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# Capital Market Imperfections and Trade Liberalization in General Equilibrium\*

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## Abstract

This paper develops a new international trade model with capital market imperfections and endogenous borrowing costs in general equilibrium. Our theoretical model is motivated by new empirical patterns from enterprise survey data of the World Bank. Observing that a substantial fraction of the variation in financial constraints is across firms within industries, we allow for firm-specific exposure to financial constraints. This leads to credit rationing and divides producers into financially constrained and unconstrained ones. We show that endogenous adjustments of capital costs represent a new channel that reduces common gains from globalization. Trade liberalization increases the demand for capital and thus the borrowing rate. This leads to a reallocation of market shares towards financially unconstrained producers and a larger fraction of credit-rationed firms. Both effects increase the within-industry variance of firm outcomes and reduce welfare gains as consumers dislike heterogeneity in prices.

*Keywords:* Credit constraints, General equilibrium, Globalization, Imperfect capital markets, Welfare.

*JEL Classification:* F10, F36, F61, L11

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# 1 Introduction

International activity of firms usually depends on access to external capital. Credit from outside investors is used to finance production costs, machinery, the purchase of material inputs and upfront investments. Empirical studies show that access to external capital and financial development are important determinants of trade activity. Countries with better-developed financial systems export relatively more in industries with higher dependence on external finance and lower asset tangibility (Beck, 2003; Svaleryd & Vlachos, 2005; Manova, 2008, 2013). Based on international trade models with firm heterogeneity à la Melitz (2003), existing theoretical work focuses on the interaction of credit constraints at the industry- or country-level with ex-ante productivity differences of firms. Recent empirical studies point to the importance of heterogeneity across producers with respect to credit constraints. Financial health and access to external finance are important determinants of export and innovation activity, even after controlling for characteristics such as size and productivity (Berman & Héricourt, 2010; Minetti & Zhu, 2011; Gorodnichenko & Schnitzer, 2013; Muûls, 2015). Furthermore, theoretical models mainly consider financial frictions in a partial equilibrium environment and treat borrowing costs as exogenously given.

The purpose of this paper is to analyze the effects of globalization on firm performance and consumer welfare when producers differ in their exposure to financial frictions and borrowing costs are endogenous. Therefore, we introduce a new international trade model with heterogeneity in credit constraints at the firm-level and capital market clearing in general equilibrium. To motivate our theoretical framework, we exploit enterprise survey data from the World Bank and highlight three novel empirical patterns. First, the majority of variation in the exposure to financial constraints is across firms within industries rather than between industries. Second, more financially constrained industries show a larger variance of firm sales. Third, countries with lower financial development are characterized by a larger within-country variance of firm sales and a higher share of credit-rationed producers.

Motivated by the first empirical pattern, we introduce heterogeneity in credit frictions at the firm-level. Firms require external capital to cover variable costs for the production of a horizontally differentiated variety. In contrast to the existing literature on firm heterogeneity in international trade, we assume that producers are homogenous in terms of marginal costs, but differ in their exposure to financial constraints. To motivate credit frictions, we introduce a simple moral hazard problem between external investors and firm managers, whereas the latter might have incentives to divert the received capital amount and not use the funds in the production process. Incentives for managerial misbehavior differ across agents which leads to credit rationing and divides producers into financially constrained and

unconstrained ones. If financial institutions are imperfect, firm-specific credit constraints translate into heterogeneity in firm performance such as prices and sales. Thus, our model rationalizes the second and third empirical pattern and shows how credit frictions lead to within-industry heterogeneity among producers, especially if financial development is low. If financial institutions are perfect, credit frictions at the firm-level do not matter and producers are homogenous.

Compared to existing theoretical work on financial frictions in international trade, we stress two additional channels of adjustment to trade liberalization. First, trade shocks affect the selection of firms into constrained and unconstrained ones. Second, the interest rate is endogenously determined and affected by trade liberalization. The main message of this analysis is that aggregate implications of globalization can be very different if general equilibrium effects on capital costs are taken into account. We model globalization as an increase in the number of countries in the world economy. This approach allows us to consider both a market size as well as a competition effect of trade liberalization. In partial equilibrium, a rise in the number of countries increases industry scale due to the dominating market size effect. However, competition from foreign firms reduces variable profits such that credit constraints become tighter. Consequently, trade liberalization leads to a larger fraction of financially constrained producers.

Whereas the borrowing rate is exogenous in partial equilibrium, we endogenize capital costs in general equilibrium. As firms face a larger market after globalization, capital demand increases which leads to upward pressure on the interest rate. This general equilibrium effect aggravates financial constraints and has two implications on the industry. First, some initially unconstrained firms face credit rationing and have to set higher prices. Second, existing constrained producers are hurt more by increased borrowing costs leading to a within-sector reallocation of profits towards unconstrained firms. These two adjustments increase the within-industry variance of prices in the economy. Considering the indirect utility associated with quadratic preferences as a welfare measure, consumers dislike price heterogeneity. In general equilibrium, the endogenous adjustment of capital costs represents an additional channel which reduces common gains from trade due to larger consumption variety and pro-competitive effects.

Our model builds on the growing literature on imperfect capital markets in international trade. Recent theoretical contributions introduce credit frictions in trade models with heterogeneous firms.<sup>1</sup> This strand of literature differs regarding (i) the usage of external funds (e.g.

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<sup>1</sup>See e.g. Muïls (2008), Manova (2013), and Chaney (2013) for extensions of the Melitz (2003) model by financial frictions. Peters & Schnitzer (2015) introduce borrowing constraints in the framework of Melitz & Ottaviano (2008).

trade related fixed or variable costs), (ii) the theoretical motivation of financial constraints (e.g. moral hazard, imperfect contractibility, information asymmetry), and (iii) the underlying preference structure (e.g. CES vs. linear demand). To the best of our knowledge, this paper is the first to introduce firm-specific credit frictions that lead to heterogeneity with respect to firm performance in the absence of ex-ante productivity or wealth differences. Furthermore, existing work analyzes the effects of credit frictions on product markets in general equilibrium without explicitly modelling capital markets. One exception is Foellmi & Oechslin (2010) who also consider an endogenous interest rate determined by capital market clearing. However, the focus of their approach is a different one. In a framework with CES preferences and heterogeneity in wealth, they analyze the distributive impact of trade liberalization in less-developed countries. The authors show that globalization impedes access to external finance, especially for poor entrepreneurs, resulting in an increase of income inequality in the economy. Formai (2013) analyzes the welfare implications of credit frictions in a general equilibrium framework based on Melitz (2003). By assuming external finance of sunk entry costs, credit frictions distort the entry decision of producers and lead to an equilibrium with a too low number of inefficient firms. In this framework, the author shows that trade liberalization can lead to negative welfare effects.

In our paper, the crucial mechanism in general equilibrium is the endogenous adjustment of the interest rate after globalization. Therefore, our analysis is related to models that study how credit frictions affect international capital and trade flows. In a Heckscher-Ohlin model with heterogeneous financial frictions across countries and sectors, Antràs & Caballero (2009) show that trade integration increases the interest rate in financially underdeveloped countries. Whereas this result is driven by specialization and across-sector reallocation of inputs, in our model interest rate adjustments after globalization lead to within-sector reallocation of market shares between constrained and unconstrained firms.

The paper is structured as follows. The next section provides empirical motivation for our theoretical setup. Section 3 presents the theoretical model and discusses comparative statics in partial equilibrium. The following section introduces the capital market and discusses general equilibrium effects of globalization. Section 5 shows simulation results of the gains from globalization in both partial and general equilibrium, and finally, section 6 concludes.

## 2 Empirical motivation

In this section, we present new empirical patterns that relate financial constraints to the variance in firm sales within industries and within countries. The empirical analysis is entirely descriptive and aims to motivate the theoretical framework. First, we show that a

substantial fraction of the total variation in the exposure to financial constraints is across firms within industries rather than between industries. This pattern implies that credit frictions at the firm-level are important and that producers within the same industry face very different degrees of credit rationing. Second, more financially constrained industries show a larger within-industry variance of firm sales. Third, countries with lower financial development are characterized by a larger within-country variance of firm sales and a higher share of credit-rationed producers. The first subsection describes the data set and variables used. The second subsection presents empirical patterns that motivate our theoretical model.

Table 1: Summary statistics

Variable	Obs.	Mean	Median	S.D.	Min	Max
Cross section 2002-2005						
Tangible over total assets	13,267	0.21	0.14	0.22	0	1
Log sales	13,175	14.05	13.77	2.89	-2.16	28.79
Cross-section 2009						
Share of constrained firms	18,911	0.30	0	0.46	0	1
Log sales	16,903	12.84	12.82	2.56	0.27	22.65
Cross-section 2013						
Share of constrained firms	21,067	0.24	0	0.42	0	1
Log sales	16,737	12.28	12.20	2.38	-0.81	28.35

Source: Authors' own computations from the WBES.

## 2.1 Data description

We use cross-sectional firm-level data from the World Bank Enterprise Surveys (WBES).<sup>2</sup> We are interested in the relationship between financial constraints and the variance of firm sales both within industries and within countries. Following existing firm-level studies, the first part of the analysis uses the ratio of tangible assets over total assets (*TOA*) as a proxy for access to external finance. We measure tangible assets as land and buildings which reflects the availability of collateral and thus better access to credit.<sup>3</sup> As this measure is only available for early waves of the enterprise surveys during the period 2002-2005, we restrict our analysis to a cross-section with 13,267 firms from 15 countries.<sup>4</sup> We use this

<sup>2</sup>The database is available at <http://www.enterprisesurveys.org>.

<sup>3</sup>Other studies that use similar proxies for financial constraints are Greenaway *et al.* (2007), Berman & Héricourt (2010), and Goerg & Spaliara (2013), among others. For a survey of empirical studies using firm-level data see Wagner (2014). Results remain significant and robust if we include machinery and equipment in our proxy for tangible assets.

<sup>4</sup>The countries are Bangladesh, Chile, El Salvador, Ethiopia, Guatemala, Honduras, India, Nicaragua, the Philippines, Sri Lanka, South Africa, Thailand, Turkey, Vietnam, and Zambia.

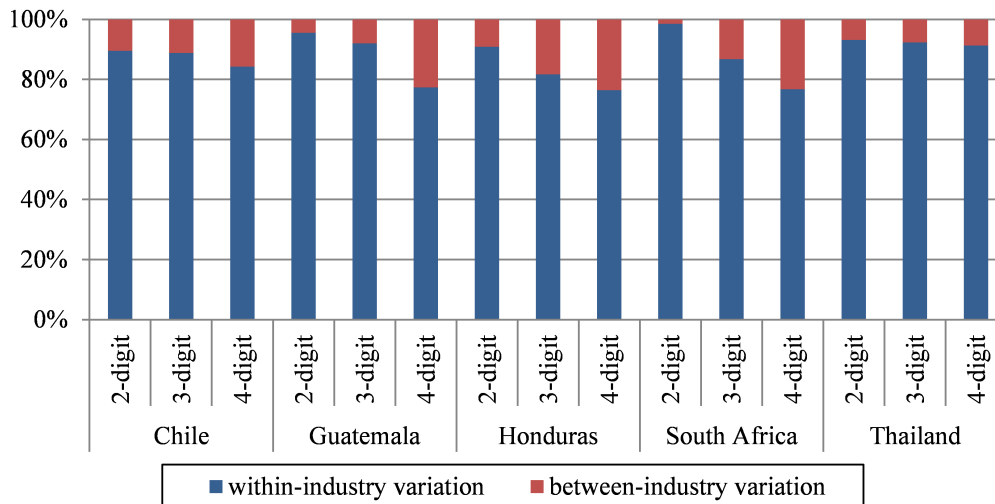


Figure 1: Within- and between-industry variation of tangible assets

continuous proxy for credit access to investigate the variation in the exposure to financial constraints across firms within industries and between industries. Furthermore, we compute the mean of tangible over total assets by industry and country and relate it to the variance in log sales across firms. As the variables are reported in local currency units, we convert it to 2005 U.S. dollars.

The second part of the empirical analysis further investigates the relationship between financial constraints and the variance of firm sales at the country-level. Therefore, we exploit cross-section data for the years 2009 and 2013 which is available for a larger set of countries.<sup>5</sup> We use domestic credit to the private sector in percentage of GDP as a proxy for financial development and relate it to the within-country variance of firm sales as well as the share of financially constrained producers by country.<sup>6</sup> To obtain the latter measure, we consider a survey question which asks firms to state whether access to financing (including availability and costs) is an obstacle to the current operations of the establishment. The categorical variable ranges from 0 (no obstacle) to 4 (very severe obstacle).<sup>7</sup> We introduce a dummy variable for financially constrained producers which takes the value of 1 if firms perceive access to financing as a major or very severe obstacle (values 3 and 4 of the categorical variable). We take means by country as a measure for credit constraints. Table 1 provides summary statistics of the variables of interest.

<sup>5</sup>Tables 6 and 7 in the Data Appendix show summary statistics by country for the years 2009 and 2013.

<sup>6</sup>The data is taken from the World Development Indicators of the World Bank.

<sup>7</sup>Gorodnichenko & Schnitzer (2013) use self-reported information from the 2002 and 2005 Business Environment and Enterprise Performance Survey (BEEPS) for 27 transition countries to analyze the effect of credit constraints on innovation activity.

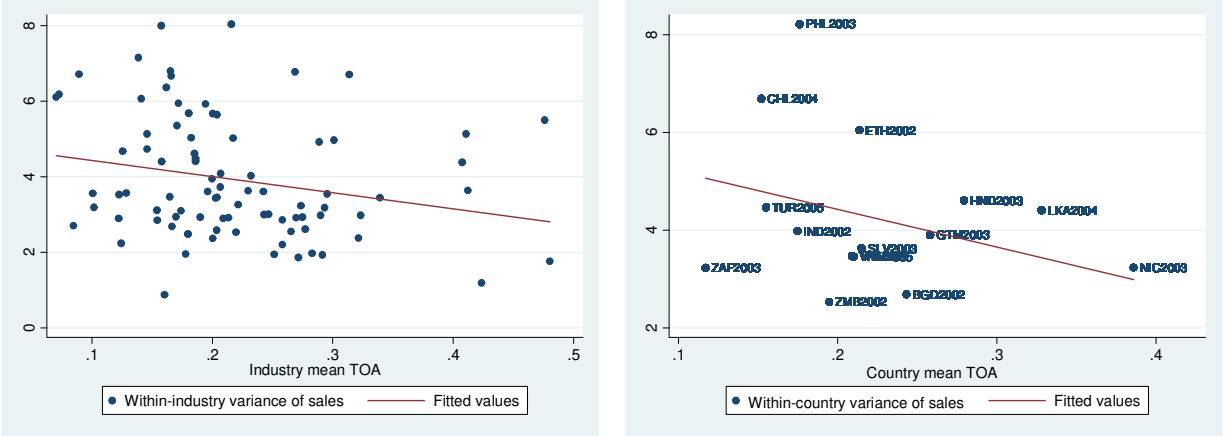


Figure 2: TOA and variance of sales within-industry (left) and within-country (right)

## 2.2 Empirical results

The first pattern decomposes the total variation in the measure for credit access (tangible over total assets) into within- and between-industry variation. Figure 1 shows results for five countries at three levels of industry aggregation and reveals that a substantial part of the variation is within industries. The observed pattern suggests that firms within the same industry are affected very differently by credit constraints.<sup>8</sup>

**Empirical pattern 1** *The majority of the variation in financial constraints is across firms within industries rather than between industries.*

In a second step, we use the mean of the firm-level tangible assets over total assets ratio to compute a measure for credit access at the industry-level. We relate this proxy to the within-industry variation of firm sales. The left panel of Figure 2 depicts within-industry variances of firm-level sales, whereas the right panel shows results at the country-level. To compute the within-industry variances, we restrict our analysis to sectors with more than 25 firm observations. Figure 2 shows that industries with a higher ratio of tangible over total assets are characterized by a lower within-industry variance of firm sales. Table 2 shows the negative correlation coefficients, whereas only the relationship for industries is significant at the 5% level.

The observed pattern suggests that the exposure to credit constraints is positively associated with firm heterogeneity. In sectors with lower asset tangibility, firms tend to be more financially constrained on average and differ more in terms of sales. Our theoretical model

<sup>8</sup>This pattern holds for all countries with available data in our sample. Table 5 in the Data Appendix shows results for the full set of countries.



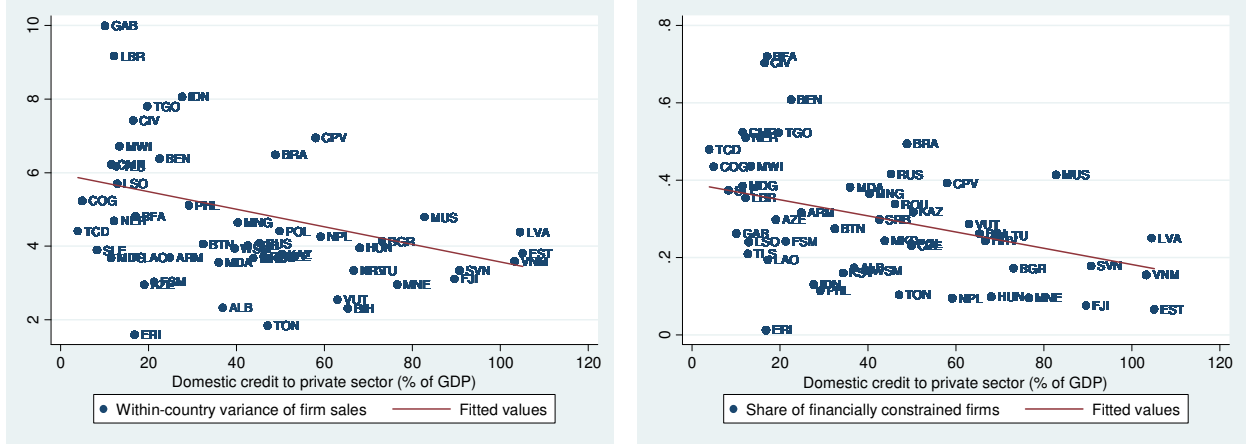


Figure 3: Financial development and within-country heterogeneity

rationalizes this second pattern as differences in financial frictions at the firm-level lead to a larger heterogeneity in firm performance within industries for which credit constraints are more restrictive.

Table 2: Correlation credit constraints and variance of firm performance

Variance of firm sales	Within-industry	Within-country
Industry / Country mean $TOA$	-0.2279**	-0.2373
Obs.	87	15

Notes: \*\* indicates 5% significance.

**Empirical pattern 2** *More financially constrained industries are characterized by a larger variance of firm sales.*

We use more recent cross-section data of the WBES for the years 2009 and 2013, which is available for a larger set of countries, to investigate the relationship between financial development and firm heterogeneity at the country-level. For the year 2009, the left panel of Figure 3 shows a significantly negative relationship between domestic credit provided to the private sector (in % of GDP) and the within-country variance of firm sales. Furthermore, the right panel depicts that financial development is associated with a lower share of financially constrained firms within a country. Table 3 summarizes the correlation coefficients for both years and furthermore shows that the share of financially constrained producers is positively related to the variance of firm sales in a country.<sup>9</sup>

<sup>9</sup>For the cross-section of the year 2013, Figure 10 in the Data Appendix shows the relationship between financial development and within-country heterogeneity. Figure 11 relates the share of financially constrained

Table 3: Correlation credit constraints and variance of firm performance

	Within-country variance sales		Share constrained firms	
	2009	2013	2009	2013
Private credit / GDP	-0.3884***	-0.4312***	-0.4683***	-0.2692*
Obs.	51	39	54	40
Share constrained firms	0.4539***	0.4051***		
Obs.	54	44		

Notes: \*\*\* indicates 1% significance, \* 10% significance.

**Empirical pattern 3** *Countries with lower financial development are characterized by a larger within-country variance of firm sales and a higher share of credit-rationed producers.*

Motivated by these empirical patterns, the next section introduces a new international trade model with heterogeneity in credit frictions at the firm-level. Existing theoretical work introduces financial frictions in international trade models with heterogeneous firms à la Melitz (2003). Credit constraints at the industry- or country-level interact with heterogeneity in productivity, whereby the latter determines a firm’s access to external finance. Therefore, financial frictions increase the cutoff productivity and intensify the selection of most productive firms into exporting. In contrast to previous work, we assume that producers are homogeneous with respect to marginal production costs, but differ in their exposure to credit constraints. This assumption is consistent with the first empirical pattern that points to the importance of within-industry variation in financial frictions across producers. Furthermore, recent empirical work exploits firm-level measures of financial constraints. Berman & Héricourt (2010), Minetti & Zhu (2011), as well as Muûls (2015) show that financial health and access to external finance are important determinants of export activity, even after controlling for firm characteristics as size and productivity. In our theoretical model, firm-specific differences in the exposure to credit constraints translate into variation in firm performance such as price setting and sales if financial institutions are imperfect. Hence, the model rationalizes a positive relationship between credit market imperfections and firm heterogeneity as shown in the empirical patterns 2 and 3. The link between credit frictions and international trade is particularly relevant in developing countries where the quality of financial institutions is low (Banerjee & Duflo, 2005, 2014). We use this framework to analyze how various shocks induce differential effects across firms within industries in the presence of credit frictions. The next section presents the setup of the theoretical model.

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firms to the within-country variance of firm sales.

### 3 The model

This section develops a model of international trade with heterogeneity in credit frictions at the firm-level. The world economy consists of  $k$  identical countries, each of which is populated by a number of  $L$  consumers and an exogenous mass of  $m$  producers. We motivate financial frictions by a simple moral hazard problem between borrowing firms and external investors. The following subsection presents the demand side of the model, whereas we assume a quadratic specification of preferences and derive market demand by aggregating over the number of consumers in the economy. Section 3.2 shows how firms optimally behave in the presence of capital market imperfections depending on their exposure to financial frictions. The industry equilibrium, outlined in section 3.3, is determined by total industry output and an endogenous share of credit-rationed producers. Finally, in section 3.4, we analyze the effects of globalization and of an interest rate shock in partial equilibrium.

#### 3.1 Consumer side

The representative consumer's utility is defined over per variety consumption  $q(i)$  and total consumption  $Q \equiv \int_{i \in \Omega} q(i) di$ , where the index  $i$  represents one variety and  $\Omega$  is the set of horizontally differentiated products:

$$U = aQ - \frac{1}{2}b \left[ (1 - e) \int_{i \in \Omega} q(i)^2 di + eQ^2 \right]. \quad (1)$$

The quadratic utility function depends on the non-negative preference parameters  $a$ ,  $b$  and on an inverse measure of product differentiation  $e$  which lies between 0 and 1. Lower values of  $e$  imply that products are more differentiated and hence less substitutable. If  $e = 1$ , consumers have no taste for diversity in products and demand depends on aggregate output  $Q$  only. Consumers maximize utility in equation (1) subject to the budget constraint  $\int_{i \in \Omega} p(i)q(i) di \leq I$ , where  $p(i)$  denotes the price for variety  $i$  and  $I$  is individual income.<sup>10</sup> The maximization problem yields the linear inverse demand function:

$$\lambda p(i) = a - b [(1 - e)q(i) + eQ], \quad (2)$$

where  $\lambda$  is the marginal utility of income, the Lagrange multiplier attached to the budget constraint. As firms are infinitesimally small in the economy, they take  $\lambda$  as given. In the

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<sup>10</sup>In general equilibrium, aggregate income consists of firm profits and factor income. We assume that capital is the only factor of production. Section 4 discusses the general equilibrium of the model.

following, we set the marginal utility of income as the numéraire equal to one.<sup>11</sup> To ensure market-clearing, total output of each firm equals the aggregate demand of all consumers in the world economy:  $x(i) = kLq(i)$ . Hence, the inverse world market demand is given by:

$$p(i) = a - b' [(1 - e)x(i) + eX], \quad (3)$$

where  $a$  is the consumers' maximum willingness to pay and  $b' \equiv \frac{b}{kL}$  is an inverse measure for the market size. Finally,  $X \equiv \int_{i \in \Omega} x(i) di$  represents the total volume of varieties produced and consumed in the world economy.

### 3.2 Firm's maximization problem

The industry consists of an exogenous mass of  $m$  firms, each producing a horizontally differentiated variety  $i$ . Firms receive revenues  $p(i)x(i)$  and have to finance total variable production costs  $cx(i)$  by external capital. There are no fixed costs of production. Motivated by empirical pattern 1 and the firm-level evidence on financial frictions and export performance, we assume that firms are homogeneous in marginal production costs  $c$ , but differ in their exposure to credit constraints. If financial institutions are imperfect, only a fraction of producers can overcome credit frictions, receives the required capital amount and is able to produce the optimal output. In contrast, firms with high exposure to credit constraints suffer from underprovision of external capital and cannot behave optimally. In equilibrium, the share of financially unconstrained firms is endogenously determined and affected by trade shocks. As we are interested in the effects of globalization on producers with different exposure to credit constraints, we do not consider endogenous entry and exit decisions. In the following, we describe the firm's maximization problem and introduce credit frictions at the firm- as well as the country-level.

The decision problem of a producer consists of two stages. At date  $t = 0$ , the firm borrows the credit amount  $d(i)$  from an outside investor at the interest rate  $r$ . In partial equilibrium, the interest rate is treated as exogenous, whereas we endogenize it in general equilibrium as discussed in section 4. To motivate credit frictions at the firm-level, we introduce a managerial action which is non-verifiable for outside investors and hence prone to moral hazard.<sup>12</sup> After credit provision, the manager of the firm can choose whether to use the external funds for production or divert the credit amount and invest it for own purposes.

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<sup>11</sup>Using the marginal utility of income as a numéraire ( $\lambda = 1$ ) is standard in the literature of oligopoly in general equilibrium (GOLE). See Neary (2003) for further discussion.

<sup>12</sup>See Holmstrom & Tirole (1997) as well as Tirole (2006) for moral hazard in corporate finance. Recent papers that introduce credit constraints motivated by moral hazard in a trade context are Ehrlich & Seidel (2013) and Egger & Keuschnigg (2015).

At date  $t = 1$ , production yields profits which consist of revenues net of loan repayment:

$$\pi(i) = p(i)x(i) - rd(i), \quad (4)$$

whereas the firm faces the following budget constraint:

$$d(i) \geq cx(i). \quad (5)$$

Alternatively, the manager can choose to divert the loan without using the provided capital in the production process. In this case, no revenues are realized and the loan cannot be repaid. Instead the manager reaps a share  $\beta(i)(1 - \phi)$  of the credit amount  $d(i)$  and invests it on the capital market at interest rate  $r$ . Hence, the non-verifiable private benefit from managerial misbehavior at date  $t = 1$  is equal to  $rd(i)\beta(i)(1 - \phi)$ . We follow Antràs *et al.* (2009) and assume that private benefits are negatively related to the quality of financial institutions captured by the parameter  $\phi \in [0, 1]$ . Countries with better financial institutions (larger  $\phi$ ) tend to enforce laws that limit the ability of managers to divert funds or enjoy private benefits.<sup>13</sup> In contrast to standard moral hazard approaches, we assume that producers are located at the unit interval and are heterogeneous in the share  $\beta(i) \in [0, 1]$ , which we denote the agency costs of a firm  $i$ , whereby a higher  $\beta(i)$  increases the private benefit and thus the incentive for managerial misbehavior. This assumption introduces heterogeneity in credit constraints at the firm-level. To prevent misbehavior of agents and thus losses from lending, investors have to ensure that the following incentive constraint holds:

$$\pi(i) \geq \beta(i)(1 - \phi)rd(i). \quad (6)$$

At period  $t = 1$ , profits in case of production and loan repayment have to be (weakly) higher than private benefits in case of misbehavior. Rearranging equation (6) shows that moral hazard restricts the borrowing capacity:

$$d(i) \leq \frac{p(i)x(i)}{r[1 + \beta(i)(1 - \phi)]}. \quad (7)$$

Firms with high agency costs  $\beta(i)$  derive large private benefits from diverting the loan. Hence, investors restrict credit provision to prevent managerial misbehavior. If financial institutions are perfect ( $\phi = 1$ ), managers have no incentives to misbehave and equation (6) collapses to a zero-profit condition. In this case, differences in agency costs  $\beta(i)$  play no role and firms are homogenous. In contrast, if financial institutions are imperfect ( $\phi < 1$ ),

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<sup>13</sup>See Tirole (2006) as well as Antràs *et al.* (2009) for a similar notion of financial contract enforcement in models with moral hazard.

firm-specific moral hazard divides agents into two groups. First, producers with relatively low  $\beta(i)$  choose the optimal output level as the financial constraint is not binding. Second, firms with higher agency costs face credit rationing and have to restrict production. To solve for outputs and prices, firms maximize profits (4) subject to the budget constraint (5) and the financial constraint (7).

**Constrained firms** For firms with high agency costs  $\beta(i)$ , the financial constraint is binding such that the constrained price equals the effective marginal production costs:

$$p_C(\beta) = cr [1 + \beta(i) (1 - \phi)]. \quad (8)$$

Producing one unit of the good yields the price  $p_C(\beta)$  which has to compensate for the marginal production costs  $cr$  and the opportunity costs of diligent behavior  $cr\beta(i) (1 - \phi)$ . The quantity of credit-rationed producers is given by:

$$x_C(\beta) = \frac{a - b'eX - cr [1 + \beta(i) (1 - \phi)]}{b'(1 - e)}. \quad (9)$$

More financially constrained firms with a higher value of  $\beta(i)$  face larger opportunity costs of production and have to set higher prices which results in lower outputs.

**Unconstrained firms** For unconstrained firms, the financial constraint is not binding such that optimal output is independent of  $\beta(i)$ :

$$x_U = \frac{a - b'eX - rc}{b'(2 - e)}. \quad (10)$$

By inserting equation (10) into the inverse demand function (3), we derive the optimal price of unconstrained firms:

$$p_U = \frac{a - b'eX + (1 - e)rc}{2 - e}. \quad (11)$$

In our model, the only source of firm heterogeneity occurs in  $\beta$ . As optimal output (10) and prices (11) do not depend on  $\beta$ , all unconstrained producers behave in the same way. It can be shown that unconstrained firms charge lower prices, earn higher markups and offer higher quantities compared to credit-rationed producers.

### 3.3 Industry equilibrium

In equilibrium, we derive a critical value of agency costs  $\tilde{\beta}$  above which firms are financially constrained. We exploit that for the marginal unconstrained producer the financial constraint

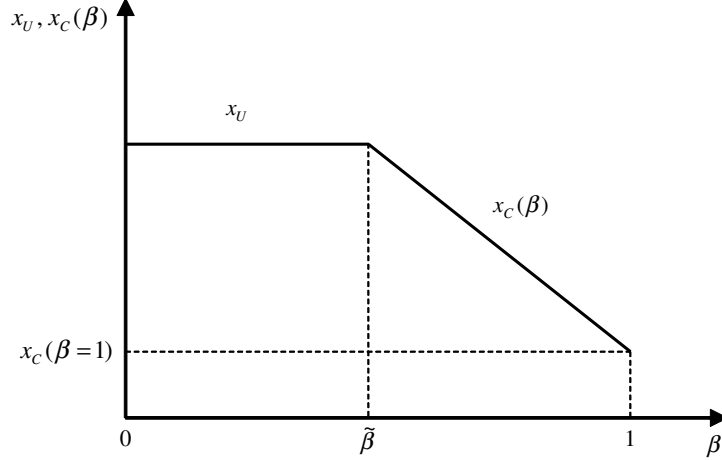


Figure 4: Output profile of constrained and unconstrained firms

(6) is just binding and insert the optimal output from equation (10) which leads to:

$$\tilde{\beta} = \frac{a - b'eX - cr}{(2 - e)(1 - \phi)cr}. \quad (12)$$

In a particular industry, a fraction  $\tilde{\beta}$  of firms is unconstrained and chooses the identical optimal output as shown in Figure 4. Following equation (9), output of constrained firms decreases in agency costs  $\beta$ . Equation (12) shows that the higher the industry output  $X$ , and therefore the tougher the competition, the more firms are financially constrained. Furthermore, conditional on industry output  $X$ , the fraction of unconstrained producers decreases in credit costs  $cr$  and, consistent with empirical pattern 3, increases in the quality of financial institutions  $\phi$ . To arrive at an output profile as depicted in Figure 4, we impose two conditions. First, to ensure that both groups of firms occur, the threshold value of  $\tilde{\beta}$  has to be smaller than one.

**Condition 1**  $\tilde{\beta} < 1$  if  $\frac{a - b'eX}{cr} < 1 + (1 - \phi)(2 - e)$

Second, the output of the firm with the highest agency costs ( $\beta(i) = 1$ ) has to be positive. Otherwise it would not be active in the market.

**Condition 2**  $x_C(\beta = 1) > 0$  if  $\frac{a - b'eX}{cr} > 2 - \phi$

Inserting Condition 2 in equation (12) leads to a lower limit value for the share of unconstrained firms  $\tilde{\beta}_l = \frac{1}{2 - e}$ . To determine the industry equilibrium, average output  $\tilde{x}$  in the

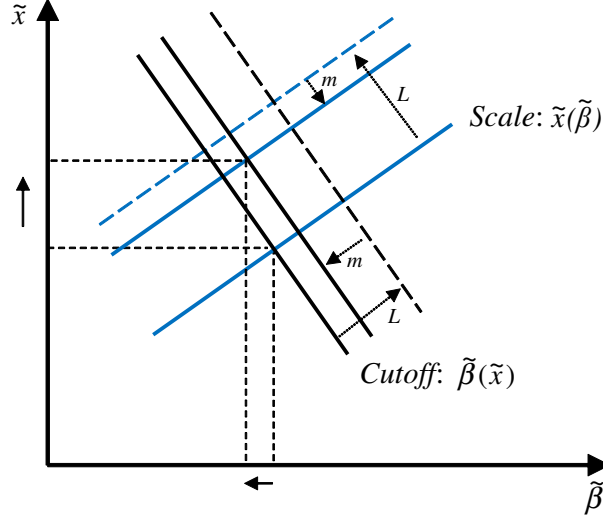


Figure 5: Industry equilibrium and trade liberalization

economy can be expressed as:

$$\tilde{x} = \int_0^{\tilde{\beta}} x_U di + \int_{\tilde{\beta}}^1 x_C(\beta) di. \quad (13)$$

Inserting the optimal outputs (9) and (10) in equation (13) and aggregating leads to:

$$\tilde{x} = \frac{(2 - e - \tilde{\beta}) a - [2 - e - \tilde{\beta} + (2 - e)(1 - \tilde{\beta}) \mu'_c (1 - \phi)] rc}{b \left( (2 - e)(1 - e) + (2 - e - \tilde{\beta}) ekm \right)}, \quad (14)$$

with  $\mu'_c \equiv \frac{1}{1-\tilde{\beta}} \int_{\tilde{\beta}}^1 \beta(i) di$  being the average agency costs within the group of constrained producers. Figure 5 depicts the industry equilibrium. As the world economy consists of  $m$  producers in  $k$  countries, the aggregate output is given by:  $X = km\tilde{x}$ . Equations (12) and (14) represent two relationships between the two endogenous variables  $\tilde{\beta}$  and  $\tilde{x}$ . The curve *Cutoff*:  $\tilde{\beta}(\tilde{x})$  illustrates equation (12) and determines the fraction of financially constrained firms dependent on average industry output. Intuitively, the negative slope captures the fact that higher industry scale increases competition and forces more firms into the constrained status. The curve *Scale*:  $\tilde{x}(\tilde{\beta})$  is derived from equation (14) and reflects that with a higher critical value  $\tilde{\beta}$  more firms are unconstrained and thus choose optimal output levels. Hence, average industry scale increases. The intersection of the two curves in Figure 5 characterizes the industry equilibrium.



### 3.4 Comparative statics in partial equilibrium

The previous section has characterized the partial equilibrium in the economy. In a next step, we investigate how globalization and an exogenous change in the interest rate affect our equilibrium. All results are derived by total differentiation of the two equilibrium conditions (12) and (14). See Appendix 7.1 for a detailed derivation.

**Globalization** Following Eckel & Neary (2010), we interpret globalization as an increase in the number of countries  $k$  in the integrated world economy. This shock affects optimal firm behavior through two channels. On the one hand, producers face a market size effect which corresponds to an increase in the number of consumers  $L$ . On the other hand, globalization is associated with increased competition from foreign firms. Therefore, this competition effect works like a rise in the number of producers  $m$ . To gain intuition for the effects of globalization, we analyze the two channels separately.

From equation (3), we observe that a larger market rotates the inverse world demand outwards without affecting the intercept. Thus, firms face a larger demand and raise output levels resulting in a one-to-one increase in industry scale. This market size effect is counteracted but not outweighed by tougher competition. Consequently, globalization increases average industry scale:

$$\frac{d \ln \tilde{x}}{d \ln k} = \underbrace{1}_{\text{Market size effect}} - \underbrace{\frac{(2 - e - \tilde{\beta}) e k m}{(2 - e)(1 - e) + (2 - e - \tilde{\beta}) e k m}}_{\text{Competition effect}} > 0. \quad (15)$$

The positive market size effects shifts the curve *Scale*:  $\tilde{x}(\tilde{\beta})$  upwards and the curve *Cutoff*:  $\tilde{\beta}(\tilde{x})$  outwards in Figure 5. A larger market increases the pledgeable income and thus relaxes the financial constraint (6). As Figure 5 shows, the change in market size does not affect the share of credit-rationed producers in equilibrium. However, the competition effect leads to a partial backward shift of the two curves. A greater number of competitors producing at a larger average scale  $\tilde{x}$  aggravates financial constraints and increases the share of credit-rationed firms:

$$\frac{d \ln \tilde{\beta}}{d \ln k} = - \underbrace{\frac{(1 - e) b' e X}{(1 - \phi) c r \tilde{\beta} \left[ (2 - e)(1 - e) + (2 - e - \tilde{\beta}) e k m \right]}}_{\text{Competition effect}} < 0. \quad (16)$$

Tougher competition reduces firm revenues and therefore pledgeable income as shown by

equation (7). If goods are perfectly differentiated ( $e = 0$ ), the competition effect disappears and globalization leads to a one-to-one increase in output without affecting the share of financially constrained producers.

**Proposition 1** *In partial equilibrium, globalization increases industry scale as the positive market size effect dominates the counteracting competition effect. The latter increases the share of financially constrained producers (lower  $\tilde{\beta}$ ).*

**Borrowing costs** In this section, we analyze the effects of an exogenous change in the interest rate  $r$ . An increase in the borrowing costs reduces average industry scale  $\tilde{x}$  and forces more producers into the constrained status:

$$\frac{d \ln \tilde{x}}{d \ln r} < 0 ; \frac{d \ln \tilde{\beta}}{d \ln r} < 0. \quad (17)$$

**Proposition 2** *In partial equilibrium, an exogenous increase in the borrowing rate leads to a higher share of financially constrained firms and reduces industry scale.*

**Proof.** See Appendix 7.1. ■

For both groups, an increase in the borrowing rate has a direct negative impact on firm outputs, whereby the effect is stronger for credit-rationed firms. By comparing equations (9) and (10), this can be explained by the agency problem which leads to higher effective marginal production costs for financially constrained producers. Whereas credit-rationed agents experience strong contraction, total differentiation of equation (10) shows a counter-acting competition effect for unconstrained firms:<sup>14</sup>

$$\frac{d \ln x_U}{d \ln r} = -\frac{cr}{b'(2-e)x_U} \left( 1 + \frac{eb'X}{cr} \underbrace{\frac{d \ln \tilde{x}}{d \ln r}}_{(-)} \right) \leq 0. \quad (18)$$

Besides the direct negative impact of an increase in the interest rate, unconstrained producers optimally react to the reduction in industry scale by an increase of individual output. If varieties are perfectly differentiated ( $e = 0$ ), the latter effect vanishes and unconstrained firms clearly reduce sales. However, the larger is the substitutability of goods, the more unconstrained firms benefit from reductions of rival firms' outputs.

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<sup>14</sup>See Appendix 7.1 for an explicit derivation of the expression  $\frac{d \ln \tilde{x}}{d \ln r} < 0$ .

## 4 General equilibrium

The partial equilibrium analysis is based on the assumption that the interest rate is exogenously given. This implies that capital supply is completely elastic. In the next subsection, we endogenize the interest rate by introducing a simple capital market with fixed supply. In the following, we analyze how endogenous adjustments of borrowing costs affect the implications of globalization. Furthermore, we show the impact of financial development in general equilibrium.

### 4.1 Capital market clearing

Each firm has to cover variable production costs by external finance and hence demands  $cx_j(i)$  units of capital, with  $j \in C, U$ . We assume that the economy is endowed with a fixed amount of capital  $K_S$ . In equilibrium, the inelastic supply of capital has to be equal to total capital demand  $K_D$  of  $m$  firms in a country:

$$K_S = K_D = cm \left( \int_0^{\tilde{\beta}} x_U di + \int_{\tilde{\beta}}^1 x_C(\beta) di \right) = cm\tilde{x}. \quad (19)$$

By evaluating the equilibrium condition (19), we can explicitly solve for the interest rate:

$$r = \frac{\left(2 - e - \tilde{\beta}\right) a - b' \left( (2 - e)(1 - e) + \left(2 - e - \tilde{\beta}\right) ekm \right) \frac{K_s}{cm}}{\left[ 2 - e - \tilde{\beta} + (2 - e) \left(1 - \tilde{\beta}\right) \mu'_c (1 - \phi) \right] c}. \quad (20)$$

We add equation (19) to the system of equations from the partial equilibrium analysis (12) and (14). In general equilibrium, profits and capital income determine the aggregate income of consumers  $I$ . A rise in the interest rate  $r$  has no effect on aggregate income as the resulting increase in capital income is exactly offset by a decrease in firm profits.

### 4.2 Comparative statics in general equilibrium

This section analyzes the effects of globalization and changes in financial development in general equilibrium. As capital market clearing pins down the average industry scale  $\tilde{x}$ , we express our equilibrium by two equations in the endogenous variables  $r$  and  $\tilde{\beta}$ . The curve  $CUT: \tilde{\beta}(r)$  in Figure 6 combines capital market clearing (19) with the financial condition (12). Intuitively, the curve is downward sloping as a higher interest rate increases the share of financially constrained firms and thus reduces the cutoff value  $\tilde{\beta}$ . The curve  $CME: r(\tilde{\beta})$  is derived by inserting equation (19) into (14), and illustrates the relationship between  $r$  and

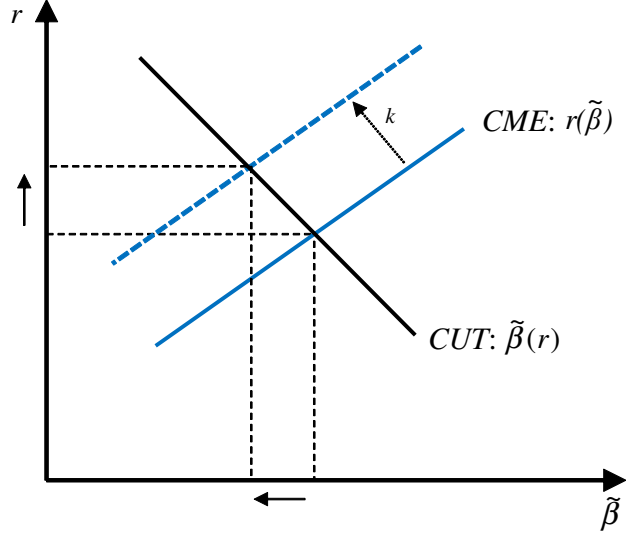


Figure 6: Globalization in general equilibrium

$\tilde{\beta}$  such that the capital market is in equilibrium. A higher share of unconstrained producers leads to an increase of average output and thus to higher capital demand. To ensure capital market clearing, the interest rate has to rise.

**Globalization** In general equilibrium, the fixed capital amount determines average industry output. Therefore, in contrast to section 3.4, globalization (an increase in  $k$ ) has no effect on industry scale:

$$\frac{d \ln \tilde{x}}{d \ln k} = 0. \quad (21)$$

Globalization leads to an upward shift of the curve  $CME: r(\tilde{\beta})$  in Figure 6. For a given share of financially constrained firms, the dominating market size effect increases capital demand resulting in a higher interest rate:

$$\frac{d \ln r}{d \ln k} > 0. \quad (22)$$

The curve  $CUT: \tilde{\beta}(r)$  is unaffected such that the new equilibrium is characterized by the intersection point with the new capital market clearing condition. Consequently, the share of financially constrained producers increases as higher borrowing costs impose stronger restrictions on the financial constraint:

$$\frac{d \ln \tilde{\beta}}{d \ln k} < 0. \quad (23)$$

**Proposition 3** *In general equilibrium, globalization increases the interest rate and the share of financially constrained firms, but has no effect on industry scale.*

**Proof.** See Appendix 7.2. ■

Comparing equations (16) and (23) shows that globalization leads to a stronger increase in the share of financially constrained producers in general equilibrium (see Appendix 7.2 for a formal proof). This result is driven by the endogenous increase in borrowing costs which forces more firms into the constrained status. In contrast to partial equilibrium, the increase in the interest rate leads to different firm responses after globalization:

$$\frac{d \ln x_U}{d \ln k} = 1 - \frac{cr}{a - b'eX - cr} \frac{d \ln r}{d \ln k} > 0, \quad (24)$$

$$\frac{d \ln x_C(\beta)}{d \ln k} = 1 - \frac{[1 + \beta(i)(1 - \phi)] cr}{a - b'eX - cr [1 + \beta(i)(1 - \phi)]} \frac{d \ln r}{d \ln k} < 0. \quad (25)$$

The increase in the number of countries  $k$  affects optimal firm behavior in two opposing ways. As shown in partial equilibrium, the market size effect dominates the competition effect which induces firms to increase outputs. The endogenous adjustment of the interest rate in general equilibrium counteracts the positive impact of globalization. The latter effect especially hurts financially constrained producers with high agency costs  $\beta(i)$  shown by the larger weight of the interest rate in equation (25) compared to unconstrained firms (24).

**Proposition 4** *In general equilibrium, globalization leads to an output expansion among unconstrained firms, whereas financially constrained producers have to reduce output due to increased capital costs.*

**Proof.** See Appendix 7.2. ■

The expansion among unconstrained firms is illustrated in Figure 7 by an upward shift of the output profile. In contrast, credit-rationed producers suffer from increased capital costs and thus decrease output depending on their agency costs. As the most constrained firm with  $\beta = 1$  faces the strongest output reduction, the constrained output profile rotates clockwise. The slope is given by  $-\frac{cr(1-\phi)}{b'(1-e)}$  (compare equation (9)) and thus increases in the interest rate and the market size. The differential responses across the two groups of producers increase the variance of output and prices within the industry. This result will be crucial for the welfare consequences which we discuss in more detail in section 5. As average industry scale is unaffected due to fixed capital supply, the output gain of unconstrained firms (region A in Figure 7) offsets the contraction of financially constrained producers (region B).

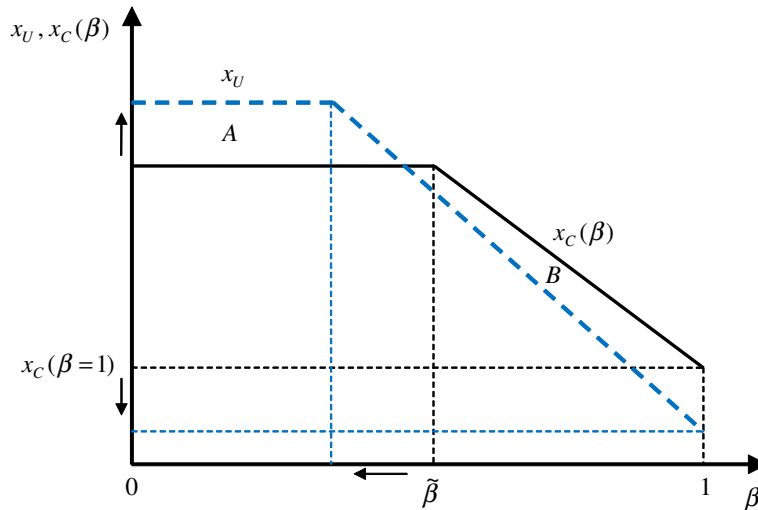


Figure 7: Output profiles and globalization

**Financial development** An increase in  $\phi$  reduces the incentives to reap private benefits and thus enhances the pledgeability of revenues. This shock can be interpreted as an improvement of financial contract enforcement. Comparable to trade liberalization, there is no effect on aggregate output due to fixed capital supply. However, an increase in  $\phi$  relaxes the financial constraint (6) and increases the share of unconstrained producers in the economy:

$$\frac{d \ln \tilde{\beta}}{d \ln \phi} > 0. \quad (26)$$

Furthermore, the increase in pledgeable income translates into higher capital demand and thus a higher borrowing rate:<sup>15</sup>

$$\frac{d \ln r}{d \ln \phi} > 0. \quad (27)$$

**Proposition 5** *In general equilibrium, higher financial development decreases the share of financially constrained firms and increases the borrowing rate.*

**Proof.** See Appendix 7.2. ■

An improvement in the quality of financial institutions increases the borrowing capacity of credit-rated firms. This direct positive effect is counteracted by an increase in capital costs. Whereas financially constrained firms expand output, unconstrained producers do not

<sup>15</sup>Appendix 7.1 provides the effects of financial development in partial equilibrium which are not discussed in the main text.

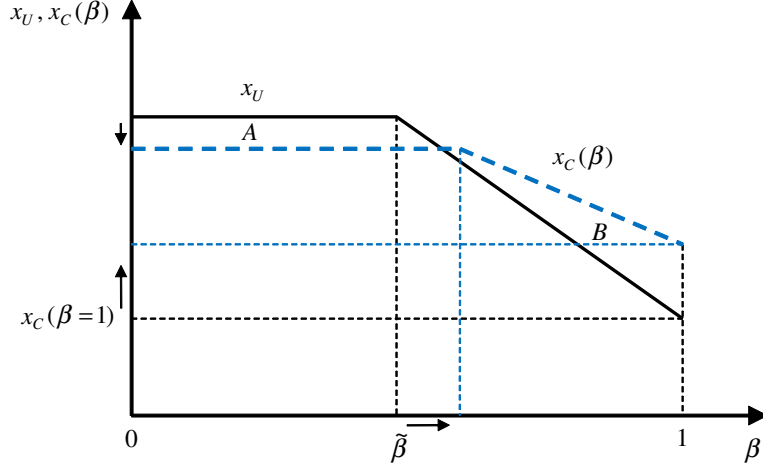


Figure 8: Output profiles and financial development

benefit from higher financial development, but face a higher interest rate:

$$\frac{d \ln x_U}{d \ln \phi} = -\frac{cr}{(2-e)b'x_U} \frac{d \ln r}{d \ln \phi} < 0, \quad (28)$$

$$\frac{d \ln x_C}{d \ln \phi} = \frac{cr}{(1-e)b'x_C} \left[ \phi\beta(i) - [1 + (1-\phi)\beta(i)] \frac{d \ln r}{d \ln \phi} \right] > 0. \quad (29)$$

Consequently, an increase in financial development induces a reallocation of market shares towards credit-rationed producers. This effect can be seen graphically by a downward shift of the unconstrained output profile as well as an outward rotation of the output line for constrained firms in Figure 8.

**Proposition 6** *Consistent with empirical pattern 3, in general equilibrium, higher financial development reduces the variance of sales within an industry as financially constrained firms expand outputs at the expense of unconstrained producers.*

**Proof.** See Appendix 7.2. ■

## 5 Welfare

This section analyzes how globalization affects consumer welfare. In a first step, we derive a welfare measure for a representative consumer. We use the latter for a numerical simulation of the effects of trade liberalization on consumer welfare.

## 5.1 Indirect utility

As an appropriate measure for consumer welfare, we derive the indirect utility function for a representative consumer associated with the preference structure in equation (1). As we choose the marginal utility of income as numéraire ( $\lambda = 1$ ), indirect utility can be expressed as follows:

$$U = km \frac{a^2(1-e) + ekm(\bar{p}^U + \bar{p}^C)^2 - [1 + e(km - 1)](\gamma_c^2 + \gamma_u^2)}{2b(1-e)[1 + e(km - 1)]}. \quad (30)$$

The welfare measure increases in the first moments of prices for unconstrained and constrained firms respectively,  $\bar{p}_U = \int_0^{\tilde{\beta}} p_U di$ ,  $\bar{p}_C = \int_{\tilde{\beta}}^1 p_C(\beta) di$ , and decreases in the second moments of prices for both groups,  $\gamma_U^2 = \int_0^{\tilde{\beta}} (p_U)^2 di$  and  $\gamma_C^2 = \int_{\tilde{\beta}}^1 (p_C(\beta))^2 di$ . The structure of the utility function is comparable to welfare measures in general oligopolistic equilibrium models.<sup>16</sup> In these papers, consumer welfare decreases in the variance of prices which in our case would be defined as  $\sigma_j^2 = \gamma_j^2 - (\bar{p}_j)^2$  for  $j \in C, U$ . Two important properties of the welfare function will be crucial for the subsequent analysis. Following from the preference structure in equation (1), consumers love variety and dislike heterogeneity in consumption levels and prices.

## 5.2 Welfare effects of trade liberalization

The aim of this section is to analyze the welfare implications of globalization. We simulate the changes of consumer welfare (30) to globalization and compare results in partial and general equilibrium.<sup>17</sup> Similar to our previous analysis, we first consider only the market size effect of globalization (change in the number of consumers  $L$ ). Subsequently, we take into account that trade liberalization increases competition and the number of varieties available to consumers (change in  $k$ ).

**Market size effect** The market size effect reflects increased export opportunities after globalization. The left panel of Figure 9 shows that a larger market has no effect on consumer welfare in partial equilibrium (PE), but leads to welfare losses in general equilibrium (GE). This difference is driven by the endogenous adjustment of the borrowing rate when the capital market equilibrium is taken into account.

As equation (30) shows, consumer welfare depends on the first and second moments of prices for both groups. In partial equilibrium, an increase in the market size  $L$  leads to

<sup>16</sup>Compare e.g. Neary (2009), among others.

<sup>17</sup>We simulate the model in general equilibrium with MATLAB. The simulation code is available from the authors upon request.



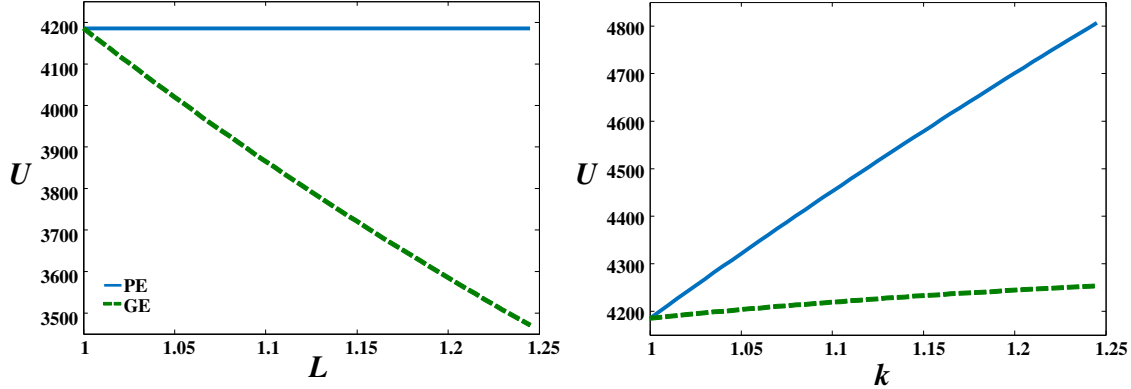


Figure 9: Welfare effects of market size ( $L$ ) and globalization ( $k$ )

a proportional expansion of output among all firms without affecting optimal price setting and the share of unconstrained firms  $\tilde{\beta}$  (compare section 3.4). Therefore, consumer welfare does not respond to changes in the market size as the first and second moments of prices remain constant. In contrast, increased capital demand raises the interest rate in general equilibrium which leads to a higher variance of prices and thus to welfare losses. As discussed in section 4.2, higher borrowing costs increase the within-industry variance of prices in two ways. First, a larger fraction of firms becomes financially constrained (lower  $\tilde{\beta}$ ). Second, unconstrained producers expand output at the expense of credit-rationed firms.

**Globalization** By considering the effect of an increase in the number of countries  $k$ , we introduce two additional channels how globalization affects consumer welfare (30). In contrast to the left graph, the right panel of Figure 9 shows that globalization leads to welfare gains both in partial and general equilibrium resulting from (i) lower prices due to increased competition and (ii) larger consumption variety. Importantly, the positive welfare effects are considerably lower in general equilibrium. Whereas the partial equilibrium analysis reflects well-known gains from trade through competition and larger variety, our model stresses an additional negative welfare channel of globalization driven by an increase in capital costs. Whereas unconstrained firms benefit from trade liberalization due to the market size effect, the higher interest rate especially hurts the most constrained producers (with high values of  $\beta$ ). Compared to existing work, the negative welfare channel of a larger market is driven by two components of our model. First, the introduction of heterogeneity in financial frictions at the firm-level induces endogenous selection of producers into unconstrained and constrained groups. Second, by considering capital market clearing in general equilibrium, the interest rate is endogenized and increases with globalization. In the presence of firm-

specific credit frictions and endogenous capital costs, trade liberalization leads to a larger variance of prices and reduces positive welfare effects. Table 4 shows outcomes of endogenous variables for different values of market size  $L$  and the number of countries  $k$ .

Table 4: Numerical simulation of trade liberalization

$L$	$U_{PE}$	$U_{GE}$	$X_{PE}$	$X_{GE}$	$\tilde{\beta}_{PE}$	$\tilde{\beta}_{GE}$	$r_{PE}$	$r_{GE}$
1	4185.43	4185.44	25.00	25.00	0.83	0.83	1.38	1.38
1.05	4185.43	4020.04	26.25	25.00	0.83	0.77	1.38	1.44
1.10	4185.43	3865.51	27.50	25.00	0.83	0.73	1.38	1.49
1.15	4185.43	3721.02	28.75	25.00	0.83	0.70	1.38	1.54
1.20	4185.43	3585.79	30.00	25.00	0.83	0.67	1.38	1.58
1.25	4185.43	3471.36	31.12	25.00	0.83	0.64	1.38	1.61
$k$	$U_{PE}$	$U_{GE}$	$X_{PE}$	$X_{GE}$	$\tilde{\beta}_{PE}$	$\tilde{\beta}_{GE}$	$r_{PE}$	$r_{GE}$
1	4185.43	4185.44	25.00	25.00	0.83	0.83	1.38	1.38
1.05	4321.50	4203.75	25.85	25.00	0.82	0.78	1.38	1.42
1.10	4452.66	4219.42	26.68	25.00	0.81	0.74	1.38	1.46
1.15	4579.11	4232.84	27.48	25.00	0.80	0.71	1.38	1.49
1.20	4701.08	4244.33	28.25	25.00	0.79	0.68	1.38	1.51
1.25	4807.18	4253.25	28.92	25.00	0.78	0.66	1.38	1.54

Notes: The table presents outcomes of endogenous variables for different values of  $L$  and  $k$ . The following parameter values are chosen:  $a = 100$ ,  $b = 1$ ,  $m = 2$ ,  $e = 0.3$ ,  $c = 30$ ,  $\phi = 0.25$ ,  $K_S = 1500$ .

**Policy implications** The additional negative welfare channel of globalization is especially relevant if financial development is low and credit frictions are significant. Thus, from a policy perspective, our model implies that trade liberalization should be accompanied by financial reforms that aim to mitigate negative effects. To do so, our theoretical framework suggests two potential policy measures: an improvement in the quality of financial institutions  $\phi$  or an increase in capital supply  $K_S$ . Both measures reduce price heterogeneity and hence dampen potential welfare losses, but work through different channels. An increase in  $\phi$  alleviates credit frictions and induces a reallocation of market shares towards financially constrained producers (see the discussion in section 4.2). As a second measure, globalization should be accompanied by an increase in capital supply  $K_S$  to weaken the increase in borrowing costs which benefits all firms.

## 6 Conclusion

This paper has developed a new international trade model with firm-specific credit frictions and endogenous adjustments of capital costs in general equilibrium. Producers offer a horizontally differentiated variety and have to finance variable production costs by external capital. We motivate credit frictions by a simple moral hazard problem between borrowing firms and outside investors. This agency problem restricts the pledgeable income which can be offered to lenders and leads to credit rationing in equilibrium. A key element of our model is that firms differ with respect to agency costs and thus are heterogeneous in their exposure to credit constraints.

The contributions of this framework are twofold. First, our model rationalizes a positive relationship between firm heterogeneity and the extent of financial constraints. Exploiting the enterprise surveys data of the World Bank, we show that stronger credit frictions at the industry-level as well as lower financial development at the country-level are positively associated with a larger variance of firm sales. In our model, if financial institutions are perfect, producers are homogenous in terms of performance. However, if financial institutions are imperfect, differences in agency costs divide firms into financially constrained and unconstrained producers and lead to heterogeneity in sales.

Second, we use this framework to analyze the effects of globalization on firm performance and consumer welfare. The main idea is that aggregate implications of trade liberalization are very different if general equilibrium effects on capital costs are taken into account. In general equilibrium, we show that endogenous adjustments of capital costs represent an additional channel which reduces gains from trade. Trade liberalization increases capital demand which pushes the borrowing rate upwards. This general equilibrium effect induces a within-sector reallocation of profits towards unconstrained firms at the expense of financially constrained producers, and increases the share of credit-rationed producers. We show that these adjustments increase the variance of prices and reduce consumer welfare.

From a policy perspective, our model implies that trade liberalization could lead to negative welfare effects and should be accompanied by financial reforms to counteract an increase in within-industry heterogeneity across firms. This implication is especially relevant in developing countries where credit frictions are significant and financial development is low.

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## 7 Mathematical Appendix

### 7.1 Comparative statics in partial equilibrium

The partial equilibrium is characterized by two endogenous variables  $\tilde{\beta}$  and  $\tilde{x}$  in equations (12) and (14). Totally differentiating the two equilibrium conditions and writing the results in matrix notation yields:

$$\begin{aligned} & \begin{bmatrix} (2-e)(1-e) + (2-e-\tilde{\beta})ekm & 0 \\ em & (1-\phi)(2-e)crL \end{bmatrix} \times \begin{bmatrix} b\tilde{x}d\ln\tilde{x} \\ \tilde{\beta}d\ln\tilde{\beta} \end{bmatrix} = \\ & + \begin{bmatrix} (2-e)(1-e) + (2-e-\tilde{\beta})ekm \\ em \end{bmatrix} \tilde{x}bd\ln L - \begin{bmatrix} (2-e-\tilde{\beta})k + (2-e)(1-\tilde{\beta})\mu'_c(1-\phi)k \\ 1 + \tilde{\beta}(1-\phi)(2-e) \end{bmatrix} crLd\ln r \\ & + \begin{bmatrix} \tilde{x}(2-e)(1-e)b \\ 0 \end{bmatrix} d\ln k + \begin{bmatrix} (2-e)(1-\tilde{\beta})\mu'_c k \\ \tilde{\beta}(2-e) \end{bmatrix} crL\phi d\ln\phi - \begin{bmatrix} (2-e-\tilde{\beta})kb \\ b \end{bmatrix} em\tilde{x}d\ln m \end{aligned}$$

The determinant of the coefficient matrix is given by:

$$\Delta = (1-\phi)(2-e)crL \left[ (2-e)(1-e) + (2-e-\tilde{\beta})ekm \right] > 0.$$

In the following, we proof Proposition 2 in the main body and show partial equilibrium results for an exogenous change in the financial development parameter  $\phi$ .

**Proposition 2 (Interest rate effect)** In partial equilibrium, we analyze the effects of an exogenous change in the interest rate  $r$ . The effect on average industry scale  $\tilde{x}$  is given by:

$$\frac{d\ln\tilde{x}}{d\ln r} = - \frac{\left[ (2-e-\tilde{\beta}) + (2-e)(1-\tilde{\beta})\mu'_c(1-\phi) \right] cr}{\left[ (2-e)(1-e) + (2-e-\tilde{\beta})ekm \right] b\tilde{x}} < 0. \quad (31)$$

The effect on the cutoff  $\tilde{\beta}$  is given by:

$$\frac{d\ln\tilde{\beta}}{d\ln r} = - \frac{1-e + (1-\phi) \left[ (1-e)(2-e)\tilde{\beta} + ekm \left( (2-e)\tilde{\beta} - \frac{1+\tilde{\beta}^2}{2} \right) \right]}{(1-\phi)L \left[ (2-e)(1-e) + (2-e-\tilde{\beta})ekm \right] \tilde{\beta}} < 0. \quad (32)$$

To derive the latter expression, note that  $(1 - \tilde{\beta}) \mu'_c = \int_{\tilde{\beta}}^1 \beta_i di = \frac{1 - \tilde{\beta}^2}{2}$ .

**Proof.** To show that  $\frac{d \ln \tilde{\beta}}{d \ln r} < 0$ , it is sufficient to proof that  $(2 - e) \tilde{\beta} - \frac{1 + \tilde{\beta}^2}{2} > 0$ . As the latter expression increases in  $\tilde{\beta}$ , inserting the lowest possible cutoff value  $\tilde{\beta}_l = \frac{1}{2 - e}$  (see Condition 2 in the main body), we derive  $\frac{(2 - e)^2 - 1}{2(2 - e)^2} > 0$ . ■

**Financial development** For the sake of completeness, we present the results for an exogenous change in the parameter  $\phi$  which are not discussed in the main body of the paper. The effect on average industry scale  $\tilde{x}$  is given by:

$$\frac{d \ln \tilde{x}}{d \ln \phi} = \frac{(2 - e) (1 - \tilde{\beta}) \mu'_c cr \phi}{\left[ (2 - e) (1 - e) + (2 - e - \tilde{\beta}) ekm \right] b' \tilde{x}} > 0. \quad (33)$$

The solution for the effect on the cutoff value is

$$\frac{d \ln \tilde{\beta}}{d \ln \phi} = \frac{\phi}{1 - \phi} \frac{(1 - e) (2 - e) \tilde{\beta} + ekm \left( (2 - e) \tilde{\beta} - \frac{1 + \tilde{\beta}^2}{2} \right)}{\left[ (2 - e) (1 - e) + (2 - e - \tilde{\beta}) ekm \right] \tilde{\beta}} > 0, \quad (34)$$

whereby the proof of Proposition 2 ensures that  $\frac{d \ln \tilde{\beta}}{d \ln \phi} > 0$ .

## 7.2 Comparative statics in general equilibrium

In general equilibrium, we add the capital market clearing condition to our system of equations. The three endogenous variables  $\tilde{\beta}$ ,  $\tilde{x}$ , and  $r$  are determined in equations (12), (14), and (19). Totally differentiating these expressions results in the following matrix equation:

$$\begin{bmatrix} b \left( (2 - e) (1 - e) + (2 - e - \tilde{\beta}) ekm \right) & 0 & \left[ 2 - e - \tilde{\beta} + (2 - e) (1 - \tilde{\beta}) \mu'_c (1 - \phi) \right] k \\ bem & (1 - \phi) (2 - e) crL & 1 + \tilde{\beta} (1 - \phi) (2 - e) \\ cm & 0 & 0 \end{bmatrix} \times$$

$$\begin{bmatrix} \tilde{x} d \ln \tilde{x} \\ \tilde{\beta} d \ln \tilde{\beta} \\ cLr d \ln r \end{bmatrix} = \begin{bmatrix} \tilde{x} b (2 - e) (1 - e) \\ 0 \\ 0 \end{bmatrix} d \ln k + \begin{bmatrix} (1 - \tilde{\beta}) \mu'_c k \\ \tilde{\beta} \\ 0 \end{bmatrix} (2 - e) crL \phi d \ln \phi + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} K_s d \ln K_s,$$

whereas the determinant of the coefficient matrix is given by:

$$\Delta_{GE} = - (1 - \phi) (2 - e) \left[ \left( 2 - e - \tilde{\beta} \right) + (2 - e) (1 - \tilde{\beta}) \mu'_c (1 - \phi) \right] r c^3 L^2 km < 0.$$



**Proposition 3 (Globalization)** In general equilibrium, a higher number of countries  $k$  increases the interest rate:

$$\frac{d \ln r}{d \ln k} = \frac{(2-e)(1-e)b'\tilde{x}}{(2-e-\tilde{\beta})a - \left[ (2-e)(1-e) + (2-e-\tilde{\beta})ekm \right] b'\tilde{x}} > 0. \quad (35)$$

The effect of globalization on the cutoff level  $\tilde{\beta}$  is given by:

$$\frac{d \ln \tilde{\beta}}{d \ln k} = - \frac{(1-e) \left[ 1 + \tilde{\beta}(1-\phi)(2-e) \right] b'\tilde{x}}{(1-\phi) \left[ (2-e-\tilde{\beta}) + (2-e)(1-\tilde{\beta})\mu'_c(1-\phi) \right] cr\tilde{\beta}} < 0. \quad (36)$$

Comparing the effects on  $\tilde{\beta}$  in partial and general equilibrium, as shown in equations (16) and (36), leads to:

$$\left| \frac{d \ln \tilde{\beta}}{d \ln k} \right|_{GE} - \left| \frac{d \ln \tilde{\beta}}{d \ln k} \right|_{PE} = \frac{(2-e) \left[ (1-e) \left[ 1 + \tilde{\beta}(1-\phi)(2-e) \right] + ekm(1-\phi) \left[ \tilde{\beta}(2-e) - \tilde{\beta}^2 - \frac{1-\tilde{\beta}^2}{2} \right] \right]}{k \left[ (2-e-\tilde{\beta}) + (2-e)(1-\tilde{\beta})\mu'_c(1-\phi) \right] \left[ (2-e)(1-e) + (2-e-\tilde{\beta})ekm \right]} > 0, \quad (37)$$

whereas the proof in Proposition 2 ensures that the last term is positive.

**Proposition 4 (Firm-level effects of globalization)** Inserting the interest rate effect of globalization (35) into equations (24) and (25) leads to the following expressions:

$$\frac{d \ln x_U}{d \ln k} = 1 - \frac{\tilde{x}}{x_U} \frac{1-e}{2-e-\tilde{\beta} + (2-e)(1-\tilde{\beta})\mu'_c(1-\phi)} > 0, \quad (38)$$

$$\frac{d \ln x_C(\beta)}{d \ln k} = 1 - \frac{\tilde{x}}{x_C(\beta)} \frac{2-e + \beta(i)(1-\phi)(2-e)}{2-e-\tilde{\beta} + (2-e)(1-\tilde{\beta})\mu'_c(1-\phi)} < 0. \quad (39)$$

As  $x_U > \tilde{x}$  and  $\frac{1-e}{2-e-\tilde{\beta}+(2-e)(1-\tilde{\beta})\mu'_c(1-\phi)} < 1$ , the effect of globalization on unconstrained output (38) is clearly positive.

**Proof.** In the case of constrained firms, note that  $x_C(\beta) < \tilde{x}$ . A sufficient condition for a negative effect of globalization on constrained output is that the last fraction of expression (39) is larger than one. This is the case if  $\beta(i) > \frac{1-\tilde{\beta}^2}{2}$ . Evaluating this condition for the marginal firm with  $\beta(i) = \tilde{\beta}$  and inserting the lower bound  $\tilde{\beta}_l$  leads to:  $\left(\frac{1}{2-e}\right)^2 + \frac{e}{2-e} > 0$ .

Thus, the effect of globalization is negative for all firms with  $\beta(i) \geq \tilde{\beta}$ . ■

**Proposition 5 (Financial development)** The effect of financial development on the cutoff level  $\tilde{\beta}$  is given by:

$$\frac{d \ln \tilde{\beta}}{d \ln \phi} = \frac{\phi \left[ (2-e) \tilde{\beta} - \frac{1+\tilde{\beta}^2}{2} \right]}{(1-\phi) \left[ (2-e-\tilde{\beta}) + (2-e) (1-\tilde{\beta}) \mu'_c (1-\phi) \right] \tilde{\beta}} > 0. \quad (40)$$

Following the proof in Proposition 2, the expression is clearly positive. Finally, the effect of an exogenous change in  $\phi$  on the interest rate is given by:

$$\frac{d \ln r}{d \ln \phi} = \frac{(2-e) (1-\tilde{\beta}) \mu'_c \phi}{(2-e-\tilde{\beta}) + (2-e) (1-\tilde{\beta}) \mu'_c (1-\phi)} > 0. \quad (41)$$

**Proposition 6 (Firm-level effects of financial development)** To show that the effect of financial development on constrained output (29) is unambiguously positive, we insert expression (41) resulting in:

$$\frac{d \ln x_i^C}{d \ln \phi} = \frac{cr\phi}{x_i^C \nu' (1-e)} \left[ \frac{(2-e-\tilde{\beta}) - (2-e) (1-\tilde{\beta}) \mu'_c}{(2-e-\tilde{\beta}) + (2-e) (1-\tilde{\beta}) \mu'_c (1-\phi)} \right] > 0.$$

**Proof.** As the numerator of the term in brackets increases in  $\tilde{\beta}$ , we insert the lower bound  $\tilde{\beta}_l = \frac{1}{2-e}$  which leads to:  $\frac{(2-e)^2-1}{2(2-e)} > 0$ . ■

## 8 Data Appendix

Table 5: Within-industry and between-industry variation of TOA

Country	Obs.	2-digit		3-digit		4-digit	
		within	between	within	between	within	between
Chile	894	89.56	10.44	88.76	11.24	84.24	15.76
El Salvador	349	95.18	4.82	88.2	11.8	79.51	20.49
Guatemala	421	95.48	4.52	92.05	7.95	77.33	22.67
Honduras	401	90.86	9.14	81.63	18.37	76.45	23.55
Madagascar	123	91.46	8.54	80.64	19.36	78.11	21.89
South Africa	495	98.48	1.52	86.74	13.26	76.75	23.25
Thailand	718	93.14	6.86	92.37	7.63	91.26	8.74
Vietnam	1,048	98.52	1.48	97.92	2.08	83.68	16.32

Source: Authors' own computations from the WBES. Due to data availability, we restrict the analysis to a subsample of countries.

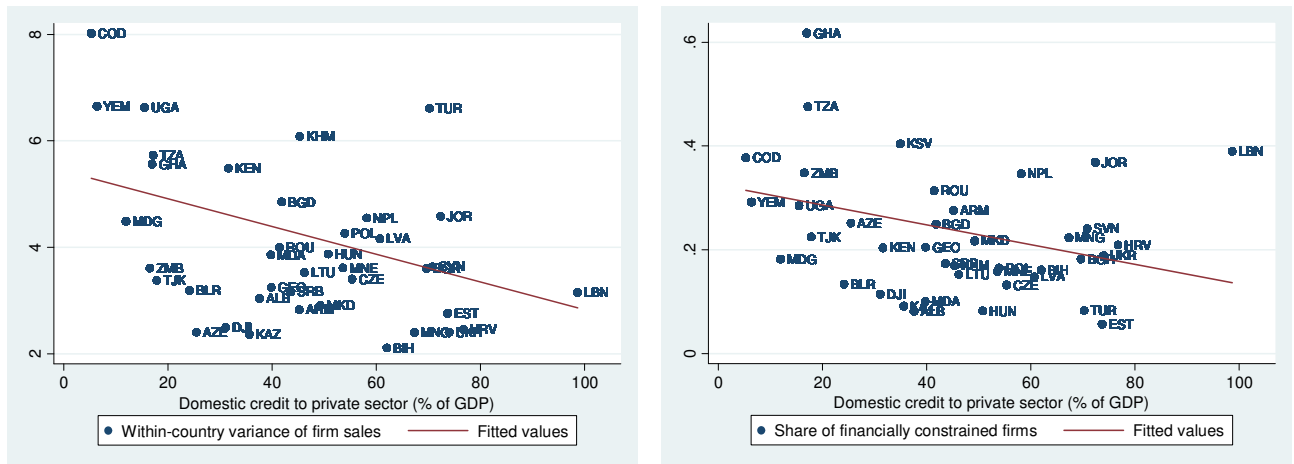


Figure 10: Financial development and within-country heterogeneity, cross-section 2013

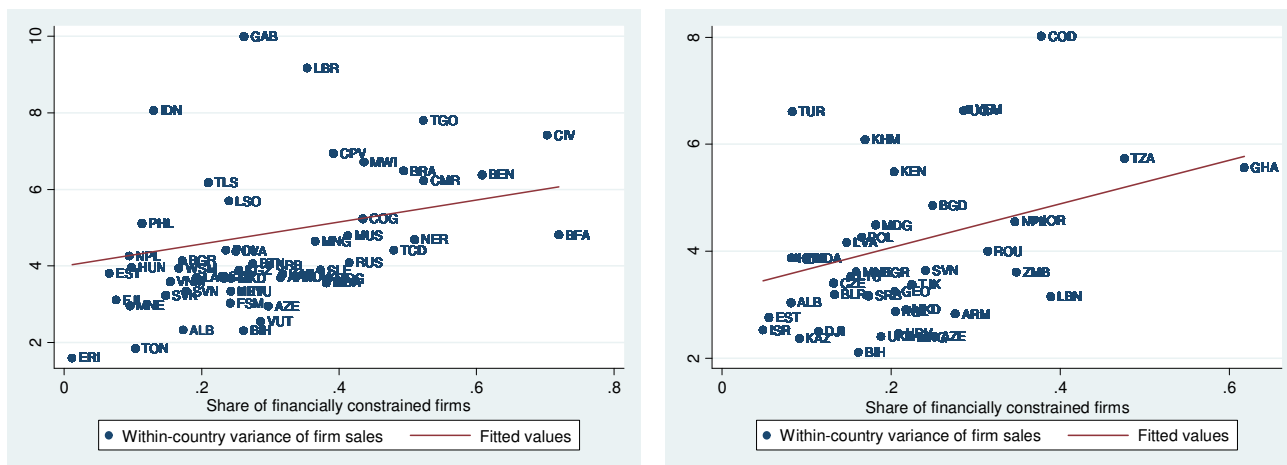


Figure 11: Credit constraints and variance of sales, for years 2009 (left) and 2013 (right)

Table 6: Summary statistics at the country level, cross-section 2013

2013									
Country	Obs.	PC / GDP	CF	VS	Country	Obs.	PC / GDP	CF	VS
Albania	357	37.58	0.08	3.04	Kosovo	198	34.94	0.40	-
Armenia	359	45.18	0.28	2.83	Latvia	332	60.70	0.15	4.16
Azerbaijan	390	25.46	0.25	2.40	Lebanon	558	98.64	0.39	3.15
Bangladesh	1,437	41.79	0.25	4.85	Lithuania	263	46.22	0.15	3.52
Belarus	353	24.15	0.13	3.19	Madagascar	336	11.92	0.18	-
Bosnia and Herzegovina	360	62.01	0.16	2.11	Moldova	350	39.74	0.10	3.86
Bulgaria	287	69.64	0.18	3.60	Mongolia	359	67.28	0.22	2.39
Cambodia	467	45.33	0.17	6.08	Montenegro	145	53.61	0.16	-
Croatia	359	76.72	0.21	2.46	Nepal	482	58.11	0.35	4.55
Czech	250	55.36	0.13	3.40	Poland	534	53.93	0.17	4.26
DRC	511	5.24	0.38	8.02	Romania	532	41.41	0.31	3.99
Djibouti	263	31.09	0.11	-	Serbia	358	43.56	0.17	3.17
Estonia	270	73.70	0.06	2.76	Slovenia	270	70.79	0.24	3.63
FYROM	359	49.21	0.22	2.90	Tajikistan	348	17.86	0.23	3.37
Georgia	357	39.85	0.20	3.24	Tanzania	771	17.21	0.48	5.73
Ghana	711	16.99	0.62	5.57	Turkey	1,319	70.19	0.08	-
Hungary	306	50.76	0.08	3.87	Uganda	736	15.52	0.29	6.63
Jordan	573	72.33	0.37	4.57	Ukraine	983	73.96	0.19	2.40
Kazakhstan	570	35.58	0.09	2.36	Yemen	353	6.34	0.29	6.65
Kenya	767	31.63	0.20	5.48	Zambia	704	16.54	0.35	3.60
					Mean		45.51	0.22	3.90

Source: Authors' own computations from the WBES. PC / GDP: credit to private sector in % of GDP; CF: share financially constrained firms; VS: within-country variance of firm sales.

Table 7: Summary statistics at the country-level, cross-section 2009

Country	2009								
	Obs.	PC / GDP	CF	VS	Country	Obs.	PC / GDP	CF	VS
Albania	52	36.92	0.17	2.32	Latvia	264	104.55	0.25	4.38
Armenia	371	24.86	0.32	3.69	Lesotho	146	12.84	0.24	5.69
Azerbaijan	360	19.07	0.30	2.95	Liberia	147	12.20	0.35	9.17
Benin	148	22.47	0.61	6.38	Lithuania	268	69.73	0.26	3.33
Bhutan	244	32.42	0.27	4.06	Madagascar	434	11.52	0.39	3.67
Bosnia and Herzegovina	360	65.37	0.26	2.30	Malawi	149	13.38	0.44	6.71
Brazil	1,783	48.87	0.49	6.48	Mauritius	397	82.74	0.41	4.78
Bulgaria	274	73.11	0.17	4.13	Micronesia	62	21.30	0.24	3.02
Burkina Faso	393	17.02	0.72	4.81	Moldova	346	36.00	0.38	3.56
Cameroon	361	11.48	0.52	6.23	Mongolia	345	40.30	0.37	4.64
Cape Verde	148	57.96	0.39	6.94	Montenegro	115	76.54	0.10	2.95
Chad	148	3.93	0.48	4.40	Nepal	486	59.18	0.10	4.26
Congo	122	4.92	0.43	5.23	Niger	147	12.20	0.51	4.69
Croatia	99	66.71	0.24	3.34	Philippines	1,280	29.16	0.11	5.11
Czech	244	49.86	0.23	3.72	Poland	429	49.75	0.24	4.40
Ivory Coast	512	16.43	0.70	7.41	Romania	497	46.15	0.34	3.71
Eritrea	172	16.77	0.01	1.59	Russia	976	45.26	0.42	4.09
Estonia	259	105.11	0.07	3.80	Samoa	108	39.53	0.17	3.94
FYROM	362	43.87	0.24	3.67	Serbia	382	42.55	0.30	4.01
Fiji	159	89.62	0.08	-	Sierra Leone	150	8.22	0.37	3.89
Gabon	172	10.12	0.26	9.99	Slovenia	276	90.69	0.18	3.33
Hungary	285	68.04	0.10	3.95	Timor-Leste	148	12.66	0.21	6.18
Indonesia	1,314	27.66	0.13	8.06	Togo	153	19.75	0.53	7.80
Kazakhstan	532	50.27	0.32	3.78	Tonga	145	47.09	0.10	1.84
Kosovo	176	34.34	0.16	-	Vanuatu	126	62.98	0.29	2.54
Laos	358	17.24	0.19	3.70	Vietnam	1,024	103.32	0.15	3.59
Mean							41.02	0.29	4.67

Source: Authors' own computations from the WBES. PC / GDP: credit to private sector in % of GDP; CF: share financially constrained firms; VS: within-country variance of firm sales.