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**Conference Paper**

## The Role of Financial Intermediation in International Trade

Beiträge zur Jahrestagung des Vereins für Socialpolitik 2016: Demographischer Wandel -  
Session: Trade Barriers, No. G18-V1

**Provided in Cooperation with:**

Verein für Socialpolitik / German Economic Association

*Suggested Citation:* Unger, Florian (2016) : The Role of Financial Intermediation in International Trade, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2016: Demographischer Wandel - Session: Trade Barriers, No. G18-V1, ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften, Leibniz-Informationszentrum Wirtschaft, Kiel und Hamburg

This Version is available at:

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# The Role of Financial Intermediation in International Trade\*

March 1, 2016

## Abstract

This paper highlights that substitution between two types of finance represents an additional channel of adjustment to credit shocks and trade liberalization. Combining firm heterogeneity à la Melitz (2003) with credit frictions based on Holmstrom and Tirole (1997), there is selection of the largest firms into exporting and unmonitored finance, such as public debt or corporate bonds. Smaller producers serve only the domestic market and have to rely on more expensive financial intermediation. The model is consistent with empirical evidence that documents the important role of substitution effects between different sources of external credit. Producers respond to financial shocks by switching the type of finance. These selection effects lead to reallocations of market shares across firms and additional adjustments on the margins of international trade. Furthermore, the model highlights a new source of gains from trade: average productivity increases as falling trade costs allow some exporters to select into cheaper unmonitored finance.

*JEL Classification:* F12, G32, L11

*Keywords:* international trade, external finance, credit constraints, heterogeneous firms, moral hazard, monitored capital, bank and bond finance

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\*This paper was awarded the “Best Paper Prize for Young Economists” at the Warsaw International Economic Meeting 2015. I am grateful to Daniel Baumgarten, Carsten Eckel, Lisandra Flach, Michael Irlacher, Sebastian Krautheim, Monika Schnitzer, Jens Südekum, and Jens Wrona, as well as participants of the 7th Annual Meeting on Economic Geography and International Trade (EGIT) 2016 in Frankfurt, of the Fall 2015 Midwest International Trade Meetings at the Pennsylvania State University, of the 17th Annual Conference of the European Trade Study Group in Paris, of the Warsaw International Economic Meeting 2015, of the Munich “IO and Trade seminar”, of the 2nd MGSE Colloquium in Munich, and of the 17th Workshop “Internationale Wirtschaftsbeziehungen” in Goettingen for helpful comments and suggestions. Financial support from the Deutsche Forschungsgemeinschaft through SFB/TR15 is gratefully acknowledged.

# 1 Introduction

Firms rely on outside investors to finance trade related production costs and up-front investments. Empirical evidence shows that credit constraints negatively affect both intensive and extensive margins of international trade (Berman and Héricourt, 2010; Minetti and Zhu, 2011; Manova, 2013; Muûls, 2015). To explain these effects, theoretical models combine firm-level heterogeneity à la Melitz (2003) with financial frictions (Chaney, 2013; Manova, 2013; Feenstra et al., 2014). These papers stress that credit constraints prevent smaller firms from exporting and restrict foreign sales below the optimal level. Trade models with firm heterogeneity and financial frictions typically rely on one source of external debt. The corporate finance literature, however, shows that firm size is an important determinant of access to different types of external credit. Large firms are more likely to use cheap finance provided with low-intensity monitoring, such as the issuance of public debt or corporate bonds.<sup>1</sup> Smaller producers suffer more from credit-rationing (Rajan and Zingales, 1995; Beck et al., 2006), and rely heavily on bank finance with intensive monitoring and higher borrowing rates (Cantillo and Wright, 2000; Denis and Mihov, 2003).<sup>2</sup>

This paper develops an international trade model that accounts for the selection of producers into exporting and two types of finance. Combining productivity sorting à la Melitz (2003) with credit frictions based on Holmstrom and Tirole (1997), the largest firms export and use unmonitored finance. Smaller producers serve only the domestic market and have to rely on more expensive bank finance. Selection effects depend on trade costs, borrowing rates and access barriers to external funds due to credit frictions. This model highlights that firms respond to financial shocks and trade liberalization by switching the type of finance. Accounting for these selection effects is important for any assessment of welfare implications. The main message of this paper is that substitution between the two types of finance leads to a reallocation of market shares across producers and new effects on the margins of international trade. The model is consistent with empirical evidence that documents the important role of substitution effects. Credit tightening leads to large adverse impacts on small, bank-dependent firms, and induces selection into other types of external debt (Kashyap et al., 1993; Faulkender and Petersen, 2006; Leary, 2009). During the financial crisis of 2008-2009, producers responded to contraction in credit supply by switching to public bonds and trade

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<sup>1</sup>In the U.S., the percentage of long-term debt held in publicly traded instruments is 32% among larger firms and 14% for smaller producers (Cantillo and Wright, 2000). In Spanish non-financial companies, public debt amounts to 10% (de Miguel and Pindado, 2001), and among publicly traded U.S. firms, it represents almost 50% of new debt issues (Denis and Mihov, 2003).

<sup>2</sup>Empirical studies suggest additional firm characteristics that are positively related to direct lending with limited monitoring, such as project quality, profitability, collateral, age and credit reputation (see Cantillo and Wright, 2000; Denis and Mihov, 2003; Becker and Ivashina, 2014).

credit.<sup>3</sup> Furthermore, the model highlights a new source of gains from trade: the average productivity within an industry increases as falling trade costs allow some exporters to select into cheaper unmonitored finance.

To analyze the role of these selection effects, this paper extends a Melitz (2003)- type model by endogenous investments and credit frictions. Heterogeneous firms decide on innovations that reduce marginal production costs, but have to be financed externally. This assumption is based on a large literature that shows the important role of external finance for innovation activity (Hall and Lerner, 2010; Maskus et al., 2012; Gorodnichenko and Schnitzer, 2013). Credit frictions emerge from moral hazard based on Holmstrom and Tirole (1997). Following this, the success of investments depends on a managerial project choice which is non-verifiable for external lenders and thus prone to moral hazard. This agency problem reduces the pledgeability of firm profits and introduces access barriers to credit.

The key feature of the model is to allow for two types of external finance that differ in credit costs and accessibility. Passive lenders provide funds without monitoring, whereas financial intermediaries are able to imperfectly control the project choice within firms. On the one hand, access barriers to monitored funds are lower as financial intermediation alleviates moral hazard. On the other hand, monitoring is associated with additional costs, resulting in higher borrowing rates relative to unmonitored finance. This approach is consistent with empirical evidence that shows the important role of banks in reducing agency costs.<sup>4</sup> The selection mechanism stressed in this paper is different from models with technology choice, in which the payment of additional fixed costs reduces marginal production costs (Lileeva and Trefler, 2010; Bustos, 2011). Unmonitored finance is associated with a lower borrowing rate, both for fixed and endogenous investments, but credit frictions impose an access barrier for smaller firms with low pledgeable income.<sup>5</sup>

The framework nests a model with one type of finance as a special case, which allows to disentangle direct effects of shocks from substitution effects. Thus, the model features intra-industry reallocation and common gains from trade liberalization (Melitz, 2003), as well as negative effects of credit frictions as stressed in the existing literature (Manova, 2013; Muûls, 2015). However, new welfare implications arise because firms switch the type of finance. These additional selection effects change the degree of competition in general equilibrium and thus influence the margins of international trade. Compared to a model with only one type of credit, lower financial development leads to additional welfare losses because

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<sup>3</sup>See Adrian et al. (2012), Becker and Ivashina (2014), and Barraza et al. (2014) for evidence on substitution into public bonds among U.S. firms, as well as Iyer et al. (2014) for Portugal. Carbó-Valverde et al. (2012) and Coulibaly et al. (2013) document substitution into trade credit.

<sup>4</sup>See Gorton and Winton (2003) and Tirole (2006), chapter 2 for a review of related literature.

<sup>5</sup>See also the following discussion of related literature.

firms select into more expensive financial intermediation. While this shock aggravates moral hazard and increases access barriers to both types of finance, monitoring of intermediaries reduces the negative impact compared to unmonitored funds. Hence, there is selection into financial intermediation and a reallocation of market shares away from firms that rely on passive investors. As now a larger fraction of producers faces higher borrowing rates, the competitive pressure in general equilibrium is reduced. This selection effect mitigates the negative reaction at the extensive margin, but amplifies welfare losses due to lower average productivity.

Likewise, additional gains from trade liberalization arise because of selection effects. Falling trade costs increase the pledgeable income of exporters and facilitate access to cheaper unmonitored funds. This leads to two new adjustments that further increase average productivity compared to a model with only one type of credit. First, some exporters gain access to cheaper unmonitored finance and reduce prices. Second, increased competitive pressure leads to even stronger exit of low productivity firms that rely on more expensive bank finance.

**Related literature** This paper is related to three distinct strands of literature. First, the notion of capital market imperfections with two sources of external finance builds on Holmstrom and Tirole (1997), whereas financial intermediation alleviates credit frictions emerging from moral hazard. Alternative theories of banking stress advantages of financial intermediaries compared to direct lenders in presence of information asymmetries. Accordingly, banks may act as screeners regarding project choice *ex ante* (Diamond, 1991; Besanko and Kanatas, 1993), conduct costly monitoring in case of unknown output realizations *ex-post* (Diamond, 1984), or take the role of reorganizers with respect to *ex-post* bargaining (Rajan, 1992; Bolton and Scharfstein, 1996).

A second strand of literature analyzes the selection of heterogeneous firms in segmented capital markets. Russ and Valderrama (2012) introduce bond and bank finance in a closed-economy version of Ghironi and Melitz (2005) and suggest a selection pattern that is consistent with this model. Large and more productive firms select into bond finance with higher fixed costs, but lower variable costs, whereas smaller producers rely on financial intermediation. Russ and Valderrama (2010) extend this framework to a small open economy. In both papers, financial choice is analogous to technology adoption in Bustos (2011). In contrast, the selection pattern of firms in this model is not only driven by profitability, but rather moral hazard introduces access barriers to external funds. Unmonitored finance is associated with lower borrowing costs, but smaller firms fail to overcome agency problems in presence of credit frictions. Financial intermediaries reduce access barriers to finance for low productivity firms, but charge higher interest rates both for fixed and endogenous in-

vestments. Egger and Keuschnigg (2015) analyze external financing of fixed R&D spending by venture capital and bank credit in a multicountry model of trade. The authors show the important role of venture capitalists in financing early-stage investments, especially for firms with little pledgeable earnings and high risk. A common feature to this paper is that moral hazard based on Holmstrom and Tirole (1997) leads to credit frictions and monitoring facilitates access to finance. However, the focus of this model is quite different. Egger and Keuschnigg (2015) analyze the effects of financial frictions on a two-stage investment decision with heterogeneity in project quality and additional production risk. This paper considers external financing of endogenous sunk costs for process innovations in a Melitz-type model with productivity differences, and shows how substitution effects between two types of finance change aggregate responses to financial shocks and trade liberalization.

Furthermore, Schmidt-Eisenlohr (2013) develops a model of payment contract choice in international trade and differentiates between exporter and importer finance, as well as bank finance, but abstracts from firm heterogeneity. Related papers are Eck et al. (2015), as well as Engemann et al. (2014), who show both theoretically and empirically the positive impact of trade credit on the probability to export, especially for lower productivity firms. The authors stress that supplier credits alleviate financial constraints due to information asymmetry and reduce uncertainty related to international transactions.

Third, this paper is related to a growing literature that incorporates financial frictions in international trade models, but neglects different sources of external finance. Manova (2013) shows that credit constraints intensify the selection of the most productive firms into export markets. Feenstra et al. (2014) introduce financial frictions, caused by information asymmetry between firms and a monopolistic bank, whereas the latter cannot observe the productivity of the former. Instead, I assume symmetric information regarding firm-specific productivity, but moral hazard introduces credit market imperfections. Felbermayr and Spiegel (2014) analyze the role of credit frictions in a dynamic model of trade and finance. Other papers extend the model of Melitz and Ottaviano (2008) with varying markups by credit constraints (Mayneris, 2011; Egger and Seidel, 2012; Peters and Schnitzer, 2015). Building on Holmstrom and Tirole (1997) as well, theoretical work analyzes the effects of credit frictions on industry agglomeration in a Krugman (1991) model (Ehrlich and Seidel, 2013) and on foreign direct investment (Antràs et al., 2009; Buch et al., 2010, 2014).

The paper is organized as follows. Section 2 presents the model setup and discusses the selection of producers into credit and export markets. The following two sections analyze the effects of financial shocks in partial and general equilibrium respectively. Section 5 presents effects of trade liberalization. Section 6 discusses assumptions as well as extensions of the theoretical framework, and finally, section 7 concludes.

## 2 Firm heterogeneity and access to external finance

This section introduces credit frictions and endogenous innovations in a heterogeneous firm model à la Melitz (2003). Firms differ in marginal production costs, decide on the optimal level of productivity enhancing investments, and require external funds to cover fixed and endogenous sunk costs for innovation activity. This assumption can be motivated by a time lag between investment outlays and the realization of sales. Based on Holmstrom and Tirole (1997), credit frictions emerge from moral hazard regarding the project choice of managers within firms. The following subsection presents the demand side of the model. Subsection 2.2 introduces two types of outside lenders and discusses optimal firm behavior with credit constraints. Subsection 2.3 shows how firms select into external finance and exporting.

### 2.1 Demand side

There are two symmetric countries with population of size  $L$ , trading in horizontally differentiated varieties. Labor is the only factor of production and is immobile across countries.<sup>6</sup> A representative consumer in one country derives utility from the consumption of a continuum of varieties, indexed by  $i \in \Omega$ , according to the following CES function:

$$X = \left[ \int_{i \in \Omega} x_i^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}}, \quad (1)$$

whereas  $\sigma > 1$  is the constant elasticity of substitution and  $\Omega$  is the set of varieties. Demand for one particular variety  $i$  is given by:

$$x_i = X \left( \frac{p_i}{P} \right)^{-\sigma}, \quad (2)$$

and the aggregate price index is defined as follows:

$$P = \left[ \int_{i \in \Omega} p_i^{1-\sigma} di \right]^{\frac{1}{1-\sigma}}. \quad (3)$$

The following subsection describes the maximization problem of firms in the presence of credit constraints and two sources of external finance.

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<sup>6</sup>Section 6 discusses how the model can be extended to capital as a second input factor.

## 2.2 Optimal firm behavior under credit constraints

The productivity of a firm is determined by two components. As in Melitz (2003), each firm manufactures one horizontally differentiated variety  $i$  and draws a productivity parameter  $\varphi_i$  from a common probability distribution  $g(\varphi)$ .<sup>7</sup> Additionally, producers choose the optimal level of productivity enhancing investments  $e_i$ . Hence, marginal production costs are given by  $mc_i(\varphi_i) = \frac{1}{\varphi_i e_i}$ . Investments are associated with endogenous sunk costs that increase in the innovation level:

$$f(e) = \frac{1}{\alpha} e_i^\alpha, \text{ with } \alpha > \sigma - 1, \quad (4)$$

whereas  $\alpha$  is a technology cost parameter that is the same across firms. Motivated by a time lag between investment outlays and profit realization, fixed and endogenous sunk costs associated with innovation activity have to be financed by external funds. Based on Holmstrom and Tirole (1997), credit frictions emerge from moral hazard between outside lenders and borrowing firms. There are two types of investors in the economy: passive lenders and financial intermediaries that are able to imperfectly monitor firms, denoted by the indices  $u$  and  $m$  in what follows. Each producer signs a credit contract with an outside lender, which defines the loan size  $d_{jl} > 0$ , at a gross interest rate  $r_j > 1$ , and the credit repayment  $k_{jl}$ , whereas  $j \in m, u$  denotes the source of external finance and  $l \in d, x$  is an index for the export status. The maximization problem of a producer can be described as follows, where asterisks stand for variables of export activity:<sup>8</sup>

$$\max_{p_{jl}, p_{jl}^*, e_{jl}} \lambda \pi_{jl} = \lambda \left[ s_{jl} - \frac{1}{\varphi e_{jl}} (x_{jl} + 1_{\{x^* > 0\}} \tau x_{jl}^*) - k_{jl} \right] \quad (5)$$

$$s.t \quad x_{jl} = X \left( \frac{p_{jl}}{P} \right)^{-\sigma} ; \quad x_{jl}^* = X \left( \frac{p_{jl}^*}{P} \right)^{-\sigma}, \quad (6)$$

$$d_{jl} \geq f_l + \frac{1}{\alpha} e_{jl}^\alpha, \quad (7)$$

$$\lambda k_{jl} \geq r_j d_{jl}, \quad (8)$$

$$\lambda \pi_{jl} \geq 0. \quad (9)$$

Depending on the source of external finance  $j$  and the export status  $l$ , firms maximize revenues net of variable production costs and loan repayment  $k_{jl}$ , whereas the variable  $1_{\{x^* > 0\}}$  takes a value of one if the firm exports and is zero otherwise. Total sales from domestic and international activity are defined as  $s_{jl} = p_{jl} x_{jl} + 1_{\{x^* > 0\}} p_{jl}^* x_{jl}^*$ . Firms realize profits with success probability  $\lambda$ . The next subsection introduces moral hazard and shows that this

<sup>7</sup>Section 4 presents the general equilibrium and assumes that productivity follows a Pareto distribution.

<sup>8</sup>For notational simplicity I drop the firm's index  $i$  in what follows.



success probability depends on a non-verifiable project choice of the firm. Exporting involves additional fixed costs ( $f_x > f_d$ ) and iceberg-type transportation costs such that  $\tau > 1$  units of a good have to be shipped for one unit to arrive. According to the budget constraint (7), the received credit amount has to cover fixed costs of production, as well as endogenous sunk costs for innovation. Internationally active firms have to raise additional external funds for fixed export costs. Investors only participate in a contract if expected loan repayments at least compensate for credit provision (8). Additionally, the firm will be active in the market if expected profits are non-negative (9). The solution to the firm's maximization problem provides the optimal investment level:<sup>9</sup>

$$e_{jl}(\varphi) = \left( \frac{\sigma - 1}{\sigma} \right)^{\frac{\sigma}{\alpha - \sigma + 1}} \left( \frac{\lambda A_l \varphi^{\sigma-1}}{r_j} \right)^{\frac{1}{\alpha - \sigma + 1}}, \quad (10)$$

Equation (10) shows that process innovations decrease in probability-weighted borrowing costs  $\frac{r_j}{\lambda}$ , but increase in productivity  $\varphi$  and the market size, denoted by  $A_d = XP^\sigma$  and  $A_x = XP^\sigma (1 + \tau^{1-\sigma})$  for domestic sellers and exporters respectively. Optimal prices are set as a constant markup over marginal production costs which decrease in exogenous productivity and endogenous innovation activity, whereas  $p_{jx}^*$  denotes the export price:

$$p_{jl}(\varphi) = \frac{\sigma}{\sigma - 1} \frac{1}{\varphi e_{jl}}; \quad p_{jx}^*(\varphi) = \tau p_{jx}(\varphi). \quad (11)$$

Firms that face higher borrowing costs choose lower investment levels and hence set higher prices resulting in lower expected profits:

$$\lambda \pi_{jl}(\varphi) = \frac{\alpha - \sigma + 1}{\alpha \sigma} \lambda s_{jl}(\varphi) - f_l r_j, \quad (12)$$

whereas sales can be expressed as follows:

$$s_{jl}(\varphi) = A_l^{\frac{\alpha}{\alpha - \sigma + 1}} \left( \left( \frac{\sigma - 1}{\sigma} \right)^{1+\alpha} \frac{\lambda \varphi^\alpha}{r_j} \right)^{\frac{\sigma-1}{\alpha - \sigma + 1}}. \quad (13)$$

The borrowing rate will be higher for firms that rely on financial intermediation ( $r_m > r_u$ ). The following subsection introduces moral hazard which motivates credit frictions and the difference in financing costs for unmonitored and monitored funds.

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<sup>9</sup>See Appendix 8.1 for a detailed derivation of the firm's maximization problem.

## 2.3 Moral hazard and selection of firms

Based on Holmstrom and Tirole (1997), financial imperfections originate from moral hazard within the firm. This leads to credit frictions and the selection of producers into two different types of external finance. Consider first the problem of firms that use unmonitored finance ( $j = u$ ). After the credit contract has been signed and the loan has been provided to the firm, the success of investments depends on a project choice of the firm manager. This action is by assumption non-verifiable for external investors and thus prone to moral hazard. Following Holmstrom and Tirole (1997), the manager can decide to behave diligently or to misbehave resulting in high or low success probabilities:  $\lambda > \lambda_b$ . In case of shirking, the manager reaps a non-verifiable private benefit that is proportional to the fixed investment  $bf_l > 0$ . Thus, agents only behave diligently if the following incentive compatibility constraint is satisfied:

$$\lambda\pi_{ul}(\varphi) \geq \lambda_b\pi_{ul}(\varphi) + bf_l. \quad (14)$$

As profits increase in  $\varphi$ , high productivity firms have no incentive to shirk. However, managers of lower productivity firms might prefer to choose the bad project and reap private benefits if the expected profits of diligent behavior are not sufficiently high. The assumption that private benefits  $b$  are proportional to fixed costs introduces access barriers to external finance beyond profitability requirements.<sup>10</sup> Hence, exporters face a trade-off between additional profits from international activity in case of diligent behavior and the prospect of higher perks in case of misbehavior. Furthermore, I assume that the net present value of the marginal firm that just meets incentive compatibility (14) is negative in case of shirking. This assumption is satisfied whenever the success probability  $\lambda_b$  is sufficiently low.<sup>11</sup> In this case, investors have to ensure that a credit contract satisfies condition (14) to avoid losses from lending. As in Holmstrom and Tirole (1997), I introduce a second investor type that is able to imperfectly monitor firms, which reduces the private benefit to  $mb$ , where  $0 < m < 1$ . Thus, monitoring effort mitigates the problem of moral hazard, but comes at additional costs,  $c_m > 1$ , leading to a higher borrowing rate of financial intermediation:  $r_m = c_m r_u > r_u$ . Incentive compatibility in case of monitored finance is given by:

$$\lambda\pi_{ml}(\varphi) \geq \lambda_b\pi_{ml}(\varphi) + mbf_l. \quad (15)$$

Incentive compatibility conditions (14) and (15) are more restrictive than zero-profit requirements (9) as long as private benefits are positive, even after monitoring:  $mb > 0$ . Hence,

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<sup>10</sup>See Section 6 for a further discussion of the moral hazard approach and possible extensions.

<sup>11</sup>See Ehrlich and Seidel (2013) as well as Egger and Keuschnigg (2015) for a similar discussion of moral hazard with heterogeneous firms.

the incentive constraints impose access barriers to unmonitored and monitored funds respectively, and describe the selection of firms into external finance. Since profits (12) are a function of productivity  $\varphi$ , the binding equations (14) and (15) determine minimum productivity levels that are necessary to obtain outside finance. Some low productivity firms meet the zero-profit condition (9) and hence would find it profitable to be active in the market. However, moral hazard prevents access to finance and a range of profitable projects is not conducted in the presence of credit frictions. Depending on export status and the type of finance, incentive compatibility (14) or (15) leads to the following cutoff productivities for access to external funds:

$$\varphi_{jl} = \left( \frac{\sigma}{\sigma-1} \right)^{\frac{1+\alpha}{\alpha}} \left( \frac{r_j}{\lambda} \right)^{\frac{1}{\alpha}} \left( \frac{\alpha\sigma\psi_j f_j}{\alpha-\sigma+1} \right)^{\frac{\alpha-\sigma+1}{\alpha(\sigma-1)}} A_l^{\frac{-1}{\sigma-1}}, \quad (16)$$

where  $\psi_m = \frac{bm}{\Delta\lambda} + \frac{r_m}{\lambda}$  and  $\psi_u = \frac{b}{\Delta\lambda} + \frac{r_u}{\lambda}$ , with  $\Delta\lambda = \lambda - \lambda_b$ , are measures of access barriers to external finance that consist of probability-weighted borrowing costs and agency costs due to moral hazard. Consider first how exporters select into unmonitored and monitored finance ( $l = x$ ). Comparing cutoff productivities for both types of funds (16) shows that the entry barrier to unmonitored lending is relatively higher if the following condition holds:

**Condition 1**  $\varphi_{ux} > \varphi_{mx}$  if  $c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} \frac{\psi_m}{\psi_u} < 1$ .

Condition 1 compares the two sources of finance and is independent of export status. On the one hand, monitored lending reduces moral hazard and facilitates access to finance. The lower private benefit ( $mb$ ) eases the restriction imposed by incentive compatibility (15). On the other hand, monitoring activity is associated with additional costs which reduces profits (12) and makes it more difficult to satisfy incentive compatibility compared to unmonitored finance. Condition 1 states that access to monitored finance is relatively easier if the benefit of financial intermediation (reduced moral hazard) outweighs additional borrowing costs.

**Lemma 1** *If Condition 1 holds, the most productive exporters with  $\varphi \geq \varphi_{ux}$  use unmonitored finance. International firms in the middle range of the distribution ( $\varphi_{mx} \leq \varphi < \varphi_{ux}$ ) have to rely on more expensive financial intermediation, while lower productivity firms ( $\varphi < \varphi_{mx}$ ) cannot raise external finance for export activity and sell only domestically.*

Figure 1 depicts the selection pattern of exporters if Condition 1 holds, whereas productivity  $\varphi$  is measured on the horizontal axis and profits are shown on the vertical axis. As financial intermediation is associated with higher interest rate payments for fixed costs and endogenous investments, the intercept as well as the slope of the profit line  $\pi_{mx}$  is lower compared to the

use of unmonitored finance. Thus, in the absence of credit frictions, unmonitored finance is always preferred to the more expensive type of credit. However, moral hazard leads to credit rationing and the selection of firms into both types of finance. The access barriers to external funds are depicted as horizontal lines in Figure 1. Passive investors are only willing to provide loans to the most productive exporters with  $\varphi \geq \varphi_{ux}$ . Producers in the intermediate range of the distribution are not able to overcome moral hazard and rely on more costly financial intermediation with lower entry barrier.

Condition 1 is violated if monitoring effectiveness is very low or monitoring costs are prohibitively high. Lower monitoring effectiveness corresponds to an upward shift of the horizontal access line (see Figure 2), whereas higher monitoring costs are reflected by a lower intercept and a smaller slope of the profit line  $\pi_{mx}$  (see Figure 3). In both cases, financial intermediaries fail to facilitate access to external finance compared to passive lenders and no firm will choose the more expensive type of credit. In the following, I assume that Condition 1 is satisfied and hence both types of finance occur in equilibrium, as illustrated in Figure 1. Compared to previous international trade models with financial imperfections, credit tightening induces exporters to substitute between the two sources of external finance. The following section shows how exporters react to financial shocks in partial equilibrium.

### 3 Effects of credit tightening in partial equilibrium

This section analyzes how financial conditions affect optimal firm behavior and the selection pattern of producers. An increase in the private benefit  $b$  can be interpreted as a worsening of financial development. In this case, a larger incentive to misbehave weakens the enforcement of credit contracts and reduces the pledgeability of profits in conditions (14) and (15). Consequently, this shock raises the cutoff productivities for access to both types of external finance (16), and is illustrated by an upward shift of marginal-access lines in Figure 4. A decrease in monitoring effectiveness (larger  $m$ ) aggravates access to financial intermediation. Hence, both shocks affect access barriers to external finance without changing innovation activity (10) and firm profits (12) in partial equilibrium.<sup>12</sup> Instead, if the borrowing rate  $r_u$  increases, profit lines in Figure 5 shift downwards and become flatter, as firms face higher costs for fixed and endogenous investments, and thus reduce innovation activity. Comparable to increases in  $b$  and  $m$ , this results in higher cutoff productivities.

Producers are affected very differently by worsening credit conditions, depending on their location along the productivity distribution. Firms in region A of Figures 4 and 5 stop

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<sup>12</sup>In general equilibrium, financial shocks change the competitive pressure and firm profits through the impact on the aggregate price. See section 4 for a discussion of general equilibrium effects.

exporting as they are not able to raise any funds for international activity after credit tightening. Firms in regions B and D change neither the export status nor the source of external finance, though face profit losses in case of higher borrowing costs. Exporters in region C, however, lose access to unmonitored finance and have to rely on more expensive monitored lending to cover fixed export and endogenous innovation costs. This substitution behavior leads to a direct negative effect on revenues and profits since switchers face larger interest rates and thus set higher prices. The following proposition summarizes the differential firm responses to credit tightening.

**Proposition 1** *Increases in  $b$  and  $r_u$  lead to higher cutoff levels  $\varphi_{jx}$ , such that least productive exporters quit international activity. Exporters in the middle range of the productivity distribution have to switch from unmonitored to monitored finance resulting in profit losses.*

So far, the discussion has focused on responses of exporters to credit tightening in partial equilibrium. In the open economy, firms select into the two types of external finance and choose their export status. Note that Condition 1 is independent of trade costs and has to hold for domestic sellers as well. Comparing the cutoff productivity for monitored finance and exporting  $\varphi_{mx}$  with the access barrier for non-exporters that use unmonitored finance  $\varphi_{ud}$ , leads to a second condition which determines the selection of firms:

**Condition 2**  $\varphi_{mx} > \varphi_{ud}$  if  $c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} \frac{\psi_m f_x}{\psi_u f_d} (1 + \tau^{1-\sigma})^{\frac{-\alpha}{\alpha-\sigma+1}} > 1$ .

Depending on whether Condition 2 holds, I distinguish two selection cases that are summarized in the following Lemma.

**Lemma 2** *If Conditions 1 and 2 hold, the selection of firms is described by the following sorting of cutoff productivities:  $\varphi_{md} < \varphi_{ud} < \varphi_{mx} < \varphi_{ux}$ . If Condition 2 does not hold, thresholds are ranked in the order:  $\varphi_{md} < \varphi_{mx} < \varphi_{ud} < \varphi_{ux}$ .*

In both cases, Condition 1 ensures that access to unmonitored finance is relatively more difficult both for international firms and domestic sellers. Hence, the most productive exporters have access to unmonitored finance, whereas the least productive firms sell only domestically and rely on financial intermediation. For given access barriers to external finance, Condition 2 is satisfied whenever trade costs are sufficiently high.<sup>13</sup> In this case, non-exporters select into both types of finance as well (see upper part of Figure 6). Lower trade costs decrease the cutoff productivities for international activity resulting in a larger fraction of exporters,

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<sup>13</sup>Note that Condition 1 implies that:  $c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} \frac{\psi_m}{\psi_u} < 1$ .

whereas higher competitive pressure increases the minimum productivities required for domestic activity  $\varphi_{jd}$ . This reduces the share of non-exporters that use unmonitored finance. If trade costs are sufficiently low, Condition 2 is violated, such that access to unmonitored finance becomes more difficult for domestic sellers compared to exporting with the aid of financial intermediation. Under conditions derived below, this scenario with low trade costs implies that domestic firms lose access to unmonitored finance (see lower part of Figure 6). Lemma 2 describes only the feasible selection patterns based on the comparison of cutoff productivities (16). The next subsections derive conditions under which the selection cases with low and high trade costs, as depicted in Figure 6, are also optimal when taking into account profitability considerations of firms. Intuitively, these conditions ensure (i) that trade costs are sufficiently high and only the most productive firms are able to export, and (ii) that credit frictions are sufficiently strong, such that the selection of firms into exporting and external finance is influenced by moral hazard. Otherwise, profitability requirements might impose higher access barriers than financial frictions.

### 3.1 Selection case 1: high trade costs

If trade costs are relatively high such that Condition 2 is satisfied, firms can be divided into four groups. The most productive ones become exporters, whereas low productivity producers sell only in the domestic market. Among both groups, only the most productive firms obtain unmonitored finance. To ensure profitability, active firms located in one of the four regions compare the available financing and production choices. Firms with  $\varphi_{md} \leq \varphi < \varphi_{ud}$  have only the possibility to sell in the domestic market by relying on financial intermediation. Profitability considerations of active producers in the remaining three groups are summarized by the following two Lemmas:

**Lemma 3**  $\pi_{ul}(\varphi) > \pi_{ml}(\varphi)$  for  $l \in d, x$ , since  $r_m = c_m r_u > r_u$ , with  $c_m > 1$ .

**Lemma 4**  $\pi_{mx}(\varphi) > \pi_{ud}(\varphi)$  if  $s_{ud}(\varphi) > \frac{r_u}{\lambda} \frac{\sigma\alpha}{\alpha-\sigma+1} \frac{c_m f_x - f_d}{(1+\tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} - 1}$ .

According to Lemma 3, it is always optimal for producers with  $\varphi_{ud} \leq \varphi < \varphi_{mx}$  and  $\varphi \geq \varphi_{ux}$  to use unmonitored finance which implies lower interest rate payments. Firms with  $\varphi_{mx} \leq \varphi < \varphi_{ux}$  face a trade-off between exporting by using monitored finance or selling only in the domestic market and obtaining unmonitored finance. On the one hand, exporting leads to additional profits. On the other hand, international activity is only possible with more costly financial intermediation. Productivities of firms within that group are not sufficient to satisfy incentive compatibility (14) and directly raise external funds for exports from

passive investors. Lemma 4 determines a cutoff productivity at which additional export profits exactly offset higher financing costs. Comparing this profitability requirement with the cutoff productivity  $\varphi_{mx}$ , defined by equation (16), leads to the following condition:<sup>14</sup>

**Condition 3** *Access to financial intermediation for exporters is more restrictive compared to profitability requirements, as described in Lemma 4, if*

$$\psi_m \geq \frac{r_u}{\lambda} \frac{c_m f_x - f_d}{f_x} \frac{(1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} c_m^{\frac{1-\sigma}{\alpha-\sigma+1}}}{(1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} - 1}.$$

Condition 3 compares the access barrier to monitored finance  $\psi_m$  with profitability requirements for marginal exporters. Larger fixed and variable trade costs,  $f_x$  and  $\tau$ , as well as higher monitoring costs  $c_m$ , increase the right-hand side of Condition 3, as it becomes more difficult for lower productivity firms to earn positive profits in the foreign market. Condition 3 is satisfied whenever the remaining private benefit after monitoring  $mb$ , and thus the entry barrier to exporting with the aid of monitored finance  $\psi_m$ , is sufficiently high compared to profitability requirements. If Conditions 1-3 hold, the selection pattern depicted in the upper part of Figure 6 describes optimal firm behavior. In this case, moral hazard imposes stronger restrictions on firms than profitability. Hence, financial frictions hinder some marginal producers with productivity  $\varphi < \varphi_{mx}$  to engage in international markets and conduct profitable investment projects. Conversely, all firms with productivity levels  $\varphi \geq \varphi_{mx}$  find it optimal to become exporters, since profitability is ensured whenever external finance is accessible.

### 3.2 Selection case 2: low trade costs

If Condition 2 is not satisfied, the entry barrier to export markets under financial intermediation is relatively lower compared to the domestic sellers' access to unmonitored finance:  $\varphi_{mx} < \varphi_{ud}$  (compare Lemma 2). As Condition 2 shows, this selection pattern becomes more likely if trade costs are low for given financial conditions. Analogous to Melitz (2003), Condition 4 ensures that fixed and variable trade costs are still sufficiently high such that only the most productive firms are able to export.<sup>15</sup>

**Condition 4**  $\varphi_{jx} > \varphi_{jd}$  if  $t = \frac{f_x}{f_d} (1 + \tau^{1-\sigma})^{\frac{-\alpha}{\alpha-\sigma+1}} > 1$ .

As in selection case 1, I still assume that Condition 3 is satisfied which implies that all firms with  $\varphi \geq \varphi_{mx}$  find it optimal to become exporters and use funds from intermediaries. This condition is now less restrictive as trade costs are lower and thus profitability of export

<sup>14</sup>See Appendix 8.4 for a derivation of Condition 3.

<sup>15</sup>Note that Condition 4 is always satisfied in selection case 1 due to Conditions 1 and 2.

activity is easier to achieve compared to the access barrier  $\psi_m$ . Because of  $\varphi_{mx} < \varphi_{ud}$ , an important implication of this second selection pattern with low trade costs is that non-exporters will never use unmonitored finance. Firms with productivity  $\varphi \geq \varphi_{ud}$  could decide to forego profits from foreign markets and use the cheaper type of finance. However, in case of low trade costs, this is never optimal for any firm that has access to external funds for international activity. This reasoning leads to the following selection pattern in equilibrium:  $\varphi_{md} < \varphi_{mx} < \varphi_{ux}$ , as depicted in the lower part of Figure 6. Compared to selection case 1, not only export status but also access to unmonitored finance is a monotone function of productivity and thus firm size. The following proposition summarizes the two cases.

**Proposition 2** *If Conditions 1-3 hold, firms optimally select into exporting and external finance according to the following order:  $\varphi_{md} < \varphi_{ud} < \varphi_{mx} < \varphi_{ux}$ . If Conditions 1 and 3-4 are satisfied, the selection pattern is described by the following ranking:  $\varphi_{md} < \varphi_{mx} < \varphi_{ux}$ .*

If trade costs are low, non-exporters have only access to financial intermediation and hence cannot react to credit tightening by switching the source of finance. In contrast, a scenario with high trade costs implies that substitution effects, as described above for exporters, occur among non-exporters as well. Based on this partial equilibrium analysis, the following section considers the effects of credit tightening in general equilibrium.

## 4 Effects of credit tightening in general equilibrium

Compared to previous theoretical work, the partial equilibrium analysis in section 3 suggests substitution effects between two sources of finance as an additional channel through which credit tightening influences export behavior. The general equilibrium analysis in this section shows that financial shocks induce reallocations of market shares across firms that use different types of external finance (subsection 4.2). These substitution effects change reactions along the extensive margin and welfare responses to credit tightening (subsection 4.3).

### 4.1 General equilibrium in the open economy

Free entry ensures that expected profits equal fixed entry costs, before potential producers know their productivity draw  $\varphi$ :

$$E\pi_k = \sum_j \sum_l E\pi_{jlk} = \frac{\delta f_e}{\chi_s}, \quad (17)$$



whereas  $k \in 1, 2$  denotes the selection case and expected profits for each group with type of external finance  $j$  and export status  $l$  are given by:

$$E\pi_{jlk} = \int_{\varphi \in D_{jlk}} \lambda \pi_{jlk}(\varphi) \mu_s(\varphi) d\varphi. \quad (18)$$

After entry, firms draw productivity  $\varphi$  from a Pareto distribution with density function  $g(\varphi) = \xi \varphi^{-\xi-1}$  and positive support over  $[1, \infty]$ , whereby  $\xi$  is the shape parameter of the Pareto distribution.<sup>16</sup> Probabilities of belonging to one of the four possible groups  $\chi_{jl}$ , as well as the probability of survival  $\chi_s$ , are defined as:

$$\chi_{jlk} = \int_{\varphi \in D_{jlk}} g(\varphi) d\varphi \quad ; \quad \chi_{sk} = \int_{\varphi \in D_k} g(\varphi) d\varphi, \quad (19)$$

where  $D_{jlk}$  denotes the set of active firms with type of external finance  $j$  and export status  $l$ , and  $D_k$  is the set of all active producers in the economy.<sup>17</sup> The corresponding conditional probabilities are given by  $\mu_{sk}(\varphi) = \frac{g(\varphi)}{\chi_{sk}}$  and  $\mu_{jlk}(\varphi) = \frac{g(\varphi)}{\chi_{jlk}}$ . Combining equations (17) and (18) determines the cutoff productivity  $\varphi_{md}$ , at which firms are just able to produce for the domestic market by relying on monitored finance. Using equation (16), the remaining cutoff productivities can be expressed as functions of  $\varphi_{md}$  and exogenous model parameters:<sup>18</sup>

$$\frac{\varphi_{ud}}{\varphi_{md}} = \left( \frac{1}{c_m} \right)^{\frac{1}{\alpha}} \left( \frac{\psi_u}{\psi_m} \right)^{\frac{\alpha-\sigma+1}{\alpha(\sigma-1)}}; \quad \frac{\varphi_{mx}}{\varphi_{md}} = t^{\frac{\alpha-\sigma+1}{\alpha(\sigma-1)}}; \quad \frac{\varphi_{ux}}{\varphi_{md}} = \left( \frac{1}{c_m} \right)^{\frac{1}{\alpha}} \left( t \frac{\psi_u}{\psi_m} \right)^{\frac{\alpha-\sigma+1}{\alpha(\sigma-1)}}. \quad (20)$$

According to equation (20), the selection of firms depends on relative costs for external finance  $\frac{\psi_u}{\psi_m}$  and trade costs  $t = \frac{f_x}{f_d} (1 + \tau^{1-\sigma})^{\frac{-\alpha}{\alpha-\sigma+1}}$ . To analyze the importance of substitution effects in response to credit tightening, I define the share of firms with type of external finance  $j$  and export status  $l$  as  $\gamma_{jl}$ . For both selection cases, the fractions of exporters are given by:

$$\gamma_{mx} = \left( \frac{\varphi_{mx}}{\varphi_{md}} \right)^{-\xi} - \left( \frac{\varphi_{ux}}{\varphi_{md}} \right)^{-\xi}; \quad \gamma_{ux} = \left( \frac{\varphi_{ux}}{\varphi_{md}} \right)^{-\xi}. \quad (21)$$

As in Melitz (2003), the share of exporters is solely determined by trade costs:  $\gamma_x = \left( \frac{\varphi_{mx}}{\varphi_{md}} \right)^{-\xi}$ . Additionally, relative credit costs influence the selection of exporters into the two sources of external finance. In selection case 1, when trade costs are high, domestic sellers select into

<sup>16</sup>For technical reasons, I assume that  $\xi > \frac{\alpha(\sigma-1)}{\alpha-\sigma+1}$ . Appendix 8.3 characterizes the equilibrium with Pareto distributed productivity.

<sup>17</sup>Appendix 8.2 defines the regions of active firms for both selection cases.

<sup>18</sup>Note that in selection case 2, the cutoff  $\varphi_{ud}$  does not occur. See the discussion in subsection 3.2.

both types of external finance as well, such that  $\sum_j \sum_l \gamma_{jl} = 1$ , with:

$$\gamma_{md} = 1 - \left( \frac{\varphi_{ud}}{\varphi_{md}} \right)^{-\xi} ; \gamma_{ud} = \left( \frac{\varphi_{ud}}{\varphi_{md}} \right)^{-\xi} - \left( \frac{\varphi_{mx}}{\varphi_{md}} \right)^{-\xi}, \quad (22)$$

whereas in case 2 domestic firms have only access to monitored finance:

$$\gamma_{md} = 1 - \left( \frac{\varphi_{mx}}{\varphi_{md}} \right)^{-\xi} ; \gamma_{ud} = 0. \quad (23)$$

Furthermore, market shares are defined as the ratio of average revenues in one group relative to average revenues in the total economy:  $\eta_{jlk} = \frac{\gamma_{jlk} \tilde{s}_{jlk}}{\tilde{s}_k}$ , such that  $\sum_j \sum_l \frac{\gamma_{jlk} \tilde{s}_{jlk}}{\tilde{s}_k} = 1$ .<sup>19</sup> Each firm uses labor as single input factor for variable production costs as well as fixed and endogenous innovation costs. Total labor demand of one producer can be written as follows:

$$\frac{1}{\varphi e_{jl}} (x_{jl} + 1_{\{x^* > 0\}} \tau x_{jx}^*) + k_{jl} = \frac{(\sigma - 1)(1 + \alpha)}{\sigma \alpha} s_{jl}(\varphi) + \frac{r_j}{\lambda} f_l. \quad (24)$$

In equilibrium, the inelastic labor supply  $L$  has to be equal to labor demands in the entry sector ( $L_e = M_e f_e$ ) and in the four groups of active producers:  $L = L_e + \sum_j \sum_l L_{jlk}$ .<sup>20</sup> Additionally, the mass of successful entrants is equal to the mass of firms that are forced to exit due to an exogenous death shock:  $\chi_s M_e = \delta M_k$ . Analogous to Melitz (2003), labor market clearing pins down the mass of active firms  $M$  in the economy:

$$M_k = \frac{L}{\lambda \tilde{s}_k}. \quad (25)$$

The borrowing rate is treated as exogenous. Section 6 introduces a capital market equilibrium which leads to an explicit solution for  $r_u$ . Average sales in equation (25) are defined as follows:

$$\tilde{s}_k = \frac{\xi \alpha \sigma \psi_m f_d \Gamma_k}{\xi (\alpha - \sigma + 1) - \alpha (\sigma - 1)}. \quad (26)$$

The term  $\Gamma_k$  is a function of trade costs as well as financial conditions and captures the average productivity in the economy, dependent on the selection case:

$$\Gamma_1 = \Theta + \left( \frac{\varphi_{md}}{\varphi_{mx}} \right)^\xi \left( \frac{f_x}{f_d} \Theta - t c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} \right); \Gamma_2 = 1 + \left( \frac{\varphi_{md}}{\varphi_{mx}} \right)^\xi \left( \frac{f_x}{f_d} \Theta - t \right), \quad (27)$$

<sup>19</sup>The market shares  $\eta_{jl}$  are defined in Appendix 8.3.

<sup>20</sup>In selection case 1, all four groups of firms are active. In case 2, domestic firms have no access to unmonitored finance and  $L_{ud} = 0$ . See section 3 for a detailed discussion of the two cases.

whereas  $\Theta$  is a measure for relative costs of external funds:

$$\Theta = 1 + \frac{\psi_u}{\psi_m} \left( \frac{\varphi_{md}}{\varphi_{ud}} \right)^\xi \left( 1 - c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \right), \quad (28)$$

which increases in effective costs for monitored finance, including borrowing rates and access barriers due to moral hazard. If there are no differences between the two sources of external finance, such that  $m = c_m = 1$ , the measure  $\Theta$  equals one. Hence, this framework nests a model with financial frictions and one source of external finance as a special case, which will be discussed in more detail below.

## 4.2 Reallocation effects of credit tightening

The partial equilibrium analysis in section 3 has stressed two effects of credit tightening. Consistent with theoretical and empirical work on credit frictions and export behavior, worsening financial conditions increase access barriers to international markets. Furthermore, credit shocks change the ratio of access barriers  $\frac{\psi_u}{\psi_m}$ , and thus trigger substitution effects between the two sources of external finance, as shown by the following proposition.<sup>21</sup>

**Proposition 3** *A higher private benefit  $b$  increases the fraction of firms that use monitored finance and raises their market share. In case 1, this selection effect is stronger for non-exporters:  $\frac{\partial \gamma_{md}}{\partial b} > \frac{\partial \gamma_{mx}}{\partial b} > 0$ .*

**Proof.** See Appendix 8.4. ■

A higher private benefit  $b$  increases the relative access barrier to unmonitored funds  $\frac{\psi_u}{\psi_m}$ , as it becomes relatively more difficult for firms using this type of finance to satisfy incentive compatibility. Producers that rely on financial intermediation are hit less, since monitoring attenuates aggravated moral hazard. In contrast, an increase in the borrowing rate  $r_u$  decreases the relative cost for unmonitored finance, as firms that rely on intermediaries are hurt relatively more due to additional monitoring costs. Consequently, relative access to unmonitored funds becomes easier and the share of firms using this type of finance increases (see Appendix 8.4 for a formal proof). Proposition 3 shows that substitution effects are stronger for non-exporters if selection case 1 applies. Deteriorating financial conditions increase access barriers to finance and thus hurt low productivity firms most. In selection case 2, if trade costs are low, non-exporters have to rely on financial intermediation and cannot react to financial shocks by switching the source of external finance.

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<sup>21</sup>Compare Proposition 1 for a summary of partial equilibrium effects of credit tightening. See Foley and Manova (2015) for a review of related theoretical and empirical literature.

The model's predictions are consistent with empirical evidence documenting large adverse effects of credit tightening on small and bank-dependent firms, as well as substitution into alternative sources of external debt during the financial crisis of 2008-2009.<sup>22</sup> Credit tightening does not only affect the selection of firms into external funds and exporting, but induces reallocations of revenue-based market shares among producers that use different sources of finance. If the private benefit goes up, market shares of exporters that rely on financial intermediation increase. Comparable to an increase in the borrowing rate  $r_u$ , a decrease in monitoring effectiveness (higher  $m$ ) leads to a larger fraction of firms that use unmonitored finance and a reallocation of markets shares away from producers that rely on financial intermediation.<sup>23</sup> These reallocation effects change the degree of price competition in general equilibrium, which has important implications for reactions of aggregate variables to financial shocks. This will be discussed in the following subsection.

### 4.3 Aggregate effects of credit tightening

As shown in section 3, an increase in the private benefit aggravates moral hazard and leads to stronger credit frictions. Consequently, this shock reduces the number of active firms (25), whereas  $k \in 1, 2$  indicates the selection case:

$$\frac{\partial M_k}{\partial b} \frac{b}{M_k} = - \underbrace{\frac{mb}{\Delta \lambda \psi_m}}_{\text{Direct effect}} - \underbrace{\frac{\partial \Gamma_k}{\partial b} \frac{b}{\Gamma_k}}_{\text{Selection effect}} < 0. \quad (29)$$

Reactions along the extensive margin can be separated into two effects. The first term in equation (29) is independent of the selection case and captures the exit of lowest productivity firms that lose access to external finance after credit tightening (compare Proposition 1). The second term is a substitution effect that would not be present in a model with one source of external finance. Substitution effects lead to an additional channel of adjustment along the extensive margin. If the private benefit  $b$  increases, a larger fraction of firms has to rely on more expensive financial intermediation, which reduces the degree of price competition and attenuates exit of low productivity firms ( $\frac{\partial \Gamma_k}{\partial b} < 0$ ). In contrast, substitution effects work in the opposite direction if the monitoring effectiveness decreases (higher  $m$ ). An increase in  $m$  raises the share of firms that use unmonitored finance and leads to a reallocation of market shares away from producers relying on financial intermediation. This selection effect increases competition in general equilibrium, as a larger fraction of producers raises cheaper finance without monitoring, resulting in a lower average price and thus stronger firm exit.

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<sup>22</sup>Compare the discussion in section 1.

<sup>23</sup>See the proof of Proposition 3 in Appendix 8.4 for details.

The same reasoning applies to an increase in the interest rate  $r_u$ .<sup>24</sup> To analyze the welfare effects of credit tightening, welfare can be expressed as a function of financial conditions and the cutoff productivity of the least productive domestic seller using bank finance  $\varphi_{mdk}$ :

$$W_k = P^{-1} = \left( \frac{\sigma - 1}{\sigma} \right)^{\frac{1+\alpha}{\alpha}} \left( \frac{\alpha - \sigma + 1}{\alpha \sigma \psi_m f_d} \right)^{\frac{\alpha - \sigma + 1}{(\sigma - 1)\alpha}} \left( \frac{L}{\lambda} \right)^{\frac{1}{\sigma - 1}} \left( \frac{r_m}{\lambda} \right)^{\frac{-1}{\alpha}} \varphi_{mdk} . \quad (30)$$

The derivative of equation (30) with respect to the private benefit  $b$  shows that credit tightening affects welfare through two channels:

$$\frac{\partial W_k}{\partial b} \frac{b}{W_k} = - \underbrace{\frac{\alpha - \sigma + 1}{\alpha (\sigma - 1)} \frac{mb}{\Delta \lambda \psi_m}}_{\text{Variety loss}} + \underbrace{\frac{\partial \varphi_{mdk}}{\partial b} \frac{b}{\varphi_{mdk}}}_{\text{Productivity gain}} . \quad (31)$$

As firms with lowest productivity and highest borrowing costs exit the market, consumers face a loss of product variety which is counteracted by a productivity gain. Compared to a model with one source of external finance, selection effects amplify negative welfare responses to credit tightening.

**Proposition 4** *A higher private benefit reduces the number of active firms if the private benefit is sufficiently high, and leads to lower welfare if the effectiveness of monitoring is sufficiently low:  $\psi_m > \frac{r_u}{\lambda f_d} \frac{\tilde{f}_k}{\Gamma_k}$ . Substitution into bank finance attenuates the negative effect on the extensive margin, but amplifies welfare losses.*

**Proof.** See Appendix 8.4. ■

Selection into more expensive financial intermediation reduces average productivity and increases average fixed costs in the industry. This results in a lower productivity gain in equation (31) and thus higher welfare losses. In contrast, an increase in  $m$  leads to substitution into unmonitored lending, increases the exit of low productivity firms and reduces welfare losses compared to a situation with only one source of external finance. The same results apply to an increase in the borrowing rate  $r_u$ . The relative cost disadvantage of financial intermediation leads to substitution into unmonitored finance and intensifies negative reactions along the extensive margin resulting in additional productivity gains. An increase in credit costs affects welfare through three channels:

$$\frac{\partial W_k}{\partial r_u} \frac{r_u}{W_k} = - \underbrace{\frac{1}{\alpha}}_{\text{IM}} - \underbrace{\frac{\alpha - \sigma + 1}{\alpha (\sigma - 1)} \frac{r_m}{\lambda \psi_m}}_{\text{Variety loss}} + \underbrace{\frac{\partial \varphi_{mdk}}{\partial r_u} \frac{r_u}{\varphi_{mdk}}}_{\text{Productivity gain}} . \quad (32)$$

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<sup>24</sup>Compare Proposition 3 and see Appendix 8.4 for details.

As producers scale down innovation activity and thus increase prices, a higher borrowing rate negatively affects the intensive margin (IM). If credit frictions in the financial intermediation sector are sufficiently high, the variety loss outweighs productivity gains and there is an additional negative reaction at the extensive margin.

**Proposition 5** *An increase in the borrowing rate  $r_u$  negatively affects welfare through the intensive margin, as well as the extensive margin if monitoring effectiveness of financial intermediation is sufficiently low.*

**Proof.** See Appendix 8.4. ■

**Special case with one source of external finance** If  $c_m = m = 1$ , there is no difference between monitored and unmonitored finance such that the relative access barrier to external funds is equal to one ( $\frac{\psi_u}{\psi_m} = 1$ ) and from equation (20) follows that  $\frac{\varphi_{ul}}{\varphi_{ml}} = 1$ . Hence, the framework nests a heterogeneous firm model with financial frictions and one source of external finance. This special case allows to analyze the effect of financial intermediation on the number of active firms and welfare. The relative number of firms in selection case  $k$  compared to a scenario with only one type of external finance, denoted by the subscript  $o$ , can be expressed as follows:

$$\frac{M_k}{M_o} = \frac{\tilde{s}_o}{\tilde{s}_k} = \frac{\psi_u}{\psi_m} \frac{\Gamma_o}{\Gamma_k}. \quad (33)$$

The first term reflects the fact that financial intermediaries facilitate access to finance ( $\psi_m < \psi_u$ ), which increases the number of available varieties in the economy. The second term captures that a higher number of producers increases the competitive pressure ( $\Gamma_k > \Gamma_o$ ). Expression (33) monotonically increases in the private benefit  $b$ . Hence, stronger credit market imperfections enhance the benefit of financial intermediation in terms of larger product variety. Analogously, welfare relative to the case without financial intermediation is given by:

$$\frac{W_k}{W_o} = \left( \frac{\psi_u}{\psi_m} \right)^{\frac{\alpha - \sigma + 1}{\alpha(\sigma - 1)}} c_m^{-\frac{1}{\alpha}} \left( \frac{E\pi_k}{E\pi_o} \right)^{\frac{1}{\xi}}. \quad (34)$$

Compared to welfare without bank finance, the positive impact on product variety ( $\frac{\psi_u}{\psi_m}$ ) is counteracted by a negative effect along the intensive margin as well as a productivity loss. Additional monitoring costs  $c_m$  reduce investments and hence increase prices resulting in lower welfare. As financial intermediaries enable lower productivity firms to enter, the average profits are reduced ( $E\pi_k < E\pi_o$ ).

**Proposition 6** *If credit frictions are sufficiently strong and monitoring effectiveness is high, financial intermediation increases product variety and welfare.*

**Proof.** See Appendix 8.4. ■

From a policy perspective, the analysis shows that better access to financial intermediation leads to relatively larger product variety and potentially higher welfare, especially in industries with strong exposure to credit frictions. More effective intermediaries facilitate export activities of lower productivity firms. Furthermore, changes in credit conditions affect producers very differently depending on their productivity and the source of external finance. Policies that aim to ease access to external funds will induce reallocations of market shares across firms and thus generate losers and winners. These selection effects change the average productivity in the economy and welfare. Besides that, financial intermediation does also affect aggregate responses to trade liberalization.

## 5 Trade liberalization

This section shows that substitution between two types of external finance represents an additional channel how firms adjust to trade liberalization. I focus on a change in export fixed costs  $f_x$ , whereas analogous results can be derived for variable trade costs  $\tau$  (see Appendix 8.5). A reduction in trade costs decreases the cutoff levels  $\varphi_{jx}$  and increases the share of exporters. Firms with productivity slightly below  $\varphi_{mx}$  before trade liberalization start exporting. Additionally, exporters near but below the initial threshold  $\varphi_{ux}$  switch from bank finance to unmonitored finance resulting in lower borrowing costs (see Figure 6). In both selection cases, trade liberalization leads to a reallocation of market shares towards exporters:

$$\frac{\partial \eta_{x1}}{\partial f_x} \frac{f_x}{\eta_{x1}} = \frac{\alpha(\sigma - 1) - \xi(\alpha - \sigma + 1)}{\alpha(\sigma - 1)} \frac{\Theta}{\Gamma_1} < 0, \quad (35)$$

$$\frac{\partial \eta_{x2}}{\partial f_x} \frac{f_x}{\eta_{x2}} = \frac{\alpha(\sigma - 1) - \xi(\alpha - \sigma + 1)}{\alpha(\sigma - 1) \Gamma_2} < 0. \quad (36)$$

As in Melitz (2003), trade liberalization increases the cutoff productivity for domestic sales  $\varphi_{md}$ . Whereas market shares are reallocated towards exporters, low productivity firms exit:

$$\frac{\partial M_1}{\partial f_x} \frac{f_x}{M_1} = -\frac{\partial \eta_{x1}}{\partial f_x} \frac{f_x}{\eta_{x1}} \left[ \Theta (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} - c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} \right] \frac{t\gamma_x}{\Theta} > 0, \quad (37)$$

$$\frac{\partial M_2}{\partial f_x} \frac{f_x}{M_2} = -\frac{\partial \eta_{x2}}{\partial f_x} \frac{f_x}{\eta_{x2}} \left[ \Theta (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} - 1 \right] t\gamma_x > 0. \quad (38)$$

The reaction of domestic firms depends on the selection case. If trade costs are high (selection case 1), some non-exporters react to increased competitive pressure by switching from unmonitored to monitored finance. This substitution effect decreases the extent of price competition, as switchers face higher borrowing costs, which leads to a reduced reaction

at the extensive margin. If trade costs are low, non-exporters cannot change the type of finance. Consequently, the comparison of equations (37) and (38) shows that exit pressure is more pronounced in selection case 2. Higher monitoring costs  $c_m$  or a lower effectiveness of monitoring (higher  $m$ ) increase the relative costs of financial intermediation compared to direct lending as captured by the term  $\Theta$ . In this case, non-exporters are hurt more by increased competition after trade liberalization which leads to stronger exit. At the same time, the gain of market shares for exporters is attenuated when financial intermediation is less effective. This result is driven by two effects. First, additional profits are lower for new exporters that rely on monitored finance. Second, stronger exit of lower productivity firms increases the cutoff productivity and thus the competitive pressure in general equilibrium. Consequently, substitution effects influence the welfare gains from trade liberalization:

$$\frac{\partial W_k}{\partial f_x} \frac{f_x}{W_k} = -\frac{1}{\xi E \pi_k} \left[ \frac{(\alpha - \sigma + 1) \lambda \tilde{s}_k}{\alpha \sigma} \frac{\partial M_k}{\partial f_x} \frac{f_x}{M_k} + r_u f_x \frac{\partial \tilde{f}_k}{\partial f_x} \right]. \quad (39)$$

**Proposition 7** *Lower trade costs lead to a reallocation of market shares towards exporters and exit of low productivity firms. If monitoring effectiveness is sufficiently low, there are welfare gains from trade  $\left( \frac{\partial W_k}{\partial f_x} \frac{f_x}{W_k} < 0 \right)$ , that increase in the relative cost for bank finance.*

**Proof.** See Appendix 8.4. ■

Equation (39) and Proposition 7 show that welfare gains increase in credit frictions with respect to financial intermediation. Higher access barriers to external finance worsen the negative consequences of trade liberalization for lower productivity firms, but increase aggregate gains in terms of average productivity and welfare. Hence, a decrease in trade costs is more beneficial in the presence of stronger credit frictions. The comparative static analysis identifies substitution into financial intermediation as an additional channel how domestic firms react to increased competitive pressure induced by trade liberalization. A higher reliance on monitored finance reduces the negative responses along the extensive margin at the expense of welfare gains. Conversely, the absence of substitution possibilities among domestic sellers intensifies product churning, but at the same time increases welfare gains after trade liberalization. Hence, the introduction of two sources of external finance in the presence of credit frictions leads to two additional sources of gains from trade. First, some exporters obtain access to finance provided without monitoring resulting in a reduction of borrowing costs and prices. Second, stronger exit of lower productivity firms that rely on more expensive financial intermediation further increases average productivity in general equilibrium. The latter effect is attenuated if non-exporters are able to select into monitored finance in case of high trade costs.



## 6 Discussion and extensions

After presenting the effects of financial shocks and trade liberalization, this section discusses assumptions of the theoretical framework and analyzes possible extensions.

**Moral hazard and external finance.** Firms have to rely on external finance to cover fixed costs and endogenous investment outlays. The reactions of the intensive and extensive margins to an increase in the borrowing rate  $r_u$  depend crucially on this assumption. If external finance is needed for innovations only, access barriers are independent of borrowing rates:  $\psi_m = \frac{bm}{\Delta\lambda} + \frac{1}{\lambda}$  and  $\psi_u = \frac{b}{\Delta\lambda} + \frac{1}{\lambda}$  (compare subsection 2.3), and there will be no reaction along the extensive margin in equation (32). Instead, if only fixed costs have to be financed by investors, the influence of borrowing costs on the intensive margin disappears. Empirical evidence suggests that firms rely on external finance for fixed up-front costs and investments, especially in international trade.<sup>25</sup> One important feature of the theoretical framework is that borrowing costs for process innovations affect price setting and the intensive margin, without assuming external financing of variable production costs.

The assumption that private benefits are only related to fixed costs introduces credit frictions regarding the extensive margin. Moral hazard increases the access barriers to external finance and raises the cutoff productivities for domestic sales as well as exporting above the level of a zero-profit condition. The model does not allow that firms use a mix of both sources of credit. Instead, differences in private benefits as well as in borrowing costs lead to selection of firms into two types of external finance. Alternatively, the private benefit could be related to endogenous investment costs as well.<sup>26</sup> This assumption would lead to a negative effect of moral hazard on innovation choices and a direct impact on the intensive margin, but considerably complicates the analysis. The reason is that firms would additionally be divided into financially unconstrained and constrained ones besides the selection into two sources of external finance. By assuming only one type of lenders, Irlacher and Unger (2015) introduce credit frictions and firm-specific moral hazard which leads to an endogenous share of credit-rationed producers. This fraction is determined by the quality of financial institutions and industry characteristics such as the degree of product market competition.

**Borrowing costs and capital market equilibrium.** The model considers labor as single factor of production. Comparable to the general equilibrium in Melitz (2003), all resources for entry, production and investment are expressed in terms of labor. This implies that the borrowing rate  $r_u$  is exogenous. The framework could be easily extended by introducing

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<sup>25</sup>See e.g. Manova (2013), Feenstra et al. (2014), as well as Muûls (2015), among others.

<sup>26</sup>Tirole (2006) discusses different specifications of moral hazard in corporate finance theory.

capital as a second input factor for endogenous innovations. If labor is used for fixed and variable production costs, equation (25) can be rewritten as:

$$M_k = \frac{\alpha \sigma L}{[\sigma(\alpha - 1) + 1] \lambda \tilde{s}_k}. \quad (40)$$

Additionally, fixed capital supply  $K$  has to be equal to aggregate investment outlays which leads to a further market clearing condition:

$$K = \lambda M_k \frac{\sigma - 1}{\alpha \sigma} \frac{\sum_l \gamma_{mlk} \tilde{s}_{mlk} + c_m \sum_l \gamma_{ulk} \tilde{s}_{ulk}}{r_m}. \quad (41)$$

Combining equations (40) and (41) yields an explicit solution for the borrowing rate  $r_u$ :

$$r_u = \frac{L}{K} \frac{\sigma - 1}{\sigma(\alpha - 1) + 1} \frac{\sum_l \gamma_{mlk} \tilde{s}_{mlk} + c_m \sum_l \gamma_{ulk} \tilde{s}_{ulk}}{c_m \tilde{s}_k}. \quad (42)$$

If there is only one type of external capital ( $c_m = m = 1$ ), borrowing costs depend on fixed parameters of the model and on relative capital supply  $\frac{K}{L}$ :

$$r_u = \frac{L}{K} \frac{\sigma - 1}{\sigma(\alpha - 1) + 1}. \quad (43)$$

Equation (43) is closely related to the general equilibrium in Eckel and Unger (2015). The interest rate decreases in relative capital supply and increases with the elasticity of substitution  $\sigma$ . A larger convexity of investment costs  $\alpha$  reduces capital demand and thus the borrowing rate. In a CES framework with one type of external finance, neither trade liberalization nor stronger credit frictions change the interest rate. This result is driven by two properties of the model. First, as in Melitz (2003), effects along the extensive margin are captured by labor market clearing. Second, the constant elasticity of substitution implies a constant marginal product of capital such that the effect of shocks on the intensive margin is fixed. In contrast, Irlacher and Unger (2015) introduce a trade model with non-CES preferences, whereas the borrowing rate is endogenously determined by industry characteristics, and changes with trade liberalization. If there are two types of finance, equation (42) reveals that capital costs are not merely pinned down by technology parameters and endowments.

**Proposition 8** *The borrowing rate  $r_u$  decreases in the private  $b$  as well as in variable and fixed trade costs.*

**Proof.** See Appendix 8.4. ■

Changes of the interest rate are caused by substitution effects between the two types of finance. If the private benefit increases, there is a reallocation of market shares away from the

most successful firms with lowest borrowing costs. As producers select into more expensive monitored finance, average capital demand and thus the interest rate decreases ( $\frac{\partial r_u}{\partial b} < 0$ ). Instead, a lower monitoring effectiveness (higher  $m$ ) leads to more innovation and higher capital demand due to selection into unmonitored finance. With endogenous borrowing costs, the reaction of welfare to an increase in the private benefit is given by:

$$\frac{\partial W}{\partial b} \frac{b}{W} = - \underbrace{\frac{\alpha - \sigma + 1}{(\sigma - 1) \alpha} \frac{mb}{\Delta \lambda \psi_m}}_{\text{Variety loss}} + \underbrace{\frac{\partial \varphi_{md}}{\partial b} \frac{b}{\varphi_{md}}}_{\text{Productivity gain}} - \underbrace{\frac{1}{\alpha} \frac{\partial r_u}{\partial b} \frac{b}{r_u}}_{\text{Interest rate effect}}. \quad (44)$$

Compared to equation (31), stronger credit frictions lead to an additional adjustment along the intensive margin which counteracts substitution effects. Whereas selection into monitored finance causes a negative effect on welfare (compare Proposition 4), a decrease in borrowing costs enhances innovation activity of firms and tends to attenuate losses of credit tightening. Analogous to financial shocks, trade liberalization changes the interest rate only through selection effects. As shown in section 5, lower trade costs lead to an additional welfare gain as marginal exporters switch from monitored to unmonitored finance. Facing lower borrowing costs, these firms increase capital demand which results in upward pressure on the borrowing rate. This induces a negative reaction along the intensive margin and reduces gains from trade.

**Credit frictions and trade finance.** The trade and finance literature discusses several reasons why exporters may be more exposed to credit frictions such as higher default risk, increased uncertainty in foreign markets or additional up-front costs.<sup>27</sup> This model could be extended in different ways to capture exporters' higher exposure to credit constraints. First, a higher uncertainty of investments in foreign markets could be modelled by a lower success probability  $\lambda$  for international firms. Second, a larger private benefit  $b$  would reflect a more difficult access to external finance. Third, it might be harder for financial intermediaries to control exporters' project choice if activity in foreign markets is associated with opaqueness of investments or weaker enforceability of financial contracts. This could be reflected by lower monitoring effectiveness  $m$  or higher borrowing costs  $c_m$  in case of exporting. These extensions imply that the share of exporters would not only depend on trade costs, but is affected by differences in financial conditions between domestic sellers and international firms (compare the discussion in section 4). Consequently, exporters would be hurt more by worsening financial conditions.

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<sup>27</sup>See Foley and Manova (2015) for a discussion of the trade and finance literature.

## 7 Conclusion

This paper highlights that substitution effects between two types of external credit represent an additional channel how firms adjust to trade liberalization and financial shocks. Models that link firm heterogeneity à la Melitz (2003) to capital market imperfections explain negative effects of credit frictions on international trade. However, previous work mainly focuses on partial equilibrium and considers only one type of external finance. The contribution of this paper is to combine firm heterogeneity à la Melitz (2003) with financial frictions and two sources of external funds. Based on Holmstrom and Tirole (1997), moral hazard reduces the pledgeability of firm profits and aggravates access to credit. Passive lenders provide cheaper unmonitored finance, whereas financial intermediaries with monitoring ability reduce moral hazard and facilitate access to credit, but charge a higher interest rate.

The model adds a new dimension to the existing theoretical literature on heterogeneous firms in international trade. Besides the selection into exporting, productivity determines access to external finance. Consistent with empirical evidence, the most productive and largest firms export and use unmonitored finance, whereas low productivity firms sell only domestically and have to rely on more expensive financial intermediation. In addition to ex-ante differences in productivity, selection into external finance introduces another source of firm heterogeneity. Larger producers that use unmonitored lending have a competitive advantage, compared to smaller producers that rely on intermediaries. The selection pattern of firms depends on trade costs, financial development and borrowing rates. This model shows that financial shocks and trade liberalization lead to heterogeneous firm responses, as well as new effects on the margins of international trade. Financial policies that aim to facilitate access to capital, change the relative costs for finance and thus lead to reallocations of market shares across producers with different source of external credit.

Besides that, the analysis highlights the importance of general equilibrium effects. The main idea is that financial shocks and trade liberalization induce firms to switch the type of finance, which influences price competition and thus aggregate responses in general equilibrium. In particular, stronger credit frictions lead to a larger share of producers that rely on more expensive financial intermediation and have to set higher prices. This selection effect reduces the competitive pressure in general equilibrium, forces less firms with low productivity to exit, but generates additional welfare losses. Furthermore, the model suggests a new source of gains from trade liberalization. Some exporters obtain access to cheaper unmonitored finance and reduce prices. Additionally, stronger exit of low productivity firms with high borrowing costs increases average productivity within an industry.

## 8 Mathematical Appendix

### 8.1 Maximization problem of firm

This section presents the maximization problem of a firm with export status  $l \in d, x$  and external finance  $j \in m, u$ , whereas  $1_{\{x^* > 0\}}$  takes a value of one if the firm is an exporter and is zero otherwise. Firms maximize profits (5) subject to the constraints (6)-(9) and the corresponding incentive compatibility condition (14) for  $j = u$  or (15) for  $j = m$ . First-order conditions for optimal prices at home  $p_{jl}$  and abroad  $p_{jx}^*$ , as well as investment  $e_{jl}$ , are:

$$XP^\sigma (\lambda + \mu_3) \left[ (1 - \sigma) p_{jl}^{-\sigma} + \frac{1}{\varphi e_{jl}} \sigma p_{jl}^{-\sigma-1} \right] = 0, \quad (\text{A1})$$

$$XP^\sigma (\lambda + \mu_3) \left[ (1 - \sigma) (p_{jx}^*)^{-\sigma} + \frac{\tau}{\varphi e_{jx}} \sigma (p_{jx}^*)^{-\sigma-1} \right] = 0, \quad (\text{A2})$$

$$\frac{\lambda + \mu_3}{\varphi e_{jl}^2} XP^\sigma \left( p_{jl}^{-\sigma} + 1_{\{x^* > 0\}} \tau (p_{jx}^*)^{-\sigma} \right) - \mu_1 e_{jl}^{\alpha-1} = 0. \quad (\text{A3})$$

Optimality conditions with respect to credit amount  $d_{jl}$  and loan repayment  $k_{jl}$  are:

$$\mu_1 - r_j \mu_2 = 0, \quad (\text{A4})$$

$$-\lambda + \lambda \mu_2 - \mu_3 = 0, \quad (\text{A5})$$

where  $\mu_1$ ,  $\mu_2$  and  $\mu_3$  are the Lagrange multipliers of the constraints (7), (8) and (14) or (15) respectively. Optimal price setting (11) follows immediately from equations (A1) and (A2). Rearranging condition (A3) leads to the optimal investment level  $e_{jl}$  as a function of prices:

$$e_{jl} = \left[ \frac{\lambda + \mu_3}{\varphi \mu_1} XP^\sigma \left( p_{jl}^{-\sigma} + 1_{\{x^* > 0\}} \tau (p_{jx}^*)^{-\sigma} \right) \right]^{\frac{1}{1+\alpha}}.$$

For unconstrained firms,  $\mu_3 = 0$  and hence it follows from equations (A4) and (A5) that  $\mu_1 = r_j > 1$  and  $\mu_2 = 1$ . If  $\mu_3 > 0$ , then  $\frac{\lambda + \mu_3}{\mu_1} = \frac{\lambda}{r_u}$ , such that optimal investment of constrained and unconstrained firms is expressed by equation (10). Profits (12) follow immediately from inserting investment (10) and prices (11) into the objective function (5) by taking into account constraints (7) and (8).

## 8.2 Regions of active firms in open economy

This section describes the regions of active firms for the two scenarios presented in section 3 of the main text. In both cases, the set of all active firms in equilibrium is characterized by:

$$D = \{\varphi \in [1, \infty] : \varphi \geq \varphi_{md}\}.$$

The regions of exporters using monitored and unmonitored finance are defined as:

$$D_{mx} = \{\varphi \in [1, \infty] : \varphi_{mx} \leq \varphi < \varphi_{ux}\},$$

$$D_{ux} = \{\varphi \in [1, \infty] : \varphi \geq \varphi_{ux}\}.$$

If case 1 occurs (see subsection 3.1), domestic firms select into two additional regions, depending on the type of external finance:

$$D_{md} = \{\varphi \in [1, \infty] : \varphi_{md} \leq \varphi < \varphi_{ud}\},$$

$$D_{ud} = \{\varphi \in [1, \infty] : \varphi_{ud} \leq \varphi < \varphi_{mx}\}.$$

If case 2 applies (see subsection 3.2), non-exporters have only access to monitored finance:

$$D_{md} = \{\varphi \in [1, \infty] : \varphi_{md} \leq \varphi < \varphi_{mx}\}.$$

## 8.3 Solution with Pareto distribution

As described in subsection 4.1, I assume that productivity  $\varphi$  is Pareto distributed to solve the model explicitly. Expected profits in equation (18) can be expressed as:

$$\begin{aligned} E\pi_k = & \lambda \psi_m f_d \left[ \gamma_{mdk} \left( \frac{\tilde{\varphi}_{mdk}}{\varphi_{mdk}} \right)^{\frac{\alpha(\sigma-1)}{\alpha-\sigma+1}} + \gamma_{udk} c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} \left( \frac{\tilde{\varphi}_{udk}}{\varphi_{mdk}} \right)^{\frac{\alpha(\sigma-1)}{\alpha-\sigma+1}} \right] \\ & + \lambda (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} \psi_m f_d \left[ \gamma_{mx} \left( \frac{\tilde{\varphi}_{mx}}{\varphi_{md}} \right)^{\frac{\alpha(\sigma-1)}{\alpha-\sigma+1}} + \gamma_{ux} c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} \left( \frac{\tilde{\varphi}_{ux}}{\varphi_{md}} \right)^{\frac{\alpha(\sigma-1)}{\alpha-\sigma+1}} \right] + \tilde{f}_k, \quad (\text{A6}) \end{aligned}$$

whereas the index  $k \in 1, 2$  denotes the selection case,  $\tilde{\varphi}_{jlk}$  is the average productivity among producers with source of finance  $j$  and export status  $l$ , and average fixed costs are given by:

$$\tilde{f}_k = (c_m \gamma_{mdk} + \gamma_{udk}) f_d + (c_m \gamma_{mx} + \gamma_{ux}) f_x.$$

For both selection cases, the components of exporters' expected profits in equation (A6) are:

$$\gamma_{ux} \left( \frac{\tilde{\varphi}_{ux}}{\varphi_{md}} \right)^{\frac{\alpha(\sigma-1)}{\alpha-\sigma+1}} = \frac{-\xi(\alpha - \sigma + 1)}{\alpha(\sigma - 1) - \xi(\alpha - \sigma + 1)} c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{\psi_u}{\psi_m} t \left( \frac{\varphi_{ux}}{\varphi_{md}} \right)^{-\xi},$$

$$\gamma_{mx} \left( \frac{\tilde{\varphi}_{mx}}{\varphi_{md}} \right)^{\frac{\alpha(\sigma-1)}{\alpha-\sigma+1}} = \frac{-\xi(\alpha-\sigma+1)}{\alpha(\sigma-1)-\xi(\alpha-\sigma+1)} t \left( \frac{\varphi_{mx}}{\varphi_{md}} \right)^{-\xi} \left[ 1 - c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{\psi_u}{\psi_m} \left( \frac{\varphi_{ud}}{\varphi_{md}} \right)^{-\xi} \right].$$

I assume that the Pareto shape parameter is sufficiently high:  $\xi > \frac{\alpha(\sigma-1)}{\alpha-\sigma+1}$  and hence  $\frac{-\xi(\alpha-\sigma+1)}{\alpha(\sigma-1)-\xi(\alpha-\sigma+1)} > 0$ . In selection case 1, the components for domestic firms are:

$$\gamma_{md} \left( \frac{\tilde{\varphi}_{md}}{\varphi_{md}} \right)^{\frac{\alpha(\sigma-1)}{\alpha-\sigma+1}} = \frac{-\xi(\alpha-\sigma+1)}{\alpha(\sigma-1)-\xi(\alpha-\sigma+1)} \left[ 1 - c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{\psi_u}{\psi_m} \left( \frac{\varphi_{ud}}{\varphi_{md}} \right)^{-\xi} \right],$$

$$\gamma_{ud} \left( \frac{\tilde{\varphi}_{ud}}{\varphi_{md}} \right)^{\frac{\alpha(\sigma-1)}{\alpha-\sigma+1}} = \frac{-\xi(\alpha-\sigma+1)}{\alpha(\sigma-1)-\xi(\alpha-\sigma+1)} \varphi_{md}^{\xi} \left[ c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{\psi_u}{\psi_m} \varphi_{ud}^{-\xi} - t \varphi_{mx}^{-\xi} \right],$$

and in case 2, when trade costs are relatively low:

$$\gamma_{md} \left( \frac{\tilde{\varphi}_{md}}{\varphi_{md}} \right)^{\frac{\alpha(\sigma-1)}{\alpha-\sigma+1}} = \frac{-\xi(\alpha-\sigma+1)}{\alpha(\sigma-1)-\xi(\alpha-\sigma+1)} \varphi_{md}^{\xi} \left( \varphi_{md}^{-\xi} - t \varphi_{mx}^{-\xi} \right).$$

The free entry condition (17) is an increasing function of the cutoff productivity level  $\varphi_{mdk}$ :

$$E\pi_k = \delta f_E \varphi_{mdk}^{\xi}.$$

Combining the free entry condition (17) and expected profits (18) leads to the following solution for the cutoff productivity  $\varphi_{mdk}$ :

$$\varphi_{mdk} = \left( \frac{1}{\delta f_E} \right)^{\frac{1}{\xi}} \left( \frac{\alpha-\sigma+1}{\alpha\sigma} \lambda \tilde{s}_k - r_u \tilde{f}_k \right)^{\frac{1}{\xi}}.$$

**Market shares.** Revenue-based market shares for exporters are defined as follows:

$$\eta_{mxk} = \frac{\gamma_{mx} \tilde{s}_{mxk}}{\tilde{s}_k} = \frac{f_x}{f_d} \left( \frac{\varphi_{md}}{\varphi_{mx}} \right)^{\xi} \frac{1 - c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{\psi_u}{\psi_m} \left( \frac{\varphi_{md}}{\varphi_{ud}} \right)^{\xi}}{\Gamma_k},$$

$$\eta_{uxk} = \frac{\gamma_{ux} \tilde{s}_{uxk}}{\tilde{s}_k} = \frac{1}{\Gamma_k} \frac{f_x}{f_d} \frac{\psi_u}{\psi_m} \left( \frac{\varphi_{md}}{\varphi_{ux}} \right)^{\xi}.$$

If trade costs are high (case 1), market shares for non-exporters can be expressed as:

$$\eta_{md1} = \frac{\gamma_{md1} \tilde{s}_{md1}}{\tilde{s}_1} = \frac{1 - c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{\psi_u}{\psi_m} \left( \frac{\varphi_{md}}{\varphi_{ud}} \right)^{\xi}}{\Gamma_1},$$

$$\eta_{ud1} = \frac{\gamma_{ud1} \tilde{s}_{ud1}}{\tilde{s}_1} = \frac{\frac{\psi_u}{\psi_m} \left( \frac{\varphi_{md}}{\varphi_{ud}} \right)^{\xi} - t c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} \left( \frac{\varphi_{md}}{\varphi_{mx}} \right)^{\xi}}{\Gamma_1},$$

and in case of low trade costs (selection pattern 2):

$$\eta_{md2} = \frac{\gamma_{md2} \tilde{s}_{md2}}{\tilde{s}_2} = \frac{1 - t \left( \frac{\varphi_{md}}{\varphi_{mx}} \right)^\xi}{\Gamma_2},$$

whereas the measures  $\Gamma_k$  and  $\Theta$  are defined in equations (27) and (28).

## 8.4 Proofs

**Proof of Condition 3.** The profitability condition for exporting with financial intermediation in Lemma 4 can be written as cutoff productivity:

$$\varphi \geq \left( \frac{\sigma}{\sigma - 1} \right)^{\frac{1+\alpha}{\alpha}} \left( \frac{r_u}{\lambda} \right)^{\frac{1}{\sigma-1}} \left( \frac{\alpha\sigma}{\alpha - \sigma + 1} \frac{c_m f_x - f_d}{(1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} - 1} \right)^{\frac{\alpha-\sigma+1}{\alpha(\sigma-1)}} A_d^{\frac{-1}{\sigma-1}}. \quad (A7)$$

Comparing profitability condition (A7) with the cutoff productivity  $\varphi_{mx}$  in equation (16):

$$\varphi_{mx} = \left( \frac{\sigma}{\sigma - 1} \right)^{\frac{1+\alpha}{\alpha}} \left( \frac{r_m}{\lambda} \right)^{\frac{1}{\alpha}} \left( \frac{\alpha\sigma\psi_m f_x}{\alpha - \sigma + 1} \right)^{\frac{\alpha-\sigma+1}{\alpha(\sigma-1)}} A_x^{\frac{-1}{\sigma-1}}, \quad (A8)$$

immediately leads to Condition 3. ■

**Proof of Proposition 3.** (i) A higher private benefit increases the relative cost for unmonitored finance:

$$\frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial b} = \frac{r_u}{\lambda \Delta \lambda} \frac{c_m - m}{\psi_m^2} > 0 \text{ as } c_m > 1 > m.$$

For both selection cases, differentiating equation (21) with respect to  $b$  yields:

$$\frac{\partial \gamma_{mx}}{\partial b} = \frac{\xi(\alpha - \sigma + 1)}{\alpha(\sigma - 1)} \left( \frac{\varphi_{md}}{\varphi_{ux}} \right)^\xi \frac{\psi_m}{\psi_u} \frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial b} > 0; \quad \frac{\partial \gamma_{ux}}{\partial b} = -\frac{\partial \gamma_{mx}}{\partial b} < 0 \text{ as } \frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial b} > 0.$$

For domestic firms, substitution effects are:  $\frac{\partial \gamma_{md}}{\partial b} = \left( \frac{\varphi_{mx}}{\varphi_{md}} \right)^\xi \frac{\partial \gamma_{mx}}{\partial b} > \frac{\partial \gamma_{mx}}{\partial b}$  in selection case 1, and  $\frac{\partial \gamma_{md}}{\partial b} = 0$  in selection case 2. (ii) A lower monitoring effectiveness (an increase in  $m$ ) and higher borrowing costs  $r_u$  reduce the relative access barrier to unmonitored finance:

$$\frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial m} = -\frac{\psi_u}{\psi_m^2} \frac{b}{\Delta \lambda} < 0; \quad \frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial r_u} = \frac{b}{\lambda \Delta \lambda} \frac{m - c_m}{\psi_m^2} < 0 \text{ as } c_m > 1 > m.$$

For both selection cases, the shares of exporters (21) react as follows:

$$\frac{\partial \gamma_{mx}}{\partial m} = \frac{\xi(\alpha - \sigma + 1)}{\alpha(\sigma - 1)} \left( \frac{\varphi_{md}}{\varphi_{ux}} \right)^\xi \frac{\psi_m}{\psi_u} \frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial m} < 0; \quad \frac{\partial \gamma_{ux}}{\partial m} = -\frac{\partial \gamma_{mx}}{\partial m} > 0 \text{ as } \frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial m} < 0;$$



$$\frac{\partial \gamma_{mx}}{\partial r_u} = \frac{\xi(\alpha - \sigma + 1)}{\alpha(\sigma - 1)} \left( \frac{\varphi_{md}}{\varphi_{ux}} \right)^\xi \frac{\psi_m}{\psi_u} \frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial r_u} < 0; \quad \frac{\partial \gamma_{ux}}{\partial r_u} = -\frac{\partial \gamma_{mx}}{\partial r_u} > 0 \text{ as } \frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial r_u} < 0.$$

In selection case 1, changes in shares of domestic sellers are given by:

$$\frac{\partial \gamma_{md}}{\partial m} = \left( \frac{\varphi_{mx}}{\varphi_{md}} \right)^\xi \frac{\partial \gamma_{mx}}{\partial m} < 0; \quad \frac{\partial \gamma_{md}}{\partial r_u} = \left( \frac{\varphi_{mx}}{\varphi_{md}} \right)^\xi \frac{\partial \gamma_{mx}}{\partial r_u} < 0,$$

whereas in selection case 2, there are no substitution effects among non-exporters:

$$\frac{\partial \gamma_{md}}{\partial m} = \frac{\partial \gamma_{md}}{\partial r_u} = 0,$$

For selection case 1, changes in  $b$ ,  $m$  and  $r_u$  lead to reallocations of market shares according to the following derivatives:

$$\begin{aligned} \frac{\partial \eta_{md}}{\partial b} &= \frac{\frac{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)}{\alpha(\sigma - 1)} c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \left( \frac{\varphi_{md}}{\varphi_{ud}} \right)^\xi \frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial b} - \eta_{md} \frac{\partial \Gamma_1}{\partial b}}{\Gamma_1} > 0, \\ \frac{\partial \eta_{mx}}{\partial b} &= \frac{\frac{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)}{\alpha(\sigma - 1)} c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{f_x}{f_d} \left( \frac{\varphi_{md}}{\varphi_{ux}} \right)^\xi \frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial b} - \eta_{mx} \frac{\partial \Gamma_1}{\partial b}}{\Gamma_1} > 0, \\ \frac{\partial \eta_{md}}{\partial r_u} &= \frac{\frac{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)}{\alpha(\sigma - 1)} c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \left( \frac{\varphi_{md}}{\varphi_{ud}} \right)^\xi \frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial r_u} - \eta_{md} \frac{\partial \Gamma_1}{\partial r_u}}{\Gamma_1} < 0, \\ \frac{\partial \eta_{mx}}{\partial r_u} &= \frac{\frac{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)}{\alpha(\sigma - 1)} c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{f_x}{f_d} \left( \frac{\varphi_{md}}{\varphi_{ux}} \right)^\xi \frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial r_u} - \eta_{mx} \frac{\partial \Gamma_1}{\partial r_u}}{\Gamma_1} < 0, \\ \frac{\partial \eta_{md}}{\partial m} &= \frac{\frac{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)}{\alpha(\sigma - 1)} c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \left( \frac{\varphi_{md}}{\varphi_{ud}} \right)^\xi \frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial m} - \eta_{md} \frac{\partial \Gamma_1}{\partial m}}{\Gamma_1} < 0, \\ \frac{\partial \eta_{mx}}{\partial m} &= \frac{\frac{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)}{\alpha(\sigma - 1)} c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{f_x}{f_d} \left( \frac{\varphi_{md}}{\varphi_{ux}} \right)^\xi \frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial m} - \eta_{mx} \frac{\partial \Gamma_1}{\partial m}}{\Gamma_1} < 0, \end{aligned}$$

whereas  $\frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial b} > 0$ ,  $\frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial r_u}$ ,  $\frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial m} < 0$  and  $\frac{\partial \Gamma_1}{\partial b} < 0$ ,  $\frac{\partial \Gamma_1}{\partial r_u}$ ,  $\frac{\partial \Gamma_1}{\partial m} > 0$ . Analogous reactions of market shares can be derived for selection case 2. ■

**Proof of Proposition 4.** The derivative (29) follows immediately from equation (25) by taking into account equation (26). Substitution effects subject to a change in the private benefit  $b$ , as stated in equation (29), are given by:

$$\frac{\partial \Gamma_1}{\partial b} = \frac{\partial \Theta}{\partial b} \left[ 1 + \left( \frac{\varphi_{md}}{\varphi_{mx}} \right)^\xi \frac{f_x}{f_d} \right] < 0; \quad \frac{\partial \Gamma_2}{\partial b} = \frac{\partial \Theta}{\partial b} \left( \frac{\varphi_{md}}{\varphi_{mx}} \right)^\xi \frac{f_x}{f_d} < 0,$$

whereas

$$\frac{\partial \Theta}{\partial b} = -\frac{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)}{\alpha(\sigma - 1)} \left(1 - c_m^{\frac{1-\sigma}{\alpha-\sigma+1}}\right) \left(\frac{\varphi_{md}}{\varphi_{ud}}\right)^\xi \frac{\partial\left(\frac{\psi_u}{\psi_m}\right)}{\partial b} < 0 \text{ as } \frac{\partial\left(\frac{\psi_u}{\psi_m}\right)}{\partial b} > 0.$$

The overall effect of an increase in  $b$  on the number of firms is negative as long as  $-\frac{mb}{\Delta\lambda\psi_m} - \frac{\partial\Gamma_k}{\partial b} \frac{b}{\Gamma_k} < 0$ , which leads to the following conditions in selection case 1:

$$\psi_u > \frac{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)}{\alpha(\sigma - 1)} \left(1 - c_m^{\frac{1-\sigma}{\alpha-\sigma+1}}\right) \frac{r_u}{\lambda} \frac{c_m - m}{m} \left(\frac{f_d}{f_x} + \gamma_x\right) \eta_{ux1},$$

and in selection case 2:

$$\psi_u > \frac{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)}{\alpha(\sigma - 1)} \left(1 - c_m^{\frac{1-\sigma}{\alpha-\sigma+1}}\right) \frac{r_u}{\lambda} \frac{c_m - m}{m} \eta_{ux2}.$$

Both conditions impose minimum requirements on the private benefit  $b$ , since the left-hand-side ( $\psi_u$ ) increases in  $b$ , whereas the market shares  $\eta_{uxk}$  decrease in  $b$ . The productivity effect in equation (31) is given by:

$$\frac{\partial\varphi_{mdk}}{\partial b} \frac{b}{\varphi_{mdk}} = -\frac{1}{\xi E\pi_k} \left( \frac{\alpha - \sigma + 1}{\alpha\sigma} \lambda \tilde{s}_k \frac{\partial M_k}{\partial b} \frac{b}{M_k} + b r_u \frac{\partial \tilde{f}_k}{\partial b} \right), \quad (\text{A10})$$

whereas average fixed costs increase in the private benefit  $b$ :  $\frac{\partial \tilde{f}_k}{\partial b} > 0$ . Inserting derivatives (A10) and (29) into equation (31), and rearranging leads to:

$$\frac{\partial W_k}{\partial b} \frac{b}{W_k} = -\frac{\alpha - \sigma + 1}{\alpha\sigma\xi E\pi_k} \left[ \left( \frac{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)}{\alpha(\sigma - 1)} \frac{mb}{\Delta\lambda\psi_m} - \frac{\partial\Gamma_k}{\partial b} \frac{b}{\Gamma_k} \right) \lambda \tilde{s}_k \right. \\ \left. + r_u \tilde{f}_k \left( \frac{\sigma\xi}{\sigma-1} \frac{mb}{\Delta\lambda\psi_m} + \frac{\alpha\sigma}{\alpha-\sigma+1} \frac{\partial \tilde{f}_k}{\partial b} \frac{b}{\tilde{f}_k} \right) \right], \quad (\text{A11})$$

whereby the definition of average profits is exploited:  $E\pi_k = \lambda \tilde{s}_k \frac{\alpha-\sigma+1}{\alpha\sigma} - r_u \tilde{f}_k$ . Substitution effects decrease average productivity ( $\frac{\partial\Gamma_k}{\partial b} < 0$ ) and increase average fixed costs ( $\frac{\partial \tilde{f}_k}{\partial b} > 0$ ), and thus, clearly amplify welfare losses of credit tightening. From the derivative (A11) follows that a sufficient condition for a negative welfare effect is given by:  $\psi_m > \frac{r_u}{\lambda f_d} \frac{\tilde{f}_k}{\Gamma_k}$ . ■ A change in monitoring effectiveness  $m$  and an increase in borrowing costs  $r_u$  both lead to a clearly negative reaction along the extensive margin:

$$\frac{\partial M}{\partial m} \frac{m}{M} = -\frac{bm}{\Delta\lambda\psi_m} - \frac{\partial\Gamma_k}{\partial m} \frac{m}{\Gamma_k} < 0, \quad \frac{\partial M_k}{\partial r_u} \frac{r_u}{M_k} = -\frac{r_m}{\lambda\psi_m} - \frac{\partial\Gamma_k}{\partial r_u} \frac{r_u}{\Gamma_k} < 0. \quad (\text{A9})$$

as selection effects aggravate firm exit:  $\frac{\partial\Gamma_k}{\partial m}, \frac{\partial\Gamma_k}{\partial r_u} > 0$ . Comparable to equation (31), the effect of a change in monitoring effectiveness  $m$  on welfare can be written as follows:

$$\frac{\partial W}{\partial m} \frac{m}{W} = -\frac{\alpha - \sigma + 1}{(\sigma - 1)\alpha} \frac{mb}{\Delta\lambda\psi_m} + \frac{\partial\varphi_{md}}{\partial m} \frac{m}{\varphi_{md}}. \quad (\text{A12})$$

Analogous to the derivation for a change in the private benefit  $b$ , the welfare response is neg-

ative if the access barrier to monitored finance is sufficiently high, as the following conditions show for selection case 1:

$$\psi_m > \frac{r_u}{\lambda f_d} \frac{f_d c_m + \gamma_x (f_x c_m - f_d)}{1 + \gamma_x t \left[ (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} - c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} \right]},$$

as well as for selection case 2:

$$\psi_m > \frac{r_u}{\lambda f_d} \frac{f_d c_m + \gamma_x (f_x - f_d c_m)}{1 + \gamma_x t \left[ (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} - 1 \right]}.$$

**Proof of Proposition 5.** The effect of the interest rate  $r_u$  on cutoff productivity  $\varphi_{mdk}$  in equation (32) is given by:

$$\frac{\partial \varphi_{mdk}}{\partial r_u} \frac{r_u}{\varphi_{mdk}} = \frac{1}{\xi E \pi_k} \left( -\frac{\alpha - \sigma + 1}{\alpha \sigma} \lambda \tilde{s}_k \frac{\partial M_k}{\partial r_u} \frac{r_u}{M_k} - r_u \tilde{f}_k - r_u^2 \frac{\partial \tilde{f}_k}{\partial r_u} \right), \quad (\text{A13})$$

whereas the reaction along the extensive margin is given in equation (A9). Substitution into unmonitored finance increases within-industry productivity:

$$\frac{\partial \Gamma_1}{\partial r_u} = \frac{\partial \Theta}{\partial r_u} \left[ 1 + \left( \frac{\varphi_{md}}{\varphi_{mx}} \right)^\xi \frac{f_x}{f_d} \right] > 0; \quad \frac{\partial \Gamma_2}{\partial r_u} = \frac{\partial \Theta}{\partial r_u} \left( \frac{\varphi_{md}}{\varphi_{mx}} \right)^\xi \frac{f_x}{f_d} > 0,$$

whereas for both selection cases it holds that:

$$\frac{\partial \Theta}{\partial r_u} = -\frac{\xi (\alpha - \sigma + 1) - \alpha (\sigma - 1)}{\alpha (\sigma - 1)} \left( 1 - c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \right) \left( \frac{\varphi_{md}}{\varphi_{ud}} \right)^\xi \frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial r_u} > 0,$$

as the relative access barrier to unmonitored finance decreases in  $r_u$ :  $\frac{\partial \left( \frac{\psi_u}{\psi_m} \right)}{\partial r_u} < 0$ . The effect on the extensive margin in equation (32) is negative if:

$$\left[ \frac{\xi (\alpha - \sigma + 1) - (\sigma - 1) \alpha}{(\sigma - 1) \alpha} \frac{c_m}{\lambda \psi_m} \Gamma_k - \frac{\partial \Gamma_k}{\partial r_u} \right] \frac{\xi (\alpha - \sigma + 1) \lambda \psi_m f_d}{\xi (\alpha - \sigma + 1) - \alpha (\sigma - 1)} > \tilde{f}_k \left[ \frac{\xi (\alpha - \sigma + 1) r_m - (\sigma - 1) \alpha \lambda \psi_m}{(\sigma - 1) \alpha \lambda \psi_m} - \frac{\partial \tilde{f}_k}{\partial r_u} \frac{r_u}{\tilde{f}_k} \right],$$

whereas  $\frac{\partial \tilde{f}_1}{\partial r_u} < 0$ . It can be easily shown that the left-hand side of this condition increases in  $m$ , whereas the right-hand side decreases in  $m$ . Hence, the reaction along the extensive margin is clearly negative as long as the monitoring effectiveness of financial intermediation is sufficiently low. ■

**Proof of Proposition 6.** Depending on the selection case  $k \in 1, 2$ , equation (33) can be rewritten by using the expression for average revenues  $\tilde{s}_k$  in equation (26). If there is only one type of finance,  $\Theta = 1$  and  $\Gamma = 1 + \left( \frac{\varphi_{md}}{\varphi_{mx}} \right)^\xi \left( \frac{f_x}{f_d} - t \right)$ , see subsection 4.1. Exploiting this,

product variety is larger ( $\frac{M_k}{M_0} > 1$ ) if the following condition holds for selection case 1:

$$\frac{\psi_u}{\psi_m} > \frac{\Theta \left[ 1 + (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} t\gamma_x \right] - c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} t\gamma_x}{1 + t\gamma_x \left[ (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} - 1 \right]}.$$

A similar condition ensures variety gains in selection case 2:

$$\frac{\psi_u}{\psi_m} > \frac{1 + t\gamma_x \left[ (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} \Theta - 1 \right]}{1 + t\gamma_x \left[ (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} - 1 \right]}.$$

Note that for both cases, the left-hand side of the condition increases in  $b$  and decreases in  $m$ , whereas the opposite holds for the right-hand side. Hence, the conditions are satisfied whenever the extent of credit frictions, as well as monitoring effectiveness of financial intermediation, is sufficiently high. ■

**Proof of Proposition 7.** The market share of exporters is given by:

$$\eta_{xk} = \frac{(1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} t\gamma_x}{\Gamma_k}. \quad (\text{A14})$$

Taking the derivative of equation (A14) with respect to fixed trade costs leads to:

$$\frac{\partial \eta_{xk}}{\partial f_x} \frac{f_x}{\eta_{xk}} = \frac{\alpha(\sigma-1) - \xi(\alpha-\sigma+1)}{\alpha(\sigma-1)} \frac{\partial t}{\partial f_x} \frac{f_x}{t} - \frac{\partial \Gamma_k}{\partial f_x} \frac{f_x}{\Gamma_k},$$

whereas  $\frac{\partial t}{\partial f_x} = \frac{(1+\tau^{1-\sigma})^{\frac{-\alpha}{\alpha-\sigma+1}}}{f_d} > 0$  and the effects of trade costs on the measures of average productivity in the economy are given by:

$$\frac{\partial \Gamma_1}{\partial f_x} = \gamma_x \left[ \Theta (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} - c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} \right] \frac{\alpha(\sigma-1) - \xi(\alpha-\sigma+1)}{\alpha(\sigma-1)} \frac{\partial t}{\partial f_x} < 0, \quad (\text{A15})$$

$$\frac{\partial \Gamma_2}{\partial f_x} = \gamma_x \left[ (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} \Theta - 1 \right] \frac{\alpha(\sigma-1) - \xi(\alpha-\sigma+1)}{\alpha(\sigma-1)} \frac{\partial t}{\partial f_x} < 0. \quad (\text{A16})$$

Inserting these expressions into the derivative of equation (A14) and simplifying leads to equations (35) and (36). For both selection cases, the reaction of market shares decreases in  $\Theta$ , and thus increases in the monitoring effectiveness of financial intermediation as  $\frac{\partial \Theta}{\partial m} > 0$ . Reactions of the extensive margin to trade costs follow immediately from the derivation of equation (25). Exit of firms is stronger if financial intermediation is less effective as:

$$\frac{\partial \left( \frac{\partial M_1}{\partial f_x} \frac{f_x}{M_1} \right)}{\partial \Theta} = \frac{\xi(\alpha-\sigma+1) - \alpha(\sigma-1)}{\alpha(\sigma-1)} \frac{t\gamma_x c_m^{\frac{\sigma-1}{\alpha-\sigma+1}}}{\Gamma_1^2} > 0,$$

$$\frac{\partial \left( \frac{\partial M_2}{\partial f_x} \frac{f_x}{M_2} \right)}{\partial \Theta} = \frac{\xi(\alpha-\sigma+1) - \alpha(\sigma-1)}{\alpha(\sigma-1)} \frac{t\gamma_x (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}}}{\Gamma_2^2} > 0.$$

The effects of fixed export costs  $f_x$  on average fixed costs for the two selection cases are:

$$\frac{\partial \tilde{f}_1}{\partial f_x} = \frac{[\alpha(\sigma - 1) - \xi(\alpha - \sigma + 1)](\gamma_{mx}c_m + \gamma_{ux}) + \xi(\alpha - \sigma + 1)\frac{f_d}{f_x}\gamma_x}{\alpha(\sigma - 1)}, \quad (\text{A17})$$

$$\frac{\partial \tilde{f}_2}{\partial f_x} = \frac{[\alpha(\sigma - 1) - \xi(\alpha - \sigma + 1)](\gamma_{mx}c_m + \gamma_{ux}) + \xi(\alpha - \sigma + 1)\frac{f_d}{f_x}c_m\gamma_x}{\alpha(\sigma - 1)}. \quad (\text{A18})$$

The welfare response in equation (39) is negative if the following condition holds:

$$-\frac{\xi(\alpha - \sigma + 1)\lambda\psi_m f_d}{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)} \frac{\partial \Gamma_k}{\partial f_x} > -r_u \frac{\partial \tilde{f}_k}{\partial f_x}.$$

Exploiting equations (A15) and (A16), as well as the reactions of average fixed costs (A17) and (A18), leads to the following conditions for selection case 1:

$$\psi_m > \frac{r_u}{\lambda} \frac{[\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)](\gamma_{mx}c_m + \gamma_{ux}) - \xi(\alpha - \sigma + 1)\frac{f_d}{f_x}\gamma_x}{\xi(\alpha - \sigma + 1)\gamma_x \left( \Theta - c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} (1 + \tau^{1-\sigma})^{\frac{-\alpha}{\alpha-\sigma+1}} \right)},$$

and correspondingly for selection case 2:

$$\psi_m > \frac{r_u}{\lambda} \frac{[\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)](\gamma_{mx}c_m + \gamma_{ux}) - \xi(\alpha - \sigma + 1)\frac{f_d}{f_x}c_m\gamma_x}{\xi(\alpha - \sigma + 1)\gamma_x \left( \Theta - (1 + \tau^{1-\sigma})^{\frac{-\alpha}{\alpha-\sigma+1}} \right)}.$$

Note that  $\frac{\partial \psi_m}{\partial m}, \frac{\partial \Theta}{\partial m} > 0$  and  $\frac{\partial(\gamma_{mx}c_m + \gamma_{ux})}{\partial m} < 0$ . Hence, the conditions are satisfied whenever the monitoring effectiveness is sufficiently low. ■

**Proof of Proposition 8.** By exploiting the properties of the model with a Pareto distributed productivity, as presented in Appendix 8.3, the borrowing rate in equation (42) can be rewritten as follows for selection case 1:

$$r_{u1} = \frac{L}{c_m K} \frac{\sigma - 1}{\sigma(\alpha - 1) + 1} \frac{\left(1 + \frac{f_x \gamma_x}{f_d}\right) \left[1 + c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{\psi_u}{\psi_m} \frac{\gamma_{ux}}{\gamma_x} \left(c_m^{\frac{\alpha}{\alpha-\sigma+1}} - 1\right)\right] - c_m^{\frac{\alpha}{\alpha-\sigma+1}} t \gamma_x}{\left(1 + \frac{f_x \gamma_x}{f_d}\right) \left[1 + c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{\psi_u}{\psi_m} \frac{\gamma_{ux}}{\gamma_x} \left(c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} - 1\right)\right] - c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} t \gamma_x}, \quad (\text{A19})$$

and in selection case 2:

$$r_{u2} = \frac{L}{c_m K} \frac{\sigma - 1}{\sigma(\alpha - 1) + 1} \frac{1 + \frac{f_x \gamma_x}{f_d} \left[1 + c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{\psi_u}{\psi_m} \frac{\gamma_{ux}}{\gamma_x} \left(c_m^{\frac{\alpha}{\alpha-\sigma+1}} - 1\right)\right] - t \gamma_x}{1 + \frac{f_x \gamma_x}{f_d} \left[1 + c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{\psi_u}{\psi_m} \frac{\gamma_{ux}}{\gamma_x} \left(c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} - 1\right)\right] - t \gamma_x}. \quad (\text{A20})$$

Taking the derivatives of equations (A19) and (A20) with respect to  $b$  leads to:

$$\frac{\partial r_{u1}}{\partial b} = \frac{(c_m - 1)L}{c_m K} \frac{\sigma - 1}{\sigma(\alpha - 1) + 1} \frac{\left(1 + \frac{f_x \gamma_x}{f_d}\right) \frac{\partial\left(\frac{\psi_u}{\psi_m} \frac{\gamma_{ux}}{\gamma_x}\right)}{\partial b} \left(1 - t\gamma_x + \frac{f_x \gamma_x}{f_d}\right)}{\left[\left(1 + \frac{f_x \gamma_x}{f_d}\right) \left[1 + c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{\psi_u}{\psi_m} \frac{\gamma_{ux}}{\gamma_x} \left(c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} - 1\right)\right] - c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} t\gamma_x\right]^2} < 0,$$

$$\frac{\partial r_{u2}}{\partial b} = \frac{(c_m - 1)L}{c_m K} \frac{\sigma - 1}{\sigma(\alpha - 1) + 1} \frac{\frac{f_x \gamma_x}{f_d} \frac{\partial\left(\frac{\psi_u}{\psi_m} \frac{\gamma_{ux}}{\gamma_x}\right)}{\partial b} \left(1 - t\gamma_x + \frac{f_x \gamma_x}{f_d}\right)}{\left[1 + \frac{f_x \gamma_x}{f_d} \left[1 + c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{\psi_u}{\psi_m} \frac{\gamma_{ux}}{\gamma_x} \left(c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} - 1\right)\right] - t\gamma_x\right]^2} < 0,$$

whereas  $\frac{\partial\left(\frac{\psi_u}{\psi_m} \frac{\gamma_{ux}}{\gamma_x}\right)}{\partial b} < 0$  and  $1 - t\gamma_x > 0$ . Taking the derivative with respect to fixed trade costs  $f_x$  and simplifying yields:

$$\frac{\partial r_{u1}}{\partial f_x} = \frac{(c_m - 1)L}{c_m K} \frac{\sigma - 1}{\sigma(\alpha - 1) + 1} \frac{c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} \left(\frac{\psi_u}{\psi_m} \frac{\gamma_{ux}}{\gamma_x} c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} - 1\right) \left[\left(1 + \frac{f_x \gamma_x}{f_d}\right) \frac{\partial(t\gamma_x)}{\partial f_x} - t\gamma_x \frac{\partial\left(\frac{f_x \gamma_x}{f_d}\right)}{\partial f_x}\right]}{\left[\left(1 + \frac{f_x \gamma_x}{f_d}\right) \left[1 + c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{\psi_u}{\psi_m} \frac{\gamma_{ux}}{\gamma_x} \left(c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} - 1\right)\right] - c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} t\gamma_x\right]^2} < 0,$$

$$\frac{\partial r_{u2}}{\partial f_x} = \frac{(c_m - 1)L}{c_m K} \frac{\sigma - 1}{\sigma(\alpha - 1) + 1} \frac{\psi_u}{\psi_m} \frac{\gamma_{ux}}{\gamma_x} \frac{\frac{\partial(t\gamma_x)}{\partial f_x} \frac{f_x \gamma_x}{f_d} + (1 - t\gamma_x) \frac{\partial\left(\frac{f_x \gamma_x}{f_d}\right)}{\partial f_x}}{\left[1 + \frac{f_x \gamma_x}{f_d} \left[1 + c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} \frac{\psi_u}{\psi_m} \frac{\gamma_{ux}}{\gamma_x} \left(c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} - 1\right)\right] - t\gamma_x\right]^2} < 0,$$

whereas  $\left(1 + \frac{f_x \gamma_x}{f_d}\right) \frac{\partial(t\gamma_x)}{\partial f_x} - t\gamma_x \frac{\partial\left(\frac{f_x \gamma_x}{f_d}\right)}{\partial f_x} < 0$  and  $\frac{\psi_u}{\psi_m} \frac{\gamma_{ux}}{\gamma_x} c_m^{\frac{1-\sigma}{\alpha-\sigma+1}} > 1$  due to Condition 1. The changes with respect to variable trade costs  $\tau$  can be derived analogously. ■

## 8.5 Effects of change in variable trade costs

This section presents comparative static results for a change in variable trade costs  $\tau$  (compare section 5 on fixed trade costs in the main text). Market shares of exporters decrease in iceberg-trade costs  $\tau$ :

$$\frac{\partial \eta_{x1}}{\partial \tau} \frac{\tau}{\eta_{x1}} = -\frac{\tau^{1-\sigma}}{1 + \tau^{1-\sigma}} \frac{\xi}{\Gamma_1} \left[ \Theta \left(1 - c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} t\gamma_x\right) + t\gamma_x c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} \frac{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)}{\xi(\alpha - \sigma + 1)} \right] < 0,$$

$$\frac{\partial \eta_{x2}}{\partial \tau} \frac{\tau}{\eta_{x2}} = -\frac{\tau^{1-\sigma}}{1 + \tau^{1-\sigma}} \frac{\xi}{\Gamma_2} \left[ 1 - t\gamma_x \frac{\alpha(\sigma - 1)}{\xi(\alpha - \sigma + 1)} \right] < 0.$$

The reaction along the extensive margin is given by:

$$\frac{\partial M_1}{\partial \tau} \frac{\tau}{M_1} = \frac{\tau^{1-\sigma}}{1 + \tau^{1-\sigma}} \frac{t\gamma_x}{\Gamma_1} \frac{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)}{\alpha - \sigma + 1} \left[ \frac{\xi \Theta(\alpha - \sigma + 1) (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}}}{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)} - c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} \right] > 0,$$

$$\frac{\partial M_2}{\partial \tau} \frac{\tau}{M_2} = \frac{\tau^{1-\sigma}}{1 + \tau^{1-\sigma}} \frac{t\gamma_x}{\Gamma_2} \frac{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)}{\alpha - \sigma + 1} \left[ \frac{\xi \Theta(\alpha - \sigma + 1) (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}}}{\xi(\alpha - \sigma + 1) - \alpha(\sigma - 1)} - 1 \right] > 0.$$

The effect of  $\tau$  on welfare can be derived as follows:

$$\frac{\partial W}{\partial \tau} \frac{\tau}{W} = -\frac{1}{\xi E \pi_k} \left[ \frac{(\alpha - \sigma + 1) \lambda \tilde{s}_k}{\alpha \sigma} \frac{\partial M_k}{\partial \tau} \frac{\tau}{M_k} + \tau r_u \frac{\partial \tilde{f}_k}{\partial \tau} \right],$$

whereas the effects on average fixed costs are:

$$\frac{\partial \tilde{f}_1}{\partial \tau} = -\frac{\xi \tau^{-\sigma} [\gamma_{mx} (f_x c_m - f_d) + \gamma_{ux} (f_x - f_d)]}{1 + \tau^{1-\sigma}} < 0,$$

$$\frac{\partial \tilde{f}_2}{\partial \tau} = -\frac{\xi \tau^{-\sigma} [\gamma_{mx} c_m (f_x - f_d) + \gamma_{ux} (f_x - f_d c_m)]}{1 + \tau^{1-\sigma}} < 0.$$

Analogous to a change in fixed export costs  $f_x$  (compare Proposition 7), the welfare response is negative ( $\frac{\partial W}{\partial \tau} \frac{\tau}{W} < 0$ ) as long as the access barrier to monitored finance is sufficiently high in selection case 1:

$$\psi_m > \frac{r_u [(\gamma_{mx} c_m + \gamma_{ux}) f_x - \gamma_x f_d] [\xi (\alpha - \sigma + 1) - \alpha (\sigma - 1)]}{\lambda f_d t \gamma_x \left[ \xi (\alpha - \sigma + 1) \left( \Theta (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} - c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} \right) + c_m^{\frac{\sigma-1}{\alpha-\sigma+1}} \alpha (\sigma - 1) \right]},$$

and in selection case 2:

$$\psi_m > \frac{r_u [(\gamma_{mx} c_m + \gamma_{ux}) f_x - c_m f_d \gamma_x] [\xi (\alpha - \sigma + 1) - \alpha (\sigma - 1)]}{\lambda f_d t \gamma_x \left[ \xi (\alpha - \sigma + 1) \left( \Theta (1 + \tau^{1-\sigma})^{\frac{\alpha}{\alpha-\sigma+1}} - 1 \right) + \alpha (\sigma - 1) \right]}.$$

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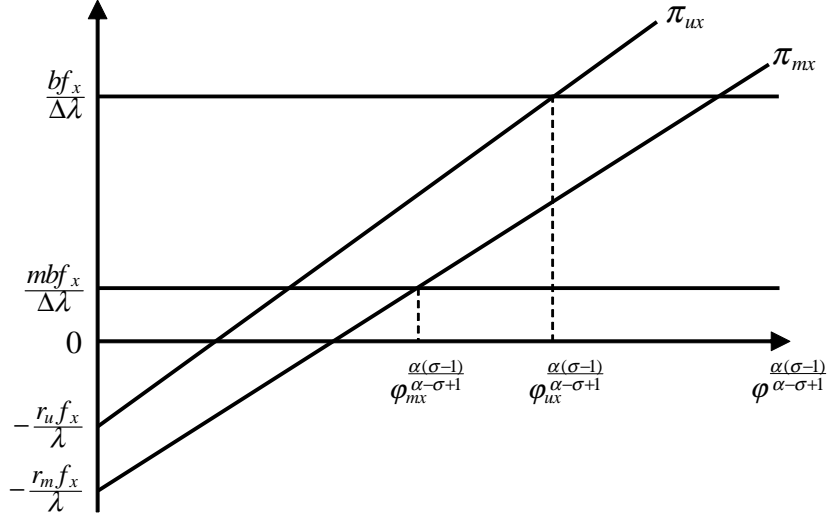


Figure 1: Selection of exporters into external finance

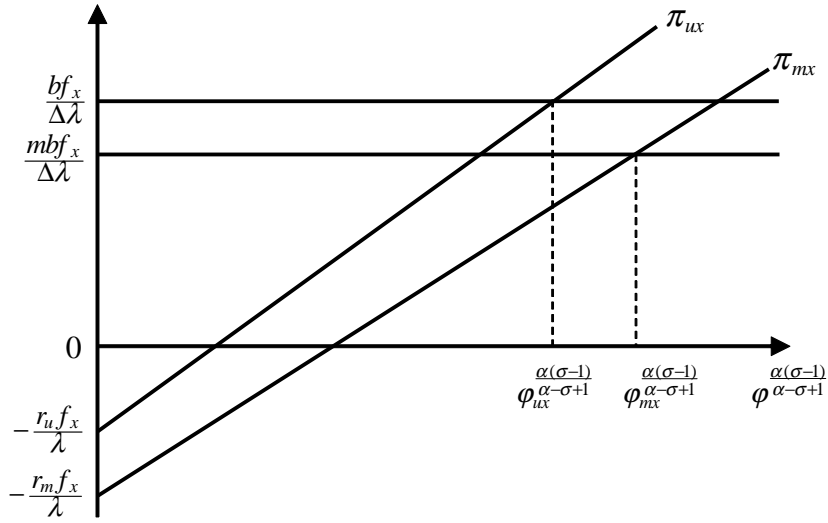


Figure 2: Selection pattern with low monitoring effectiveness

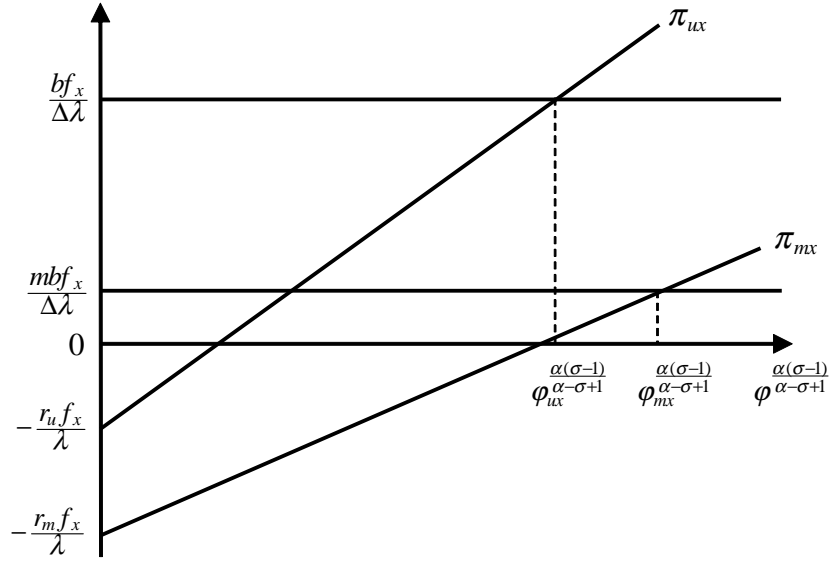


Figure 3: Selection pattern with high monitoring costs

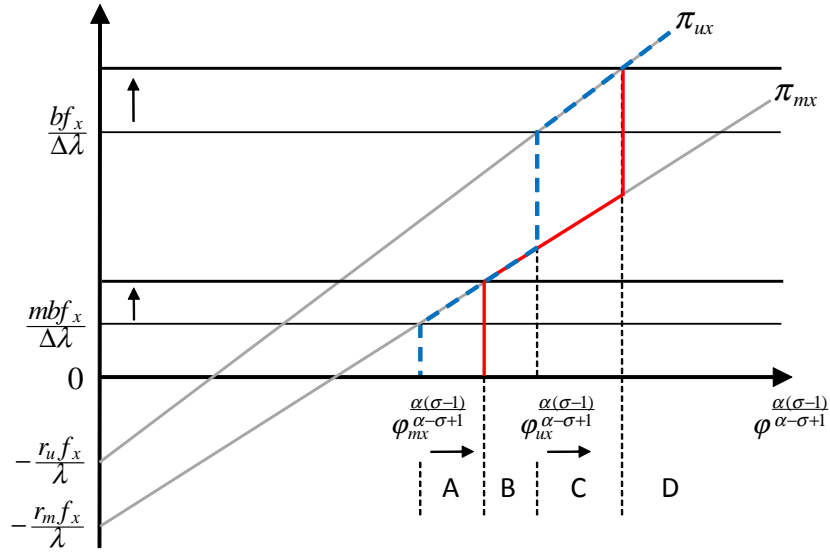


Figure 4: Increase in private benefit  $b$

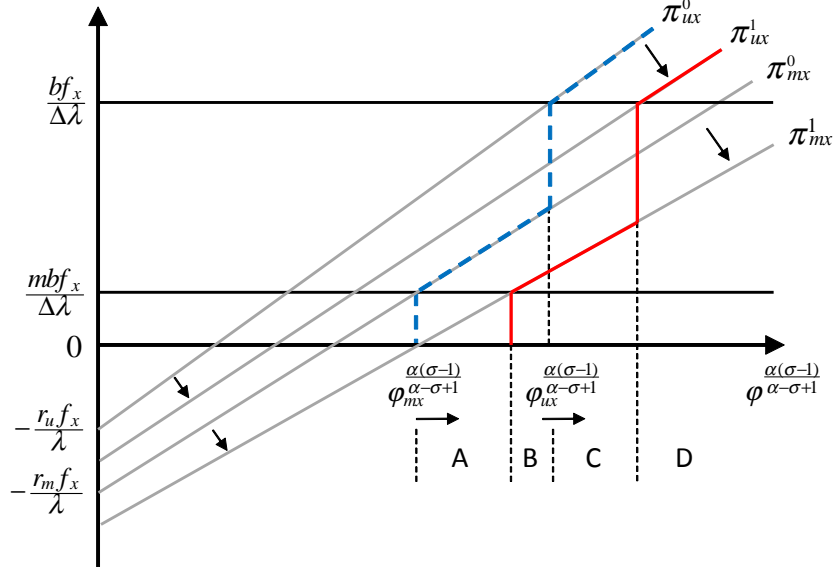
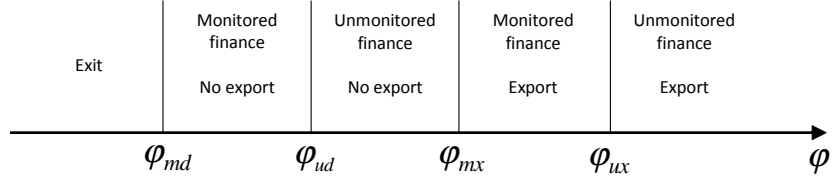
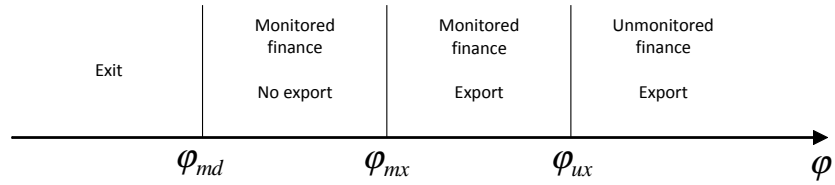


Figure 5: Increase in unmonitored interest rate  $r_u$



Case 1: High trade costs



Case 2: Low trade costs

Figure 6: Selection into external finance and exporting