Credit frictions, selection into external finance, and gains from trade*

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Abstract

This paper analyzes the effects of credit frictions in a trade model where heterogeneous firms select both into exporting and into two types of external finance. While small producers face stronger credit frictions and rely on bank finance, large firms have access to cheaper bond finance. The analysis shows that a bank credit shock leads to an increase in the share of firms that use bond finance. This selection effect is used to explain the observed decrease in bank finance relative to bond finance during the global financial crisis 2008-2009. A calibration of the model to the crisis period documents that endogenous selection into external finance reduces the negative implications of credit frictions on product variety, exports and gains from trade.

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1 Introduction

Credit frictions are one of the most important obstacles to business operations. Firms rely on external lenders to finance working capital and upfront costs. Typical reasons are the lack of internal funds and time lags between investments and the realization of sales. In particular small firms are most constrained by credit frictions, which are associated with higher borrowing costs and insufficient access to external finance (Beck et al., 2005, 2006). These barriers are especially relevant in international trade, as exporting requires upfront investments and additional time to serve foreign markets (Hummels and Schaur, 2013; Feenstra et al., 2014). Empirical evidence shows that credit frictions have negative impacts on export decisions (Berman and Héricourt, 2010; Minetti and Zhu, 2011; Manova, 2013; Muûls, 2015). The relationship between financial frictions and exports has been analyzed by introducing financial frictions in trade models with firm heterogeneity (Manova, 2013; Chaney, 2016). These models typically assume that exporters face a borrowing constraint and rely on one type of external credit.

While this modeling approach is able to explain negative consequences of credit frictions on export performance, it does not take into account that small firms rely more on bank credit, whereas large producers use additional sources of finance, such as public debt and corporate bonds (Cantillo and Wright, 2000; Denis and Mihov, 2003; Faulkender and Petersen, 2006).[1] Access to different sources of external finance plays an important role when credit conditions tighten. Bank credit shocks especially hurt small firms, and induce selection of larger producers into bond finance (Kashyap et al., 1993; Leary, 2009). During the financial crisis 2008-2009, substitution from bank loans to public bonds and trade credit has been documented as an important channel of adjustment.[2] This has led to a strong decline in

[1] In the United States, 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). Empirical studies suggest other firm variables that are positively related to bond finance, such as project quality, profitability, collateral, age and reputation (Cantillo and Wright, 2000; Denis and Mihov, 2003; Becker and Ivashina, 2014).

[2] See Adrian et al. (2013), Becker and Ivashina (2014), and Barraza et al. (2015) for evidence on substitution into public bonds among U.S. firms, as well as Iyer et al. (2014) for Portugal. Carbó-Valverde et al.

the ratio of private bank credit to bond finance, for example, by 10% in Brazil and 39% in Columbia. Shortages in the supply of bank credit have substantially reduced export sales (Paravisini et al., 2015), especially in financially vulnerable industries (Chor and Manova, 2012). However, firms were affected very differently depending on their financing structure. (Paunov, 2012) shows that that negative effects on investments were less pronounced for firms with access to public funding. For Brazil, Cortes et al. (2019) find that especially firms that were borrowing from private-owned banks were hit by the contraction in credit supply leading to a substantially lower survival probability.

Given this evidence, the goal of this paper is to analyze the effects of a bank credit shock on exports, welfare and gains from trade when two types of credit are present. For this purpose, we extend a Melitz (2003) trade model with heterogeneous firms to include credit frictions and selection into bank and bond finance. Firms have to rely on external lenders to cover a share of fixed and variable production costs. The key feature of the model is a trade-off between the two types of external finance with respect to accessibility and credit costs based on the moral hazard approach of Holmstrom and Tirole (1997). While credit frictions lead to aggravated access to cheaper unmonitored finance, e.g. corporate bonds, banks provide facilitated access to monitored finance, but charge a higher borrowing rate.[3] Consistent with empirical evidence, the model captures that small producers face stronger credit frictions, pay a higher borrowing rate and rely on bank finance, whereas larger firms select into cheaper bond finance.

The main contribution of this paper is to show that endogenous selection into bank and bond finance changes the effects of a credit shock compared to a model with only bank finance. In both variants, the shock increases the access barrier to finance which forces low productivity firms to exit. This represents a negative welfare channel as the number of available products is reduced. However, there is a counteracting effect as the exit of low

(2016) and Coulibaly et al. (2013) document substitution into trade credit.

[3] The trade-off between easier credit access and lower expected returns with bank finance is well established in the corporate finance literature (Repullo and Suarez, 2000; Agarwal and Elston, 2001; Blass and Yosha, 2003; Gorton and Winton, 2003).

productivity firms reduces the average price of available varieties. We show that the negative variety effect dominates which leads to an overall decrease in welfare. Besides this direct effect of credit frictions on the extensive margin, the model features an additional channel of adjustment: the banking shock increases the share of firms that use bond finance. This selection effect leads to a reduction in the ratio of bank to bond finance as documented during the financial crisis. In the open economy, we additionally show that a banking shock reduces the share of exporters and the gains from trade if the external finance dependence of exporters is larger than of non-exporters.

To evaluate the quantitative importance of the selection channel, we exploit that our framework nests a model with only bank credit as a special case whenever access barriers to bond finance become prohibitively high. We calibrate both model variants to match key financial indicators (e.g. private credit to GDP) and measures of export performance (i.e. the share of exporters, and exports to GDP) for Mexico before the global financial crisis.[4] During the crisis period 2008-2009, Mexico has experienced a decline in the bank to bond ratio by 8%. We simulate an increase in credit frictions related to monitored finance that matches this decline and apply this shock to both model variants.

We show that the implications of stronger credit frictions differ substantially between the two specifications. While the model with two types of finance captures the observed decline in the ratio of private bank credit to GDP, the variant with one type of finance can only explain around 30% of the contraction. The key finding is that the real effects of a bank credit shock are considerably lower in the presence of endogenous selection into external finance. In the open economy, the model with two types of credit explains almost 90% of the decline in the number of Mexican exporters during the global financial crisis. In contrast, the version with one type of finance overestimates the effect by 30%. Consequently, this model variant predicts welfare losses that are approximately 80% larger than in case of two types of finance.

[4] We show additional results for Brazil and Columbia in Appendix C.3.

The most important implication of our results is that ignoring endogenous selection into external finance might overestimate the real effects of credit frictions. Hence, the paper contributes to the existing literature on trade and financial frictions that typically focuses on one type of credit (Foellmi and Oechslin, 2010; Manova, 2013; von Ehrlich and Seidel, 2015; Chaney, 2016). Our selection mechanism is similar to Russ and Valderrama (2012) who introduce bond finance associated with larger fixed costs in a closed-economy version of Ghironi and Melitz (2005). Cho et al. (2017) extend this model to a small open economy and show that trade liberalization induces switching from bank to bond finance which leads to additional gains from trade. Egger and Keuschnigg (2015) show the important role of venture capital compared to bank credit in financing early-stage investments. Instead, this article shows that endogenous selection into bond finance reduces the negative implications of a bank credit shock on exporters and welfare.[5]

While the paper builds on a static framework which nests a heterogeneous firms model of trade as a special case, dynamic approaches are used to analyze corporate finance choices. Related to our counterfactual analysis, Crouzet (2018) studies a contraction in bank credit supply in a dynamic model with firm heterogeneity and the choice between bank and bond finance. Firms face a different trade-off as they compare greater flexibility of banks in case of financial distress with lower marginal costs of bond finance. The analysis focuses on intensive margin effects of a bank credit shock and hence is applied to large U.S. corporations that use both types of finance. The author shows that substitution of bank finance with bonds increases financial fragility and represents an additional channel how investment is negatively affected. Instead, this paper shows that endogenous selection of firms into either bank or bond finance reduces the negative implications of credit frictions on product variety, welfare and the gains from trade. This modeling approach focuses on the extensive margin

[5]Financial choice in Russ and Valderrama (2012) and Cho et al. (2017) is analogous to technology adoption (Lileeva and Trefler, 2010; Bustos, 2011), whereas bond finance is associated with higher fixed costs but lower marginal costs compared to bank finance. This paper features a different selection mechanism: bond finance is associated with a lower borrowing rate, both for fixed costs and variable production costs, but credit frictions aggravate access to credit. We discuss an extension of our model to capture higher fixed costs of bond finance in Appendix B.

of selection into external finance and hence might be more relevant for developing countries where access to credit is a major issue (Banerjee and Duflo, 2005). The focus on extenive margin effects is common with De Fiore and Uhlig (2011) who introduce selection of heterogeneous firms into bank versus bond finance in a dynamic general equilibrium model and calibrate it to replicate patterns of corporate finance in the US and the euro area. De Fiore and Uhlig (2015) use this model two show that a combination of different shocks, related to an increase in firm-level uncertainty and larger costs of bank financing, can explain the observed changes in corporate debt structure during the financial crisis.

This paper shows that endogenous selection into two types of finance has also important implications for measuring productivity and welfare gains from trade. First, the type of finance and the associated credit costs negatively affect firm-level productivity. Second, as productivity is positively related with access to cheaper bond finance, selection effects influence the measures of average productivity for different groups of firms along the productivity distribution. These results are relevant for studies that confront the predictions of heterogeneous firms models with observed firm-size distributions (Head et al., 2014; Fernandes et al., 2019). Third, the presence of two types of finance changes the welfare formula for gains from trade that is present in a wide class of trade models (Arkolakis et al., 2012). Welfare gains are no longer determined by the domestic trade share but rather depend on the fraction of average export profits in total profits.

The paper is organized as follows. Section 2 presents the closed economy equilibrium. Sections 3 and 4 analyze the effects of credit frictions in the closed and open economy. Section 5 shows extensions and further results of the model, and Section 6 concludes.

2 Closed economy

This section introduces credit frictions and two types of finance in a Melitz (2003) model and starts with the equilibrium of a closed economy, which is populated by L consumers.

2.1 Demand side

The representative consumer derives utility from the consumption of a continuum of varieties, indexed by $i \in \Omega$, according to the following CES function:

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

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

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

and the aggregate price index is defined as follows:

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

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

2.2 Firm behavior with credit frictions

As in Melitz (2003), there is a continuum of firms that are heterogeneous in productivity φ and offer one horizontally differentiated variety i. Labor is the only factor of production, whereas the wage is chosen as numeraire and set to one. At the entry stage, each firm pays a sunk cost f_e and draws a productivity parameter φ from a common probability distribution $g(\varphi)$.[6] Production involves both fixed costs f_d and variable costs that are inversely related to firm productivity.

We introduce credit frictions and two types of finance based on moral hazard as in Holmstrom and Tirole (1997). Throughout the paper, we distinguish between two types of

[6] To solve the general equilibrium, we assume that productivity is Pareto distributed, see Section 2.3.

finance that differ in accessibility and credit costs: bonds as unmonitored finance and bank credit as monitored finance, with index $k \in m, u$. After the entry stage, the timing of events is as follows. First, firms have to finance a fraction of fixed and variable costs before sales realize and hence sign a credit contract with an outside investor.[7] Second, after producers have received the loan, the success of investment projects depends on a project choice of the firm owner. This action is by assumption non-verifiable for external lenders and thus prone to moral hazard. Hence, investors have to ensure incentive compatibility to prevent misbehavior and potential losses from lending. This moral hazard problem creates credit rationing and selection into both types of external finance. To see this, we first consider the maximization problem of firms that sell only in the domestic market, denoted by the subscript d, whereas Section 4 extends the model to an open economy.

Empirical studies show that firms rely on external credit to finance a fraction of fixed investments and production costs (Rajan and Zingales, 1995; Hall and Lerner, 2010). This is especially relevant in less-developed countries where credit frictions play an important role (Banerjee and Duflo, 2005). Evidence from the World Bank Enterprise Surveys (WBES) suggests that Mexican firms finance 60% of investments and 20% of their working capital by external sources.[8] Consistent with this evidence, we assume that there is a time lag between the payment of production costs and the realization of revenues. Hence, a fraction $\alpha_{df} \in [0, 1]$ of fixed costs, as well as a share of variable costs $\alpha_{dv} \in [0, 1]$ is borne up-front and has to be financed by external credit. These shares are constant across firms and capture a sector's external finance dependence based on differences in technology or capital intensity (Rajan and Zingales, 1995; Manova, 2013; Feenstra et al., 2014). The fractions $(1 - \alpha_{dv})$ and $(1 - \alpha_{df})$ reflect the part of variable and fixed production costs that can be financed

[7] We abstract from external finance of entry costs, whereas Bonfiglioli et al. (2018) analyze how financial frictions at the entry stage affect firm-level heterogeneity.

[8] This evidence comes from the 2006-wave of the WBES, which is used to calibrate the model. See Table 1 in subsection 3.2 for details. Evidence for U.S. firms indicates substantial heterogeneity in the use of external finance. During the period 2001-2008, Zetlin-Jones and Shourideh (2017) find that privately held firms finance between 70% and 95% of investments by external sources, whereas this fraction is only 23% for publicly held firms. By considering a long-time series between 1980-2014, Eisfeldt and Muir (2016) find that 47% of firms raise external finance.

internally. Note that heterogeneous firms models of international trade without external finance assume that $\alpha_{dv} = \alpha_{df} = 0$, which implies that firms can finance all production costs by retained earnings.[9] The need of external finance requires a credit contract with an outside lender that determines the gross interest rate $r_k > 1$, and the amount of credit repayment F_{dk}. After having received the loan, each firm faces a positive probability of a bad shock which makes production impossible, whereas profits realize with $0 < \lambda < 1$. The maximization problem of firms can be written as:[10]

$$\begin{aligned}
\max_{p_{dk}} \lambda \pi_{dk}(\varphi) &= \lambda \left[p_{dk}(\varphi) x_{dk}(\varphi) - (1-\alpha_{dv}) \frac{x_{dk}(\varphi)}{\varphi} - (1-\alpha_{df}) f_d - F_{dk}(\varphi) \right] && (4) \\
s.t \quad x_{dk}(\varphi) &= X P^{\sigma} p_{dk}^{-\sigma}(\varphi), && (5) \\
\lambda F_{dk}(\varphi) &\geq r_k \left[\alpha_{dv} \frac{x_{dk}(\varphi)}{\varphi} + \alpha_{df} f_d \right], && (6) \\
\lambda \pi_{dk}(\varphi) &\geq 0. && (7)
\end{aligned}$$

If the project succeeds, firms realize sales, use their earnings to finance a fraction $(1-\alpha_{dv})$ of variable production costs, as well as a share $(1-\alpha_{df})$ of fixed costs, and they repay the amount F_{dk} to the lender. As a bad shock prevents production, firms do not realize sales and hence lenders receive no loan repayment. The participation constraint of lenders (6) ensures that expected loan repayments at least compensate for credit costs and implies that there is no alternative option of investments than lending to firms. Additionally, Eq. (7) ensures that firms will only be active if expected profits are non-negative.

We assume that there is perfect competition in credit markets such that Eq. (6) holds with equality. Solving the maximization problem leads to optimal prices which are set as a

[9]Following Manova (2013), this assumption of liquidity constraints implies that firms cannot use profits from past periods to finance production costs in the future or have to rely on external finance after all retained earnings have been spent. Note that Manova (2013) only allows for external financing of export costs, while this paper also considers credit needs of non-exporters. Related to this, Holmstrom and Tirole (1997) consider wealth differences, whereas we focus on heterogeneity in firm productivity. Foellmi and Oechslin (2010) analyze wealth differences and credit frictions in general equilibrium with one type of finance.

[10]See Appendix A.1 for a derivation of the firm's maximization problem.

constant markup over marginal production costs:

$$p_{dk}(\varphi) = \frac{\sigma}{\sigma - 1}\frac{\psi_{dkv}}{\varphi}, \tag{8}$$

where $\psi_{dkv} = 1 + \alpha_{dv}\frac{r_k - \lambda}{\lambda}$ increases in the need of external credit for variable costs α_{dv}, and in r_k. Note that the effective borrowing rate is given by $\frac{r_k}{\lambda}$, as the credit contract takes into account the success probability $\lambda < 1$. By inserting Eq. (8) into Eqs. (4)-(6), profits can be written as follows:

$$\pi_{dk}(\varphi) = \frac{s_{dk}(\varphi)}{\sigma} - \psi_{dkf} f_j, \tag{9}$$

where $\psi_{dkf} = 1 + \alpha_{df}\frac{r_k - \lambda}{\lambda}$, and sales are given by:

$$s_{dk}(\varphi) = p_{dk}(\varphi) x_{dk}(\varphi) = XP^{\sigma}\left(\frac{\sigma}{\sigma - 1}\frac{\psi_{dkv}}{\varphi}\right)^{1-\sigma}. \tag{10}$$

A higher borrowing rate r_k increases prices resulting in a reduction of sales and expected profits. In a next step, we describe the moral hazard problem that creates credit rationing and selection into external finance. After provision of the loan, a non-verifiable project choice determines the success probability. If the agent behaves diligently, profits realize with high success probability λ, as shown in the profit function (4). In case of shirking, we assume without loss of generality that the success probability is reduced to zero, whereas the firm owner can reap a private benefit $b_k > 0$, which is observable but non-verifiable for external lenders. Hence, borrowers have incentives to pursue own advantages at the expense of project success, which can be interpreted as opportunity costs from managing the project diligently (Holmstrom and Tirole, 1997). We further impose that private benefits are proportional to the fraction of fixed costs financed by external credit ($\alpha_{df} f_d b_k$). This assumption introduces access barriers to external finance, following the idea that larger investment projects might be more opaque and monitoring by external lenders becomes more difficult.[11] In equilibrium,

[11]For simplicity, we do not relate private benefits to variable production costs or firm profits. See Section 5 for a further discussion of the moral hazard approach and possible extensions.

lenders have to ensure that a credit contract satisfies the following incentive-compatibility constraint to prevent losses from lending:

$$\lambda \pi_{dk} (\varphi) \geq \alpha_{df} f_d b_k. \tag{11}$$

As in Holmstrom and Tirole (1997), we assume that this constraint differs between the two types of credit. On the one hand, banks are able to imperfectly monitor firms, which reduces the private benefit compared to unmonitored finance ($b_u > b_m \geq 0$). On the other hand, monitoring is associated with additional costs, leading to a higher borrowing rate ($r_m > r_u \geq 1$), which reduces profits (9).

The key feature of this modeling approach is a trade-off between accessibility and credit costs between the two types of finance. Note that this pattern could also be obtained if the private benefit is a constant. Appendix B shows that the framework is consistent with a model where firms have to pay additional fixed costs in order to obtain unmonitored finance. While this variant requires additional restrictions on the size of fixed costs relative to production costs, our modeling approach is more tractable as it allows us to express the strength of credit frictions relative to production costs, as well as export costs in the open economy (see Section 5 for a further discussion).

Note that incentive compatibility is more restrictive than the expected zero-profit requirement (7) as long as $b_k > 0$. Hence, the private benefits can be interpreted as access barriers to the two types of credit. As profits increase in φ, only the most productive firms overcome the incentive compatibility constraint (11), especially for unmonitored finance. Instead, low productivity firms are more likely to face credit constraints and have to rely on more expensive bank finance.[12] Accordingly, incentive compatibility (11) leads to the

[12] See von Ehrlich and Seidel (2015) as well as Egger and Keuschnigg (2015) for a similar discussion of moral hazard with heterogeneous firms.

following cutoff productivity for access to finance:

$$\varphi_{dk} = \frac{\sigma \psi_{dkv}}{\sigma - 1} \left(\frac{\sigma f_d}{X P^{\sigma}} \frac{\Omega_{dkf}}{\lambda} \right)^{\frac{1}{\sigma-1}}, \tag{12}$$

where $\Omega_{dkf} = \lambda \psi_{dkf} + \alpha_{df} b_k$ captures financial conditions consisting of credit costs and access barriers to finance. Hence, the required minimum productivity increases in credit costs ψ_{dkv} and in private benefits b_k. This result is consistent with empirical studies showing that obstacles to finance are associated with higher borrowing costs, as well as insufficient access to external credit, whereas these obstacles are especially relevant for smaller producers (Beck et al., 2005, 2006). If firms do not rely on external finance for production costs ($\alpha_{dv} = \alpha_{df} = 0$), Eq. (12) collapses to the zero-profit condition as in Melitz (2003). Comparing marginal access to finance for both types of credit leads to:

$$\frac{\varphi_{du}}{\varphi_{dm}} = \frac{\psi_{duv}}{\psi_{dmv}} \left(\frac{\Omega_{duf}}{\Omega_{dmf}} \right)^{\frac{1}{\sigma-1}}. \tag{13}$$

Larger firms are more likely to raise funds directly from the financial market, such as public debt or corporate bonds, whereas smaller firms rely more on bank finance (Cantillo and Wright, 2000; Denis and Mihov, 2003). Consistent with this fact, we introduce a condition under which access to unmonitored finance is relatively more difficult:

Condition 1 $\varphi_{du} > \varphi_{dm}$ *if* $\frac{\psi_{duv}}{\psi_{dmv}} \left(\frac{\Omega_{duf}}{\Omega_{dmf}} \right)^{\frac{1}{\sigma-1}} > 1$

Intuitively, Condition 1 states that access to monitored finance is relatively easier if the benefit of financial intermediation (reduced moral hazard) outweighs additional borrowing costs. If the effectiveness of monitoring is very low (relatively large m) or monitoring costs c_m are very high, Condition 1 is violated and there is no selection into bank finance.

Lemma 1 *If Condition 1 holds, the most productive firms with* $\varphi \geq \varphi_{du}$ *use unmonitored finance. Producers with* $\varphi_{dm} \leq \varphi < \varphi_{du}$ *have to rely on more expensive monitored finance, while lower productivity firms (*$\varphi < \varphi_{dm}$*) cannot raise external finance at all and exit.*

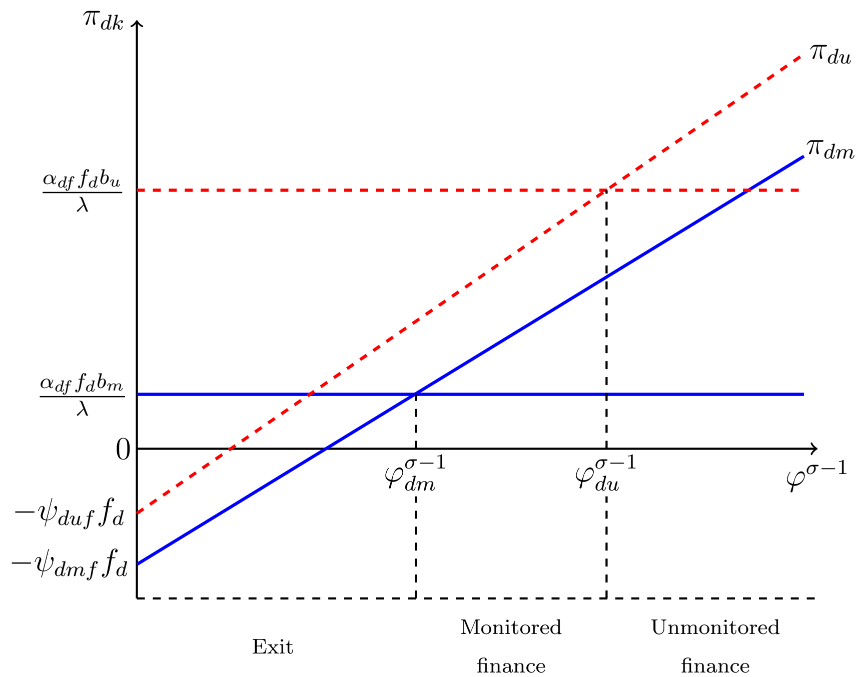

Figure 1: Selection of firms into external finance

Fig. 1 depicts the selection pattern of firms if Condition 1 holds, whereas a function of productivity $\varphi^{\sigma-1}$ is measured on the horizontal axis and profits are shown on the vertical axis. This selection pattern is different from models that introduce technology adoption with larger fixed costs and lower marginal production costs as in Bustos (2011). As monitored finance is associated with a higher borrowing rate for fixed costs and variable production costs, the intercept as well as the slope of the profit line π_{dm} is lower compared to unmonitored finance π_{du}. Hence, 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, whereas access barriers to external funds are depicted as horizontal lines in Fig. 1. Only the most productive firms with $\varphi \geq \varphi_{du}$ obtain unmonitored finance. Producers in the intermediate range of the distribution are not able to overcome moral hazard and rely on more costly monitored finance with lower entry barrier, whereas the least productive firms have to exit.

Hence, compared to the marginal firm in the market, relative sales are determined by relative differences in productivity and borrowing costs:

$$\frac{s_{dm}(\varphi)}{s_{dm}(\varphi_{dm})} = \left(\frac{\varphi}{\varphi_{dm}}\right)^{\sigma-1}, \frac{s_{du}(\varphi)}{s_{dm}(\varphi_{dm})} = \left(\frac{\varphi}{\varphi_{dm}}\right)^{\sigma-1} \left(\frac{\psi_{dmv}}{\psi_{duv}}\right)^{\sigma-1}. \tag{14}$$

As Eq. (14) shows, firms that select into unmonitored finance have an additional advantage due to lower borrowing costs. One important implication is that firm-level productivity measured as the inverse of marginal production costs (φ/ψ_{dkv}) also depends on credit costs and hence is larger for firms that use unmonitored finance. If no external finance is needed for variable productions costs ($\alpha_{dv} = 0$), then $\psi_{dkv} = 1$, and hence the inverse of marginal production costs is just given by the firm productivity draw φ. Empirical studies often use revenue-based productivity measures at the plant or firm level. The ratio of sales over total input, including fixed production costs, is given by $\frac{s_{dk}(\varphi)}{l_{dk}(\varphi)} = \frac{s_{dk}(\varphi)}{\frac{\sigma-1}{\sigma}s_{dk}(\varphi)+\psi_{dkf}f_d}$. This measure increases monotonically in firm productivity and depends negatively on credit costs related to fixed production costs, whenever the external finance dependence is positive ($\alpha_{df} > 0$). The selection pattern focuses on the extensive margin and hence does not capture that firms use a mix of both types of finance as for example analyzed by Crouzet (2018).[13] Note that this result changes in the open economy as some exporters use both unmonitored and monitored credit (see the discussion in Section 4). For the following analysis, we assume that Condition 1 is satisfied and hence both types of finance occur in equilibrium, as illustrated in Fig. 1.

2.3 General equilibrium

In general equilibrium, free entry ensures that expected profits equal sunk entry costs:[14]

$$f_e = [1 - G(\varphi_{dm})]\, \lambda\bar{\pi}, \tag{15}$$

[13] Note that relaxing this assumption would considerably complicate the analysis without additional significant insights. It would still hold that a larger share of unmonitored finance is associated with a competitive advantage compared to firms that rely more on bank finance. Hence, the presence of two types of finance would also lead to additional responses to changes in credit frictions, as analyzed below.

[14] Appendix A.2 shows the general equilibrium in the open economy.

where $[1-G(\varphi_{dm})]\,\lambda$ is the probability of successful entry. Domestic average profits $\bar{\pi}_d$ are given by:

$$\bar{\pi}_d = \gamma_{dm}\int_{\varphi_{dm}}^{\varphi_{du}} \pi_{dm}(\varphi)\mu_{dm}(\varphi)d\varphi + \gamma_{du}\int_{\varphi_{du}}^{\infty} \pi_{du}(\varphi)\mu_{du}(\varphi)d\varphi, \tag{16}$$

with conditional probabilities $\mu_{dm}(\varphi) = \frac{g(\varphi)}{G(\varphi_{du})-G(\varphi_{dm})}$ and $\mu_{du}(\varphi) = \frac{g(\varphi)}{1-G(\varphi_{du})}$. We define the shares of firms that use one type of finance as $\gamma_{dm} = \frac{G(\varphi_{du})-G(\varphi_{dm})}{1-G(\varphi_{dm})}$ and $\gamma_{du} = \frac{1-G(\varphi_{du})}{1-G(\varphi_{dm})}$. Average productivity for both groups of firms can be written as follows:

$$\bar{\varphi}_{dm} = \left[\int_{\varphi_{dm}}^{\varphi_{du}} \varphi^{\sigma-1}\mu_{dm}(\varphi)d\varphi\right]^{\frac{1}{\sigma-1}}; \; \bar{\varphi}_{du} = \left[\int_{\varphi_{du}}^{\infty} \varphi^{\sigma-1}\mu_{du}(\varphi)d\varphi\right]^{\frac{1}{\sigma-1}}. \tag{17}$$

Using the access condition (12) and relative sales (14) allows to express average profits as:

$$\bar{\pi}_d = \frac{f_d\Omega_{dmf}}{\lambda}\left[\gamma_{dm}\left(\frac{\bar{\varphi}_{dm}}{\varphi_{dm}}\right)^{\sigma-1} + \gamma_{du}\left(\frac{\psi_{dmv}}{\psi_{duv}}\right)^{\sigma-1}\left(\frac{\bar{\varphi}_{du}}{\varphi_{dm}}\right)^{\sigma-1}\right] - \bar{f}_d, \tag{18}$$

where average fixed costs are given by $\bar{f}_d = (\gamma_{dm}\psi_{dmf} + \gamma_{du}\psi_{duf})\,f_d$. Additionally, market clearing implies that labor supply L is used for entry costs ($L_e = M_e f_e$), and for production of the two groups of firms: $L = L_e + \sum_k L_{dk}$. Analogous to Melitz (2003), we exploit that the mass of successful entrants is equal to the mass of firms that is forced to exit, which implies that $[1-G(\varphi_{dm})]\,M_e = M$.[15] Labor market clearing determines the mass of active firms:

$$M_d = \frac{L}{\sigma\lambda\left(\bar{\pi}_d + \bar{f}_d\right)}. \tag{19}$$

Welfare can be measured as the inverse price index associated with Eq. (3):

$$W_d = \frac{1}{P} = \frac{\sigma-1}{\sigma}\left(\frac{L}{\sigma f_d\Omega_{dmf}}\right)^{\frac{1}{\sigma-1}}\frac{\varphi_{dm}}{\psi_{dmv}}. \tag{20}$$

Welfare decreases in credit frictions related to fixed costs Ω_{dmf}, as access barriers to finance increase and hence product variety is reduced.[16] There is an additional negative impact of

[15] For simplicity, we assume that the probability of the death shock is equal to 1.
[16] Note that no private benefit are consumed in equilibrium as incentive compatibility is satisfied.

credit costs for variable production ψ_{dmv}, driven by increasing prices. Finally, stronger credit frictions increase the cutoff productivity φ_{dm}, and hence reduce average prices, as the least productive firms have to exit. To show these effects analytically, we follow the literature and assume that firms draw productivity from a Pareto distribution with density $g(\varphi) = \xi\varphi^{-\xi-1}$ and positive support over $[1, \infty]$, whereas ξ is the shape parameter of the Pareto distribution. In this case, the shares of firms using monitored and unmonitored finance respectively are:

$$\gamma_{dm} = 1 - \left(\frac{\varphi_{du}}{\varphi_{dm}}\right)^{-\xi}; \ \gamma_{du} = \left(\frac{\varphi_{du}}{\varphi_{dm}}\right)^{-\xi}. \tag{21}$$

The number of firms in Eq. (19) can then be rewritten as:

$$M_d = \frac{\xi - \sigma + 1}{\xi\sigma} \frac{L}{f_d \Omega_{dmf} (1 + \Gamma_d)}. \tag{22}$$

Credit frictions aggravate access to external finance and hence enter Eq. (22) directly through Ω_{dmf}. Additionally, the difference in the two types of finance is captured by $\Gamma_d = \left(\frac{\psi_{duv}}{\psi_{dmv}}\right)^{-\xi} \left(\frac{\Omega_{duf}}{\Omega_{dmf}}\right)^{\frac{\sigma-1-\xi}{\sigma-1}} \frac{\psi_{dmv}^{\sigma-1} - \psi_{duv}^{\sigma-1}}{\psi_{dmv}^{\sigma-1}}$. This term increases both in variable credit costs ψ_{dmv} and access barriers for monitored finance Ω_{dmf} relative to unmonitored finance.

3 Effects of credit frictions in closed economy

This section analyzes the effects of a banking shock that increases credit frictions for firms that use monitored finance. Throughout the analysis we highlight the different implications of this shock in our framework compared to a model with only bank finance. We first show analytically how financial indicators and endogenous model outcomes react to this banking shock. In a second step, we calibrate both model variants and evaluate the quantitative difference of the changes related to financial development and welfare.

3.1 Comparative statics and selection effects

We consider an increase in the private benefit b_m.[17] In general equilibrium, this shock leads to two effects. First, firms that rely on monitored finance face now a higher access barrier Ω_{dmf} and hence a larger cutoff productivity level φ_{dm} in Eq. (12). We denote this adjustment as the direct effect of the banking shock, which can be illustrated by an upward shift of the marginal-access line of monitored finance in Fig. 1. This reaction is consistent with existing studies that document strong negative effects of credit frictions on small firms (Beck et al., 2005, 2006). In general equilibrium, a larger cutoff productivity φ_{dm} implies that also the access barrier of unmonitored finance in Eq. (13) increases as exit of low productivity firms leads to tougher competition. Hence, marginal firms with productivity just above φ_{du} lose access to unmonitored finance. Note that this switch to bank finance also implies that firm-level productivity is reduced due to higher borrowing costs. However, from Eq. (13) follows that the increase in the cutoff level φ_{du} is less than proportionate compared to the effect on the entry cutoff φ_{dm}, which leads to an additional selection effect.

Proposition 1 *A banking shock (reflected by an increase in b_m) raises the share of firms that use unmonitored finance:* $\frac{d\ln\gamma_{du}}{d\ln b_m} = \frac{\xi}{\sigma-1}\frac{d\ln\Omega_{dmf}}{d\ln b_m} = \frac{\xi}{\sigma-1}\frac{\alpha_{df}b_m}{\Omega_{dmf}} > 0.$

This result follows immediately from Eqs. (13) and (21). We calculate the theoretical counterparts of two observable financial indicators and show how these variables are affected by the banking shock. First, the ratio of aggregate bank credit to bond finance is given by:

$$\frac{F_{md}}{F_{ud}} = \frac{\frac{\alpha_{dv}\Omega_{dmf}}{\lambda\psi_{dmv}}\left(1-\left(\frac{\psi_{duv}}{\psi_{dmv}}\right)^{\sigma-1}\frac{\gamma_{du}\Omega_{duf}}{\Omega_{dmf}}\right)+\eta\alpha_{df}\gamma_{dm}}{\gamma_{du}\left(\frac{\alpha_{dv}\Omega_{duf}}{\lambda\psi_{duv}}+\eta\alpha_{df}\right)}, \tag{23}$$

where $\eta = \frac{\xi-\sigma+1}{\xi(\sigma-1)}$. Note that the ratio in Eq. (23) captures relative aggregate demand for monitored finance related to variable costs and fixed costs of production, depending on the needs of external finance α_{dv} and α_{df}, respectively. The effect of an increase in b_m on the

[17] Besides this, credit conditions are also affected by changes in the borrowing rate, see Section 5.

ratio in Eq. (23) is given by:

$$\frac{d\ln\left(\frac{F_m}{F_u}\right)}{d\ln b_m}=\frac{1}{\Upsilon_1}\left[\frac{\alpha_{dv}\Omega_{dmf}}{\lambda\psi_{dmv}}\frac{d\ln\Omega_{dmf}}{d\ln b_m}-\left(\frac{\alpha_{dv}\Omega_{dmf}}{\lambda\psi_{dmv}}+\eta\alpha_{df}\right)\frac{d\ln\gamma_{du}}{d\ln b_m}\right], \tag{24}$$

where $\Upsilon_1=\frac{F_m}{F_u}\gamma_{du}\left(\frac{\alpha_{dv}\Omega_{duf}}{\lambda\psi_{duv}}+\eta\alpha_{df}\right)$. The direct effect of the increased access barrier to finance Ω_{dmf} leads to exit of lower productivity firms with relatively low demand for credit. Hence, the average firm that relies on monitored finance is more productive after the shock and has higher demand for bank credit. Note that this effect is only present if the external finance needs for variable costs are positive ($\alpha_{dv}>0$), as high productivity firms have also higher variable input requirements. There is a counteracting effect as the banking shock increases the share of firms that use unmonitored finance and hence reduces the relative use of bank finance (compare Prop. 1). We show in Appendix A.3 that the selection effect dominates such that the overall effect of an increase in b_m reduces the ratio in Eq. (24).

As a second measure we consider aggregate private credit provided by banks as a fraction of GDP, which is commonly used as a proxy for financial development in empirical studies:[18]

$$\frac{F_{md}}{L}=\frac{\sigma-1}{\sigma}\frac{\frac{\alpha_{dv}\Omega_{dmf}}{\lambda\psi_{dmv}}\left(1-\left(\frac{\psi_{duv}}{\psi_{dmv}}\right)^{\sigma-1}\frac{\gamma_{du}\Omega_{duf}}{\Omega_{dmf}}\right)+\alpha_{df}\eta\gamma_{dm}}{\Omega_{dmf}\left(1+\Gamma_d\right)}. \tag{25}$$

The effect of an increase in b_m on the ratio of bank credit to GDP is given by:

$$\frac{d\ln\left(\frac{F_{md}}{L}\right)}{d\ln b_m}=\frac{\Upsilon_2-\eta\alpha_{df}}{\Upsilon_1}\frac{d\ln\Omega_{dmf}}{d\ln b_m}-\frac{\Upsilon_2}{\Upsilon_1}\frac{d\ln\gamma_{du}}{d\ln b_m}-\frac{\Gamma_d}{1+\Gamma_d}\frac{d\ln\Gamma_d}{d\ln b_m}, \tag{26}$$

where $\Upsilon_2=\left(\frac{\alpha_{dv}\Omega_{duf}}{\lambda\psi_{dmv}}\left(\frac{\psi_{duv}}{\psi_{dmv}}\right)^{\sigma-1}+\eta\alpha_{df}\right)\gamma_{du}$. Similar to the reaction of the relative demand of bank finance in Eq. (24), there is a positive direct effect of credit frictions and a counter-acting selection effect, captured by the first two terms on the right-hand side of Eq. (26).

[18] See e.g. Manova (2013), among others. Note that total production in our framework is given by ωL, where the wage ω is normalized to one. Related to this measure of financial development, Antràs et al. (2009) introduce credit frictions by moral hazard and assume that private benefits are negatively related to the level of investor protection.

However, the direct effect is reduced or even reversed by the fact that lower productivity firms exit, which reduces aggregate demand for bank credit, captured by $-\frac{\eta\alpha_{df}}{\Upsilon_1}\frac{d\ln\Omega_{dmf}}{d\ln b} < 0$. The last term on the right-hand side of Eq. (26) is a general-equilibrium effect. It reflects that selection into cheaper unmonitored finance increases the average productivity in the economy, $\frac{d\ln\Gamma_d}{d\ln b_m} > 0$. Note that these last two effects would not occur in a model with only one type of finance. We can show that these selection effects dominate, as the following proposition shows.

Proposition 2 *A bank credit shock (reflected by an increase of b_m) decreases both the share of bank credit to GDP and the ratio of bank finance to bond finance: $\frac{d\ln\left(\frac{F_m}{L}\right)}{d\ln b_m} < 0$, and $\frac{d\ln\left(\frac{F_m}{F_u}\right)}{d\ln b} < 0$.*

Proof. See Appendix A.3. ■

The main insights of this analysis is that the ratio of bank credit to GDP as well as the ratio of bank to bond finance are endogenously determined in our model and react negatively to stronger credit frictions in the banking sector. The effect of the bank credit shock on the number of active firms (22) can be separated into two effects:

$$\frac{d\ln M_d}{d\ln b_m} = -\frac{d\ln\Omega_{dmf}}{d\ln b} - \frac{\Gamma_d}{1+\Gamma_d}\frac{d\ln\Gamma_d}{d\ln b_m} < 0. \tag{27}$$

Both the direct effect of stronger credit frictions and selection into unmonitored finance make it more difficult for lower productivity firms to survive. Consequently, there is a clearly negative effect of the banking shock on the number of active producers.

In heterogeneous firms models, welfare gains can arise through two channels: an increase in product variety and larger average productivity, which reduces the average price of available products for consumers. Hence, the banking shock has two opposing effects on welfare in Eq. (20):

$$\frac{d\ln W_d}{d\ln b_m} = -\frac{1}{\sigma-1}\frac{d\ln\Omega_{dmf}}{d\ln b_m} + \frac{d\ln\varphi_{dm}}{d\ln b_m} < 0. \tag{28}$$

On the one hand, there is a negative welfare effect as the exit of firms reduces the number of available varieties. On the other hand, the second term on the right-hand side of Eq. (28) captures that this leads to an increase in the average productivity and hence a reduction in the average price for consumers.

Proposition 3 *A bank credit shock (an increase of b_m) reduces the number of active firms and increases average productivity due to exit of low productivity firms. The effect on welfare is always negative as the reduction in available varieties dominates the counteracting productivity effect.*

Proof. See Appendix A.3. ■

Note that average productivity relative to the cutoff level is given by $\left(\frac{\bar{\varphi}_d}{\varphi_{dm}}\right)^{\sigma-1} = \frac{\xi}{\xi-\sigma+1}$. This is a common feature that our framework shares with a standard Melitz-Pareto model. However, the relative average productivity differs for the two groups of firms that select into monitored and unmonitored finance. In particular, selection into bond finance additionally increases the average productivity compared to smaller firms that have only access to more expensive bank finance. This selection effect is not taken into account by empirical studies that contrast the properties of the Melitz-Pareto model with observed firm-size distributions (Head et al., 2014; Fernandes et al., 2019). Consistent with empirical evidence, our framework suggests that the type of finance is systematically correlated with firm size, as only the largest producers select into unmonitored finance. The relationship between productivity and the financing structure of firms is especially relevant in settings with low financial development and hence larger access barriers to external credit.[19]

Special cases Before we turn to the quantitative exercise, we discuss two special cases that we will use to evaluate the importance of the selection channel. Most importantly, our framework nests a model with only monitored finance. If $b_u \to \infty$, then the access barrier to unmonitored finance becomes prohibitively high. In this case, the share of firms that use this

[19] This argument is also valid in the open economy. More technical details on average productivity across different types of firms are provided in Appendix A.2.

source of credit approaches zero ($\gamma_{du}, \Gamma_d \to 0$ as $\Omega_{duf} \to \infty$). Hence, the bank credit to GDP ratio in Eq. (25) simplifies to $\frac{F_m}{L} = \frac{\sigma-1}{\sigma}\left(\frac{\alpha_{dv}}{\psi_{dmv}} + \frac{\eta\alpha_{df}}{\Omega_{dmf}}\right)$. This implies that all selection effects disappear and only the direct effects are present in Eqs. (26)-(28). As a second special case, we assume that firms have to finance only a fraction of fixed production costs ($\alpha_{dv} = 0$). The banks to bonds ratio in Eq. (23) is then solely determined by the share of firms that use unmonitored finance: $\frac{F_{md}}{F_{ud}} = \frac{1-\gamma_{du}}{\gamma_{du}}$. As in the case of only one type of finance, the selection effect related to variable costs disappears ($\Gamma_d = 0$), which implies that there is only a direct negative effect on the number of firms in Eq. (27).

3.2 Quantitative results

The goal of this section is to apply the framework to the period of the global financial crisis 2007-2010 and quantify the effects of a bank credit shock compared to a benchmark model with only bank finance. We calibrate the model for Mexico to match observable characteristics pior to the crisis by using the World Bank's Enterprise Surveys and Financial Development Indicators.

Panel A of Table 1 reports the chosen parameter values. The elasticity of substitution σ and the Pareto shape parameter ξ are set to standard values which are in line with Crozet and Koenig (2010).[20] We normalize the interest rate for unmonitored finance $r_u = 1$, and set the probability of success $\lambda = 0.95$, such that r_u/λ is equal to Mexico's lending rate of 1.055 in 2006. Additionally, the interest rate for monitored finance r_m is set to 1.0807, which corresponds to Mexico's net bank interest margin in the year 2006 reported by the World Bank. We further use the World Bank Enterprise Surveys (WBES) data to obtain reasonable values for the share of variable production costs (α_{dv}) and the fraction of fixed costs (α_{df}), that are financed by external credit. The survey contains detailed information on Mexican firms in 2006. One question asks producers to report the fraction of working capital that

[20] Crozet and Koenig (2010) use French firm-level export data to estimate the structural parameters of a Melitz (2003)-type model. The authors report trade-weighted means across industries of the elasticity of substitution $\sigma = 2.25$ and of the Pareto shape parameter $\xi = 3.09$.

is financed by external sources. We use the average value reported among Mexican non-exporters as a proxy for the external finance dependence of variable costs ($\alpha_{dv} = 0.20$). A similar variable reports the proportion of investments financed by external sources, which leads to $\alpha_{df} = 0.59$.[21]

In case of two types of finance, we have to calibrate three parameters as presented in Panel B of Table 1: fixed production costs f_d, as well as the private benefits of unmonitored and monitored finance, b_m and b_u. They are jointly set to match three moments from the data. We first use the number of firms relative to production workers in Eq. (22) to match the ratio of the total number of firms relative to permanent full-time production workers obtained from the 2006-wave of the WBES. Second, we use the ratio of bank credit provided to non-financial corporations relative to the outstanding amount of debt securities of the non-financial sector, which corresponds to Eq. (23). The third measure is the amount of bank credit to private non-financial corporations as a fraction of GDP (25). For these two financial indicators, we use the quarterly average from the first quarter of 2007 until the second quarter of 2008. In the special case of only bank finance, we target the ratio of firms to production workers and the credit to GDP ratio in order to solve for f_d and b_m. The calibration of the model implies that Condition 1 is satisfied as $\frac{\psi_{duv}}{\psi_{dmv}} \left(\frac{\Omega_{duf}}{\Omega_{dmf}} \right)^{\frac{1}{\sigma-1}} = 1.7387$. The corresponding share of firms that use monitored finance γ_{dm} is equal to 0.81. Appendix C.1 provides more technical details on the calibration procedure in the closed economy.

Mexico has experienced a substantial substitution away from bank credit towards bond finance during the global financial crisis. The ratio of bank to bond finance was reduced from 2.73 before the crisis to 2.51 until the end of 2009, which corresponds to a decrease of 8.24% compared to the pre-crisis average. To match this drop quantitatively, the agency cost parameter b_m has to increase by 6.18%. We apply this shock to both variants of the model, which are calibrated to the same observed moments. This procedure allows us to quantify the differential responses related to selection into two types of finance. The results

[21] We normalize sunk entry costs $f_e = 1$. Note that this will not affect relative changes and hence the comparison between the two model variants.

of this quantitative exercise are reported in Panel C of Table 1.

Table 1: Effects of banking shock in model with two types and one type of finance

Panel A. Parameter values					
Parameter	Symbol	(a)	(b)	(c)	(d)
Elasticity of substitution	σ	2	2	2	2
Pareto shape parameter	ξ	3	3	3	3
Interest rate unmonitored finance	r_u	1	–	1	–
Interest rate monitored finance	r_m	1.0807	1.0807	1.0807	1.0807
Success probability	λ	0.95	0.95	0.95	0.95
External finance variable costs	α_{dv}	0.20	0.20	0	0
External finance fixed costs	α_{df}	0.59	0.59	1	1
Private benefit monitored finance	b_m	1.8323	6.4179	0.6218	1.2454
Private benefit unmonitored finance	b_u	4.6569	–	1.6403	–
Fixed costs of production	f_d	3.7528	1.6527	4.6728	3.4200
Panel B. Targeted moments					
Target	Data				
Ratio of firms to production workers (M_d/L)	0.0419	0.0419	0.0419	0.0419	0.0419
Private bank credit to GDP (F_{md}/L)	0.1433	0.1433	0.1433	0.1433	0.1433
Ratio of bank to bond finance (F_{md}/F_{ud})	2.7300	2.7300	–	2.7300	–
Panel C. Effects of banking shock (% change)					
Variable					
Ratio of bank to bond finance (F_{md}/F_{ud})	-8.24	-8.24	–	-8.24	–
Private bank credit to GDP (F_{md}/L)	-3.50	-18.60	-4.99	-4.35	-2.98
Number of firms (M_d)	–	−12.30	−17.51	-2.05	-2.98
Cutoff productivity (φ_{dm})		5.78	7.65	1.21	2.02
Welfare (W_d)		−7.08	−11.20	-0.87	-1.56

Calibration of model for Mexico with two types of finance in column (a), one type of finance in column (b). Special case with financing of only fixed costs ($\alpha_{dv} = 0$) for two types of finance (c) and one type of finance (d). Data: World Bank Enterprise Surveys 2006, World Bank Financial Development Indicators, OECD Main Economic Indicators.

The bank credit shock implies that the share of firms that use bank finance γ_{dm} decreases from 0.81 to 0.72.[22] As discussed in Prop. 2, the banking shock reduces the fraction of private credit to GDP, whereas the selection effect in case of two types of finance leads to a much stronger negative reaction compared to the observed decline by 3.5% during the crisis period. We show that taking into account the reaction of exporters to the bank credit shock is important to explain the observed decline in bank credit relative to GDP (see Table 2 in Section 4). The comparison of columns (a) and (b) further shows that the banking

[22]Note that this share is larger than the fraction of firms with a bank loan or line of credit (0.48), as reported by the WBES. One obvious reason is that our model does not capture other financing sources, such as supplier credit or equity.

shock leads to a larger loss in product variety and hence to a stronger increase in the cutoff productivity φ_{dm}. Intuitively, selection into unmonitored finance shields firms from the negative implications of the banking shock, which leads to a lower impact on the extensive margin. Consequently, the welfare loss is smaller in the model with two types of finance (-7.08%) compared to the special case (-11.2%).

In columns (c) and (d), we calibrate both variants of the model for the case when only fixed costs have to be financed by external credit ($\alpha_{dv} = 0, \alpha_{df} = 1$). All other parameters remain unchanged compared to the baseline calibration and the same banking shock is applied. The results in Panel C show that the magnitudes of the effects become substantially lower if there is no external financing of variable production costs. Intuitively, the banking shock has a stronger impact in columns (a) and (b) as it affects not only selection of firms but also the intensive margin. Note that differences in credit costs directly influence firm sales and hence the degree of competition, captured by $\Gamma_d > 0$. However, the result that welfare losses are relatively lower in case of two types of finance remains valid.

4 Open economy

In the open economy, active firms decide whether to additionally ship goods to an identical country. Exporting involves additional fixed costs f_x and iceberg trade costs, such that $\tau_x > 1$ units of a good have to be shipped for one unit to arrive. Moreover, we allow the external finance dependence to differ across exporters and non-exporters, captured by α_{xv} and α_{xf}. Analogous to Eq. (6), the budget constraint is given by $\lambda F_{xk}(\varphi) \geq r_k \left[\alpha_{xv} \frac{x_{xk}(\varphi)}{\varphi} + \alpha_{xf} f_x\right]$. Taking into account this cost structure, profit maximization yields the export price $p_{xk}(\varphi) = \frac{\sigma}{\sigma-1} \frac{\tau_x \psi_{xkv}}{\varphi}$, whereas $\psi_{xkv} = 1 + \alpha_{xv} \frac{r_k - \lambda}{\lambda}$. Following Eq. (11) in the closed economy, moral hazard restricts access to external finance for exports, whereas incentive compatibility is achieved whenever $\lambda \pi_{xk}(\varphi) \geq \alpha_{xf} f_x b_k$. As in the closed economy, we assume that the private benefit is positively related to fixed costs, which implies that larger projects require more effort of firm owners, or are more opaque for external lenders.[23]

Compared to the closed economy equilibrium, the selection pattern in the open economy is determined by both credit conditions and trade costs. As in Section 2.2, we assume that Condition 1 holds among exporters as well, such that $\frac{\psi_{xuv}}{\psi_{xmv}}\left(\frac{\Omega_{xuf}}{\Omega_{xmf}}\right)^{\frac{1}{\sigma-1}} > 1$. Hence, access to unmonitored finance is more difficult ($\varphi_{xu} > \varphi_{xm}$), and only the most productive firms can use the cheaper source of credit to finance export costs. We derive a second condition in the open economy by comparing the cutoff productivity for monitored finance and exporting φ_{xm} with the access barrier for non-exporters that use unmonitored finance φ_{du}:

Condition 2 $\varphi_{xm} > \varphi_{du}$ *if* $\frac{\tau_x \psi_{xmv}}{\psi_{duv}}\left(\frac{f_x}{f_d}\frac{\Omega_{xmf}}{\Omega_{duf}}\right)^{\frac{1}{\sigma-1}} > 1$

This second condition is satisfied whenever trade costs and the external finance dependence of exporters compared to non-exporters are sufficiently large.

Lemma 2 *If Conditions 1 and 2 hold, the selection of firms is described by the following sorting of cutoff productivities:* $\varphi_{dm} < \varphi_{du} < \varphi_{xm} < \varphi_{xu}$.

The corresponding selection pattern is depicted in Fig. 2. In line with Melitz (2003), only the most productive firms with $\varphi > \varphi_{xm}$ export. Analogous to the closed economy, firms with $\varphi \geq \varphi_{du}$ have access to unmonitored finance for domestic sales. Firms with productivity $\varphi_{xm} \leq \varphi < \varphi_{xu}$ use unmonitored finance for domestic production, but have to rely on more expensive monitored finance for exporting. Note that this result is based on Condition 2. If trade costs are large and/or exporters have to finance a substantial fraction of additional trade costs by external credit, they face a larger access barrier to unmonitored finance. Hence, only the most productive firms with $\varphi \geq \varphi_{xu}$ finance both domestic production and exports by unmonitored credit. The selection pattern is based on the assumption that external finance is raised for exports and non-exports separately. In an earlier working paper version, we show that the same selection pattern as depicted in Fig. 2 can also occur if firms need external credit for endogenous investments that are not separable

[23] Appendix A.2 describes the open economy equilibrium in more technical detail.

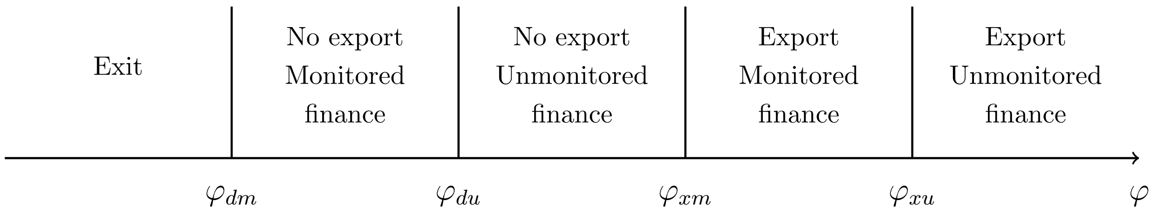

Figure 2: Selection of firms in the open economy

across markets.[24] Compared to this variant, our modeling approach allows for differences in the external finance dependence of exporters and non-exporters, which will be important for the subsequent analysis.

We introduce two additional variables of export performance that depend on the relative external finance dependence of exporters. First, the share of exporters is given by:

$$\gamma_x = \left(\frac{\tau_x \psi_{xmv}}{\psi_{dmv}}\right)^{-\xi} \left(\frac{f_x}{f_d}\frac{\Omega_{xmf}}{\Omega_{dmf}}\right)^{\frac{-\xi}{\sigma-1}}, \tag{29}$$

where $\Omega_{xmf} = \lambda\psi_{xmf} + \alpha_{xf} b_m$ captures the access barrier to finance for exporters that use monitored finance. The effect of agency costs b_m on the share of exporters depends on the relative external finance dependence of exporters compared to non-exporters: $\frac{d\ln\gamma_x}{d\ln b_m} = -\frac{\xi}{\sigma-1}\frac{\left(\alpha_{xf}-\alpha_{df}\right)\lambda b_m}{\Omega_{dmf}\Omega_{xmf}}$. This effect is negative whenever exporters have to finance a relatively larger fraction of fixed costs by external credit ($\alpha_{xf} > \alpha_{df}$). As a second measure, exports as a fraction of GDP can be written as follows:

$$\frac{S_x}{L} = \frac{\left(1+\Gamma_x\right)\gamma_x f_x \Omega_{xmf}}{\left(1+\Gamma_d\right) f_d \Omega_{dmf} + \left(1+\Gamma_x\right)\gamma_x f_x \Omega_{xmf}}, \tag{30}$$

with $\Gamma_x = \left(\frac{\psi_{xuv}}{\psi_{xmv}}\right)^{-\xi}\left(\frac{\Omega_{xuf}}{\Omega_{xmf}}\right)^{\frac{\sigma-1-\xi}{\sigma-1}} \frac{\psi_{xmv}^{\sigma-1}-\psi_{xuv}^{\sigma-1}}{\psi_{xmv}^{\sigma-1}}$. This ratio captures the relative impact of access

[24]Similar to Condition 2, this selection pattern arises if fixed export costs are sufficiently high. In this case, there is an additional trade-off for intermediate productivity firms as they can realize export profits only by financing investments through more costly bank credit, see Unger (2016) for details. Related to this, Eckel and Unger (2016) analyze how credit frictions affect endogenous innovations in processes and quality. Cho et al. (2017) show that trade liberalization leads to switching from bank credit to bonds which is associated with higher fixed costs, but lower marginal costs. Note that changes in trade costs do not influence the relative share of bond finance versus bank credit among exporters in our model. Instead, we show how the presence of bank finance changes the welfare response to credit frictions.

barriers on exporters both at the intensive and the extensive margin.

Before turning to the quantitative exercise, we analyze how the gains from trade change in the presence of credit frictions and two types of external finance. Arkolakis et al. (2012) show for a wide class of trade models that welfare gains can be expressed as a function of the domestic expenditure share, defined as the proportion of domestic sales in total sales. In our case, however, this convenient formula does not capture differences in fixed costs that arise with credit frictions and two types of finance. Instead, welfare gains from trade depend negatively on the share of domestic profits in total profits, which can be expressed as follows:[25]

$$\frac{W_T}{W_A} = \left(1 + \frac{\gamma_x \bar{\pi}_x}{\bar{\pi}_d}\right)^{\frac{1}{\xi}}, \tag{31}$$

where $\bar{\pi}_j = \bar{s}_j/\sigma - \sum_k \gamma_{jk}\psi_{jkf} f_j$, with $j \in d, x$, denotes average profits of (non-)exporters, and average sales are $\bar{s}_j = \frac{\sigma\xi\Omega_{jmf} f_j(1+\Gamma_j)}{(\xi-\sigma+1)\lambda}$. Note that Eq. (31) nests the welfare expression of Arkolakis et al. (2012) as a special case if $\alpha_{jv} = \alpha_{jf} = 0$, such that $\psi_{juv} = \psi_{juf} = 1$. The effect of credit frictions b_m on relative welfare in Eq. (31) can be separated into three channels:

$$\frac{d\ln\left(\frac{W_T}{W_A}\right)}{d\ln b_m} = \frac{\gamma_x\bar{\pi}_x}{\xi\bar{\pi}}\left(\underbrace{\frac{d\ln\gamma_x}{d\ln b_m}}_{<>0} + \underbrace{\frac{d\ln\bar{\pi}_x}{d\ln b_m}}_{>0} - \underbrace{\frac{d\ln\bar{\pi}_d}{d\ln b_m}}_{>0}\right). \tag{32}$$

$\bar{\pi} = \bar{\pi}_d + \gamma_x\bar{\pi}_x$ denotes total average profits. The first effect in Eq. (32) captures the change in the share of exporters, which is negative whenever exporters have to finance a larger fraction of fixed costs compared to non-exporters ($\alpha_{xf} > \alpha_{df}$), and vice versa. The change in welfare gains is further determined by the relative response of average profits of exporters compared to non-exporters. Credit frictions increase access barriers to finance, force least productive firms to exit and hence average profits increase. Gains from trade are affected whenever there is a reallocation of average profits between non-exporters and exporters, which will be the case if the external finance dependence differs across these two groups.

[25] See Appendix A.2 for a derivation of welfare in the open economy.

As in Melitz (2003), trade liberalization leads to a higher share of exporters, reallocates market shares towards the largest firms and forces the least productive firms to exit the market. Consequently, average productivity increases which leads to welfare gains from trade. If exporters have to finance a larger fraction of fixed costs compared to non-exporters, credit frictions aggravate this selection effect. Compared to a model without credit frictions, trade liberalization induces a smaller increase in the share of exporters. As the reallocation effect is attenuated, more domestic firms survive, and average productivity increases by less. Hence, the welfare gains in Eq. (32) are reduced.

We summarize the discussion in the following proposition.

Proposition 4 *If exporters have to externally finance a larger fraction of fixed costs compared to non-exporters, stronger credit frictions reduce (i) the share of exporters, and (ii) lead to a decrease in the gains from trade.*

Proof. *See Appendix A.3.* ■

To quantify the effects of credit frictions in the open economy, we extend the calibration of the model in Section 3.2 by considering also trade costs and selection of firms into exporting. We now solve for five parameters: agency costs b_m and b_u, fixed costs of production f_d and of exporting f_x, as well as iceberg trade costs τ_x. Solutions for these parameters are obtained by simultaneously targeting five moments from the data. As in the closed economy, we use the quarterly averages of the fraction of private bank credit in GDP and the ratio of bank to bond finance over the period 2007 until the second quarter of 2008. We additionally target the average ratio of exports in GDP (29) over the same pre-crisis period. From the 2006-wave of the WBES, we further use the share of exporters $\gamma_x = 0.0899$ as expressed in Eq. (29) and target the number of exporters relative to production workers $M_x/L = \gamma_x M_d/L$. The first two panels of Table 2 report the parameter values and the targeted moments. More technical details on the numerical solution of the model are provided in Appendix C.2.

The fixed parameters are set to the same values as in the closed economy, reported in Table 1. Additionally, we allow the external finance dependence for both fixed and variable costs to differ across exporters and non-exporters, which are obtained from the WBES. The values are reported in Panel A of Table 2 and show that the external finance dependence related to fixed costs is larger for exporters. This difference is consistent with empirical evidence that exporters rely more on external finance (Manova, 2013; Feenstra et al., 2014).[26] Note that our model also captures that within the group of (non-)exporters firm size is negatively correlated with credit frictions (Beck et al., 2005, 2006). Additional to Condition 1, the calibration in the open economy also satisfies the second selection condition such that $\varphi_{xm} > \varphi_{du}$.[27]

As in the closed economy, Panel C of Table 2 reports the effects of a banking shock that leads to a reduction of the ratio of bank to bond finance by 8.24%. The higher external finance dependence of export fixed costs leads to a slightly stronger decrease in the number of exporters compared to non-exporters. The reaction suggested by the model with two types finance is very close to the actual decrease in the number of Mexican exporters of 3.39% in 2009, which follows from the World Bank's Exporter Dynamics Database. In contrast, credit frictions lead to a stronger reaction in the model with only one type of finance. Compared to the results in Table 1, the reactions are quantitatively smaller. In particular, the closed economy version leads to very strong reactions of the ratio of bank credit in GDP and the number of firms. In contrast, the open economy model with two types of finance shows a reduction in the credit to GDP ratio that is very close to the actual decrease by 3.50% in 2009. The reason for these quantitative differences is that credit frictions lead to reallocation effects between exporters and non-exporters which counteract each other. A higher external finance dependence of exporters implies that a banking shock hits them relatively more compared to non-exporters, which attenuates the direct negative impact on smaller producers. In contrast, without these reallocation effects, larger access

[26]The literature provides various reasons for this finding as larger upfront investments related to exports and product customization, additional risk in foreign markets, considerable time lags between investments and the realization of sales or transit times. See Foley and Manova (2015) for an overview of the trade and finance literature.

[27]Condition 2 is satisfied as $\frac{\tau_x \psi_{xmv}}{\psi_{duv}} \left(\frac{f_x}{f_d} \frac{\Omega_{xmf}}{\Omega_{duf}} \right)^{\frac{1}{\sigma-1}} = 1.28 > 1$.

Table 2: Effects of banking shock in the open economy

Panel A. Parameter values					
Parameter	Symbol	(a)	(b)	(c)	(d)
External finance variable export costs	α_{xv}	0.19	0.19	0.19	0.19
External finance variable production costs	α_{dv}	0.20	0.20	0.20	0.20
External finance fixed export costs	α_{xf}	0.70	0.70	1.00	1.00
External finance fixed production costs	α_{df}	0.59	0.59	0.59	0.59
Private benefit monitored finance	b_m	1.85	7.43	1.98	6.75
Private benefit unmonitored finance	b_u	4.63	–	4.77	–
Relative export fixed costs	f_x/f_d	3.53	3.39	2.80	2.52
Panel B. Targeted moments					
Target	Data	(a)	(b)		
Ratio of exporters to production workers (M_x/L)	0.005	0.005	0.005	0.005	0.005
Private bank credit to GDP (F_{md}/L)	0.143	0.143	0.155	0.143	0.141
Ratio of bank to bond finance (F_{md}/F_{ud})	2.730	2.730	–	2.730	–
Share of exporters (γ_x)	0.090	0.090	0.089	0.090	0.087
Exports to GDP (S_x/L)	0.259	0.259	0.258	0.259	0.255
Panel C. Effects of banking shock (% change)					
Variable					
Ratio of bank to bond finance (F_{md}/F_{ud})	-8.24	-8.24	–	-8.24	–
Private bank credit to GDP (F_{md}/L)	-3.50	-3.52	-0.98	-3.57	-1.00
Number of exporters (M_x)	-3.38	-2.92	-4.00	-3.64	-4.09
Number of non-exporters (M_d)	–	-2.38	-3.73	-2.15	-3.34
Cutoff productivity (φ_{dm})	–	1.84	1.99	1.07	1.32
Welfare (W)	–	-1.28	-2.40	-1.34	-2.24
Panel D. Change of welfare gains from trade (in%)					
- in case of bank credit shock		-0.436	-1.103	-1.239	-3.617
- when eliminating credit frictions		1.235	2.352	5.178	8.889

Calibration of model for Mexico with two types of finance in column (a), with one type of finance in column (b). Data: World Bank Enterprise Surveys 2006, World Bank Financial Development Indicators, OECD Main Economic Indicators.

barriers translate into stronger negative consequences for smaller firms and hence a larger adjustment on the extensive margin. As a consequence, the welfare losses are also lower compared to the closed economy. However, note that the model variant with two types of finance still leads to substantially smaller adjustments as selection into unmonitored finance attenuates negative responses both of exporters and non-exporters. In particular, the model with only bank credit shows a welfare loss of 2.40% instead of 1.28% in case of two types of finance.

Panel D reports the implications for the gains from trade. The first line shows the quantitative effect of the banking shock on the change in the welfare gains from trade as shown in Eq. (32). As discussed above, the reallocation effects between exporters and non-exporters are less pronounced in a model with two types of finance. The banking shock decreases gains from trade by 1.10% with one type of finance, but only by -0.44% in the presence of two types of credit. Note that the magnitudes are smaller compared to total welfare changes as the gains from trade depend on the fraction of export profits in total profits in Eq. (32), and on the relative external finance dependence of exporters which determines reallocation effects with respect to non-exporters.

The main result that the reaction is stronger in case of only bank finance also holds for the reversed effect. The second line of Panel D shows the increase in welfare gains from trade when eliminating credit frictions. In case of one type of finance, this additional increase in welfare relative to autarky is almost twice as high (2.35%) compared to a model with selection into both types of finance (1.24%). The difference can be interpreted as the additional gain that endogenous selection into external finance generates for trade in the open economy.

The magnitude of the effects, especially concerning the gains from trade, depends on the external finance dependence of exporters. The trade and finance literature often focuses on the case that exporters have to finance upfront costs by external finance (Manova, 2013; Chaney, 2016). In columns (c) and (d) we present results for the case that exporters have to finance fixed costs completely by external credit ($\alpha_{xf} = 1$), whereas all other parameters remain unchanged. In this case, the banking shock leads to a stronger effect on exporters relative to non-exporters which leads to a stronger decrease in the gains from trade. Conversely, the scope for gains from trade when eliminating credit frictions becomes larger, which is 5.2% and 8.89% in the two model variants, respectively.

Our analysis in the open economy shows that accounting for endogenous selection into external finance is crucial to evaluate the effects of credit shocks on trade. By considering a single type of debt, the negative implications of financial frictions on trade might be overestimated. The results further highlight that the external finance dependence of exporters relative to non-exporters is crucial to evaluate the real effects of credit frictions.

5 Discussion and extensions

After presenting the effects of credit frictions in the closed and open economy, this section discusses further implications and extensions of the model.

Robustness of results. Table 3 in Appendix C.3 shows results for Brazil and Colombia. The calibration of the two model variants follows the same procedure as in the previous section. Before the global financial crisis, bank finance has played a very prominent role in Colombia. The calibration of the model for this country implies that only 1% of non-exporters use bond finance. Consequently, the selection channel has considerably less significance and the two model variants predict very similar effects of the bank credit shock on the number of firms and exporters. However, the model with with two types of finance is able to capture a substantial part of the observed decline in the ratio of private bank credit to GDP (-6.41%) during the crisis period. Additionally, the negative effect on gains from trade still differs between the variant with one type of finance (-3.03%) and the case of endogenous selection (-1.12%).

In contrast, selection effects play a more important role for Brazil, which is reflected by a much lower ratio of bank to bond finance. The implied share of non-exporters that use bank finance in the model is about 4%. The implications of the banking shock differ substantially between the two model variants. While the framework with two types of finance explains almost 90% of the decline in the number of exporters and is very close to the actual decrease of private credit to GDP, the model with one type of finance heavily overestimates the effects. In this case, the welfare loss due to the banking shock amounts to 17%. However, with two types of finance, this loss reduced to 0.54%. The difference becomes even more pronounced for the reaction of gains from trade, which is -0.72% with endogenous selection compared to -34.86% in case of one type of finance. These effects can be explained by the more important role of selection effects combined with the larger external finance dependence of exporters compared to non-exporters. Toghether with the results for Mexico, the application of the model to these countries shows that selection effects can considerably change the welfare implications of credit frictions.

Table 4 in Appendix C.3 shows results for Mexico and Brazil when the elasticity of substitution $\sigma = 2.5$ and the Pareto shape parameter $\xi = 4$. This parameter choice corresponds to the estimates of Crozet and Koenig (2010) for the machine tools industry. While these values are larger compared to the baseline specification, all other parameters remain the same. In this case, the effect of the banking shock on the extensive margin is magnified. A larger ξ implies that the productivity distribution is less dispersed. This implies that there is a relatively larger mass of low productivity firms which are hit most by the banking shock. Hence, the negative implications for gains from trade become slightly larger. However, the main result that effects of the banking shock are more pronounced in the case of one type of finance remains robust.

Increase in borrowing rate Besides the impact of credit frictions shown above, we consider the effects of a change in credit costs on the closed economy equilibrium. A higher borrowing rate r_m increases both fixed costs and variable production costs, and hence induces firms to set higher prices, which results in lower sales and profits. In Fig. 1, profit lines shift downwards and become flatter. Comparable to an increase in the private benefits b_m, access barriers to finance in Eq. (12) rise as well. Similar to Prop. 1, this shock decreases the share of firms that use unmonitored finance and has a negative impact on the number of firms in equilibrium.

Proposition 5 *A higher borrowing rate r_m increases the share of firms that use unmonitored finance, reduces the number of active firms and increases average productivity.*

Proof. *See Appendix A.3.* ■

Prop. 5 shows that the adjustments to an increase in the borrowing rate r_m go into the same direction compared to the banking shock discussed above. Welfare is now affected via three channels:

$$\frac{d\ln W_d}{d\ln r_m} = -\frac{1}{\sigma-1}\frac{d\ln \Omega_{dmf}}{d\ln r_m} - \frac{d\ln \psi_{dmv}}{d\ln r_m} + \frac{d\ln \varphi_{dm}}{d\ln r_m}. \tag{33}$$

Analogous to Eq. (28), the first term captures the negative effect of credit costs on the extensive margin, and the last term reflects the increase in average productivity due to exit of least productive firms. As long as a fraction of variable costs has to be financed by external credit ($\alpha_{dv} > 0$), there is an additional negative effect on the intensive margin, which is shown by the second term in Eq. (33). In this case, a higher borrowing rate increase prices and hence reduces consumer welfare.

Moral hazard and external finance dependence. Whereas credit costs immediately affect prices and sales, there is no direct impact of private benefits b_k on the intensive margin. This result is based on the assumption that moral hazard is only related to fixed costs (see Section 2.2). Alternatively, private benefits could depend on the variable part of credit demand as well. However, this assumption considerably complicates the analysis, as it would not be possible to derive closed-form solutions of aggregate variables.[28] In contrast, our model allows to analytically disentangle different effects of credit frictions while remaining highly tractable. Importantly, differences in credit costs and hence effects on the intensive margin arise as a result of endogenous selection into external finance.

Note that the higher access barrier for firms that use unmonitored finance could also be generated by the assumption that producers have to pay additional fixed costs to obtain cheaper finance. In Appendix B, we show that this variant of the model will lead to a similar selection pattern that only the most productive firms use unmonitored finance if fixed costs for this type of credit are sufficiently large compared to credit frictions related to bank finance. In the open economy, we have to impose an additional restriction on the relative size of fixed costs of unmonitored finance. On the one hand, fixed costs of unmonitored

[28] By assuming only one type of finance, Irlacher and Unger (2018) develop a trade model with non-CES preferences and firm-specific credit frictions. This leads to an endogenous share of credit-rationed producers that is determined by the quality of financial institutions and industry characteristics. Related to this work, Altomonte et al. (2018) analyze the effects of firm-level credit constraints on productivity and markups.

finance have to be sufficiently high such that only the most productive firms obtain the cheaper type of credit. On the other hand, the cutoff productivity of exporting has to be above the one for domestic production with unmonitored finance ($\varphi_{xm} > \varphi_{du}$). This last condition restricts the fixed costs of bond finance from above. We show in Appendix B that a well-defined range for the fixed costs of unmonitored finance and hence a similar selection pattern as depicted in Fig. 2 arises whenever the external finance dependence of exporters is larger than the one of non-exporters.

6 Conclusion

This paper analyzes the effects of credit frictions in a trade model where heterogeneous firms select into two types of external finance. Consistent with empirical evidence, the model captures that smaller producers face access barriers to credit, pay higher borrowing costs and rely on bank finance, whereas larger firms use cheaper bond finance. The model captures that a bank credit shock increases the share of firms that use bond finance. This selection effect changes the aggregate implications of credit frictions compared to a model with only one type of finance.

We apply both model variants to the period of the global financial crisis 2008-2009 by targeting moments of firm-level performance and financial indicators. We show that a bank credit shock reduces the amount of bank credit over GDP in both specifications, while the model with two types of finance additionally explains the observed decline in the ratio of bank to bond finance and captures heterogeneous effects across producers depending on the source of external credit.

The results demonstrate that models wit only one type of finance may be overestimating the aggregate effects of credit frictions. We show that selection effects mitigate the negative consequences of a banking shock on the number of exporters, and can substantially reduce welfare losses. One important implication is that policy measures that reduce credit frictions have stronger positive effects on gains from trade in a model with a single source of finance. Although the analysis focuses on a bank credit shock, this result might apply to other reforms that address firm-level frictions.

The analysis leaves some open questions for future research. We evaluate the impact of credit frictions on equilibrium outcomes and do not consider dynamic adjustment effects. Moreover, the framework builds on perfect competition in credit markets. The role of competition among banks and non-bank lenders might shape the selection of firms into external finance. Finally, the model does not consider asymmetric effects which might be an interesting issue to explain differences in financial choice and heterogeneous aggregate implications across countries.

A Appendix

A.1 Maximization problem of firm

Analogous to the closed economy in Section 2.2, profit maximization of a firm with export status $j \in d, x$ and external finance $k \in m, u$, leads to the following first-order condition:

$$\frac{\partial \lambda \pi_{jk}(\varphi)}{\partial p_{jk}(\varphi)} = \lambda (1-\sigma) p_{jk}(\varphi)^{-\sigma} X P^{\sigma} + \sigma \left[(1-\alpha_{jv}) \lambda + \alpha_{jv} r_k\right] \frac{\tau_j}{\varphi} X P^{\sigma} p_{jk}(\varphi)^{-\sigma-1} = 0,$$

where $\tau_d = 1$ and $\tau_x > 1$. Solving for the optimal price immediately leads to Eq. (8) in case of $j = d$. Profits (9) are obtained by inserting Eq. (8) into the objective function (4) and taking into account constraints (5) and (6). From Eq. (11) follows that incentive compatibility is just satisfied whenever $s_{jk}(\varphi_{jk}) = \frac{\sigma f_j \Omega_{jkf}}{\lambda}$, with $\Omega_{jkf} = \lambda \psi_{jkf} + \alpha_{jf} b$. Inserting optimal sales (10) leads to the cutoff productivity in Eq. (12).

A.2 General equilibrium in the open economy

Analogous to Eq. (16), average profits in the open economy can be written as:

$$\bar{\pi} = \sum_j \left[\gamma_{jm} \int_{\varphi_{jm}}^{\varphi_{ju}} \pi_{jm}(\varphi) \mu_{jm}(\varphi) d\varphi + \gamma_{ju} \int_{\varphi_{ju}}^{\infty} \pi_{ju}(\varphi) \mu_{ju}(\varphi) d\varphi\right]. \tag{A1}$$

We insert profits (9) into Eq. (A1), and express firm sales relative to the marginal non-exporter that uses monitored finance with $s_{dm}(\varphi_{dm}) = \frac{\sigma f_d \Omega_{dmf}}{\lambda}$, which leads to:

$$\begin{aligned}
\bar{\pi} \;&=\; \frac{f_d \Omega_{dmf}}{\lambda} \left[\gamma_{dm} \int_{\varphi_{dm}}^{\varphi_{du}} \left(\frac{\varphi}{\varphi_{dm}}\right)^{\sigma-1} \mu_{dm}(\varphi) d\varphi + \gamma_{du} \int_{\varphi_{du}}^{\infty} \left(\frac{\psi_{dmv}}{\psi_{duv}} \frac{\varphi}{\varphi_{dm}}\right)^{\sigma-1} \mu_{du}(\varphi) d\varphi\right] \\
&+\; \frac{f_d \Omega_{dmf}}{\lambda} \left[\gamma_{xm} \int_{\varphi_{xm}}^{\varphi_{xu}} \left(\frac{\psi_{dmv}}{\tau_x \psi_{xmv}} \frac{\varphi}{\varphi_{dm}}\right)^{\sigma-1} \mu_{xm}(\varphi) d\varphi + \gamma_{xu} \int_{\varphi_{xu}}^{\infty} \left(\frac{\psi_{dmv}}{\tau_x \psi_{xuv}} \frac{\varphi}{\varphi_{dm}}\right)^{\sigma-1} \mu_{xu}(\varphi) d\varphi\right] \\
&-\; \sum_j \left[\gamma_{jm} \psi_{jmf} + \gamma_{ju} \psi_{juf}\right] f_j,
\end{aligned}$$

where conditional probabilities $\mu_{jk}(\varphi)$ and shares of firms γ_{jk} are defined analogous to Section 2.3. Using the definitions of average productivity

$$\bar{\varphi}_{jm} = \left[\int_{\varphi_{jm}}^{\varphi_{ju}} \varphi^{\sigma-1} \mu_{jm}(\varphi) d\varphi \right]^{\frac{1}{\sigma-1}} ; \; \bar{\varphi}_{ju} = \left[\int_{\varphi_{ju}}^{\infty} \varphi^{\sigma-1} \mu_{ju}(\varphi) d\varphi \right]^{\frac{1}{\sigma-1}}, \tag{A2}$$

allows to rewrite average profits analogous to the closed economy case in Eq. (18):

$$\bar{\pi} = \frac{\bar{s}}{\sigma} - \sum_{j} \left(\gamma_{jm} \psi_{jmf} + \gamma_{ju} \psi_{juf} \right) f_j, \tag{A3}$$

where average sales are given by:

$$\bar{s} = \frac{\sigma \Omega_{dmf} f_d}{\lambda \varphi_{dm}^{\sigma-1}} \left[\gamma_{dm} \bar{\varphi}_{dm}^{\sigma-1} + \gamma_{du} \left(\frac{\psi_{dmv} \bar{\varphi}_{du}}{\psi_{duv}} \right)^{\sigma-1} + \gamma_{mx} \left(\frac{\psi_{dmv} \bar{\varphi}_{xm}}{\tau_x \psi_{xmv}} \right)^{\sigma-1} + \gamma_{ux} \left(\frac{\psi_{dmv} \bar{\varphi}_{xu}}{\tau_x \psi_{xuv}} \right)^{\sigma-1} \right].$$

Labor market clearing. Labor requirements of a single firm with export status j and source of finance k are given by $l_{jk}(\varphi) = \frac{\psi_{jkv}\tau_j}{\varphi} x_{jk}(\varphi) + \psi_{jkf} f_j$, which can be written in terms of sales (10), such that $l_{jk}(\varphi) = \frac{\sigma-1}{\sigma} s_{jk}(\varphi) + \psi_{jkf} f_j$. We express labor requirements relative to the marginal non-exporter with productivity φ_{dm} and aggregate over all firms M. Labor market clearing in the open economy requires that $L = M_e f_e + \lambda \sum_j (L_{jm} + L_{ju})$, whereas $[1 - G(\varphi_{dm})] M_e = M$, and aggregate labor demand by group is defined as:

$$L_{jm} = M_{jm} \int_{\varphi_{jm}}^{\varphi_{ju}} l_{jm}(\varphi) \mu_{jm}(\varphi) d\varphi; \; L_{ju} = M_{ju} \int_{\varphi_{ju}}^{\infty} l_{ju}(\varphi) \mu_{ju}(\varphi) d\varphi. \tag{A4}$$

After some modifications, we obtain $L_{jk} = M_{jk} \left(\frac{\sigma-1}{\sigma} \bar{s}_{jk} + \psi_{jkf} f_j \right)$, whereas $\bar{s}_{jk}$ denotes average sales of firms with export status j and type of finance k. Finally, aggregation over the total number of firms leads to $L = \lambda M \bar{s}$.

Pareto distribution. As described in Section 2.3, we assume that productivity φ is Pareto distributed with density function $g(\varphi) = \xi \varphi^{-\xi-1}$. Whereas the shares of non-exporters are still given by Eq. (21), the share of exporters is:

$$\gamma_x = \left(\frac{\tau_x \psi_{xmv}}{\psi_{dmv}}\right)^{-\xi} \left(\frac{f_x}{f_d}\frac{\Omega_{xmf}}{\Omega_{dmf}}\right)^{\frac{-\xi}{\sigma-1}}.$$

The share of exporters that use (un)monitored finance is given by:

$$\gamma_{xu} = \left(\frac{\varphi_{xu}}{\varphi_{dm}}\right)^{-\xi} = \left(\frac{\tau_x \psi_{xuv}}{\psi_{dmv}}\right)^{-\xi} \left(\frac{f_x}{f_d}\frac{\Omega_{xuf}}{\Omega_{dmf}}\right)^{\frac{-\xi}{\sigma-1}},$$

$$\gamma_{xm} = \left(\frac{\varphi_{xm}}{\varphi_{dm}}\right)^{-\xi} - \left(\frac{\varphi_{xu}}{\varphi_{dm}}\right)^{-\xi} = \gamma_x - \gamma_{xu}.$$

We can write average sales in the open economy as:

$$\bar{s} = \frac{\xi\sigma\Omega_{dmf} f_d \left[1 + \Gamma_d + \gamma_x \frac{f_x}{f_d}\frac{\Omega_{xmf}}{\Omega_{dmf}}\left(1+\Gamma_x\right)\right]}{\left(\xi-\sigma+1\right)\lambda}, \tag{A5}$$

where $\Gamma_j = \left(\frac{\psi_{juv}}{\psi_{jmv}}\right)^{-\xi}\left(\frac{\Omega_{juf}}{\Omega_{jmf}}\right)^{\frac{\sigma-1-\xi}{\sigma-1}} \frac{\psi_{jmv}^{\sigma-1}-\psi_{juv}^{\sigma-1}}{\psi_{jmv}^{\sigma-1}}$. Note that this term collapses to the closed economy case as described in Section 2.3, if trade costs are prohibitively high such that $\gamma_x = 0$. We assume that $\xi > \sigma - 1$, to ensure a well-defined equilibrium.

Under the assumption of Pareto distributed productivity, free entry (15) implies that $\varphi_{dm} = \left(\frac{\lambda\bar{\pi}}{f_E}\right)^{\frac{1}{\xi}}$, which leads to an explicit solution for φ_{dm} in combination with Eqs. (A3) and (A5).

Measurement of productivity and selection into external finance. By combining the definitions in Eq. (A2) with the assumption of Pareto distributed productivity, we can express the ratios of average productivity to marginal productivity by group as follows:

$$\left(\frac{\bar{\varphi}_{dm}}{\varphi_{dm}}\right)^{\sigma-1} = \frac{\xi}{\xi-\sigma+1}\frac{1}{\varphi_{dm}^{\sigma-1}}\frac{\varphi_{dm}^{\sigma-\xi-1}-\varphi_{du}^{\sigma-\xi-1}}{\varphi_{dm}^{-\xi}-\varphi_{du}^{-\xi}};\ \left(\frac{\bar{\varphi}_{du}}{\varphi_{dm}}\right)^{\sigma-1} = \frac{\xi}{\xi-\sigma+1}\left(\frac{\varphi_{du}}{\varphi_{dm}}\right)^{\sigma-1}, \tag{A6}$$

$$\left(\frac{\bar{\varphi}_{xm}}{\varphi_{dm}}\right)^{\sigma-1} = \frac{\xi}{\xi-\sigma+1}\frac{1}{\varphi_{dm}^{\sigma-1}}\frac{\varphi_{xm}^{\sigma-\xi-1}-\varphi_{xu}^{\sigma-\xi-1}}{\varphi_{xm}^{-\xi}-\varphi_{xu}^{-\xi}};\ \left(\frac{\bar{\varphi}_{xu}}{\varphi_{dm}}\right)^{\sigma-1} = \frac{\xi}{\xi-\sigma+1}\left(\frac{\varphi_{xu}}{\varphi_{dm}}\right)^{\sigma-1}. \tag{A7}$$

Eqs. (A6) and (A7) show that the average productivity by group depends on selection effects, captured by the relative cutoff productivity levels. As in a standard Melitz-Pareto model, the average productivity of domestic firms relative to marginal productivity is still given by the constant ratio: $\left(\frac{\bar{\varphi}_d}{\varphi_{dm}}\right)^{\sigma-1} = \frac{\xi}{\xi-\sigma+1}$. Note, however, that the equivalent ratio in the open economy additionally depends on the relative external finance dependence of exporters compared to non-exporters:

$$\left(\frac{\bar{\varphi}}{\varphi_{dm}}\right)^{\sigma-1} = \frac{\xi}{\xi-\sigma+1}\left[1+\left(\frac{\varphi_{xm}}{\varphi_{dm}}\right)^{\sigma-1-\xi}\right] = \frac{\xi}{\xi-\sigma+1}\left[1+\left(\frac{\tau_x\psi_{xuv}}{\psi_{dmv}}\right)^{\sigma-1-\xi}\left(\frac{f_x\Omega_{xuf}}{f_d\Omega_{dmf}}\right)^{\frac{\sigma-1-\xi}{\sigma-1}}\right].$$

Welfare in the open economy. From Eq. (20) follows that welfare in autarky is $W_A = \frac{\sigma-1}{\sigma}\left(\frac{L}{\sigma f_d\Omega_{dmf}}\right)^{\frac{1}{\sigma-1}}\frac{\varphi_{dmA}}{\psi_{dmv}}$. Analogously, welfare under trade is $W_T = \frac{\sigma-1}{\sigma}\left(\frac{L}{\sigma f_d\Omega_{dmf}}\right)^{\frac{1}{\sigma-1}}\frac{\varphi_{dmT}}{\psi_{dmv}}$. Hence, welfare relative to autarky can be written as:

$$\frac{W_T}{W_A} = \frac{\varphi_{dmT}}{\varphi_{dmA}}. \tag{A8}$$

By taking into account free entry (15), we can rewrite welfare as in Eq. (31). Inserting the expressions of average profits as defined in the text, leads to:

$$\frac{W_T}{W_A} = \left(1+\frac{f_x}{f_d}\frac{\gamma_x\xi\Omega_{xmf}\left(1+\Gamma_x\right)-\left(\xi-\sigma+1\right)\lambda\left(\gamma_{xm}\psi_{xmf}+\gamma_{xu}\psi_{xuf}\right)}{\xi\Omega_{dmf}\left(1+\Gamma_d\right)-\left(\xi-\sigma+1\right)\lambda\left(\gamma_{dm}\psi_{dmf}+\psi_{duf}\gamma_{du}\right)}\right)^{\frac{1}{\xi}}. \tag{A9}$$

A.3 Proofs

Proof of Proposition 2. We use the result from Proposition 1 that $\frac{d\ln\gamma_{du}}{d\ln b_m} = \frac{\xi}{\sigma-1}\frac{d\ln\Omega_{dmf}}{d\ln b_m} > 0$, and insert it into Eq. (24). After some modifications, the reaction of the ratio of monitored finance to unmonitored finance simplifies to:

$$\frac{d\ln\left(\frac{F_m}{F_u}\right)}{d\ln b_m} = -\frac{\xi-\sigma+1}{\sigma-1}\frac{1}{\Upsilon_1}\left(\frac{\alpha_{dv}\Omega_{dmf}}{\lambda\psi_{dmv}}+\frac{\alpha_{df}}{\sigma-1}\right)\frac{d\ln\Omega_{dmf}}{d\ln b_m} < 0.$$

To derive the effect of b_m on the private credit to GDP ratio in Eq. (25), we further exploit that $\frac{d\ln\Gamma_d}{d\ln b_m} = \frac{\xi-\sigma+1}{\sigma-1}\frac{d\ln\Omega_{dmf}}{db_m} > 0$. Inserting this effect together with the result of Proposition

1 into Eq. (26), leads to:

$$\frac{d\ln\left(\frac{F_{md}}{L}\right)}{d\ln b_m} = \left(\frac{\Upsilon_2 - \eta\alpha_{df}}{\Upsilon_1} - \frac{\Upsilon_2}{\Upsilon_1}\frac{\xi}{\sigma-1} - \frac{\Gamma_d}{1+\Gamma_d}\frac{\xi-\sigma+1}{\sigma-1}\right)\frac{d\ln\Omega_{dmf}}{d\ln b_m},$$

which can be simplified to:

$$\frac{d\ln\left(\frac{F_{md}}{L}\right)}{d\ln b_m} = -\frac{\xi-\sigma+1}{\sigma-1}\left(\frac{\Upsilon_2 + \frac{\alpha_{df}}{\xi}}{\Upsilon_1} + \frac{\Gamma_d}{1+\Gamma_d}\right)\frac{d\ln\Omega_{dmf}}{d\ln b_m} < 0,$$

where $\Upsilon_1 = \frac{F_m}{F_u}\gamma_{du}\left(\frac{\alpha_{dv}\Omega_{duf}}{\lambda\psi_{duv}} + \eta\alpha_{df}\right)$ and $\Upsilon_2 = \left(\frac{\alpha_{dv}\Omega_{duf}}{\lambda\psi_{dmv}}\left(\frac{\psi_{duv}}{\psi_{dmv}}\right)^{\sigma-1} + \eta\alpha_{df}\right)\gamma_{du}$. ∎

Proof of Proposition 3. Using the results from the proof of Proposition 2, the effect of b_m on the number of active firms in Eq. (27) can be written as follows:

$$\frac{d\ln M_d}{d\ln b_m} = -\left(1 + \frac{\Gamma_d}{1+\Gamma_d}\frac{\xi-\sigma+1}{\sigma-1}\right)\frac{d\ln\Omega_{dmf}}{d\ln b} < 0.$$

The reaction of the cutoff productivity level φ_{dm} with respect to b_m as shown in Eq. (28) is:

$$\frac{d\ln\varphi_{dm}}{d\ln b_m} = \frac{f_d}{\lambda\bar{\pi}_d}\left[\frac{\Omega_{dmf}\left(1+\Gamma_d\right)}{\xi-\sigma+1}\left(\frac{d\ln\Omega_{dmf}}{d\ln b_m} + \frac{\Gamma_d}{1+\Gamma_d}\frac{d\ln\Gamma_d}{d\ln b_m}\right) + \frac{\lambda}{\xi}\left(\psi_{dmf} - \psi_{duf}\right)\gamma_{du}\frac{d\ln\gamma_{du}}{d\ln b_m}\right]$$

Note that all three effects lead to a clearly positive reaction of the cutoff productivity level, which can be simplified to:

$$\frac{d\ln\varphi_{dm}}{d\ln b_m} = \frac{\Omega_{dmf}\left(1+\frac{\xi\Gamma_d}{\sigma-1}\right) + \frac{\xi-\sigma+1}{\sigma-1}\lambda\left(\psi_{dmf}-\psi_{duf}\right)\gamma_{du}}{\xi\Omega_{dmf}\left(1+\Gamma_d\right) - \left(\xi-\sigma+1\right)\lambda\tilde{f}_d}\frac{d\ln\Omega_{dmf}}{d\ln b_m} > 0.$$

Inserting this expression into the welfare response shown in Eq. (28), leads to:

$$\frac{d\ln W_d}{d\ln b_m} = -\left[\frac{1}{\sigma-1} - \frac{\Omega_{dmf}\left(1+\frac{\xi\Gamma_d}{\sigma-1}\right) + \frac{\xi-\sigma+1}{\sigma-1}\lambda\left(\psi_{dmf}-\psi_{duf}\right)\gamma_{du}}{\xi\Omega_{dmf}\left(1+\Gamma_d\right) - \left(\xi-\sigma+1\right)\lambda\tilde{f}_d}\right]\frac{d\ln\Omega_{dmf}}{d\ln b_m}.$$

We can simplify this derivative to show that the welfare effect of an increase in b_m is always negative:

$$\frac{d\ln W_d}{d\ln b_m} = -\frac{f_d \Omega_{dmf}}{\xi(\sigma-1)\lambda\bar{\pi}} \frac{d\ln \Omega_{dmf}}{d\ln b_m} < 0.$$

■

Proof of Proposition 4. Taking the derivative of Eq. (29) immediately leads to

$$\frac{d\ln \gamma_x}{d\ln b_m} = -\frac{\xi}{\sigma-1}\left(\frac{d\ln \Omega_{xmf}}{d\ln b_m} - \frac{d\ln \Omega_{dmf}}{d\ln b_m}\right) = -\frac{\xi}{\sigma-1}\frac{(\alpha_{xf}-\alpha_{df})\lambda b_m}{\Omega_{xmf}\Omega_{dmf}}, \tag{A10}$$

which is negative whenever $\alpha_{xf} > \alpha_{df}$. The changes in average profits in Eq. (32) can be expressed as follows:

$$\frac{d\ln \bar{\pi}_x}{d\ln b_m} = \frac{\xi f_x}{(\sigma-1)\bar{\pi}_x}\left[\frac{\Omega_{xmf}(\sigma-1+\xi\Gamma_x)}{(\xi-\sigma+1)\lambda} + (\psi_{xmf}-\psi_{xuf})\frac{\gamma_{xu}}{\gamma_x}\right]\frac{d\ln \Omega_{xmf}}{d\text{ln}b_m} > 0,$$

$$\frac{d\ln \bar{\pi}_d}{d\ln b_m} = \frac{\xi f_d}{(\sigma-1)\bar{\pi}_d}\left[\frac{\Omega_{dmf}(\sigma-1+\xi\Gamma_d)}{(\xi-\sigma+1)\lambda} + (\psi_{dmf}-\psi_{duf})\gamma_{du}\right]\frac{d\ln \Omega_{dmf}}{d\ln b_m} > 0.$$

In case of one type of finance, these effects simplify to:

$$\frac{d\ln \bar{\pi}_x}{d\ln b_m} = \frac{\xi f_x}{(\sigma-1)\bar{\pi}_x}\frac{(\sigma-1)\Omega_{xmf}}{(\xi-\sigma+1)\lambda}\frac{d\ln \Omega_{xmf}}{d\text{ln}b_m} > 0, \tag{A11}$$

$$\frac{d\ln \bar{\pi}_d}{d\ln b_m} = \frac{\xi f_d}{(\sigma-1)\bar{\pi}_d}\frac{(\sigma-1)\Omega_{dmf}}{(\xi-\sigma+1)\lambda}\frac{d\ln \Omega_{dmf}}{d\ln b_m} > 0. \tag{A12}$$

Inserting Eqs. (A10)-(A12) into Eq. (32) leads to:

$$\frac{d\ln\left(\frac{W_T}{W_A}\right)}{d\text{ln}b_m} = -\frac{(\alpha_{xf}-\alpha_{df})\lambda\gamma_x\bar{\pi}_x b_m}{\bar{\pi}\Omega_{xmf}\Omega_{dmf}}\left[1-\frac{(\xi-1)\Omega_{xmf}\Omega_{dmf}}{(\xi\Omega_{xmf}-\lambda\psi_{xmf})(\xi\Omega_{dmf}-\lambda\psi_{dmf})}\right].$$

There are two conditions that have to be satified such that the effect of credit frictions on gains from trade is negative, $\frac{d\ln\left(\frac{W_T}{W_A}\right)}{d\text{ln}b_m} < 1$. First, a necessary condition is that the external finance dependence related to fixed costs is larger for exporters than non-exporters: $\alpha_{xf} > \alpha_{df}$. Second, it has to hold that $\frac{(\xi\Omega_{xmf}-\lambda\psi_{xmf})(\xi\Omega_{dmf}-\lambda\psi_{dmf})}{(\xi-1)\Omega_{xmf}\Omega_{dmf}} > 1$. Note that the left-hand side of this condition increases in the agency cost parameter b_m. If b_m=0, then the condition collapses to $\xi > 2$. With increasing credit frictions, an even lower Pareto shape parameter is sufficient such that credit frictions lead to negative effects on the gains from trade. Note that a similar argument applies to the case of two types of finance.

■

Proof of Proposition 5. Taking the derivative of Eq. (21) with respect to r_m leads to:

$$\frac{d\ln\gamma_{du}}{d\ln r_m} = \xi\frac{d\ln\psi_{dmv}}{d\ln r_m} + \frac{\xi}{\sigma-1}\frac{d\ln\Omega_{dmf}}{d\ln r_m} > 0,$$

where $\frac{d\ln\psi_{dmv}}{d\ln r_m} = \frac{\alpha_{dv}r_m}{\lambda\psi_{dmv}} > 0$ is the effect on the intensive margin and $\frac{d\ln\Omega_{dmf}}{d\ln r_m} = \frac{\alpha_{df}r_m}{\Omega_{dmf}} > 0$ captures the effect on the extensive margin.

Analogous to Eq. (27), the impact of r_u on the number of active firms can be derived as:

$$\frac{d\ln M_d}{d\ln r_m} = -\frac{d\ln\Omega_{dmf}}{d\ln r_m} - \frac{\Gamma_d}{1+\Gamma_d}\frac{d\ln\Gamma_d}{d\ln r_m} < 0, \tag{A13}$$

where the selection effect is:

$$\frac{d\ln\Gamma_d}{d\ln r_m} = \frac{\frac{(\sigma-1)\gamma_{du}\Omega_{duf}}{\Omega_{dmf}}\left(\frac{\psi_{duv}}{\psi_{dmv}}\right)^{\sigma-1} + \xi\Gamma_d}{\Gamma_d}\frac{d\ln\psi_{dmv}}{d\ln r_m} + \frac{\xi-\sigma+1}{\sigma-1}\frac{d\ln\Omega_{dmf}}{d\ln r_m} > 0.$$

The effect of r_m on the cutoff productivity φ_{dm} in Eq. (33) is

$$\frac{d\ln\varphi_{dm}}{d\ln r_m} = \frac{f_d\Omega_{dmf}\left(1+\Gamma_d\right)\left(\frac{d\ln\Omega_{dmf}}{d\ln r_m} + \frac{\Gamma_d}{1+\Gamma_d}\frac{d\ln\Gamma_d}{d\ln r_m}\right) - \frac{\xi-\sigma+1}{\xi}\lambda\tilde{f}_d\frac{d\ln\tilde{f}_d}{d\ln r_m}}{\xi f_d\Omega_{dmf}\left(1+\Gamma_d\right) - \left(\xi-\sigma+1\right)\lambda\tilde{f}_d},$$

with $\frac{d\ln\tilde{f}_d}{d\ln r_m} = \frac{r_m f_d}{\lambda\tilde{f}_d}\left[\alpha_{df}\gamma_{dm} - \frac{\psi_{dmf}-\psi_{duf}}{\psi_{dmv}}\xi\gamma_{du}\left(\alpha_{dv} + \frac{\alpha_{df}\lambda\psi_{dmv}}{(\sigma-1)\Omega_{dmf}}\right)\right]$. Note that there are two opposing effects of credit costs r_m on average fixed costs. The first term in brackets captures that the fixed costs increase for the share of firms that use monitored finance γ_{dm}. The second term shows that selection into unmonitored finance decreases average fixed costs. A decrease in average fixed costs increases average profits and the cutoff productivity φ_{dm}. Hence, a sufficient condition for $\varphi_{dm} > 0$ is to show that the first direct effect of credit frictions on the cutoff productivity outweighs the positive effect on fixed costs: $f_d \Omega_{dmf} \frac{d \ln \Omega_{dmf}}{d \ln r_m} > \frac{\xi - \sigma + 1}{\xi} \alpha_{df} r_m f_d$. This condition can be simplified to $1 > \frac{\xi - \sigma + 1}{\xi}$ and hence is always satisfied. ■

B Model with fixed costs of unmonitored finance

We consider a variant of the model, in which firms have to pay fixed costs $f_u > 0$ to obtain unmonitored finance rather than facing agency problems as described in subsection 2.2. Instead, firms that use monitored finance still face the incentive compatibility constraint in Eq. (11). In case of unmonitored finance, firms maximize the following expected profits:

$$\lambda \pi_{du}(\varphi) = \lambda \left[p_{du}(\varphi) x_{du}(\varphi) - (1 - \alpha_{dv}) \frac{x_{du}(\varphi)}{\varphi} - (1 - \alpha_{df})(f_d + f_u) - F_{du}(\varphi) \right],$$

subject to the budget constraint:

$$\lambda F_{du}(\varphi) \geq r_u \left[\alpha_{dv} \frac{x_{du}(\varphi)}{\varphi} + \alpha_{df}(f_d + f_u) \right].$$

Domestic profits in case of unmonitored finance can then be written as $\pi_{du}(\varphi) = \frac{s_{du}(\varphi)}{\sigma} - \psi_{duf}(f_d + f_u)$. The zero-profit condition of using unmonitored finance for domestic production is given by $s_{du}(\varphi) = \sigma \psi_{duf}(f_d + f_u)$, which can be written as cutoff productivity level:

$$\varphi_{du} = \frac{\sigma \psi_{duv}}{\sigma - 1} \left(\frac{\sigma \psi_{duf}(f_d + f_u)}{X P^{\sigma}} \right)^{\frac{1}{\sigma - 1}}. \tag{B1}$$

Analogous to Eq. (13), the comparison of this cutoff level with the one for monitored finance in Eq. (12) leads to:

$$\frac{\varphi_{du}}{\varphi_{dm}} = \frac{\psi_{duv}}{\psi_{dmv}} \left(\frac{\lambda \psi_{duf}}{\Omega_{dmf}} \frac{f_d + f_u}{f_d} \right)^{\frac{1}{\sigma - 1}}. \tag{B2}$$

Access to unmonitored finance is relatively more difficult, $\varphi_{du} > \varphi_{dm}$, if $\frac{\psi_{duv}}{\psi_{dmv}} \left(\frac{\lambda \psi_{duf}}{\Omega_{dmf}} \frac{f_d + f_u}{f_d} \right)^{\frac{1}{\sigma-1}} > 1$. From the comparison of Eq. (B2) with Condition 1 in subsection 2.2 follows that the two models are equivalent if $f_u = \frac{\alpha_{df} b_u}{\lambda \psi_{duf}} f_d$. Hence, the fixed costs of unmonitored finance can be expressed as a function of the agency costs b_u to obtain the same selection pattern of firms in both variants.

In the open economy, the new cutoff productivity level for financing exports by unmonitored finance is given by:

$$\varphi_{xu} = \frac{\sigma \tau_x \psi_{xuv}}{\sigma - 1} \left(\frac{\sigma \psi_{xuf} \left(f_x + f_u \right)}{X P^{\sigma}} \right)^{\frac{1}{\sigma-1}}.$$

Analogous to Condition 2 in Section 4, selection into exporting with the use of monitored finance is more difficult than financing domestic sales by unmonitored finance, $\varphi_{xm} > \varphi_{du}$, if $\frac{\tau_x \psi_{xmv}}{\psi_{duv}} \left(\frac{\Omega_{xmf}}{\lambda \psi_{duf}} \frac{f_x}{f_d + f_u} \right)^{\frac{1}{\sigma-1}} > 1$. This condition implies that fixed costs of unmonitored finance are sufficiently low compared to export costs. Additionally, we impose that access to unmonitored finance is more difficult among exporters, $\varphi_{xu} > \varphi_{xm}$, which implies that $\left(\frac{\psi_{xuv}}{\psi_{xmv}} \right)^{\sigma-1} \frac{\lambda \psi_{xuf}}{\Omega_{xmf}} \frac{f_x + f_u}{f_x} > 1$. Taking these two conditions together, the level of fixed costs of unmonitored finance is restricted to the following range:

$$\left(\frac{\psi_{xmv}}{\psi_{xuv}} \right)^{\sigma-1} \frac{\Omega_{xmf} f_x}{\lambda \psi_{xuf}} - f_x < f_u < \left(\frac{\tau_x \psi_{xmv}}{\psi_{duv}} \right)^{\sigma-1} \frac{\Omega_{xmf} f_x}{\lambda \psi_{duf}} - f_d. \tag{B3}$$

A well-defined range in Eq. (B3) requires that $\left(\frac{\psi_{xmv}}{\psi_{xuv}} \right)^{\sigma-1} \frac{\Omega_{xmf} f_x}{\lambda \psi_{xuf}} \left[\left(\frac{\tau_x \psi_{xuv}}{\psi_{duv}} \right)^{\sigma-1} \frac{\psi_{xuf}}{\psi_{duf}} - 1 \right] + f_x - f_d > 0$. This condition is satisfied if export costs are sufficiently large $f_x > f_d$ and the external finance dependence of exporters is larger than of non-exporters, $\psi_{xuv} > \psi_{duv}$ and $\psi_{xuf} > \psi_{duf}$.

C Calibration of model

C.1 Calibration of model in closed economy

To quantify the effects of credit frictions in the closed economy, we solve for three parameters as shown in Table 1: agency costs of unmonitored finance b_m, agency costs of monitored finance b_m, and fixed production costs f_d. These parameters are jointly set to match three empirical moments from the data. First, we use the 2006-wave of the World Bank Enterprise Surveys to compute the ratio of active firms to the number of permanent full-time production workers. We match this ratio to the theoretical counterpart in Eq. (22), which allows us to solve for:

$$Z_1 \equiv f_d \Omega_{dmf} \left(1 + \Gamma_d\right) = \frac{\xi - \sigma + 1}{\xi \sigma} \frac{L}{M_d}. \tag{C1}$$

We use two additional moments from the World Bank Financial Development Indicators: the amount of bank credit provided to non-financial corporations as a fraction of GDP, and the ratio of bank credit to debt securities in the private non-financial sector. We use these moments to match Eqs. (23) and (25). Note that both financial measures are functions of the access barriers Ω_{dmf} and Ω_{xmf}, where we exploit that $\gamma_{du} = \left(\frac{\psi_{duv}}{\psi_{dmv}}\right)^{-\xi} \left(\frac{\Omega_{duf}}{\Omega_{dmf}}\right)^{\frac{-\xi}{\sigma-1}}$ and $\Gamma_d = \gamma_{dm}^{\frac{\xi-\sigma+1}{\xi}} \left[\left(\frac{\psi_{dmv}}{\psi_{duv}}\right)^{\sigma-1} - 1\right]$. Hence, we use Eqs. (C1), (23) and (25) to solve for three parameters: f_d, Ω_{dmf}, Ω_{duf}. In a last step, we use the estimated values to obtain the agency cost parameters of each source of credit k: $b_k = \frac{\Omega_{dkf} - \lambda}{\alpha_{df}} - (r_k - \lambda)$.

In case of one type of finance ($\Gamma_d = 0$ and $\gamma_{du} = 0$), we solve for only two parameters: production costs f_d and agency costs for monitored finance b_m. Note that the private credit to GDP ratio in Eq. (25) simplifies to $\frac{F_m}{L} = \frac{\sigma-1}{\sigma} \frac{\frac{\alpha_{dv}\Omega_{dmf}}{\lambda\psi_{dmv}} + \eta\alpha_{df}}{\Omega_{dmf}}$, which can be solved for $\Omega_{dmf} = \frac{\xi-\sigma+1}{\xi\sigma} \frac{\alpha_{df}}{\frac{F_m}{L} - \frac{\sigma-1}{\sigma}\frac{\alpha_{dv}}{\lambda\psi_{dmv}}}$. The estimate of production costs follows immediately from Eq. (22): $f_d = \frac{\xi-\sigma+1}{\xi\sigma} \frac{L}{\Omega_{dmf} M_d}$.

C.2 Calibration of model in open economy

In the open economy, we solve for five parameters that are jointly set to match moments from the data: fixed production costs f_d, export fixed costs f_x, iceberg trade costs τ, as well as agency costs of monitored finance b_m and unmonitored finance b_u. First, analogous to the procedure in the closed economy as described in Appendix C.1, we target the number of exporters relative to permanent full-time production workers, $\frac{M_x}{L} = \frac{\xi-\sigma+1}{\sigma\xi}\frac{\gamma_x}{Z_1}$, to solve for:

$$Z_1 \equiv (1+\Gamma_d)\, f_d \Omega_{dmf} + \gamma_x f_x \Omega_{xmf}\,(1+\Gamma_x)\,. \tag{C2}$$

Second, we use the exports to GDP ratio in Eq. (30) which leads to:

$$Z_2 \equiv f_x \gamma_x \Omega_{xmf}\,(1+\Gamma_x) = Z_1 \frac{S_x}{L}. \tag{C3}$$

Third, we match the share of exporters γ_x in Eq. (29), which implies that:

$$f_x \Omega_{xmf}\,(1+\Gamma_x) = \frac{Z_2}{\gamma_x};\, (1+\Gamma_d)\, f_d \Omega_{dmf} = Z_1 - Z_2. \tag{C4}$$

Fourth, we exploit the open-economy versions of the ratio of bank to bond finance and the fraction of bank credit in GDP, which can be written as follows:

$$\frac{F_m}{F_u} = \frac{\sum_j \frac{\alpha_{jv}\gamma_j f_j \Omega_{jmf}}{\lambda \psi_{jmv}} \left(1 - \left(\frac{\psi_{juv}}{\psi_{jmv}}\right)^{\sigma-1} \frac{\gamma_{ju}\Omega_{juf}}{\gamma_j \Omega_{jmf}}\right) + \eta \sum_j \gamma_{jm}\alpha_{jf} f_j}{\sum_j \frac{\alpha_{jv}\gamma_{ju}\Omega_{juf} f_j}{\lambda \psi_{juv}} + \eta \sum_j \gamma_{ju}\alpha_{jf} f_j}, \tag{C5}$$

$$\frac{F_m}{L} = \frac{\sigma-1}{\sigma} \frac{\sum_j \frac{\alpha_{jv}\gamma_j f_j \Omega_{jmf}}{\lambda \psi_{jmv}} \left(1 - \left(\frac{\psi_{juv}}{\psi_{jmv}}\right)^{\sigma-1} \frac{\gamma_{ju}\Omega_{juf}}{\gamma_j \Omega_{jmf}}\right) + \eta \sum_j \gamma_{jm}\alpha_{jf} f_j}{\sum_j (1+\Gamma_j)\, \gamma_j f_j \Omega_{jmf}}. \tag{C6}$$

Hence, we have a system of five equations (C2)-(C6) in five unknowns. As in the closed economy, we numerically solve for the following parameters: f_d, f_x, τ_x, as well as agency costs b_m and b_u.

We follow an analogous procedure to estimate the model with a single type of finance. In this case, we exploit that $\Gamma_j = 0$ in Eqs. (C2)-(C4), whereas Eq. (C5) is not targeted. The ratio of bank credit to GDP in Eq. (C6) simplifies to:

$$\frac{F_m}{L} = \frac{\sigma - 1}{\sigma} \frac{\frac{\alpha_{dv} f_d \Omega_{dmf}}{\lambda \psi_{dmv}} + \frac{\alpha_{xv} \gamma_x f_x \Omega_{xmf}}{\lambda \psi_{xmv}} + \eta \left(\alpha_{df} f_d + \gamma_x \alpha_{xf} f_x \right)}{f_d \Omega_{dmf} + \gamma_x f_x \Omega_{xmf}}. \tag{C7}$$

Hence, we use four equations to solve for the parameters f_d, f_x, τ_x and b_m.

C.3 Additional results

Table 3 presents additional results of the counterfactual analysis for the countries Brazil and Colombia. The calibration of the two model variants in the open economy follows the procedure as described in Section 4 and Appendix C.2. The elasticity of substitution σ and the Pareto shape parameter are set to the same values as in the case of Mexico described in the main text. The interest rate of monitored finance is chosen to match the bank net interest margin in 2006, which is 8.3% for Brazil and 4.5% for Columbia. The success probability λ is set such that r_u/λ equals the lending rate in the same year (12.9% in Colombia, and 50.8% in Brazil).

Analogous to the calibration in Section 4, we use the external finance dependence related to working capital for (non-)exporters obtained from the World Bank Enterprise Surveys (WBES). As for Mexico, data for Colombia are available for the year 2006, while we use data from a 2009-wave of the survey for Brazil. The ratio of exporters to production workers and the share of exporters is obtained from the WBES data as well. For the remaining moments reported in Table B (private bank credit to GDP, ratio of bank to bond finance, exports as a fraction of GDP), we use the average level of the four quarters prior to the crisis period which started in the third quarter of 2008.

Panel C shows the simulated effects of a banking shock which is reflected by an increase in the private benefit of monitored finance b_m in the model. This increase is chosen to match the decline in the ratio of bank to bond finance as reported in the first line of Panel C. In Colombia, this ratio declined by 39% until the end of 2009 compared to the pre-crisis level. The reaction was less pronounced but still substantial in Brazil with a change of -10% during the same period.

Note that the ratio of bank to bond finance was very large in Columbia before the crisis. Hence, the calibration of the model implies a very high share of firms that use bank finance ($\gamma_{dm} = 0.99$). Consequently, the selection margin is less important and the two model variants lead to very similar results. The model with two types of finance explains a substantial part of the observed decline in the private bank credit to GDP ratio of 6.41% during the crisis period. Both specifications overestimate the change in the number of exporters, which decreased by 14.52% during the crisis period. The strong decline in bank finance translates into a large welfare loss around 12% in both specifications.

In contrast, the difference between the two model variants is more important in the case of Brazil. While the model with two variants is very close to the observed decline in the number of exporters and in the private bank credit to GDP ratio, the model with one type of finance considerably overestimates the effects. As a consequence, the welfare implications differ substantially with small effects (-0.54%) in case of two types of finance, but large losses (-17.10%) in case of one type of finance.

Table 3: Effects of banking shock in the open economy - results for Brazil and Columbia

Panel A. Parameter values		Colombia			Brazil	
Parameter	Symbol	(a)	(b)		(c)	(d)
Elasticity of substitution	σ	2	2		2	2
Pareto shape parameter	ξ	3	3		3	3
Interest rate unmonitored finance	r_u	1	–		1	–
Interest rate monitored finance	r_m	1.045	1.045		1.083	1.083
Success probability	λ	0.89	0.89		0.67	0.67
External finance variable export costs	α_{xv}	0.53	0.53		0.64	0.64
External finance variable production costs	α_{dv}	0.50	0.50		0.45	0.45
External finance fixed export costs	α_{xf}	0.53	0.53		0.64	0.64
External finance fixed production costs	α_{df}	0.50	0.50		0.45	0.45
Private benefit monitored finance	b_m	3.85	3.49		0.112	2.30
Private benefit unmonitored finance	b_u	28.31	–		4.42	–
Relative export fixed costs	f_x/f_d	1.56	1.57		1.034	0.968
Panel B. Targeted moments						
Target	Data	(a)	(b)	Data	(c)	(d)
Ratio of exporters to production workers (M_x/L)	0.0067	0.0067	0.0067	0.0016	0.0016	0.0016
Private bank credit to GDP (F_{md}/L)	0.308	0.308	0.323	0.409	0.409	0.354
Ratio of bank to bond finance (F_{md}/F_{ud})	28.25	28.25	–	10.58	10.58	–
Share of exporters (γ_x)	0.103	0.103	0.102	0.146	0.146	0.118
Exports to GDP (S_x/L)	0.178	0.178	0.177	0.144	0.144	0.127
Panel C. Effects of banking shock (% change)						
Variable	Data	(a)	(b)	Data	(c)	(d)
Ratio of bank to bond finance (F_{md}/F_{ud})	-39.01	-39.01	–	-10.11	-10.11	–
Private bank credit to GDP (F_{md}/L)	-6.41	-5.57	-3.82	-2.40	-2.58	-5.81
Number of exporters (M_x)	-14.52	-20.37	-19.63	-7.78	-6.72	-29.15
Number of non-exporters (M_d)	–	-19.55	-18.95	–	-3.63	-28.98
Cutoff productivity (φ_{dm})	–	9.47	9.31	–	3.48	15.79
Welfare (W)	–	-11.99	-11.49	–	-0.543	-17.10
Panel D. Change in welfare gains from trade (in%)						
- in case of bank credit shock		-1.120	-3.034		-0.720	-34.857
- when eliminating credit frictions		0.381	0.360		0.036	1.235

Calibration of model for Colombia and Brazil, with two types of finance in column (a), with one type of finance in column (b). Data: World Bank Enterprise Surveys 2006, World Bank Financial Development Indicators, OECD Main Economic Indicators.

Table 4: Effects of banking shock in the open economy - additional results

Panel A. Parameter values		Mexico			Brazil	
Parameter	Symbol	(a)	(b)		(c)	(d)
Elasticity of substitution	σ	2.5	2.5		2.5	2.5
Pareto shape parameter	ξ	4	4		4	4
Interest rate unmonitored finance	r_u	1	–		1	–
Interest rate monitored finance	r_m	1.0807	1.0807		1.083	1.083
Success probability	λ	0.95	0.95		0.67	0.67
External finance variable export costs	α_{xv}	0.19	0.19		0.64	0.64
External finance variable production costs	α_{dv}	0.20	0.20		0.45	0.45
External finance fixed export costs	α_{xf}	0.70	0.70		0.64	0.64
External finance fixed production costs	α_{df}	0.59	0.59		0.45	0.45
Private benefit monitored finance	b_m	1.71	7.31		0.30	1.66
Private benefit unmonitored finance	b_u	5.25	–		7.46	–
Relative export fixed costs	f_x/f_d	3.54	3.38		1.034	0.968
Panel B. Targeted moments						
Target	Data	(a)	(b)	Data	(c)	(d)
Ratio of exporters to production workers (M_x/L)	0.005	0.005	0.005	0.0016	0.0016	0.0016
Private bank credit to GDP (F_{md}/L)	0.143	0.143	0.149	0.409	0.409	0.399
Ratio of bank to bond finance (F_{md}/F_{ud})	2.73	2.73	–	10.58	10.58	–
Share of exporters (γ_x)	0.090	0.090	0.089	0.146	0.146	0.116
Exports to GDP (S_x/L)	0.259	0.259	0.258	0.144	0.144	0.127
Panel C. Effects of banking shock (% change)						
Variable	Data	(a)	(b)	Data	(c)	(d)
Ratio of bank to bond finance (F_{md}/F_{ud})	-8.24	-8.24	–	-10.11	-10.11	–
Private bank credit to GDP (F_{md}/L)	-3.50	-3.46	-0.93	-2.40	-2.31	-2.71
Number of exporters (M_x)	-3.38	-3.52	-4.99	-7.78	-7.59	-15.74
Number of non-exporters (M_d)	–	-2.91	-4.68	–	-4.59	-14.97
Cutoff productivity (φ_{dm})	–	1.08	1.37	–	2.60	5.78
Welfare (W)		-0.93	-1.87		-0.71	-4.85
Panel D. Change in welfare gains from trade (in%)						
- in case of bank credit shock		-0.460	-1.343		-1.237	-15.323
- when eliminating credit frictions		0.703	1.402		0.085	0.576

Calibration of model for Brazil and Mexico, with $\sigma = 2.5$ and $\xi = 4$ with two types of finance in column (a), with one type of finance in column (b). Data: World Bank Enterprise Surveys 2006, World Bank Financial Development Indicators, OECD Main Economic Indicators.

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