variety of upfront investments, such as market research, product customization, or the development of distribution networks (Baldwin and Krugman 1989, Dixit 1989). Continuing to export can also be costly, for instance involving upfront costs to maintain distribution networks or to update products. Then, limited access to external finance can prevent firms with low internal funds from undertaking such export-specific expenditures. Similarly, international trade transactions are typically subject to higher variable trade costs, due to shipping expenses, du-

[2]Anderson and van Wincoop (2004) show that international trade barriers are large in developing countries. Waugh (2010) estimates large welfare gains from reducing them to the level of developed 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) document additional firm-level evidence. For a more exhaustive review of the empirical evidence, see Contessi and de Nicola (2013).

ties, or freight insurance. By lowering profits from foreign sales, these costs reduce the extent to which firms can use them to overcome distortions on export decisions along the intensive margin.[4]

The goal of this paper is to investigate the industry-level and aggregate implications of financial development on international trade through the lens of a standard general equilibrium model of international trade with one key ingredient: frictions in financial markets. I study a multi-industry model with input-output linkages in which firms heterogeneous in productivity produce goods with capital, labor, and intermediate inputs subject to credit constraints. Individuals endogenously choose whether to be workers or entrepreneurs, and entrepreneurs endogenously choose the industry in which to operate. Among other dimensions, industries differ in capital-intensity, which leads to differences in their dependence on external finance. International trade is subject to export entry costs, fixed export costs, and variable trade costs.[5] Exporting is more finance-intensive than domestic sales since export entry costs and fixed export costs need to be paid upfront. I parameterize the model to match key features of firm-level data and use it to quantify the impact of financial frictions on international trade relative to production sold domestically.

Financial frictions affect industry-level and aggregate trade shares through two key channels. First, financial frictions distort the production decisions of exporters relative to non-exporters, reducing the share of output that is sold internationally. While financial frictions reduce the production scale of both exporters and non-exporters by limiting the amount of capital 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 the decision to export, leading firms to delay export entry until sufficient internal funds are accumulated to

[4]Foley and Manova (2015) survey recent studies that investigate various channels through which financial frictions distort international trade decisions.

[5]International trade is modeled following Melitz (2003) and Chaney (2008), with dynamic features from Alessandria and Choi (2014b). Financial frictions are modeled following Midrigan and Xu (2014) and Buera and Moll (2015). The approach to modeling the interaction between financial frictions and international trade builds on earlier theoretical work by Chaney (2016) and Manova (2013).

make it a profitable 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 estimate the parameters of the model to match key moments from Chilean firm-level data. I follow a Simulated Method of Moments (SMM) approach by targeting moments of the data informative about firms' export decisions and the extent to which financial constraints distort production, among other dimensions targeted.

I use the parameterized economy as a laboratory to study the impact of financial frictions on international trade at the industry and aggregate levels. To do so, I contrast the stationary equilibrium of the estimated model with the stationary equilibria of economies featuring alternative levels of financial development. On the one hand, I contrast the estimated model to an economy without credit. On the other hand, I contrast it to 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 development has a heterogeneous impact across industries. In capital-intensive industries, highly dependent on external finance, relaxing the financial constraint increases the trade share since it allows more firms to finance the entry and fixed export costs and to increase their scale relative to non-exporters. In contrast, the trade share decreases in labor-intensive industries, with low dependence on external finance, since higher equilibrium prices of production inputs offset the increased incentives to trade and expand 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 use the model to derive an empirical specification that explains an industry's trade share in a given country and year as a function of the country's level of financial development, the industry's capital intensity, and the interaction between them. I estimate the empirical specification using the cross-country industry-level dataset from Manova (2013), with financial development measured as the ratio of aggregate credit to GDP. I extend this dataset to include a measure of industry-level capital intensity, which I compute using firm-level U.S. data from Compustat following the approach of Rajan and Zingales (1998). Finally, I use the estimated specification to compute the change of industry-level trade shares associated with a change in financial development of the same magnitude implied by the quantitative model.

The empirical estimates are consistent with the industry-level implications of the model. While financial development is associated with an increase of the trade share in capital-intensive industries, it is associated with a decrease of the trade share in labor-intensive ones. Moreover, I find that the trade share changes featured by the industries of the model account for a significant fraction of the changes implied by their empirical counterpart.

I then study the impact of financial development on international trade at the aggregate level. In contrast to the strong relation between trade and finance implied by the model at the industry level, I find that financial development leads to a modest increase of the trade share in the aggregate. The substantial reallocation of industry-level trade shares largely offset each other, leading to a significantly smaller change of the aggregate trade share.

To contrast these findings with estimates from data at the country-level, I aggregate the cross-country industry-level dataset from Manova (2013) across industries. I use these data to examine the relation between financial development and aggregate trade shares using a specification analogous to the one estimated at the industry level.[6] Consistent with the implications of the model, the empirical estimates imply that there is a positive but mild relation between financial development and the aggregate trade share.[7]

I then investigate the welfare implications of these findings. I find that

[6] Evidence on the aggregate relation between trade and finance has been elusive given the challenge to interpret such estimates causally. 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.

[7] While Beck (2002) documents a strong link between trade and finance in the aggregate, his measures of interest (the ratio of manufacturing exports to total GDP, and the ratio of manufacturing exports to total exports), are not directly comparable to the one I study: they capture the combined impact of financial development on the size of the manufacturing sector and the manufacturing trade share.

financial development leads to nontrivial welfare gains: 6.07% in consumption-equivalence units. However, I find that international trade plays a very minor role in accounting for these gains. These findings are consistent with the aggregate implications of financial development on international trade documented in the paper as well as with previous studies from the literature.

Finally, I show that the findings reported in the paper are robust to alternative modeling assumptions and extensions of the model. I summarize these findings in the paper and report the details in the Online Appendix.

This paper is closely related to previous empirical studies, such as Beck (2003) and Manova (2013), which investigate the relation between financial development and the level of international trade flows across industries. These studies document that better financial markets lead to relatively larger trade flows in finance-intensive industries. I quantify the aggregate implications of their findings by setting up a state-of-the-art quantitative general equilibrium model of international trade and disciplining it to match salient features of firm-level data. In doing so, I document the underlying qualitatively heterogeneous response of trade shares across industries: financial development is associated with higher trade shares in capital-intensive industries, but with lower trade shares in labor-intensive ones.[8] The quantitative implications of the model suggest that the strong reallocation observed in the data is, to a large extent, a causal response to the development of financial markets. My findings show that this heterogeneity across industries is key for understanding the aggregate impact of financial development on international trade.

This paper is also related to 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 (2020), Caggese and Cuñat (2013), and Kohn, Leibovici, and Szkup (2020b) investigate their quantitative impact on the gains from reducing trade barriers. My paper combines the quantita-

[8]In the Online Appendix I also investigate the impact of financial development on the level of international trade flows.

tive approach of the latter with the multi-industry approach of the former to investigate the extent to which frictions in financial markets act as a barrier to international trade.[9]

Finally, this paper is also broadly related to a literature that investigates the role of domestic institutions as a barrier to 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 the extent to which this is the case for frictions in financial markets.

The paper is organized as follows. Section 2 presents the model. Section 3 discusses the channels through which financial frictions distort international trade flows. Section 4 presents the quantitative analysis. Section 5 contrasts the quantitative findings with estimates from the data. Section 6 concludes.

2 Model

The model consists of an economy populated by a unit measure of infinitely-lived individuals who choose whether to be workers or entrepreneurs. Entrepreneurs choose the tradable sector in which to operate, and produce differentiated varieties that can be sold domestically and abroad. The economy is also populated by the rest of the world, by representative producers of sectoral tradable and non-tradable goods, and by representative producers of final goods.

There are five types of goods in the economy: domestic tradable varieties, imported tradable varieties, sectoral tradable and non-tradable goods, and final goods. Domestic tradable varieties are produced by entrepreneurs with labor, capital, and intermediate inputs according to the input-output structure of the economy, while imported tradable varieties are produced by the rest of the world; these are the only goods that can be traded internationally. Sectoral tradable goods are produced by aggregating domestic and imported

[9] See also Kohn, Leibovici, and Szkup (2020a) and Jiao and Wen (2019) for related quantitative studies of the interaction between credit market frictions and trade.

tradable varieties, while sectoral non-tradable goods are produced using labor and intermediate inputs according to the sector's input-output linkages with the rest of the economy. Sectoral tradable and non-tradable goods are used to produce final goods and as intermediate inputs. Final goods are used by all individuals for consumption, and entrepreneurs also use them for investment.

Individuals are indexed by i, while sectors are indexed by j and q. Variables corresponding to domestic sales, exports, and imports have d, x, and m superscripts, respectively.

2.1 Individuals

2.1.1 Preferences

Individuals have 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 of an individual i is given by $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{c_{it}^{1-\gamma}}{1-\gamma}$, 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 idiosyncratic productivity process described below, conditional on the information set in period zero.[10]

2.1.2 Occupational choice

Every period individuals choose whether to be workers or entrepreneurs. Individuals that choose to be entrepreneurs then decide in which tradable sector $j = 1, ..., .J$ to operate, where J denotes the number of tradable sectors in the economy. To operate in sector j, entrepreneurs are required to pay a per-period fixed cost of operation ζ_j denominated in units of labor; choosing to be a worker is costless. As described below, tradable sectors also differ in the production technology operated by entrepreneurs and the trade costs that they face. Throughout the paper, I use the terms "sectors" and "industries" interchangeably.

An individual i's occupational choice is denoted as $\mathcal{o}_{it} \in \{W, 1, ..., J\}$, where $\mathcal{o}_{it} = W$ if the individual chooses to be a worker and $\mathcal{o}_{it} = j$ if the individual chooses to be an entrepreneur in tradable sector $j = 1, ..., J$.

[10] If $\gamma = 1$, the utility function is given by $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \ln c_{it}$.

2.1.3 Workers

Individuals that choose to be workers supply labor inelastically to producers of tradable and non-tradable goods through a competitive labor market. They supply one unit of labor and are paid a wage rate w_t. Workers then allocate their labor income and savings from previous periods between consumption and savings to carry over to the following period at a risk-free interest rate r; workers cannot borrow.

2.1.4 Entrepreneurs

Technology An entrepreneur i that chooses to operate in tradable sector $j = 1, ..., J$ produces a differentiated variety with a constant-returns-to-scale production technology $y_{it} = z_{it} \left(k_{it}^{\alpha_j} n_{it}^{1-\alpha_j} \right)^{1-\varphi_j} \left(\prod_{q=0}^{J} h_{it}^{q\,\Omega_{jq}} \right)^{\varphi_j}$, where y_{it} denotes the quantity produced by entrepreneur i in period t, z_{it} is its idiosyncratic level of productivity; k_{it} is its capital stock; n_{it} is the amount of labor hired; h_{it}^{q} is the amount of intermediate inputs from sector $q = 0, 1, ..., J$ that are used in production, where $q = 0$ denotes demand for non-tradable goods; $\varphi_j \in (0, 1)$ is the share of intermediate inputs in gross output; $\Omega_{jq} \in (0, 1)$ is the share of intermediate inputs purchased from sector q; and $\alpha_j \in (0, 1)$ is the capital share in value added.[11,12]

Idiosyncratic productivity z_{it} is individual-specific, common across sectors, and follows an autoregressive process of degree one, $\ln z_{it} = (1 - \rho_z) \ln \mu_z + \rho_z \ln z_{i,t-1} + \varepsilon_{it}$, where ε_{it} is an *i.i.d.* shock distributed Normal with mean zero and standard deviation σ_z.

Each entrepreneur accumulates capital internally by transforming final goods invested in period t, ν_{it}, into physical capital $k_{i,t+1}$ in period $t + 1$. Capital depreciates at rate δ after being used for production, leading to a law of motion for capital given by $k_{i,t+1} = (1 - \delta) k_{it} + \nu_{it}$.

International trade Entrepreneurs in tradable sector $j = 1, ..., J$ can trade internationally. To export, they need to pay export entry costs and fixed ex-

[11] $\sum_{q=0}^{J} \Omega_{jq} = 1$ for every $j = 0, 1, ..., J$.

[12] Sector j subscripts are omitted from the variables in the production technology given in each period entrepreneurs can only choose to operate in one sector; thus, all output and factor inputs correspond to the sector chosen.

port costs. Export entry costs ξ_0 are common across sectors and only paid if entrepreneurs didn't export in the previous period; in contrast, fixed export costs $\xi_{1,j}$ are sector-specific and paid every period. Both ξ_0 and $\xi_{1,j}$ are denominated in units of labor. Exporters are also subject to sector-specific per-period ad-valorem iceberg trade costs $\tau_j > 1$, which require firms to ship τ_j units of the good exported for every unit sold at destination.

Following Manova (2013) and Chaney (2016), entrepreneurs need to pay the fixed and entry costs of exporting before production takes place and revenues are received, making exporting more finance-intensive than domestic sales.

Financial markets Entrepreneurs have access to an internationally integrated financial market, in which they can save or borrow from each other, from workers, and from the rest of the world by trading a one-period risk-free bond. The bond is denominated in units of the final good and trades at interest rate r.

Entrepreneurs can borrow but are subject to a borrowing constraint, which limits the amount owed to a fraction θ of the value of the capital stock at the time that the loan is due for repayment. Thus, in period t entrepreneurs can borrow an amount $\frac{b_{i,t+1}}{1+r}$ that requires the payment of $b_{i,t+1}$ units of final goods in period $t+1$. The borrowing constraint is then given by $p_{t+1}b_{i,t+1} \leq \theta p_{t+1}k_{i,t+1}$ and the natural borrowing limit, where p_{t+1} denotes the price of final goods.

Market structure Within each tradable sector $j = 1, ..., J$, entrepreneurs compete with each other and with producers of imported varieties under monopolistic competition, and choose the quantities and prices for each market subject to their respective demand schedules. In the domestic market, the demand schedule faced by entrepreneurs in sector j is such that it solves its respective sectoral 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.

For an entrepreneur i who chooses to operate in sector $o_{it} = 1, ..., J$, I denote the quantity produced and priced charged in the domestic market by

y_{it}^d and p_{it}^d, and their corresponding values in the world (or "export") market by y_{it}^x and p_{it}^x, respectively.

2.1.5 Timing protocol

A period begins with a partition of individuals between workers and entrepreneurs, and a partition of entrepreneurs across tradable sectors $j = 1, ..., J$ and export status. Then, the timing of the decisions of individuals is as follows. Workers begin the period by supplying labor to both entrepreneurs and producers of non-tradable goods. Entrepreneurs begin the period by hiring labor, purchasing intermediate inputs, producing their differentiated domestic variety, and then selling it in each of the markets in which they chose to operate at the end of the previous period.

After productive activities have taken place, individuals repay the debt taken in the previous period (or receive the savings from the previous period, with interest), and choose how to allocate the remaining resources between consumption and net worth, $a_{i,t+1}$, to carry over to the following period.

At the end of the period, they observe the shock that determines the following period's productivity level and, then, choose next period's occupation: worker or entrepreneur in some tradable sector $j = 1, ..., J$. Finally, entrepreneurs allocate their net worth between savings (or debt), physical capital, and the upfront payment of the fixed and entry costs of exporting if they choose to start or continue exporting in the following period.[13]

2.1.6 Individuals' problem

Given this setup, the problem of each individual i at time zero consists of choosing sequences of consumption c_{it}, net worth a_{it}, and occupations $\mathcal{O}_{it} \in \{W, 1, ..., J\}$, in order to maximize their lifetime expected utility.

In periods in which individuals choose to be workers, these choices are made subject to a sequence of period-by-period budget constraints given by $p_t c_{it} + p_t a_{i,t+1} = w_t + (1+r) p_t a_{it}$. Workers earn income by supplying labor to

[13]The assumption that capital accumulation and savings decisions are made after observing next period's productivity follows Midrigan and Xu (2014) and Buera and Moll (2015), among others. This assumption simplifies the numerical solution of the model by making the capital accumulation decision risk-free; see the Online Appendix for details.

entrepreneurs and from the interest accrued by their net worth. Earnings and net worth accumulated in previous periods are spent between consumption and net worth to carry over to the following period.

Individuals that choose to be entrepreneurs in tradable sector $j \in \{1, ..., J\}$ also choose investment ν_{it}, hire workers n_{it}, purchase intermediate inputs h_{it}^q from each sector $q \in \{0, 1, ..., J\}$, decide whether or not to export e_{it}, and choose prices and quantities y_{it}^d, p_{it}^d, y_{it}^x, p_{it}^x at which to sell their differentiated variety in each of the markets. If they choose to export in period t, then $e_{it} = 1$; otherwise, $e_{it} = 0$. In addition to the borrowing constraint $p_{t+1}b_{i,t+1} \leq \theta p_{t+1}k_{i,t+1}$ 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, laws of motion of capital $k_{i,t+1} = (1-\delta)k_{it} + \nu_{it}$, production technologies $y_{it} = z_{it}\left(k_{it}^{\alpha_j} n_{it}^{1-\alpha_j}\right)^{1-\varphi_j}\left(\prod_{q=0}^{J} h_{it}^{q\ \Omega_{jq}}\right)^{\varphi_j}$, and allocations of production across markets $y_{it}^d + \tau_j y_{it}^x = y_{it}$. Their budget constraint in period t is given by $p_t a_{it} = p_t k_{it} + w_t \xi_0 \mathbb{I}_{\{e_{it}=1, e_{i,t-1}=0\}} + w_t \xi_{1,j} \mathbb{I}_{\{e_{it}=1\}} - \frac{p_t b_{it}}{1+r}$ and $p_t c_{it} + p_t a_{i,t+1} + p_t b_{it} + w_t \zeta_j + w_t n_{it} + \sum_{q=0}^{J} p_{qt} h_{it}^q = p_{it}^d y_{it}^d + p_{it}^x y_{it}^x + (1-\delta)p_t k_{it}$, where p_t denotes the price of the final good; $\{p_{qt}\}_{q=0}^{J}$ are the prices of sectoral tradable ($q = 1, ..., J$) and non-tradable ($q = 0$) goods; w_t denotes the wage rate; and $\mathbb{I}_{\{.\}}$ is an indicator function that is equal to one if its argument is true and zero otherwise.[14] Net worth is allocated every period between capital, export entry and fixed costs, and bond-holdings. Entrepreneurs earn income from the profits obtained through the sales of a differentiated variety and from the interest accrued by their net worth. Earnings and net worth accumulated in previous periods are spent between consumption and net worth to carry over to the following period.

2.2 Rest of the world

The rest of the world demands domestic varieties from entrepreneurs (the domestic economy's exports) and supplies foreign varieties to sectoral tradable-

[14] The combined period t budget constraint is given by $p_t c_{it} + p_t \nu_{it} + p_t\left[\frac{w_{t+1}}{p_{t+1}}\xi_0 \mathbb{I}_{\{e_{i,t+1}=1, e_{it}=0\}} + \frac{w_{t+1}}{p_{t+1}}\xi_{1,j}\mathbb{I}_{\{e_{i,t+1}=1\}}\right] + p_t b_{it} + w_t \zeta_j + w_t n_{it} + \sum_{q=0}^{J} p_{qt} h_{it}^q = p_{it}^d y_{it}^d + p_{it}^x y_{it}^x + p_t \frac{b_{i,t+1}}{1+r}$.

good producers (the domestic economy's imports). The demand for varieties produced by an entrepreneur i who chooses to operate in sector $o_{it} \in \{1, ..., J\}$ is assumed to be given by a downward-sloping demand function with constant elasticity of substitution σ, $y_{it}^{x} = \left(\frac{p_{it}^{x}}{\bar{p}^{*}}\right)^{-\sigma} \bar{y}^{*}$, where $\bar{y}^{*}$ and $\bar{p}^{*}$ are parameters that denote aggregate absorption and its associated price index, respectively, in the rest of the world. The supply of varieties from the rest of the world is assumed to be perfectly elastic at price $\bar{p}^{m}$; imports of varieties by sectoral good producer $j \in \{1, ..., J\}$ are subject to the same sector-specific ad-valorem iceberg trade costs τ_j faced by exported varieties within such sector.

Domestic entrepreneurs also trade with the rest of the world in international financial markets, where they face a perfectly elastic supply (or demand) at exogenous interest rate r.

2.3 Producer of sectoral nontradable goods

A representative producer of sectoral nontradable goods operates a constant-returns-to-scale technology that uses labor and intermediate inputs from potentially all sectors of the economy. The technology is such that $n_{0,t}$ units of labor and a bundle of intermediate inputs $\left\{h_{0,t}^{q}\right\}_{q=0}^{J}$ produce $y_{0,t} = n_{0,t}^{1-\varphi_0} \left(\prod_{q=0}^{J} {h_{0,t}^{q}}^{\Omega_{0q}}\right)^{\varphi_0}$ units of nontradable goods, where $\varphi_0 \in (0, 1)$ is the share of intermediate inputs in gross output and $\Omega_{0q} \in (0, 1)$ is the share of intermediate inputs purchased from sector q.

Given the price of sectoral nontradable goods $p_{0,t}$, wages w_t, and prices $\{p_{jt}\}_{j=1}^{J}$ charged by producers of sectoral tradable goods, the producer of sectoral nontradable goods chooses the amount of labor and intermediate inputs from each sector to maximize profits. Then, the problem of the producer of sectoral nontradable goods is given by:

$$\max_{y_{0,t}, n_{0,t}, \left\{h_{0,t}^{q}\right\}_{q=1}^{J}} p_{0,t} y_{0,t} - w_t n_{0,t} - \sum_{q=0}^{J} p_{qt} h_{0,t}^{q}, \quad \text{subject to} \quad y_{0,t} = n_{0,t}^{1-\varphi_0} \left(\prod_{q=0}^{J} {h_{0,t}^{q}}^{\Omega_{0q}}\right)^{\varphi_0}.$$

The solution to this problem implies the price of nontradables is given by:

$$p_{0,t} = \left(\frac{w_t}{1-\varphi_0}\right)^{1-\varphi_0} \left[\prod_{q=0}^{J}\left(\frac{p_{qt}}{\varphi_0\Omega_{0q}}\right)^{\Omega_{0q}}\right]^{\varphi_0}.$$

2.4 Producer of sectoral tradable good $j \in \{1, ..., J\}$

A representative producer of sectoral tradable goods $j \in \{1, ..., J\}$ aggregates domestic and imported varieties to produce sectoral tradable good j. To do so, it operates a constant elasticity of substitution (CES) production technology, with elasticity of substitution $\sigma > 1$.[15]

Let the set $[0, 1]$ index the unit measure of individuals in the economy, and let $\mathcal{S}_{jt} \subset [0, 1]$ denote the set of individuals that choose to be entrepreneurs in each sector $j = 1, ..., J$. Given prices $\left\{p_{it}^d\right\}_{i\in\mathcal{S}_{jt}}$ charged by entrepreneurs in each sector and the price of imported varieties $\bar{p}^m$ charged by the rest of the world, the producer of sectoral tradable good j chooses the bundle of inputs of domestic varieties $\left\{y_{it}^d\right\}_{i\in\mathcal{S}_{jt}}$ and imported varieties y_{jt}^m to maximize profits. The problem of the producer of sectoral tradable good j is then given by:

$$\max_{y_{jt},\left\{y_{it}^d\right\}_{i\in\mathcal{S}_{jt}},y_{jt}^m} p_{jt}y_{jt} - \int_{i\in\mathcal{S}_{jt}} p_{it}^d y_{it}^d di - \tau_j \bar{p}^m y_{jt}^m, \quad \text{subject to} \quad y_{jt} = \left[\int_{i\in\mathcal{S}_{jt}} {y_{it}^d}^{\frac{\sigma-1}{\sigma}} di + {y_{jt}^m}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}},$$

where p_{jt} and y_{jt} denote the price and quantity of sectoral tradable good j. The demand for the variety produced by entrepreneur $i \in \mathcal{S}_{jt}$ is given by $y_{it}^d = \left(\frac{p_{it}^d}{p_{jt}}\right)^{-\sigma} y_{jt}$, while the demand for imported varieties is given by $y_{jt}^m = \left(\frac{\tau_j\bar{p}^m}{p_{jt}}\right)^{-\sigma} y_{jt}$. These demand functions along with the production technology imply that the price p_{jt} of sectoral good j is given by:

$$p_{jt} = \left[\int_{i\in\mathcal{S}_{jt}} {p_{it}^d}^{1-\sigma} di + {p_{jt}^m}^{1-\sigma}\right]^{\frac{1}{1-\sigma}}.$$

[15] The technology to aggregate domestic and imported varieties within tradable sectors follows Armington (1969), Melitz (2003), and Alessandria and Choi (2014b).

2.5 Producer of final goods

Finally, a representative producer of final goods purchases sectoral tradable goods from each sector $j = 1, ..., J$ and sectoral nontradable goods ($j = 0$), and aggregates them to produce a final good. To do so, it operates a constant-returns-to-scale Cobb-Douglas production technology $y_t = \prod_{j=0}^{J} \left(y_{jt}^f\right)^{\Phi_j}$, where y_t denotes the amount of final goods produced, y_{jt}^f denotes the amount of sectoral good j used in the production of final goods; and Φ_j denotes the weight of sectoral good j in the production of final goods, where $\sum_{j=0}^{J} \Phi_j = 1$.[16] Given the price of final goods p_t and prices $\{p_{jt}\}_{j=0}^{J}$ charged by producers of sectoral goods, the producer of final goods chooses the bundle of sectoral goods to maximize profits. Then, its problem is given by:

$$\max_{y_t, \left\{y_{jt}^f\right\}_{j=0}^{J}} p_t y_t - \sum_{j=0}^{J} p_{jt} y_{jt}^f, \quad \text{subject to} \quad y_t = \prod_{j=0}^{J} \left(y_{jt}^f\right)^{\Phi_j}.$$

The optimal demand for sectoral good j by the final good producer is given by: $y_{jt}^f = \Phi_j \frac{p_t y_t}{p_{jt}}$. These demand functions along with the production technology imply that the price of final goods p_t is given by:

$$p_t = \prod_{j=0}^{J} \left(\frac{p_{jt}}{\Phi_j}\right)^{\Phi_j}.$$

2.6 Individuals' problem: Recursive formulation

Consider an individual at the end of a given period, after the following period's productivity level z is realized but before next period's occupation and net worth allocation decisions are made. The state of this individual is given by (a, e, z) and its associated value function is $g(a, e, z)$; with net worth a, export status e (equal to one if the individual exported earlier in the period, and zero otherwise), and productivity level z.[17] The individual first chooses

[16] The technology to aggregate sectoral goods follows Caliendo and Parro (2014), Alessandria and Choi (2014b), and Ruhl (2008), among others.

[17] Period t subscripts are removed to write the problem recursively; for any variable x, I denote its value next period as x'. I also omit i subscripts and, instead, use their state

whether to be a worker, $\mathcal{O}(a,e,z)=W$, or an entrepreneur in a tradable sector, $\mathcal{O}(a,e,z)\in\{1,...,J\}$:

$$g(a,e,z)=\max_{\mathcal{O}\in\{W,1,...,J\}} g_{\mathcal{O}}(a,e,z),$$

where $g_{\mathcal{O}}(a,e,z)$ denotes the value function conditional on occupation $\mathcal{O}\in\{W,1,...,J\}$. If the individual chooses to be a worker, its value is given by:

$$\begin{aligned} &g_W(a,e,z)=\max_b \beta v_W(b,z)\\ &\text{subject to}\quad pa=-\frac{pb}{1+r}, \end{aligned}$$

where $v_W(b,z)$ denotes the value function of a worker that begins the following period with debt level b (savings, if negative) and productivity level z. This value function is given by:

$$\begin{aligned} &v_W(b,z)=\max_{c,a'} \frac{c^{1-\gamma}}{1-\gamma}+\mathbb{E}_z\left[g(a',0,z')\right]\\ &\text{subject to}\quad pc+pa'+pb=w,\quad a'\geq 0. \end{aligned}$$

If the individual chooses to be an entrepreneur in tradable sector $j\in\{1,...,J\}$, the value function is given by:

$$\begin{aligned} &g_j(a,e,z)=\max_{k,b,e'\in\{0,1\}} \beta v_j(k,b,e',e,z)\\ &\text{subject to}\quad pa=pk+w\xi_0\mathbb{I}_{\{e=0,e'=1\}}+w\xi_{1,j}\mathbb{I}_{\{e'=1\}}-\frac{pb}{1+r},\quad pb\leq\theta pk, \end{aligned}$$

where $v_j(k,b,e',e,z)$ denotes the value function of an entrepreneur in tradable sector j with current and previous export decisions e' and e, who begins the period with capital stock k, debt level b, and productivity level z. This function

variables to characterize the problem of the different individuals of the economy.

is given by:

$$v_j(k,b,e',e,z) = \max_{c,a'\geq 0,n,\{h^q\}_{q=0}^{J},p^d,y^d,p^x,y^x} \frac{c^{1-\gamma}}{1-\gamma} + \mathbb{E}_z\left[g(a',e',z')\right]$$

subject to

$$pc + pa' + pb = p^d y^d + p^x y^x \mathbb{I}_{\{e'=1\}} - wn - \sum_{q=0}^{J} p_q h^q - w\zeta_j + (1-\delta)pk,$$

$$y^d + \tau_j y^f = z\left(k^{\alpha_j} n^{1-\alpha_j}\right)^{1-\varphi_j}\left(\prod_{q=0}^{J}\left(h^q\right)^{\Omega_{jq}}\right)^{\varphi_j},\ y^d = \left(\frac{p^d}{p_j}\right)^{-\sigma} y_j,\ y^x = \left(\frac{p^x}{\bar{p}^*}\right)^{-\sigma}\bar{y}^*.$$

2.7 Equilibrium

Let $\mathcal{S} := \mathcal{A} \times \mathcal{E} \times \mathcal{Z}$ denote the individuals' state space, where $\mathcal{A} = \mathbb{R}^+$, $\mathcal{E} = \{0,1\}$, and $\mathcal{Z} = \mathbb{R}^+$ denote the set of possible values of net worth, export status, and productivity, 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, policy functions, value functions, and a measure $\phi : \mathcal{S} \to [0,1]$ over individuals' states such that:

1. Policy and value functions solve the individuals' problem
2. Policy functions solve problem of producers of sectoral good $j \in \{0,1,...,J\}$
3. Policy functions solve the problem of producers of final goods
4. Labor market clears:

$$\int_{\mathcal{S}}\left[n(s) + \sum_{j=1}^{J}\zeta_j \mathbb{I}_{\{\mathcal{O}(s)=j\}} + \xi_0 \mathbb{I}_{\{e=0,e'(s)=1\}} + \sum_{j=1}^{J}\xi_{1,j}\mathbb{I}_{\{e'(s)=1,\mathcal{O}(s)=j\}}\right]\phi(s)ds + n_0 = \int_{\mathcal{S}}\mathbb{I}_{\{\mathcal{O}(s)=W\}}\phi(s)ds$$

5. Sectoral good j's market clears $\forall j = 0,1,...,J$:

$$y_j = y_j^f + \sum_{q=1}^{J}\left[\int_{\mathcal{S}} h^j(s)\mathbb{I}_{\{\mathcal{O}(s)=q\}}\phi(s)ds\right] + h_0^j$$

6. Final-goods market clears: $y = \int_{\mathcal{S}}\left[c(s) + \nu(s)\right]\phi(s)ds$
7. Measure ϕ is stationary

3 Mechanism

I now investigate the channels through which financial frictions distort international trade flows in this economy. While recent studies have examined the extent to which financial frictions distort allocations in economies closed to international trade (see, for instance, Buera, Kaboski, and Shin, 2011; and Midrigan and Xu, 2014), the degree to which international trade flows might be relatively more distorted than production for the domestic market is much less understood. Therefore, I restrict attention to the effect of financial frictions on industry-level and aggregate trade shares rather than on the level of trade. As in the rest of the paper, I refer to trade shares in the tradable sectors as "industry-level trade shares," and to the trade share across all tradable goods as the "aggregate trade share."[18]

In this economy the ratio of aggregate exports to aggregate domestic sales of tradable goods, the aggregate trade share,[19] is given by:

$$\frac{\text{Exports}}{\text{Domestic sales}} = \sum_{j=1}^{J} \left(\frac{D_j}{D} \times \frac{X_j}{D_j} \right),$$

where D_j and X_j denote domestic sales and exports, respectively, in industry $j \in \{1, ..., J\}$; and $D = \sum_{j=1}^{J} D_j$ denotes total domestic sales of tradable goods.[20] Therefore, to understand the impact of financial frictions on the aggregate trade share, it is key to investigate their effect on industry-level trade shares, $\frac{X_j}{D_j}$.

The ratio of exports to domestic sales in industry $j \in \{1, ..., J\}$ is given by:

$$\frac{X_j}{D_j} = \frac{\bar{y}^*}{y_j} \times \left(\frac{\bar{p}^*}{p_j} \right)^{\sigma} \times \widehat{\tau}_j^{1-\sigma}, \tag{1}$$

where $\widehat{\tau}_j$ is an endogenous object that captures the impact of trade-related

[18] See the Online Appendix for derivations of all the expressions presented in this section.

[19] The ratio of exports to domestic sales is a monotonic function of the ratio of exports to total sales, which is also often referred to as the "trade share": $X/D = (\frac{1}{X/Y} - 1)^{-1}$, where X, D, and Y denote exports, domestic sales, and total sales.

[20] Where $D_j = \int_{\mathcal{S}_j} p^d(s) y^d(s) \phi(s) ds$, $X_j = \int_{\mathcal{S}_j} p^x(s) y^x(s) \phi(s) ds$, $\mathcal{S}_j = \{s \in \mathcal{S} | \mathcal{O}(s) = j\}$.

costs and distortions on firms' decisions and the trade share; I refer to it as a "trade wedge" and describe it below in more detail. On the one hand, financial frictions affect the trade share by distorting sectoral quantities and prices: they increase the trade share by reducing the domestic demand for sectoral goods y_j, and have an ambiguous impact on it by distorting domestic prices p_j.[21] On the other hand, financial frictions distort export decisions, increasing the trade wedge and leading to a lower trade share. To the extent that the latter effect dominates, financial frictions reduce the ratio of exports to domestic sales.

Given that the distortions of financial frictions on prices and quantities have already been examined in detail in previous studies, I focus on the determinants of trade-specific distortions. To do so, I study the forces that determine the trade wedge $\widehat{\tau}_j$, for $j \in \{1, ..., J\}$:

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

where μ is the Lagrange multiplier on the entrepreneurs' borrowing constraint; $\mathcal{X}_j$ is the set of firms that export in sector j; E_j denotes the measure of exporters in sector j; and S_j is the measure of entrepreneurs in sector j.[22]

The first term consists of the share of firms that export. As I discuss below, financial frictions reduce the share of firms that export, which leads to a higher trade wedge $\widehat{\tau}_j$ and a lower trade share. The second term measures the relative production scale between exporters in industry j and all entrepreneurs that operate in industry j.[23] While the optimal scale of entrepreneurs is increasing in productivity, their scale of production is decreasing in the magnitude of the Lagrange multipliers. Then, to the extent that financial frictions reduce the

[21] The impact of financial frictions on domestic prices depends on the net impact on firms' marginal costs from lower factor prices and increased capital misallocation.

[22] This decomposition is closely related to the empirical decomposition of the aggregate ratio of exports to total sales conducted by Alessandria and Choi (2014a). $\mathcal{X}_j$, E_j, and S_j are given by $\mathcal{X}_j := \{s \in \mathcal{S}_j | e'(s) = 1\}$, $E_j := \int_{\mathcal{S}_j} \mathbb{I}_{\{e'(s)=1\}}\phi(s)ds$, and $S_j := \int_{\mathcal{S}} \mathbb{I}_{\{o(s)=j\}}\phi(s)ds$.

[23] Scale is determined by the average productivity across firms, adjusted by the extent to which the financial constraints bind.

average scale of exporters (the numerator) relative to that of all firms that sell in the domestic market (the denominator), they increase the trade wedge $\widehat{\tau}_j$ and, thus, reduce the trade share. The last term consists of the variable trade cost τ_j and is, thus, unaffected by the extent of financial development.[24]

3.1 Financial frictions reduce relative scale of exporters

I now argue that financial frictions indeed reduce the scale of exporters relative to all domestic producers, decreasing the second term of Equation 2.

Financial frictions distort the production decisions of entrepreneurs by reducing the scale at which they operate the firm. If $\theta < 1+r$, entrepreneurs in tradable sector $j \in \{1, ..., J\}$ with net worth a cannot operate the firm with a capital stock higher than $\frac{1+r}{1+r-\theta}\left[a - \frac{w}{p}\xi_0 \mathbb{I}_{\{e=0,e'=1\}} - \frac{w}{p}\xi_{1,j}\mathbb{I}_{\{e'=1\}}\right]$, leading firms with low net worth to hold sub-optimal levels of capital.[25] In contrast, if θ is sufficiently higher than $1+r$, firms can operate with a capital stock that is as high as desired, regardless of net worth a. To illustrate the impact of financial frictions on firms' production scale, 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 (e, z) and industry j.[26]

The impact of financial constraints on firms' production decisions depends on their net worth and desired scale of operation. In particular, productive firms that sell to multiple markets have a relatively higher optimal scale than unproductive ones that only sell domestically. Therefore, conditional on a given level of net worth a in a given industry j, the model implies that the financial constraint of the former will be relatively more binding, as the gap between their effective and optimal scale of operation is relatively larger. Figure 1 shows that, indeed, conditional on states (a, e, z) in industry j, exporters

[24] However, the impact of variable trade costs on allocations does depend on the degree of financial development: with financial frictions, higher variable trade costs reduce the extent to which firms can overcome distortions on export decisions by accumulating internal funds.

[25] For simplicity, I focus on the reformulated problem of individuals derived in the Online Appendix, which casts the problem with a single value function g and two endogenous state variables a and e.

[26] To sharpen the contrast between exporters and non-exporters, I restrict attention to an economy where the entry and fixed export costs do not need to be paid upfront. With export costs paid upfront there is an even wider gap between exporters and non-exporters.

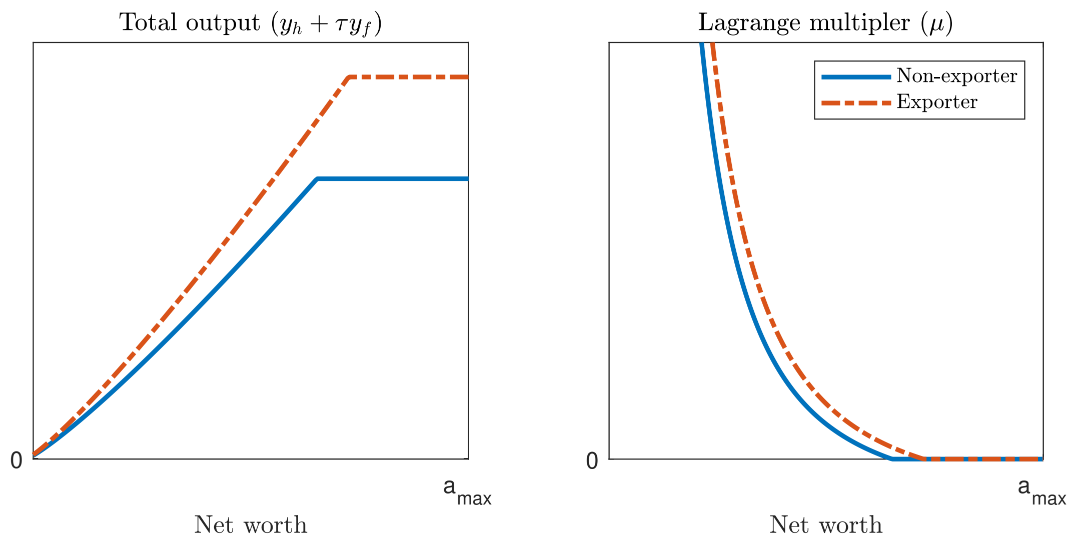

Figure 1: Total output and Lagrange multipliers

produce more even if constrained, as their higher optimal scale makes it profitable to increase production by hiring more workers and intermediate inputs. Thus, exporters also have higher Lagrange multipliers than non-exporters.

3.2 Financial frictions reduce the share of exporters

I now argue that financial frictions also reduce the share of firms that export, leading to a decrease in the first term of Equation 2.

On the one hand, firms with sufficiently low net worth cannot afford to finance the entry and fixed export costs using the external and internal funds available. On the other hand, the distortions to the production scale of firms reduce the returns to exporting, leading firms with intermediate levels of net worth to avoid paying the entry and fixed export costs even if they can afford them. Thus, in either case, financial frictions induce productive firms with low net worth to avoid exporting, reducing the share of exporters.

To illustrate the impact of these forces on firms' decision to export, Figure 2 partitions the individuals' state space based on their optimal occupation and exporting decisions. To do so, I focus on the economy with three tradable sectors studied in the following section. Among other differences, sectors differ in capital intensity, so I denote regions based on the export decison ($e' = 1$ if

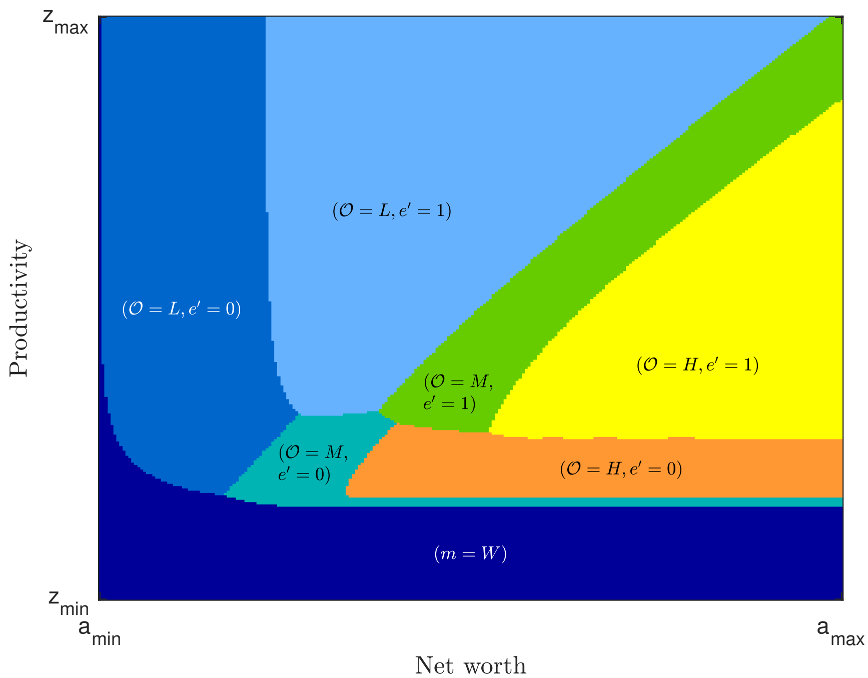

Figure 2: Occupation and Export Entry Decisions

export and zero otherwise) and sectoral relative capital-intensity α_j: low (L), medium (M), and high (H).[27]

While productivity is an important determinant of the decision to be an entrepreneur and to export, I find that these decisions are significantly affected by the level of net worth. In particular, high-productivity entrepreneurs with low-net-worth choose to be non-exporters, while they choose to export with higher levels of net worth. Then, financial frictions reduce the share of firms that choose to export.

As observed in Figure 2, financial frictions also distort the intensive and extensive margins of exports by affecting the individuals' choice between being a worker or an entrepreneur, and the entrepreneurs' choice across tradable sectors. Individuals only choose to be entrepreneurs, and entrepreneurs only

[27] I restrict attention to individuals that did not export in the previous period ($e = 0$), and partition the rest of the state space according to their occupation-exporting choices.

choose capital-intensive sectors, if net worth is sufficiently high, since these choices require high levels of net worth to operate at a profitable scale. In the next section, I examine the overall impact of these additional channels by investigating the quantitative effect of financial frictions on international trade at the industry and aggregate levels.

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 estimating the parameters of the model to match key features of firm-level data. I then use the estimated model as a laboratory to study the impact of financial frictions on international trade at the industry and aggregate levels. In Section 5, I contrast my findings with estimates from the data.

4.1 Estimation

4.1.1 Data

I estimate the parameters of the model to match salient features of data from Chilean manufacturing firms over the period 1995 to 2007. The data were collected by the Chilean National Institute of Statistics (INE) as part of its Annual Census of Manufactures (ENIA). The census collects longitudinal data on all plants with more than ten workers and provides information on foreign and domestic sales, factor inputs, and other variables.[28] To focus on firms, I aggregate plants within firms. The dataset that I study then contains information on 9,610 different firms over the 13-year period from 1995 to 2007, with 61,004 firm-year observations in total and 4,693 firms on average per year.

[28] I exclude firms with negative or missing total sales. I interpret negative values of domestic sales, exports, or any of the production inputs as missing. I also exclude observations from the following Chile-specific International Standard Industrial Classification (ISIC) rev. 3 categories given their large dependence on natural resource extraction: category 2720 (manufactures of basic precious and non-ferrous metals; in particular, this category includes copper) and category 2411 (manufactures of basic chemicals except for fertilizers and nitrogen compounds; in Chile, this category includes petroleum refineries). The results are robust to the inclusion of these industries.

4.1.2 Mapping between industries in the model and the data

The estimation approach presented below is designed to parameterize the model to capture several dimensions of heterogeneity observed across industries in the data. I keep the quantitative analysis manageable (specifically, the number of estimated parameters) by considering an economy with three aggregate sectors ($J = 3$). Thus, computing empirical moments to discipline the sectors in the model requires one to map the latter to the industries observed in the data.

I design a mapping between the industries in the data and the model that is motivated by related studies such as Beck (2003) and Manova (2013). They exploit differences in finance-intensity across industries to identify the impact of financial development on international trade. In the model, a key determinant of an industry's finance-intensity is its capital-intensity, since capital is one of the key uses of external finance.

Thus, I partition the set of industries in the data into three groups according to a measure of their capital-intensity: industries' capital per worker. To do so, I compute each firm's average capital per worker (in constant 1995 prices), and compute each industry's capital per worker as the median across all firms within the industry.[29] Industries with capital per worker above the 75^{th} percentile across industries are grouped into sector H (capital-intensive), those between the 75^{th} and 25^{th} percentiles across industries are grouped into sector M, while those below the 25^{th} percentile across industries are grouped into sector L (labor-intensive).[30] I henceforth refer to sectors $j = 0, 1, 2, 3$ in the model as NT, L, M, and H, respectively.

[29] This approach to computing an industry's finance-intensity as the median across firms within the industry is analogous to Rajan and Zingales (1998)'s approach to computing external finance dependence. I restrict attention to industries based on the ISIC rev. 2 industry classification to map the quantitative analysis of this section with the empirical analysis conducted in Section 5.

[30] The quantitative implications of the model are robust to parameterizations based on alternative classifications.

4.1.3 Parameterization

To choose the parameters of the model, I begin by partitioning the parameter space into three groups. The first group consists of predetermined parameters set to standard values from the literature. The second group consists of predetermined parameters that control input-output linkages and are estimated directly from the data. The third group of parameters is estimated jointly following a simulated method of moments (SMM) approach to match key features of Chilean manufacturing firms. The parameter values are presented in Table 1,[31] while the moments targeted and their model counterparts are presented in Table 2.[32]

Predetermined parameters: Preferences, depreciation, interest rate The set of standard predetermined parameters consists of the preference parameters γ and σ, the depreciation rate δ, and the interest rate r. The coefficient of relative risk aversion γ is set to 1, which implies a unitary intertemporal elasticity of substitution and a period utility function given by $\ln c$. 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 are well within the range of values previously used in the literature to parameterize similar economic environments.[33] I interpret a period in the model as a year in the data. Thus, I set the interest rate to 5.54%, to match the average annual real interest rate in Chile over the period 1995-2007, as reported by the IMF's International

[31] I report standard errors for the estimated parameters in the Online Appendix.

[32] I solve the model through value function iteration, approximating the idiosyncratic productivity process following Tauchen (1986). I compute the statistics of the model that are only a function of the current period's state variables using the stationary distribution of individuals, following the approach of Heer and Maussner (2005). I compute the rest of the moments by Monte Carlo simulation, as the average across 250 simulated panels of 200,000 individuals followed over 13 years; the baseline parameterization features approximately 6,700 firms per year on average. Further details on the numerical solution of the model are provided in the Online Appendix.

[33] 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 and the rate of capital depreciation. The intertemporal elasticity of substitution falls within 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).

Financial Statistics.

Analogous to Buera, Kaboski, and Shin (2011), I capture the larger size of firms in the capital-intensive sector relative to labor-intensive firms by considering an economy with fixed operation costs that are higher in this sector; $\zeta_H > \zeta_M = \zeta_L$. To simplify the estimation, I set $\zeta_L = \zeta_M = 0$.

I normalize the following parameters to one: the price of imported goods $\bar{p}^m$, the average level of productivity μ_z, and the price level in the rest of the world $\bar{p}^*$.

Predetermined parameters: Input-output linkages The set of predetermined parameters that control input-output linkages in the model consists of the shares of intermediate inputs $\{\varphi_j\}_{j\in\{NT,L,M,H\}}$, the parameters of the input-output matrix $\{\Omega_{jq}\}_{j,q\in\{NT,L,M,H\}}$, and the sectoral composition of final goods $\{\Phi_j\}_{j\in\{NT,L,M,H\}}$.

To parameterize the shares of intermediate inputs φ_j across tradable producers $j \in \{L, M, H\}$, I exploit the model's implication that $\varphi_j = \frac{\sigma}{\sigma-1}\frac{\sum_{q\in\{NT,L,M,H\}} p_{qt}h_{it}^q}{p_{it}^d y_{it}^d + p_{it}^x y_{it}^x}$ for all firms i that operate in sector j. That is, φ_j is proportional to the ratio between total firm-level expenditures on intermediate inputs and total firm-level sales. I first compute the share of intermediates for each firm and time period using data on sales and intermediate inputs from the firm-level dataset of Chilean manufactures described above. Then, I compute each firm's share of intermediates as their average share over time, and compute each industry's share of intermediates as the median across all firms within the industry. I use these industry-level shares along with σ to compute φ_j using the expression above.

The share of intermediates used to produce non-tradables φ_{NT} and the parameters of the input-output matrix $\{\Omega_{jq}\}_{j,q\in\{NT,L,M,H\}}$ are estimated using the OECD's input-output tables for Chile over the period 1995-2007. Industries in this data can be easily mapped to industries in the firm-level dataset used above. However, they are available at a coarser level of aggregation, so I map industries in the OECD data to the industries in the model following an approach analogous to the approach described in section 4.1.2.[34] In addition,

[34]Specifically, I compute the median capital per worker across all firms within each in-

I classify all non-manufacturing industries as non-tradable. Given the model's implication that $\varphi_{NT} = 1 -$ Value added/Gross output, I use data on gross output and value added across non-tradables from the OECD's input-output tables to compute φ_{NT} as the average over the period 1995-2007. Similarly, for each $j, q \in \{NT, L, M, H\}$, I compute Ω_{jq} as the average share of intermediates purchased by sector j from sector q over the period 1995-2007.

Finally, I assume that all differences across tradable industries are technological and not driven by differences in demand. Thus, I compute the share of non-tradables demanded by final good producers Φ_{NT} using the OECD data described above, and then set Φ_j for $j \in \{L, M, H\}$ to be proportional to the share of industries underlying the industry partition described in section 4.1.2. Thus, I set $\Phi_L = \Phi_H = 0.25 \times (1 - \Phi_{NT})$ and $\Phi_M = 0.50 \times (1 - \Phi_{NT})$.

Parameters estimated via SMM The set of parameters estimated via SMM consists of β, θ, ζ_H, ξ_0, σ_z, ρ_z, $\bar{y}^*$, and $\{\alpha_j, \tau_j, \xi_{1,j}\}_{j \in \{L,M,H\}}$. I estimate them jointly, following the simulated method of moments, to minimize the objective function MWM', where W is the identity matrix and M is a row vector whose elements are given by the squared difference between each target moment and its model counterpart.

I target the following moments of the data: (1) 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; (2) the ratio of aggregate credit to aggregate value added in manufactures; (3) the ratio between the aggregate capital stock and the aggregate wage bill in manufactures; (4) the ratio between the average capital per worker across industries in sector H and the average capital per worker across industries in sector L; (5) the ratio between average capital per worker across industries in sector M and the average capital per worker across industries in sector L; (6) the ratio between the average number of workers across industries in sector H and the average number of workers across in-

dustry available in the OECD data. I then partition industries in the OECD data into three groups as above: Industries with capital per worker above the 75$^{\text{th}}$ percentile across industries are grouped into sector H (capital-intensive), those between the 75$^{\text{th}}$ and 25$^{\text{th}}$ percentiles across industries are grouped into sector M, while those below the 25$^{\text{th}}$ percentile across industries are grouped into sector L (labor-intensive).

dustries in sector L; (7)-(9) the ratio of total exports to total sales in sectors L, M, and H; (10)-(12) the share of firms that export in sectors L, M, and H; (13) the rate at which firms stop exporting, conditional on continuing to produce for the domestic market (the export exit rate); (14) the ratio between the average sales of exporters and the average sales of non-exporters; (15) the rate at which firms stop operating (the firms' exit rate);[35] and (16) the ratio between Chile's absorption and the rest of the world's. All target moments (1)-(15) are computed using the Chilean firm-level dataset described above. To compute (2), I also use the total stock of credit outstanding in the manufacturing sector, as reported by the Superintendencia de Bancos e Instituciones Financieras de Chile. To compute (16), I approximate relative differences in absorption using GDP data from the World Bank.[36] Given I target moments from data on Chilean manufactures, I measure these moments in the model by restricting attention to the set of all producers of tradable goods.

Fit I find that the model accounts reasonably well for the target moments, as well as for salient features of the dynamics and cross-sectional features of firms not targeted in the estimation; see the Online Appendix for details.

4.1.4 Identification

While all the estimated parameters simultaneously affect all the target moments, I now provide a heuristic argument to map the former to the latter.

The discount factor β affects the amount of net worth held by individuals when they become entrepreneurs, determining the extent to which they are constrained upon entry and their growth thereafter. Similarly, the borrowing constraint parameter θ determines the amount that firms borrow and, thus, the amount of credit in the economy.

The capital shares $\{\alpha_j\}_{j\in\{L,M,H\}}$ affect the aggregate capital to wage-bill

[35] In the model, I measure the firms' exit rate as the share of entrepreneurs in period t who become workers in period $t+1$.

[36] Consistent with the mapping in section 4.1.2, I compute moments (4)-(6) in the data measuring capital per worker and the number of workers in each industry as the median across firms. I then compute capital per worker and the number of workers in each sector $j \in \{L, M, H\}$ as the average across the industries that make up such sector. In the model I simply compute them as the median across firms in each sector.

Table 1: Parameterization

	Predetermined parameters	
Risk aversion	γ	1
Substitution elasticity	σ	4
Depreciation rate	δ	0.06
Interest rate	r	0.055
Intermediate input shares	$(\varphi_{NT}, \varphi_L, \varphi_M, \varphi_H)$	$(0.42, 0.84, 0.67, 0.73)$
Final good shares	$(\Phi_{NT}, \Phi_L, \Phi_M, \Phi_H)$	$(0.72, 0.07, 0.14, 0.07)$
Input-output matrix	$\mathbf{\Omega}=$	$\begin{pmatrix} 0.70 & 0.05 & 0.12 & 0.13 \\ 0.67 & 0.19 & 0.06 & 0.08 \\ 0.51 & 0.01 & 0.29 & 0.19 \\ 0.67 & 0.02 & 0.04 & 0.27 \end{pmatrix}$
	Estimated parameters	
Discount factor	β	0.849
Borrowing constraint	θ	0.175
Capital share: Sector L	α_L	0.417
Capital share: Sector M	α_M	0.428
Capital share: Sector H	α_H	0.663
Fixed operation cost: Sector H	ζ_H	0.122
Iceberg trade cost: Sector L	τ_L	5.502
Iceberg trade cost: Sector M	τ_M	5.128
Iceberg trade cost: Sector H	τ_H	5.789
Fixed export cost: Sector L	$\xi_{1,L}$	0.935
Fixed export cost: Sector M	$\xi_{1,M}$	1.078
Fixed export cost: Sector H	$\xi_{1,H}$	1.576
Sunk export entry cost	ξ_0	0.210
Productivity dispersion	σ_z	0.129
Productivity persistence	ρ_z	0.987
Size of the rest of the world	$\bar{y}^*$	39.629

Note: Elements Ω_{jq} of the input-output matrix denote the share of intermediate inputs used by sector j that are purchased from sector q. Sectors are ordered as in the paper: NT, L, M, and H.

ratio as well as the relative capital per worker across industries. Given these technological differences, the fixed cost ζ_H to operate in sector H affects the relative scale of firms in this industry relative to firms in other industries. Thus, the target moments capture capital-intensity and scale differences across industries in the data, helping to discipline the degree of heterogeneity across the industries in the model. Given that I also target the ratio of aggregate

Table 2: Moments

Moment	*Data*	*Model*
Average sales (age 5/age 1)	1.568	1.913
Credit / Value added	0.188	0.188
Capital stock / Wage bill	4.848	4.613
Capital per worker (sector H/sector L)	7.229	7.262
Capital per worker (sector M/sector L)	1.950	2.049
# of workers (sector H/sector L)	2.895	2.615
Exports / Sales: Sector L	0.231	0.186
Exports / Sales: Sector M	0.150	0.188
Exports / Sales: Sector H	0.279	0.257
Share of exporters: Sector L	0.161	0.198
Share of exporters: Sector M	0.254	0.236
Share of exporters: Sector H	0.409	0.428
Export exit rate	0.118	0.111
Average sales (exporters/non-exporters)	8.258	8.142
Exit rate	0.119	0.104
Absorption / World absorption	0.246%	0.237%

Note: Data moments computed using data on Chilean manufacturing firms. Model moments measured across producers of tradable goods. See Section 4.1.3 for details.

capital to the aggregate wage bill in manufactures, the model implies a realistic aggregate production technology of manufactures while also capturing the heterogeneous technologies operated at the firm- and industry-level.

The iceberg trade costs $\{\tau_j\}_{j\in\{L,M,H\}}$ and the size of the rest of the world $\bar{y}^*$ play a key role in determining the sector-specific ratios of exports to total sales as well as the size of the domestic economy relative to the rest of the world.[37] The sunk export entry cost ξ_0 and the fixed export costs $\{\xi_{1,j}\}_{j\in\{L,M,H\}}$ determine the export entry and exit thresholds and, thus, the sector-specific shares of firms that export and the economy-wide rate at which firms stop exporting.

Finally, the dispersion σ_z and persistence ρ_z of idiosyncratic productivity determine the size of exporters relative to non-exporters as well as the firms' exit rate, respectively.

[37] I interpret τ_j broadly, as a residual that may capture channels not modeled explicitly which account for the amount of trade observed in the data. In particular, it may capture more than technological trade costs; for instance, it may reflect policy distortions or demand-side factors that affect international trade (Fieler 2011) but which are not modeled explicitly.

4.2 The experiment: Financial development

To study the impact of financial development on international trade flows, I contrast the stationary equilibrium allocations of the estimated model with those of two economies at different levels of financial development. In the first economy, I consider an environment in which firms have no access to external finance; to do so, I set θ to zero, while keeping all other parameters unchanged. 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 as an economy with highly developed financial markets.[38] 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 1985-1995. The value of θ required to match this moment, while keeping all other parameters unchanged, is 0.932.

I refer to the implications of the model for each tradable sector as "industry-level," and to the implications across all producers of tradable goods as "aggregate-level."

4.3 Industry-level implications

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

I report the industry-level implications of the counterfactual experiment in Panel A of Table 3. The columns of the table report the equilibrium outcomes corresponding to the different economies under study. I label the economy with $\theta = 0$ as "No credit," the baseline model with $\theta = 0.175$ as "Baseline," and the economy with $\theta = 0.932$ as "High credit." Rows 1 to 6 of this panel report the trade share and the share of exporters corresponding to each of the types of entrepreneurs, or industries, in the economy.

I find that, as the financial constraint is relaxed, exports increase relative to domestic sales in the more capital-intensive industry (sector H) — the ratio

[38] While the frictionless benchmark is given by $\theta = \infty$, I restrict attention to degrees of financial development feasible to the most advanced economies. Thus, I study the impact of improving financial markets to the level of developed economies, rather than to an abstract frictionless counterpart.

Table 3: Financial development and international trade

		No credit	*Baseline*	*High credit*
A. Industry-level implications				
$\frac{\text{Exports}}{\text{Domestic sales}}$	Sector L	0.25	0.23	0.08
	Sector M	0.23	0.23	0.22
	Sector H	0.33	0.35	0.47
Share of exporters	Sector L	0.22	0.20	0.07
	Sector M	0.23	0.24	0.28
	Sector H	0.39	0.43	1.00
Avg. sectoral productivity (H/L)		1.15	1.21	2.10
Avg. sectoral productivity (M/L)		0.98	1.00	1.10
B. Aggregate implications				
Agg. credit / Agg. value added		0.00	0.19	1.63
Agg. exports / Agg. domestic sales		0.28	0.28	0.30
C. Prices				
Real wage (w/p)		0.98	1.00	1.11
Real price of intermediates (p_j^h/p)	Sector NT	1.00	1.00	0.99
	Sector L	1.00	1.00	1.01
	Sector M	1.01	1.00	0.96
	Sector H	1.00	1.00	0.98
Real sectoral price (p_j/p)	Sector NT	1.00	1.00	1.03
	Sector L	1.00	1.00	1.01
	Sector M	1.02	1.00	0.91
	Sector H	1.02	1.00	0.88
Real exchange rate ($\overline{p}^*/p$)		1.01	1.00	0.96

Notes: Prices are reported such that their baseline value is equal to 1. Sectoral productivities are computed as the average value of z across the entrepreneurs in each sector. The price index of intermediates purchased by sector j is given by $p_j^h = \prod_{q=0}^{J} \left(\frac{p_q}{\Omega_{jq}}\right)^{\Omega_{jq}}$.

between them increases from 0.33 in the economy without credit, to 0.47 in the high-credit environment. In contrast, I find that the ratio of exports to domestic sales declines in the industries that are more labor-intensive (sectors M and L). This decline is particularly sharp in sector L — from 0.25 in the economy with no credit, to 0.08 in the economy with developed financial markets.

The response of industry-level trade shares to an increase in θ depends on the relative magnitude of two 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 and fixed export costs, thereby increasing the returns to exporting and the trade share. On the other hand, the higher scale of firms increases the demand for labor and, thus, the equilibrium wage (see Panel C of Table 3), reducing the returns to exporting and the trade share. These two effects lead industry-level prices to change, altering the cost of the sector-specific bundles of intermediate inputs. Then, the overall effect of financial development on industry-level trade shares depends on the relative magnitude of these two opposing forces: to the extent that the benefits of operating at an increased scale dominate the impact of financial development on production costs, then the trade share increases — and vice-versa.

Production decisions are relatively more distorted by financial frictions among firms in capital-intensive industries since they have a higher optimal capital stock. Thus, capital-intensive firms experience a relatively larger increase in the incentives to trade when financial markets develop, which leads to an increase in the share of exporters. Similarly, access to external finance enables high-productivity entrepreneurs to operate capital-intensive technologies closer to their optimal scale, increasing the relative productivity of the entrepreneurs that choose to operate in capital-intensive sectors. In contrast, the higher labor costs that result from financial development have a higher impact on labor-intensive industries, given their higher use of labor and labor-intensive intermediates in production. Therefore, firms in capital-intensive industries experience a relatively larger net increase in the incentives to trade than labor-intensive producers, explaining the differential response of industry-level trade shares.

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 these industry-level implications are quantitatively consistent with empirical estimates of these effects.

4.4 Aggregate implications

Next, I ask: to what extent do financial frictions affect 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 Panel B of Table 3. As before, each column reports the equilibrium outcomes corresponding to the different economies.

On the one hand, as financial frictions are relaxed from the economy without credit to its financially-developed counterpart, firms increase the amount borrowed and the aggregate ratio of credit to value added increases sharply, from 0.00 to 1.63. On the other hand, financial development leads to a minor increase in the aggregate trade share, from 0.28 to 0.30. With financial development, higher factor input prices partially offset the increased incentives to trade internationally that result from better access to external finance. Then, while financial frictions lead to a strong reallocation of industry-level trade flows, their impact on aggregate trade flows is considerably milder.

These findings also stand in contrast to the strong empirical relationship between trade and finance previously documented in the literature at the industry-level. While such evidence may suggest that financial frictions have a sizable impact on international trade flows at the aggregate level, my findings show that this is not necessarily the case.

4.5 Welfare gains

I now investigate the welfare implications of financial development. To do so, I restrict attention to comparing the well-being of individuals in the stationary equilibrium of the economy without credit relative to the well-being of individuals in the stationary equilibrium of the economy with developed financial markets. Following Lucas (1987), I measure the welfare change in terms of consumption-equivalent units. In particular, I ask: If one were to take the place of a randomly-chosen individual of the economy with no credit, what proportional state-independent lifetime increase $\Delta \geq 0$ of consumption would one need to be offered to remain indifferent from becoming a randomly-chosen individual of the economy with developed credit markets?

To answer this question, I first compute the expected lifetime utility of becoming a randomly-chosen individual from the stationary equilibrium of the economy with developed credit markets $\int_{\mathcal{S}} \bar{g}_{\theta_H}(a,e,z)\phi(s)ds$, where $\bar{g}_{\theta}(a,e,z)$ denotes the value function of an individual with net worth a, export status e, and productivity z, in the stationary equilibrium of an economy with collateral constraint parameter θ. Then, I solve the stationary equilibrium of an economy without credit markets, and compute the expected lifetime utility of a randomly-chosen individual in this economy under alternative period utility function $u(c) = \ln[(1+\Delta)c]$: $\int_{\mathcal{S}} \bar{g}^{\Delta}_{\theta_L}(a,e,z)\phi(s)ds$, where $\bar{g}^{\Delta}_{\theta}(a,e,z)$ denotes the value function of the respective equilibrium allocations evaluated under the alternative period utility function. Note that θ_H and θ_L refer to the values of θ in the economies with high credit and no credit from Section 4.2.

The welfare gains from financial development are given by the value of Δ that solves $\int_{\mathcal{S}} \bar{g}_{\theta_H}(a,e,z)\phi(s)ds = \int_{\mathcal{S}} \bar{g}^{\Delta}_{\theta_L}(a,e,z)\phi(s)ds$. Analogous to Mendoza, Quadrini, and Ríos-Rull (2007), Δ can be computed directly as:[39]

$$\Delta = e^{(1-\beta)\left[\int_{s\in\mathcal{S}} \bar{g}_{\theta_H}(a,e,z)\phi(s)ds - \int_{s\in\mathcal{S}} \bar{g}_{\theta_L}(a,e,z)\phi(s)ds\right]} - 1.$$

The value in the first row and column of Table 4 reports the welfare gains from financial development corresponding to the experiment conducted in the previous subsections. I find that if one were to become a randomly-chosen individual from the economy without credit, one would need to be offered a permanent state-independent increase of consumption equal to 6.07% to remain indifferent from becoming a randomly-chosen individual from the economy with developed credit markets. Similarly, the remaining results reported in the first column show that real aggregate consumption and real aggregate absorption increase by 3.56% and 5.20%, respectively, between these economies.

4.5.1 Role of international trade

While financial development enables productive firms with low net worth to take advantage of exporting opportunities that may not have been profitable

[39] See the Online Appendix for details.

Table 4: Gains from financial development

	Baseline	Financial autarky	Closed economy	Role of trade
Welfare	6.07%	3.59%	3.19%	0.40%
Consumption	3.56%	3.07%	2.65%	0.43%
Absorption	5.20%	3.40%	2.87%	0.53%

Note: Welfare gains are expressed in consumption-equivalent units, as described in the text. Consumption and absorption gains are expressed as the percentage change between the no credit economy and the financially developed economy.

in the economy without credit, better financial markets also impact firms not directly involved in international trade (Buera and Shin 2011, Midrigan and Xu 2014). Thus, I now investigate the role of international trade in accounting for the welfare gains from financial development.[40]

To do so, one approach would be to recompute the results reported in the previous subsection for an economy closed to international trade but otherwise identical to the baseline. However, given that the economy cannot operate under international financial integration if closed to trade, I proceed in steps.

First, I contrast the implications of the baseline experiment with those from a counter-factual economy that operates under international financial autarky but is open to international trade ("financial autarky" column in Table 4). Then, I examine a counter-factual economy that operates under international financial autarky and is also closed to trade ("closed economy" column in Table 4). All parameters are otherwise identical to those in Table 1.[41] The second and third columns of Table 4 report the gains in these economies when moving from an environment without credit ($\theta = 0$) to an economy with developed credit markets ($\theta = 0.932$, as in the baseline experiment).

I first find that the welfare gains from financial development under international financial autarky are lower than in the baseline model (3.59% vs. 6.07%, respectively). Moreover, I also find that access to international trade increases the gains from financial development: in the economy under international financial autarky and closed to trade the gains are lower than in its

[40]See the Online Appendix for related results on the welfare gains from international trade under alternative degrees of financial development.

[41]Under international financial autarky, the interest rate r clears domestic financial markets: $\int_{\mathcal{S}} b(s)\phi(s)ds = 0$. The economy without trade is such that $\xi_0 = \overline{p}^m = \infty$ and $\tau_j = \xi_{1,j} = \infty \ \forall j$.

open-to-trade counterpart (3.19% vs. 3.59%, respectively). Thus, I conclude that the contribution of trade to the welfare gains from financial development is equal to 0.40% (that is, the difference between 3.59% and 3.19%).

Similarly, the second and third rows of the table show that the contribution of international trade to the change in consumption and absorption in response to financial development is equal to 0.43% and 0.53%, respectively.

4.6 Robustness

I now investigate the sensitivity of the quantitative findings reported in the previous subsections to alternative modeling assumptions and extensions of the model. To ease the exposition, I omit some details about the estimation and results; see the Online Appendix for a more exhaustive presentation.

4.6.1 Model with multiple export destinations

I consider an economy where firms can choose the set of export destinations rather than exporting to a unified world market. I assume that firms have access to L export markets, indexed by $\ell = 1, ..., L$. In each market ℓ, entrepreneurs face a destination-specific demand schedule $y^x_{it,\ell} = \left(\frac{p^x_{it,\ell}}{\bar{p_\ell}^*}\right)^{-\sigma} \bar{y_\ell}^*$, where $\bar{y_\ell}^*$ and $\bar{p_\ell}^*$ are exogenous parameters that denote the aggregate absorption and its associated price index in market ℓ. While entrepreneurs need to pay a destination-independent sunk export entry cost ξ_0 if they didn't export in the previous period, they are subject to destination-specific fixed and variable export costs $\xi_{1,j\ell}$ and $\tau_{j\ell}$. All fixed costs are denominated in units of labor.

This extension of the model introduces an additional extensive margin of adjustment: financial development may now lead continuing exporters to expand their exports by increasing the number of export destinations. To quantify the potential importance of this channel, I consider an economy in which export destinations are given by the different continents of the world. I set $L = 4$ and explicitly model the entrepreneurs' decision to export to America, Europe, Asia-Oceania, and Africa.

To reduce the number of additional parameters, I assume that the fixed and variable costs of exporting in sector j to destination ℓ are given by the product of destination- and sector-specific parameters: $\xi_{1,j\ell} = \xi_{1,j} \times \eta_\ell$ and $\tau_{j\ell} = \tau_j \times \kappa_\ell$. Then, the extended model features 12 additional parameters, which I discipline by targeting 12 additional destination-specific moments: (1) the ratio between total exports to destination ℓ and aggregate exports, (2) the share of exporters that export to destination ℓ, and (3) the ratio between absorption and destination ℓ's absorption.[42] Moments (1) and (2) are computed using a transaction-level dataset with information on the universe of Chilean exports over the period 2003-2007.

I find that the industry-level and aggregate implications of the model are not significantly affected by allowing exporters to endogenously choose the set of export destinations served. As we move from the economy without credit to its financially developed counterpart, there is a similar degree of reallocation of trade across sectors, and the aggregate ratio of exports to domestic sales increases by 0.03 (vs. 0.02 in the baseline).

4.6.2 Model with productivity-specific death shocks

I consider an economy with productivity-specific death shocks estimated to match the non-trivial rate of exit observed in the data among large firms (8.3% of firms with sales among the top third exit every year). I model the dependence of exit rates on productivity following Alessandria and Choi (2014b). New individuals are born with zero net worth, and assets of dead individuals are transferred to surviving individuals through perfect annuity markets.

Accounting for the high exit rate among large firms could affect the estimated export costs, potentially affecting the quantitative implications of financial development. For instance, insofar a significant share of large exporters exit every period, it may suggest that the returns to paying the export entry costs are sufficiently high to compensate the future exit probability.

I find that the industry-level and aggregate implications of the model are not significantly affected by accounting for the high exit rates among large firms. As we move from the economy without credit to its financially developed counterpart, there is a similar degree of reallocation of trade across sectors,

[42] Destination ℓ's absorption is given by $\bar{p}_\ell{}^* \bar{y}_\ell{}^*$. As in the baseline, I approximate relative differences in absorption using GDP data from the World Bank.

and the aggregate ratio of exports to domestic sales increases by 0.02 as in the baseline.

4.6.3 Additional robustness

In the Online Appendix I also examine the sensitivity of the quantitative results to several additional versions of the model. First, I consider an economy in which export costs are not paid upfront but instead are paid after revenues are realized. Second, I consider two economies with alternative intensities of the precautionary savings motive. Third, I consider an economy under international financial autarky. Finally, I consider an economy in which the non-tradable sector is also subject to financial constraints. I find that the industry-level and aggregate implications of the model are not significantly affected under these alternative specifications.

5 Empirical evidence

In this section, I contrast the quantitative implications of the model with estimates from the data.

5.1 Industry-level estimates

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

To answer this question, I construct an empirical counterpart to the industry-level implications of the model. First, I use cross-country industry-level data to estimate the trade share of an industry in a given country and year 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 industry's capital-intensity. Then, I use the estimated specification to compute the change in the trade share associated with a change in the level of financial development across industries with different degrees of capital-intensity. Finally, I contrast these empirical estimates with the implications of the model.

5.1.1 Empirical specification

Equations (1) and (2) of the model imply that the trade share of tradable sector j in a given country can be expressed as:

$$\ln \frac{\text{Exports}_j}{\text{Domestic sales}_j} = \ln\left(\frac{\overline{p}^{*\sigma}\overline{y}^{*}}{p^{\sigma}y}\right) + (1-\sigma)\ln\tau_j + \ln\left(\frac{p^{\sigma}y}{p_j^{\sigma}y_j}\right) + \ln\left(\frac{E_j}{S_j}\right) + \ln\left[\frac{\frac{1}{E_j}\int_{\mathcal{X}_j}\left[z(s)\left(\frac{r+\delta}{r+\delta+\mu(s)\frac{1+r-\theta}{1+r}}\right)^{\alpha_j(1-\varphi_j)}\right]^{\sigma-1}\phi(s)ds}{\frac{1}{S_j}\int_{\mathcal{S}_j}\left[z(s)\left(\frac{r+\delta}{r+\delta+\mu(s)\frac{1+r-\theta}{1+r}}\right)^{\alpha_j(1-\varphi_j)}\right]^{\sigma-1}\phi(s)ds}\right].$$

To obtain an empirical counterpart to this expression, I follow an approach analogous to Manova (2013) and Beck (2003). Notice that the first term is identical across all industries within a given economy since it only depends on country-level characteristics (such as the level of financial development or the productivity distribution). The rest of the terms are also a function of industry-level characteristics (such as their capital-intensity and the share of exporters).

Then, I estimate an industry's trade share in a given country as a function of the country's level of financial development, as well as a function of the interaction between the country's level of financial development and the industry's capital-intensity. As in Manova (2013), I also include country, industry, and year fixed effects, as well as additional variables, to control for systematic differences in industry-level trade shares unrelated to financial development and capital-intensity. Given that the borrowing constraint parameter θ in the model is not industry-specific, I also control for differences in asset tangibility across industries following Manova (2013) and Braun (2003).

Then, I estimate:

$$\ln \frac{\text{Exports}_{ijt}}{\text{Domestic sales}_{ijt}} = \alpha_i + \beta_j + \gamma_t + \frac{\text{Credit}_{it}}{\text{GDP}_{it}}\left[\omega_1 + \omega_2 \times \text{Capital-per-worker}_j + \omega_3 \times \text{Tangibility}_j\right] + \boldsymbol{\eta} \times \boldsymbol{X_{it}} + \varepsilon_{ijt},$$

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 total domestic sales; $\frac{\text{Credit}_{it}}{\text{GDP}_{it}}$ denotes the ratio of credit to GDP, which is a widely-used outcome-based measure of financial development; Capital-per-worker$_j$

denotes a measure of industry j's capital per worker; Tangibility_j denotes a measure of asset tangibility; $\boldsymbol{X_{it}}$ is a vector of additional control variables; and, finally, ε_{ijt} is an error term.

5.1.2 Data

The data used to estimate the specification above are based on the dataset from Manova (2013) for manufacturing industries across countries between 1985 and 1995.[43]

I compute industry-level trade shares as 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 gross output, as measured by the United Nations Industrial Development Organization (UNIDO) at the 3-digit ISIC rev. 2 level; both exports and gross output are measured in current U.S. dollars.[44]

Country-level credit-to-GDP is obtained from Beck, Levine, et al. (1999) and covers the total amount of credit issued by banks and other financial intermediaries to the private sector. This variable ranges from 0.005 in Tanzania in 1988, 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 0.47, and its standard deviation is 0.36.

To measure the industries' technologically-driven capital-intensity while abstracting from potential distortions and other factors that may affect an industry's equilibrium capital-intensity, I follow an approach analogous to Rajan and Zingales (1998). To do so, I use firm-level data of publicly-listed U.S. companies from Compustat's annual industrial files over the period 1985-1995. First, I compute each firm's capital per worker over the period. Then, I let each industry's capital per worker be given by the median capital per worker across all firms within the industry. This variable ranges from \$5.50 million U.S.

[43] This dataset is publicly available from the publisher's website.

[44] Observations with negative industry-level domestic sales are dropped; this is the case for 10.54% of all otherwise-valid observations. In the Online Appendix, I show that the estimation results are robust to accounting for these observations.

dollars (at constant 1985 prices) per thousand workers for footwear products (except rubber or plastic), to \$50.40 million per thousand workers for miscellaneous petroleum and coal products. The mean of this variable is \$23.67 million per thousand workers, and its standard deviation is \$15.98 million per thousand workers.[45]

Analogous to Rajan and Zingales (1998), this measure is informative about the industries' technological capital-intensity in different countries under the following two assumptions: (*i*) given that the U.S. is one of the world's most financially developed economies and that large public firms are the least likely to face credit constraints, I assume that the capital-per-worker of large U.S. firms provides an undistorted measure of the industries' technological capital-intensity; and (*ii*) I also assume that differences in capital-per-worker across U.S. industries are representative of capital-intensity differences across industries in the rest of the world. While (*i*) has become a standard assumption following Rajan and Zingales (1998), there is also evidence in support of (*ii*): the correlation between industry-level capital per worker in the U.S. and Chile is 0.737, while their Spearman's rank correlation is 0.703.

Following Manova (2013), I use Braun (2003)'s measure of asset tangibility based on data for publicly-listed U.S. companies from Compustat's annual industrial files. At the firm-level, asset tangibility is measured as the share of net property, plant, and equipment in the book value of total assets; a firm's book value may include assets that cannot be seized by a bank as easily as physical capital and, thus, may not be accepted as collateral. Then, industry-level tangibility is defined as the median tangibility across all firms within an industry. This variable ranges from 0.07 in the pottery, china, and earthenware industry to 0.56 in the paper industry, with a mean value of 0.28 and a standard deviation of 0.12.

Finally, I control for GDP per capita (PPP-adjusted) from the Penn World Tables 6.3. Then, the dataset consists of an unbalanced panel with 106 countries and 26 sectors at the 3-digit ISIC rev. 2 level, from 1985 to 1995.[46]

[45] To ensure comparability with the quantitative analysis conducted in the previous section, I exclude the same industries as in the Chilean firm-level dataset.

[46] I examine the sources of missing observations in the Online Appendix; I show that the

Table 5: Industry-level implications, regression estimates

	ln(Exports/Domestic sales)
Credit/GDP	-0.700
	(0.151)
Credit/GDP $\times$ Capital per worker	0.042
	(0.003)
Credit/GDP $\times$ Tangibility	-2.673
	(0.333)
R-squared	0.519
Number of observations	15,158

Note: Country, industry, and year fixed effects are included. I also control for GDP per capita (in logs). Heteroskedasticity-robust standard errors are reported in parentheses.

5.1.3 Regression estimates

Table 5 reports the ordinary least squares (OLS) estimates of the empirical specification above. I only report the coefficients on the aggregate ratio of credit to GDP and its interactions since these are the main objects of interest.

To examine the empirical relationship between financial development and international trade across industries, I compute the partial derivative of the trade share (in logs) with respect to the credit-to-GDP ratio, which is given by $\omega_1 + \omega_2 \times \text{Capital-per-worker}_j + \omega_3 \times \text{Tangibility}_j$. The estimate of ω_2, which is positive and statistically significant, implies that capital-intensive industries have relatively higher trade shares in countries with better developed financial markets. These estimates are qualitatively consistent with the model's industry-level implications, as well as with the evidence documented by Manova (2013).

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 above.

To do so, I use the regression estimates to compute the trade share change across industries heterogeneous in capital-intensity associated with the development of financial markets. In particular, I consider a change of the credit-to-GDP ratio from 0.00 to 1.63, the same change featured by the credit to

findings are robust to accounting for various sources of missing data.

value added ratio in the model between the no-credit and financially-developed economies.

To construct an empirical counterpart to the change of the trade share in the model's capital-intensive industry (sector H), I evaluate the estimated regression at the average capital per worker across industries with capital per worker above the 75$^{\text{th}}$ percentile: \$ 47.88 million U.S. dollars (at constant 1985 prices) per thousand workers. Similarly, I compute the empirical counterpart to the change of the trade share in sector M of the model evaluating the estimated regression at the average capital per worker across industries with capital per worker between the 25$^{\text{th}}$ and 75$^{\text{th}}$ percentiles: \$ 19.49 million U.S. dollars (at constant 1985 prices) per thousand workers. Finally, I compute the empirical counterpart to the change of the trade share in the model's labor-intensive industry (sector L) by evaluating the estimated regression at the average capital per worker across industries with capital per worker below the 25$^{\text{th}}$ percentile: \$ 9.21 million U.S. dollars (at constant 1985 prices) per thousand workers. This mapping between the industries in the model and those observed in the data is consistent with the approach that I follow to estimate the model.[47]

Finally, I evaluate the estimated regression at its average value of tangibility, equal to 0.28. Thus, I estimate the relationship between financial development and international trade across industries with an average degree of net worth collateralizability.

Table 6 contrasts the log-change of industry-level trade shares, in response to financial development, between the data and the model. In particular, I restrict attention to financial development as a move from the economy without credit to the financially-developed economy. I find that the model can account for a large fraction of the trade share changes implied by the empirical specification estimated above.

On the one hand, both the model and the data imply that financial de-

[47] Recall that I estimate differences across sectors H, M, and L of the model to match their empirical counterpart among the set of industries with capital per worker above the 75$^{\text{th}}$ percentile, between the 25$^{\text{th}}$ and 75$^{\text{th}}$ percentiles, and below the 25$^{\text{th}}$ percentile, respectively.

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

$\Delta \ln \frac{\text{Exports}}{\text{Domestic sales}}$	*Data*	*Model*
Sector L	-1.74	-1.21
Sector M	-1.04	-0.08
Sector H	0.89	0.35

velopment is associated with a substantial increase of the ratio of exports to domestic sales in capital-intensive industries (sector H). In particular, it increases by 0.89 and 0.35 log-points in the data and the model, respectively. On the other hand, I find that there is a sharp decrease of the trade share in labor-intensive industries (sector L): by -1.74 and -1.21 log-points in the data and the model, respectively. Thus, the model accounts for 39.9% and 69.6% of the log-changes of the trade share estimated from the data for capital- and labor-intensive industries.

The model also captures the qualitative relationship between trade shares and financial development observed in the data for sector M. However, the model implies a much milder quantitative relationship between financial development and the trade share in sector M than estimated in the data.

I conclude that the model can quantitatively account for a large fraction of the empirical relationship between trade shares and financial development across industries. These findings provide further support to the implications of the model and to the importance of its underlying mechanisms.

5.2 Aggregate-level estimates

Finally, I ask: to what extent are the implications of the model consistent with 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 from Manova (2013) across industries, to obtain a panel where each observation corresponds to the manufacturing sector of a given country-year pair.[48] Then, I estimate a country-level empirical specification analogous to

[48]For every country-year pair, I aggregate across all industries with non-missing observa-

Table 7: Aggregate-level implications, regression estimates

	ln(Exports/Domestic sales)
Credit/GDP	0.172
	(0.235)
R-squared	0.892
Number of observations	823

Note: Fixed effects for each country and year are included. I also control for GDP per capita. Heteroskedasticity-robust standard errors are reported in parentheses.

the one above, but excluding industry-level variables and industry fixed effects. Then, I estimate:

$$\ln \frac{\text{Exports}_{it}}{\text{Domestic sales}_{it}} = \alpha_i + \gamma_t + \omega \times \frac{\text{Credit}_{it}}{\text{GDP}_{it}} + \boldsymbol{\eta} \times \boldsymbol{X_{it}} + \varepsilon_{it},$$

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 manufacturing exports to total manufacturing domestic sales; $\frac{\text{Credit}_{it}}{\text{GDP}_{it}}$ denotes the ratio of credit to GDP; $\boldsymbol{X_{it}}$ denotes additional control variables (GDP per capita); and, ε_{it} is an error term.

Table 7 reports the estimation results. I find that the coefficient on the credit-to-GDP ratio is positive but statistically insignificant. Consistent with the implications of the model, this evidence shows that financial development is associated with a minor change of aggregate trade shares.

6 Conclusion

Recent studies have documented a strong empirical relationship between measures of access to external finance and the extent of international trade at both the firm and industry levels, suggesting that financial development has a significant impact on international trade in the aggregate. In this paper, I examine the extent to which this is the case using a quantitative general equilibrium model estimated to match salient features of firm-level data.

My findings show that, while financial frictions have a significant impact on international trade at the industry-level, they have a minor impact on it

tions of exports and output.

at the aggregate-level. I show that these findings are consistent with evidence from cross-country industry-level and aggregate data.

These results point to the importance of general equilibrium effects in interpreting firm- or industry-level evidence. While some distortions may play an important role when studying firms or industries in isolation, their importance at the aggregate level may be offset by changes in equilibrium prices.

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