# Trade and Firm Financing

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**Abstract**
Financial frictions pose a barrier to export entry by altering a firm's long-term capital structure. The focus on long-term firm financing is motivated by our empirical finding that exporting firms tend to be more leveraged than non-exporting firms in terms of long-term debt, as distinct from short-term working capital. We explain this new fact by marrying a corporate finance model of capital structure, featuring an endogenous choice between equity and long-term debt, with a trade model featuring heterogeneous firms and export entry. The model predicts that exporting firms will prioritize reducing the cost of long-term capital over relaxing a short-term working capital constraint to scale up production.

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## 1. Introduction

The trade collapse during the global financial crisis of 2007-9 served to highlight the importance of financial considerations in shaping international trade.[1] Numerous works in the trade literature have studied how limited access to short-term external financing, as working capital to cover the costs of production and shipping, creates a barrier to exporting. (See, for example, Amiti and Weinstein, 2011; Manova, 2013; Manova, Wei and Zhang, 2015; Minetti and Zhu, 2011.) In particular, Kohn et al. (2016) presents this short-term financial friction as an alternative to the one-time sunk export entry cost, which is the more standard barrier to export entry in earlier trade literature.[2]

This paper raises the question of how firms go about financing the payment of the one-time sunk entry costs. It argues that the implications of long-term firm financing used to pay sunk entry costs are also consequential for export participation. Intuitively, if external financing is needed for working capital to pay for labor or shipping costs before sales are realized later in a given period, then the role for external financing likely is even more relevant when a one-time sunk entry cost needs to be paid long in advance of the stream of future profits that motivates the entry decision. However, existing trade literature studying financial frictions generally models only the external financing of short-term working capital recurring each period, not the financing of the long run, one-time sunk cost. Even while sunk entry costs often are present in these models, there typically is no discussion of how firms pay for them.[3]

As motivation for emphasizing long-term firm financing, we present empirical

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[1] See Amiti and Weinstein (2011), Bricongne et al. (2012), Paravisini et al. (2015), and Chor and Manova (2012), etc. For a detailed literature review on the empirical evidence, see Bems et al. (2013).
[2] See for example, Das et al. (2007); Alessandria and Choi (2014).
[3] Even though Kohn et al. (2016) posit a general theoretical model with sunk cost in the working capital constraint, this is only a device to nest their two cases; the models they simulate either include a sunk cost or financial frictions, never both together. Further, we will argue that the financing of sunk cost should be viewed as a combination of equity and long-term debt, not financed out of short-term working capital. Chaney (2016) also considers entry costs to be covered by external borrowing, but precludes any capital structure choice.

evidence, using financial data of public U.S. manufacturing firms which distinguish between long-term debt with maturities of greater than a year and shorter-term debt like working capital. Not only is it immediately clear that the average firm's long-term debt is multiple times larger than the short-term debt, but we present a new stylized fact that long-term debt is even more important for exporters than for non-exporters. In particular, panel regressions indicate that exporting firms tend to have a higher leverage ratio of long-term debt relative to overall firm value, while this is not true for short-term debt. About two-thirds of the higher leverage ratio of exporters can be attributed to their larger firm size. This is not surprising, as the corporate finance literature has documented that larger firms tend toward more leveraged capital structures, while the trade literature has documented that exporters tend to be larger in size than non-exporters.[4] About one-third of the extra leverage of exporters remains after we control for firm size.

The theoretical contribution of the paper is to develop a model that is consistent with the new facts above, by marrying a corporate finance model featuring a capital structure choice between equity and long-term debt, with a trade model featuring heterogeneous firms and export entry.[5] In particular, the model includes a standard short-term working capital constraint, where access to intratemporal debt to finance current production must be secured with collateral, mainly in the form of firm equity. Notably, working capital must cover per-period fixed production costs. Firms also face a capital structure decision regarding long-term firm financing, issuing both intertemporal (interest bearing) debt as well as selling firm equity. The choice between debt and equity financing has consequences for real economic activity in our model, as tax benefits of debt suspend the Modigliani-Miller (MM) theorem.[6] So firms face a tradeoff between long-term and short-term debt,

[4] See Xu, 2012; Kurshev and Strebulaev, 2015.

[5] The model builds on the closed economy model of Bergin, Feng and Lin (2018a), but studies heterogeneous firms, as well as an open economy setting with financing related to export activity.

[6] This is consistent with developments in the corporate finance literature, where there is ample empirical

where long-term debt is cheaper than equity financing due to tax advantages, but it also lowers the amount of equity collateral available to secure short-term working capital.

An entry condition specifies that firms enter the domestic market if the expected firm value equals a one-time sunk entry cost; likewise for entering the export market, if the additional value of exporting than non-exporting exceeds a one-time sunk export entry cost. Given that the entry condition equates entry cost to firm value, and the firm financing decision divides this firm value into debt and equity, these conditions together describe the means by which the marginal firm finances payment of the sunk entry cost.

We study the long-run implications for participation of the export market by solving for the general equilibrium of the model in steady state. We find that endogenizing the capital structure actually makes it easier to solve for the general equilibrium, as it allows us to apply the standard approach of Melitz (2003) to aggregate over heterogeneous firms even in the presence of firm financial constraints.

The model provides a ready explanation for the empirical finding above that exporting firms are more leveraged. As the size of firm sales grows with the firm-specific productivity level, profits and hence firm value grow proportionately. But the presence of fixed costs implies the need for working capital to finance production costs grows less than proportionately with size. So there is less benefit from firms issuing equity as collateral to procure working capital, and the firm raises leverage to benefit from the tax benefits of debt. This logic applies in particular to exporters, since the entry condition implies more productive and hence larger firms with greater firm value self-select into exporting. We also allow for the possibility that exporter status confers firms with access to additional sources of collateral other than equity, which further raises their optimal leverage ratio.

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evidence of failure in Modigliani-Miller (see Rajan and Zingales (1995) and Hovakimiana et al. (2004) as examples), as well as significant research focused on implications of capital restructuring between debt and equity (see Strebulaev and Whited (2011) for a survey).

A key lesson from the model regards the tradeoff firms face between short-term and long-term financing: when capital structure is endogenous, it is generally optimal for firms to adjust the level of equity collateral to nearly fully offset any changes in the tightness of the short-term financial constraint. One implication is that larger and financially stronger firms should not take advantage of a more relaxed financial constraint to scale up production closer to the unconstrained optimal, but instead should increase long-term leverage to cash in on its tax benefits. A second implication is that even if exporters tend to face higher working capital needs than non-exporters, optimal capital structure will adjust to augment equity collateral, thereby relaxing the tightness of the short-term constraint to be the same as non-exporters. This result contrasts with recent work that claims, in the absence of endogenous capital structure, that higher working capital needs of exporting pose a significant barrier to export activity. A further implication is that in the presence of endogenous capital structure, the usual financial frictions in the form of working capital constraints should affect trade primarily by raising the cost of long-term capital used to pay sunk entry investment, rather than by restricting access to short-term working capital for current production.

Our paper finds motivation in the extensive empirical literature studying how financial frictions influence international trade. Part of this literature finds evidence that firm financial health and financial market access increase export market participation, using firm-level data from a variety of countries (Bellone, et al. (2010), Berman and Héricourt (2010), Muûls (2015), Paravisini et al. (2012)), or using sector-level or aggregate trade flow data (Manova (2008), Iacovone and Zavacka (2019), Behrens et al. (2014)).[7]

However, the literature also includes work showing a relationship that runs the other direction, finding that exporting can improve firm financial health. This includes

[7] See the online appendix 3 for a more complete literature survey of these papers.

Greenaway et al. (2007), which finds that U.K exporting manufacturers are financially healthier than non-exporters and have greater liquidity. Their tests reject the idea that firms with greater financial strength ex-ante tend to become exporters, but rather find that the distinctive financial position of exporters appears to be the consequence of export status.[8] This conclusion is also supported by evidence in Campa and Shaver (2002), Bridges and Guariglia (2008), and Blalock and Roy (2007). The finding that financial health could change with exporting highlights the need for the trade literature to better understand how measures of financial health, in particular firm leverage, are endogenous results of decisions by firms rather than exogenous firm characteristics, and how this decision is made jointly with that to engage in export activity.

Our work is also related to recent theoretical research in the trade literature. Kohn et al. (2016) examines the relevance of financial frictions on working capital in shaping new exporter dynamics. Brooks and Dovis (2020) show that when allowing future profitability to affect firms' ability to borrow, their model can account for the fact that access to credit affects both export participation and export value. Manova (2013) and Chaney (2016) show that more productive firms and less credit-constrained firms will be more likely to export. We differ from all these in introducing a capital structure choice between debt and equity for long-term firm financing and studying the financing of sunk entry costs.[9]

The next section of the paper presents empirical work supporting our stylized fact.

[8] The fact we distinguish between short-term and long-term finance allows us to be consistent with the finding of Greenaway et al. (2007). They study short-term debt, and their finding of lower leverage for exporters is consistent with our empirical estimates of short-term leverage; however, we find that overall leverage is greater for exporters than non-exporters, and this is driven by the fact that long-term leverage is much higher, and this dominates the overall result.

[9] Our result focusing on the long run is complementary rather than contradictory to that of Kohn et al. (2016), which focus on transition dynamics. For example, if we augment our model with adjustment costs for changing dividends, in order to introduce meaningful dynamics, the short-run of the model would be consistent with the result of Kohn et al. (2016). We also are related to theoretical work in Russ and Valderrama (2012); however, they study a different financial choice, between alternative forms of debt finance, rather than equity versus debt. Smith and Valderrama (2009) does show a choice of firm financing between equity and bonds (as well as FDI), but it does not study interaction with firm heterogeneity and export participation.

Section 3 presents the benchmark theoretical model. Section 4 uses numerical solutions to demonstrate the model can explain the key facts, along with sensitivity analysis to explore the mechanism. Section 5 discusses implications for how financial frictions interact with endogenous capital structure to pose a barrier to export entry. Section 6 concludes.

## 2. Empirical Motivation

We use a panel dataset which covers the financial data of public U.S. manufacturing firms from 1975 to 2014 to study the relationships of financial choice, firm size and trade behavior. Financial data come from Compustat.[10] Since our interest focuses on firms' choice between debt and equity financing, the leverage ratio in the benchmark model is defined as book debt to total assets as in Baker and Wurgler (2002), where book debt is defined as total asset minus book equity. We also consider other measures of debt with varying maturities: short-term borrowing, long-term debt, debt in current liabilities, and book debt minus short-term borrowing.[11]

Table 1 reports summary statistics for the full sample of firms, and subsamples based on firms' export market participation.[12] Comparison of columns (2) and (3) indicates a clear pattern in terms of leverage among these groups. Exporters tend to be more leveraged than non-exporters in terms of a leverage ratio of overall book debt to overall firm value. As a metric for future comparison, the average leverage ratio of exporters divided by that for non-exporters is 1.062. A battery of difference-in-means tests all reject at the 1%

[10] The sample includes manufacturing firms (SIC: 2000-3999), where we drop firms that appear only once in the sample, have missing values for explanatory variables, and have negative values for the foreign income variable. See Appendix Table 4.1 (in the online appendix) for details of how the sample changes over time.

[11] Short-term borrowing represents the approximate average aggregate short-term financing outstanding during the company's reporting year, which is usually in the form of lines of credit with banks. Long-term debt represents debt obligations due more than one year from the company's Balance Sheet date or due after the current operating cycle. Debt in current liabilities represents the total amount of short-term notes and the current portion of long-term debt that is due in one year.

[12] We identify exporters as firms with positive values for the Compustat measure of firm-wide foreign income. Although a firm's foreign income may include income from exporting, FDI or both, we rely upon empirical findings that indicate that firms with positive FDI also tend to export (see Oberhofer and Pfaffermayr (2008) and Conconi et al. (2016)).

significance level the null of equal average leverage ratios for exporters and non-exporters. (See Appendix Table 4.2 in the online appendix.) Higher leverage among exporters applies also to the two categories listed as long-term debt and book debt minus short-term debt.

In contrast, exporters are less leveraged in measures of debt labeled as short term or current liabilities. We infer that the greater overall leverage of exporters compared to non-exporters is due to longer-term debt, and not due to greater short-term debt. This stands in contrast with the usual focus in the trade literature on working capital and trade credit, included in short-term debt, and instead suggests additional focus should be placed on the decisions determining longer-term forms of debt financing. Though an examination of the underlying data indicates the raw value of short-term debt per firm indeed is larger on average for exporting firms than non-exporting terms, taken as ratio to total assets, short term debt is smaller for exporters.

Columns (4) and (5) report results for subsamples of newly exporting firms, and continuing exporting firms (where the former are defined as firms that export in year *t* but not *t-1*). The leverage ratios of these exporters are very similar to each other, and hence to the full sample of exporters discussed above. For our purposes, this supports the choice to use a model that does not focus on dynamics of new entry for the current issue at hand.

To investigate this pattern more systematically, we estimate panel regressions below:

$$Y_{j,t} = \alpha_0 + \alpha_1 size_{j,t} + \alpha_2 D\_\exp_{j,t} + F_j + \phi t + \varepsilon_{j,t} \qquad (1)$$

where $Y_{j,t}$ is the leverage ratio of firm *j*, and $size_{j,t}$ is measured as the log of net sales of firm *j*. The regressor $D\_\exp_{j,t}$ indicates if the firm is an exporter. We include a firm fixed effect $F_j$ to control for the large set of firm-specific characteristics that the corporate finance literature has found to influence a firm's choice of leverage, such as industry and other firm characteristics that do not vary over time. A time fixed effect $t$ is included to help control for common trends and business cycle fluctuations.

Estimates of Eq. (1) are presented in Column (1) of Table 2, indicating that size is significantly and positively correlated with the leverage ratio ( $\alpha_1 > 0$ , significant at the 1% level). The estimate indicates that as the firm size doubles, the leverage ratio increases about 1.2 percentage points on average. This is not a surprise, as a standard finding in the corporate finance literature on firm capital structure is that firm size raises leverage (see Xu (2012)). Regression results also indicate that if the firm is an exporter, it has a higher overall book leverage ratio ( $\alpha_2 > 0$ , significant at the 1% level). Given that we control for size, this finding indicates that comparing firms with the same size, the leverage ratio will be higher by 1.58 percentage points if the firm is associated with exporting.

Thus, there are two reasons why exporters are more leveraged on average than non-exporters. First, given that exporters tend to be larger than non-exporters (as supported in Table 1), this in itself tends to make exporters more leveraged. But the finding that $\alpha_2 > 0$ indicates there is something beyond size leading to higher leverage for exporters. By combining information from the panel regressions with the mean levels of regressors we can compute that a bit over two-thirds (69.0%) of the higher leverage ratio observed for exporters on average is due to their larger size, and the remaining one-third is due to some other factor associated with export status.[13]

To discuss how the maturities of debt affect the results, we replace the leverage ratio in the benchmark regression by other measure of leverage ratios. Results in Table 2 indicate

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[13] In particular, by substituting the average log sales from a given year (2014, since this is the final year of the sample) into the regression equation with estimated coefficients (including fixed effect coefficients not reported in Table 2), we compute a leverage ratio of 0.4266 for the average non-exporter in that year. By including the value of the estimated exporter dummy, we compute a leverage ratio of 0.4775 for the average exporter in that year. We then synthetically construct the predicted value for the leverage ratio of a non-exporter with the same size as the average exporter (using the average size of exporters but excluding the exporter dummy) to be 0.4617. This implies that the larger size of the average exporter explains (0.4617 - 0.4266) / (0.4775 – 0.4266) = 68.96% of the higher leverage ratio of the average exporter compared to non-exporter, with the remaining portion of the total gap (0.4775 - 0.4617) / (0.4775 – 0.4266) = 31.04% explained by the exporter dummy.

that firm size and the exporter dummy are not significantly correlated with short-term borrowing to total assets (see columns (2) and (4) in Table 2). However, as the terms of debts become longer, the ratios of debt to total assets are consistently positively correlated to size and being an exporter (see Columns (3) and (5) in Table 2). This finding further supports our choice of model that studies the choice of long-term debt rather than shorter-term working capital loans alone.

The dataset also provides support for other modeling choices in our theoretical work, so we briefly summarize some extensions of the regression analysis. Since the model will make use of the idea that export sales and the accounts receivable might be an additional source of collateral for exporting, we have extended our empirical regression by including inventories of finished goods. Regression results indicate that, holding size constant, firms with higher inventories have higher long-term leverage. This is consistent with inventories providing an alternative to equity as a source of collateral, leading to a lower share of equity in optimal capital structure. Further, comparison of results with the benchmark regressions indicates that including inventories in the regressions decreases the magnitude of the effect of export status on long-term leverage ratio. This supports the idea that higher inventories of exporters contributes to why exporters have a higher long-term leverage ratio. (See Appendix Table 4.3 in the online appendix for detailed results.)

Since our theoretical explanation for leverage to follow will focus on the role of fixed costs, we also estimate the correlation of short-term leverage with the log of spending on selling, general, and administrative expenditures (XSGA), which is typically treated as a proxy of organizational capital and fixed cost in the literature (see Lev and Radhakrishnan, 2005). While controlling firm size and export status, the correlation of XSGA and log of short-term borrowing is 0.524 and the correlation of XSGA and log of debt in current liabilities is 0.523, both statistically significant. Results indicate that higher fixed costs as a share of overall costs raise a firm's short-term debt (working capital), which supports our model's specification. (See Appendix Table 4.4 in the online appendix for detailed results.)

## 3. Benchmark Model

The model considers a small open economy, where the home country is in financial autarky, but trades goods with the rest of world. The analysis will focus on the steady state solution to the dynamic model defined below, in which aggregate variables do not change over time.

### 3.1 Household preferences and optimization

There is a continuum of homogeneous households who derive utility from consuming the basket of goods ($C_t$) and disutility from labor ($L_t$), and maximize expected lifetime utility,

$$\max \; E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t), \qquad with \qquad U(C_t, L_t) = \frac{C_t^{1-\rho}}{1-\rho} - \kappa \frac{L_t^{1+\psi}}{1+\psi},$$

where $\rho$ is the households' degree of risk aversion, $\beta$ is the subjective discount factor, and $\kappa$ and $\psi$ are the relative weight of labor and inverse Frisch elasticity, respectively.

Households derive labor income at the real wage rate ($w_t$), and also receive payments from holding the corporate bond portfolio ($\tilde{b}_{t-1}$) and receive dividends ($\tilde{d}_t$) from holding the share ($s_{t-1}$) of the equity portfolio of the $N_{t-1}$ existing firms that survive from the death shock which takes place at the end of each period. Households also update their asset portfolio, including a mutual fund of corporate bonds at price $1/(1+r_t)$ and equity investments at a price of $\tilde{q}_t$, for the set of incumbent firms $(N_{t-1})$ and newly entering firms $(Ne_t)$. The period budget constraint thus may be written as:

$$C_t + (N_{t-1} + Ne_t)\frac{\tilde{b}_t}{1+r_t} + s_t \tilde{q}_t (N_{t-1} + Ne_t) + T_t \le w_t L_t + N_{t-1}\tilde{b}_{t-1} + N_{t-1} s_{t-1}(\tilde{q}_t + \tilde{d}_t),$$

where $\tilde{b}_t$, $\tilde{q}_t$ and $\tilde{d}_t$ are the average values across firms of corporate bonds, equities and dividends respectively. $T_t$ is a lump-sum tax used to finance the tax benefits for firms issuing bonds ($T_t = (N_{t-1} + Ne_t)\left(\tilde{b}_t / R_t - \tilde{b}_t / (1+r)\right)$).

The households maximize expected lifetime utility subject to the budget constraint, implying the following first-order conditions:

$$U_{C_t} w_t + U_{L_t} = 0 , \tag{1}$$

$$\beta(1\text{-}\lambda) E_t \left[ U_{C_{t+1}} (1 + r_t) \right] = U_{C_t} , \tag{2}$$

$$\beta(1\text{-}\lambda) E_t \left[ U_{C_{t+1}} \left( \tilde{q}_{t+1} + \tilde{d}_{t+1} \right) \right] = U_{C_t} \tilde{q}_t , \tag{3}$$

where Eq. (1) is the labor-leisure tradeoff condition, Eqs. (2) and (3) are the Euler equations for holding the corporate bond portfolio and equity portfolio.

### 3.2 Goods market structure

The final good ( $Y$ ) is produced under perfect competition using intermediate goods, both domestically produced and imported, with a CES production function $Y_t \equiv \left[ \left( Y_t^D \right)^{\frac{\sigma-1}{\sigma}} + \left( Y_t^{X*} \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$. $Y_t^{X*}$ represents foreign exports (home imports), which we treat as a standardized unit without varieties; $Y_t^D$ is a composite of all domestically produced varieties of intermediate goods.

Among intermediates, we assume a one-to–one correspondence between a home variety and a firm producing it, indexed by $i$. Firms are heterogeneous in productivity, $z_i$. Let $I_t^x$ represent the set of indexes of firms that export, and $I_t^{nx}$ the set that are non-exporters. For an exporting firm, $i \in I_t^x$, we denote the amount of production sold in the domestic market as $y_t^{xd}(z_i)$, and the amount for export as $y_t^{xx}(z_i)$. Production of a non-exporting firm is $y_t^{nx}(z_i)$. The aggregator for domestically produced goods may be written:

$Y_t^D = \left( \int_{i \in I_t^{nx}} \left( y_t^{nx}(z_i) \right)^{\frac{\sigma-1}{\sigma}} di + \int_{i \in I_t^x} \left( y_t^{xd}(z_i) \right)^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}$. The corresponding consumption price index is:

$$P_t = \left( \int_{i \in I_t^{nx}} \left( p_t^{nx}(z_i) \right)^{1-\sigma} di + \int_{i \in I_t^x} \left( p_t^{xd}(z_i) \right)^{1-\sigma} di + \left( P_t^{x*} \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} , \tag{4}$$

and the implied relative demand functions for different products are

$$y_t^{nx}(z_i) = \left( \frac{p_t^{nx}(z_i)}{P_t} \right)^{-\sigma} Y_t, \quad y_t^{xd}(z_i) = \left( \frac{p_t^{xd}(z_i)}{P_t} \right)^{-\sigma} Y_t, \quad Y_t^{x*} = \left( \frac{P_t^{x*}}{P_t} \right)^{-\sigma} Y_t, \tag{5-7}$$

where $p_t^{nx}(z_i)$, $p_t^{xd}(z_i)$, and $P_t^{x*}$ are the domestic market prices of the products produced by a home non-exporter, home exporter and foreign exporter, respectively.

The corresponding foreign market demand for domestic exports ($y_t^{xx}(z_i)$) is

$$y_t^{xx}(z_i) = \left( \frac{p_t^{xx}(z_i)}{P_t^*} \right)^{-\sigma} Y_t^* = \left( \frac{p_t^{xx}(z_i)}{P_t} \right)^{-\sigma} \left( \frac{P_t}{P_t^*} \right)^{-\sigma} Y_t^*, \tag{8}$$

where $p_t^{xx}(z_i)$ is the foreign market price for home exporter with a productivity $z_i$, and $P_t^*$ is the Foreign consumption price index. $Y_t^*$ is the foreign market size.

### 3.3 Intermediate goods sector

#### 3.3.1 Firm dynamics

Following Chaney (2008), we assume that the total mass of potential new entrants, $M_{et}$, is proportional to the national income.[14] Firms are assigned a random productivity level, $z_i$, from a common cumulative distribution function $G(z)$.[15] Entrants then pay a one-

[14] The particular value of the proportionality $M_e/Y$ has no effect on results we present, provided it is large enough to keep the domestic cutoff margin greater than the minimum value for which the Pareto productivity distribution, $G(z) = 1 - z^{-\theta}$, is defined ($z_d$ >1). As Chaney (2008) offers no suggestion for a value, we choose one to ensure consistent scaling to facilitate numerical solution: a value of $M_e/Y = 0.05$ ensures that for the range of $z_d$ in our exercises, the total mass of firms will be increasing with the income level.

[15] As discussed in Chaney (2008), this specification differs from Melitz (2003) which requires a sunk cost in order to take a productivity draw. It greatly simplifies analysis of domestic entry, and it is similar to Eaton and Kortum (2003) where the set of goods is exogenously given.

time sunk cost, $K_t^E$, if they wish to produce and sell in the domestic market, and pay an additional one-time sunk export entry cost, $K_t^{EX}$ if they wish to sell in the foreign market. Since we limit our study to the steady-state case in which there are no aggregate shocks and in which firm productivity remains fixed, we follow Melitz (2003) in specifying endogenous firm exit only at the initial point of the productivity draw; the only reason for exit of a producing firm is if the firm is hit by an exogenous death shock.

The entry decisions to domestic and export markets define the cut-off productivity levels of the marginal domestic producers (represented by the notation, $d$), $z_{dt}$, and the marginal exporters (represented by $x$), $z_{xt}$, respectively. As a result, $Ne_t$ new entrants successfully enter the domestic market, and $Ne_t^x$ new exporters enter the foreign market. After entry, a total mass $M_t = N_{t-1} + Ne_t$ of firms, including incumbents and new entrants, issue corporate bonds and stocks to adjust capital structure, hire labor and produce goods. When all markets clear, an exogenous death shock hits these firms with probability $\lambda$. The mass of firms and exporters surviving the death shock becomes $N_t$ and $N_t^x$, respectively, with $N_t = (1-\lambda)M_t$. Firm dynamics are thus characterized as follows:

$$N_t = (1-\lambda)(N_{t-1} + Ne_t), \quad N_t^x = (1-\lambda)(N_{t-1}^x + Ne_t^x), \tag{9-10}$$

and

$$Ne_t = p_{in,t} M_{et}, with: p_{in,t} = 1\text{-}G(z_{dt}), \quad \frac{N_t^x}{N_t} = \frac{1\text{-}G(z_{xt})}{1\text{-}G(z_{dt})}, \quad N_t^{nx} = N_t\text{-}N_t^x, \tag{11-13}$$

where $N_t^{nx}$ is the number of non-exporters surviving the death shock at the end of period $t$.

### 3.3.2 Firm enforcement constraint

Following Jerman and Quadrini (2009, 2012), we assume that firm $i$ uses debt $(b_t(z_i))$ and equity to finance production, where debt is preferred to equity because of a tax advantage. The effective gross interest rate for the debt is $R_t = 1 + r_t(1-\tau)$ , where $\tau$ is the tax rate on corporate income. Additionally, each period a firm must pay a fixed cost $w_t f_t^d$ to produce domestically, and an extra fixed cost $w_t f_t^x$ if the firm also exports.

Firms must make factor payments, including variable and fixed production costs, at the beginning of each period before the realization of revenue. In addition to the inter-temporal debt, $b_t^k(z_i)$, $k = x, nx$ as described above, a firm must borrow an intra-period loan to pay a certain portion of the labor cost in advance ($\phi^d$ for domestic production and $\phi^x$ for export production), that is, $loan_t^{nx}(z_i) = \phi^d w_t l_t^{nx}(z_i) + \phi^d w_t f_t^d$ for non-exporter $nx$ and $loan_t^x(z_i) = \phi^d w_t \left(l_t^{xd}(z_i) + f_t^d\right) + \phi^x w_t \left(l_t^{xx}(z_i) + f_t^x\right)$ for exporter $x$. A specification that distinguishes between the working capital requirement of exports and domestic sales is consistent with the empirical evidence documented in Kohn et al. (2016) which shows that exporters face higher working capital needs, reflecting the greater inventory held by exporters and the extended transport period between production and sale. The intra-period loan is repaid at the end of each period and there is no interest.

Because firms may default on their debt repayments, their access to intratemporal loans to use as working capital is restricted by an enforcement constraint:

$$\xi E_t\left(m_{t+1} V_{t+1}^{nx}\left(b_t^{nx}(z_i)\right)\right) \geq \phi^d\left(w_t l_t^d(z_i) + w_t f_t^d\right) \quad \text{for non-exporters,}$$

and
$$\xi E_t\left(m_{t+1} V_{t+1}^{x}\left(b_t^{x}(z_i)\right)\right) + \gamma^{xx} \frac{p_t^{xx}(z_i) y_t^{xx}(z_i)}{P_t} \geq \phi^d\left(w_t l_t^{xd}(z_i) + w_t f_t^d\right) + \phi^x\left(w_t l_t^{xx}(z_i) + w_t f_t^x\right) \quad \text{for exporters.} \tag{14}$$

As in Bergin et al. (2018a), the primary source of collateral available to firms in securing their working capital is the end-of-period firm value, $E_t\left(m_{t+1} V_{t+1}^k\left(b_t^k(z_i)\right)\right)$ , where $m_{t+1} = \beta(1-\lambda) U_{C_{t+1}} / U_{C_t}$ is the discount factor, as the firms are owned by the household.

Equation (14) includes an additional source of collateral for exporters, in the form of a portion, $\gamma^{xx}$, of current export sales: $\frac{p_t^{xx}(z_i)y_t^{xx}(z_i)}{P_t}$. The idea of an additional source of collateral is not new, and it could take a variety of forms. For example, exporters tend to represent more capital-intensive industries, suggesting greater quantity of physical capital to post as collateral.[16] In the context of our model, it is analytically convenient to associate this additional collateral with current period export sales, as it is not double-counted in our primary source of collateral, end-of-period firm value, $E_t\left(m_{t+1}V_{t+1}^k\left(b_t^k(z_i)\right)\right)$. The primary specification of collateral follows Jermann and Quadrini (2009), who regarded current domestic sales as too liquid and divertible. However, Tornell and Westermann (2003) present survey evidence that exporting firms tend to feel that they are less constrained by a shortage of collateral than are non-exporters, and they offer an explanation that export receivables are better collateral for access to foreign credit. We view this specification as a particularly fitting counterpart to our assumption that exporters have greater working capital needs ($\phi^x > \phi^d$): if exporters need trade credit to cover the extended time waiting for shipping and delivery of certain goods, then it seems fitting that firms can pledge part of these physical goods as collateral to secure this trade credit. This specification also receives empirical support from our regressions reported above that included inventories of finished goods. (Sensitivity analysis to follow will compare results of this specification with an alternative that extends the use as collateral to domestic sales.)

### 3.3.2 Firm production and pricing

Each firm produces a unique variety, requiring only one factor, labor:

$$y_t^{nx}(z_i) = A_t z_i l_t^{nx}(z_i), \quad y_t^{xd}(z_i) = A_t z_i l_t^{xd}(z_i), \quad \frac{y_t^{xx}(z_i)}{1-\tau_x} = A_t z_i l_t^{xx}(z_i) \tag{15}$$

[16] Similarly, Manova (2013) suggests that exporters could use the capital represented by their sunk entry cost as a source of collateral. In our model, such interpretations would have a disadvantage, in that this capital is implicitly incorporated in firm value, and we wish to avoid double counting it as a source of collateral.

where $A_t$ is the aggregate productivity common to all firms, $\tau_x$ is the iceberg cost for firms engaged in exports. Firm dividends ($d_t^k(z_i), k = x, nx$) are given by:

$$d_t^{nx}(z_i) = \frac{p_t^{nx}(z_i)y_t^{nx}(z_i)}{P_t} - w_t\left(l_t^{nx}(z_i) + f_t^d\right) - \left(b_{t-1}^{nx}(z_i) - \frac{b_t^{nx}(z_i)}{R_t}\right) \tag{16}$$

$$d_t^x(z_i) = \frac{p_t^{xd}(z_i)y_t^{xd}(z_i)}{P_t} + \frac{p_t^{xx}(z_i)y_t^{xx}(z_i)}{P_t} - w_t\left(l_t^{xd}(z_i) + l_t^{xx}(z_i)\right) - b_{t-1}^x(z_i) + \frac{b_t^x(z_i)}{R_t} - w_t\left(f_t^d + f_t^x\right). \tag{17}$$

A firm with productivity $z_i$ chooses pricing rule, $p_t^k(z_i)$, dividend payout, $d_t^k(z_i)$, and new debt, $b_t^k(z_i)$, to maximize the beginning-of-period firm value ($V_t^k(b_{t-1}(z_i))$):

$$V_t^k\left(b_{t-1}^k(z_i)\right) = \max_{p_t^k(z_i), d_t^k(z_i), b_t^k(z_i)} \left(d_t^k(z_i) + E_t(m_{t+1}V_{t+1}^k\left(b_t^k(z_i)\right)\right), \quad k = nx, x, \tag{18}$$

subject to the enforcement constraint, (Eq. 14), market demand, (Eq. 8 and Eqs. 10-11), production technology (Eq. 15), and cash flow, (Eq. 16 - 17).

The optimization implies the following pricing rules

$$\frac{p_t^{nx}(z_i)}{P_t} = \frac{\sigma}{\sigma-1}\frac{w_t}{A_t z_i}\left(1+\phi^d \mu_t^{nx}(z_i)\right), \qquad \frac{p_t^{xd}(z_i)}{P_t} = \frac{\sigma}{\sigma-1}\frac{w_t}{A_t z_i}\left(1+\phi^d \mu_t^{x}(z_i)\right), \tag{19-20}$$

$$\frac{p_t^{xx}(z_i)}{P_t} = \frac{\sigma}{\sigma-1}\frac{w_t}{A_t z_i}\frac{1+\phi^x \mu_t^x(z_i)}{(1\text{-}\tau_x)\left(1+\gamma_t^{xx}\mu_t^x(z_i)\right)}, \qquad \mu_t^k(z_i) = \frac{1/R_t - E_t m_{t+1}}{\xi_t E_t m_{t+1}} \quad k = nx, x \tag{21-22}$$

where $\mu_t^k(z_i)$ is the Lagrange multiplier associated with the enforcement constraint. From Eq. (22), it can be seen that $\mu_t^{nx} = \mu_t^x = \mu_t$, independent of firm productivity and export activity. $\mu_t$ is the shadow price of the intra-period loan on firm value, and measures the relative cost of bond financing ($R_t$) to equity financing ($1/E_t m_{t+1}$), adjusted by the financial market condition ($\xi_t$). Additionally, given $R = 1 + r(1\text{-}\tau)$ and $m = \frac{1}{1+r}$, Eq. (22) shows that, in steady state it is always the case that $\mu > 0$ (the constraint is binding), as firms prefer bond financing, which is cheaper due to its tax advantage.

### 3.4 The entry condition for the marginal firm

The existence of the one-time sunk production cost, $K_t^E$, paid after the productivity level is known implies the following entry condition, where only firms whose values net of entry cost are non-negative will produce for the domestic market:[17]

$$\frac{p_t^{nx}(z_d)y_t^{nx}(z_d)}{P_t} - w_t\left(l_t^{nx}(z_d) + f_t^d\right) + \frac{b_t^{nx}(z_d)}{R_t} + E_t(m_{t+1}V_{t+1}^{nx}\left(b_t^{nx}(z_d)\right) - K_t^E = 0 \,. \tag{23}$$

The term $E_t(m_{t+1}V_{t+1}^{nx}\left(b_t^{nx}(z_d)\right)$ represents the end-of-period firm value, and the three preceding terms compute dividends paid in the initial period, so together they represent beginning-of-period firm value, for comparison with the sunk entry cost, the last term.

An additional one-time sunk export entry cost, $K_t^{EX}$ implies a marginal exporter for which the profit earned from the foreign market plus the additional value of bond and equity issuance for being an exporter must equal the sunk export entry cost,

$$\left(\frac{p_t^{xx}(z_x)y_t^{xx}(z_x)}{P_t} - w_t l_t^{xx}(z_x)\right) - w_t f_t^x + \frac{b_t^x(z_x) - b_t^{nx}(z_x)}{R_t} + \left(q_t^x(z_x) - q_t^{nx}(z_x)\right) = K_t^{EX} \,. \tag{24}$$

These entry conditions with the financial enforcement constraint generate the cut-off productivity levels, $z_d$ and $z_x$, for being a non-exporter and an exporter, respectively.

### 3.5 Aggregation and equilibrium

We close the model with market clearing conditions for the labor and goods markets, and imposing balanced trade. For the small open economy, $P^{x*}$ and $P^*$ are exogenous. We normalize $P^{x*}=1$, and calibrate $P^*$ below. See Appendix Table 1.1 in the online appendix for the full list of equilibrium conditions in steady state.

We follow the aggregation in Melitz (2003), as we likewise study only the steady state

[17] In general, the value function could include the possibility that a firm might become an exporter in the future. However, given that we study only the steady state in which there are no aggregate shocks, and in which firm productivity draws are fixed (and in which there is an additional sunk cost for exporting), we can conclude that the marginal entrant will not be an exporter, but only produce for the domestic market.

of the model, which greatly simplifies aggregation.[18] As in Melitz (2003), steady state implies an aggregate stability condition in which the mass $p_{in}M_e$ of successful new entrants must exactly replace the mass $\lambda M$ of dying incumbents: $p_{in}M_e = \lambda M$. With this aggregate stability condition, the equilibrium distribution of productivity $\left[z_d, \infty\right)$ will remain unchanged.[19]

For the numerical analysis firms' idiosyncratic productivity follows a Pareto distribution with a cumulative distribution function (CDF) of $G(z)$ where $G(z) = 1 - z^{-\theta}$. Correspondingly, the probability density function (pdf) would be that $g(z) = \theta z^{-\theta-1}$. Using the pricing rule, Eq. (4), as in Melitz (2003), we can define the average productivity level for all home producing firms, $\tilde{z}_t$, the average productivity level for the non-exporters, $\tilde{z}_t^{nx}$, and the average productivity level for the exporters, $\tilde{z}_t^{x}$, as follows, respectively,

$$\tilde{z}_t = \left( \frac{1}{1\text{-}G(z_{dt})} \int_{z_{dt}}^{\infty} z_i^{\sigma-1} dG(z_i) \right)^{\frac{1}{\sigma-1}}, \quad \tilde{z}_t^{nx} = \left( \frac{1}{G(z_{dt}) - G(z_{xt})} \int_{z_{dt}}^{z_{xt}} z_i^{\sigma-1} dG(z_i) \right)^{\frac{1}{\sigma-1}}, \quad \tilde{z}_t^{x} = \left( \frac{1}{1 - G(z_{xt})} \int_{z_{xt}}^{\infty} z_i^{\sigma-1} dG(z_i) \right)^{\frac{1}{\sigma-1}} \quad (25\text{-}27)$$

## 4. Quantitative Analysis of the Leverage Ratio

This section presents quantitative results. The first part explains our parameterization. The second part demonstrates that the parameterized model can replicate the facts from the empirical section, and the third part uses sensitivity analysis to explore the mechanism. The last section interprets the economic significance of the mechanism.

### 4.1 Parameter values

Values for some trade-related parameters are taken from the trade literature. Following

[18] Simplification due to steady state analysis is especially helpful in the case of our model, where multiple sunk costs imply potentially complex dynamics involving option value and effects of firm history that prevent aggregation by simply integrating over the exogenous productivity distribution.

[19] It can be shown that in steady state this aggregate stability condition is consistent with Eq. (9), the establishment dynamics in the domestic market.

Ghironi and Melitz (2005), the Pareto distribution parameter and substitution elasticity are set at $\theta = 3.8$ and $\sigma = 3.8$, respectively. Following Bergin et al. (2018b), the iceberg trade cost is set at $\tau_x = 0.16$. The benchmark version of the model initially sets the fixed cost of exporting $f^x = 0$, based on the empirical finding in Das et al. (2007), though we also present an alternative calibration with $f^x > 0$.[20] The sunk cost of domestic firm entry is normalized ($K^E = 1$), as its absolute level does not affect the model implications for the ratios reported below. We follow trade literature in setting the rest of world income at 5 times that of the small open economy ($Y^* = 5Y$, see Feenstra et al., 2018).

Values for some trade-related parameters are chosen to match key cross-sectional firm characteristics from the firm dynamics and trade literature. The sunk cost of exporting, $K^{EX} = 0.478$, is set so that 25.5% of firms participate in exporting, taken from Ruhl and Willis (2017). (In the data set used for our empirical motivation, a similar value of 23.9% of firms have foreign income in a given year.) To match their corresponding finding that the share of exports in total sales of exporters is 13%, we set the value of $P^* = 0.198$.

It is reassuring that key cross-sectional implications of the model not directly targeted in the calibration match cross-sectional facts in the literature. For example, the ratio of sunk export cost to median firm sales (where the median firm is a non-exporter) takes the value 2.4 in our benchmark calibration, which is comparable to the approximately 3.0 implied by estimates in Das et al. (2007).[21] These values are higher than the ratio of sunk cost to median firm sales reported in Ruhl and Willis (2017), either for their sunk cost model or their extended model (0.96 and 0.59, respectively), but we will consider an

[20] Table 1 of Das et al. (2007) finds a low and statistically insignificant value for the fixed cost of exporting, in contrast with larger and statistically significant value of the sunk cost. The authors conclude: "The means of the posterior fixed cost ($\gamma_F$) distributions are very close to zero for all three sectors, and variances of these distributions are sufficiently large to imply that these costs, on average, are negligible." (p. 854)

[21] Reading from figure 3 in Das et al. (2007), for the basic chemicals sector the median plant profit is approximately 2 mil. 1986 pesos, while the sunk cost estimate is around 60 mil 1986 pesos in figure 1. Given that the elasticity used in table 1 is 12, this implies that the ratio of sunk cost to sales is 60/(11*2) = 2.7. For knitting mills the corresponding ratio is 61/(9*2) = 3.4. Taking an average of these two sectors indicates an average ratio around 3.

alternative calibration of sunk and fixed costs from Ruhl and Willis (2017), which demonstrates that our main result is robust.

Another standard cross-sectional fact is the average size of exporters to non-exporters. While Das et al. (2007) does not report a value for the "exporter size premium" Ruhl and Willis (2017) does, finding the ratio of the geometric mean of exporter size to the geometric mean of non-exporter of 3.68 (in terms of domestic sales). The corresponding ratio of geometric means in our benchmark model simulation is very similar, also 3.68, and the corresponding value in the dataset used in our empirical work is 4.0.

Regarding parameters related to firm financing, some values we take directly from the finance literature. We follow Jermann and Quadrini (2012) to set the tax benefit parameter at $\tau = 0.35$, which differentiates debt from equity financing. The exogenous death shock probability is set to $\lambda = 0.005$.[22] We adopt the values of working capital requirements for domestic and export productions from Kohn et al. (2016) by setting $\phi^d = 0.53$, and $\phi^x = 1$. Sensitivity analysis will consider other values.

Other financial parameters are set to match the cross-sectional implications of the model to facts from our firm finance data set. The enforcement constraint parameter, $\xi = 0.07$, is set to match the average ratio of debt to total assets for all firms in our firm-level data.[23] Similarly, we choose the exporter enforcement constraint parameter, $\gamma^{xx} = 0.283$, to match the average in our firm level data for exporters' ratio of debt to total assets. Sensitivity analysis to follow will demonstrate the effect of alternative values. The fixed cost of production, $f^d = 0.00073$, is set to match the range in debt ratio to total assets

[22] This value is taken from Atkeson and Burstein (2010), who match the average annual employment-based failure rate of U.S. firms with more than 500 employees, 1997-2002.

[23] This is nearly equivalent to how Kohn et al. (2016) set their enforcement constraint parameter to match the ratio of debt to collateral in their data, and it is similar to how Jermann and Quadrini (2012) choose their corresponding parameter value, producing a steady state ratio of aggregate debt over GDP which matches aggregate data.

for non-exporting firms.[24]

Values for standard macro parameters are taken directly from the macro literature. The weight of the disutility of labor is set at $\kappa = 3.409$. The inverse of the labor supply elasticity is set at $\psi = 0.5$, following Hall (2009). We set $\beta = 0.96$ to coincide with an annual frequency. Risk aversion is set at $\rho = 2$ (Arellano et al., 2012).

### 4.2 Benchmark results

This section uses numerical solution to demonstrate that the model can replicate the facts uncovered in the empirical section. The main objective is to generate a cross-sectional distribution of leverage ratios among firms that is consistent with the empirical finding that exporters have higher leverage ratios than non-exporters. Given that the empirical fact was based upon leverage ratios as averages over time, our strategy is to solve numerically for the steady state of the model, which gives a stationary distribution of leverage ratios.

Figure 1 plots the cross-sectional distribution across firms for key variables. The top left panel shows that firm sales grow exponentially with the firm productivity index, with a jump at the productivity cutoff for the marginal exporter.[25] The rest of the panels plot the cross section of financial variables against the log level of real firm sales (domestic plus exports) rather than against productivity index, as this facilitates comparison with our empirical results, where regressions used the log of real sales as a regressor. Firm profits and firm value grow nearly linearly in firm sales (all in logs). While equity and bond issues

[24] The calibrated value of $f^d$ implies in the benchmark model solution that fixed costs represent 0.81% of median firm sales. While there is not clear guidance in the trade literature regarding this parameter, Atkeson and Burstein (2010) choose a larger value (10% of the sunk cost). We are unable to fully adopt this calibration, as it implies large negative leverage ratios for small firms. Nonetheless, robustness experiments to follow will show that raising $f^d$ serves to strengthen our mechanism.

[25] In simulations, non-exporters cover the productivity range $[z_d, z_x)$ and exporters the productivity range to $[z_x, \infty)$. Since there is no finite upper bound on the distribution of productivities and sales for exporters, figures necessarily do not report the full range of exporters. The full range of sales for exporters is used when reporting statistics on the average leverage ratios among firms in the simulation, and for regressions on simulated data a random sampling of 200 firms from the full Pareto distribution is taken.

both grow in firm size, bond issue grows more quickly. As a result, the ratio of bond to equity ($b(z_i)/q(z_i)$) and the total leverage ratio, defined as $\frac{loan(z_i)+b(z_i)}{q(z_i)+loan(z_i)+b(z_i)}$, grow in firm size. So the model reflects the first of our two key empirical findings: larger firms have higher leverage ratios.

The leverage ratio exhibits concavity when plotted against log sales. This arises, of course, in part from the upper bound of 1 on the ratio of $\frac{loan(z_i)+b(z_i)}{q(z_i)+loan(z_i)+b(z_i)}$; however concavity is present even in the $b(z_i)/q(z_i)$ ratio which has no upper bound. The reason is that the fixed cost, which is shown in experiments below to be the source of positive slope of leverage in firm size, becomes a smaller share of firm value as firm size grows. See online Appendix 2 for analytical results detailing how fixed cost determines the rise of leverage ratio with firm size.

Another notable feature is that the leverage ratio jumps discontinuously for the marginal exporter. Given that leverage is plotted against firm size, it is easy to verify visually that this jump in leverage is greater than that which would occur just due to the larger size of exporting firms. This too reflects our empirical finding, that exporting firms tend to have leverage ratios higher than non-exporting firms in terms of long-term debt, even after controlling for firm size.

One way to gauge the model's success is its ability to match key sample averages for our data set: the ratio of average leverage of exporters to non-exporters equals 1.073 in the simulation, compared to our empirical value of 1.062. In addition, a simple cross–sectional regression on the simulated data confirms that our model can replicate the two main findings from the empirical section. We collect the set of leverage ratios for the full sample of firms in the simulation, and regress these data on the log of real sales for each firm as a measure of firm size, as well as on an indicator of whether the firm is an exporter. The coefficient on firm size is 0.0115, which is very close to the value from the empirical regression, 0.0118, reflecting the empirical finding that leverage rises with size. This outcome is not surprising, as it reflects the fact that we calibrated the fixed cost of production to match this empirical implication. The regression coefficient for the effect of export status on leverage is 0.0117 which is positive, though somewhat smaller than the value 0.0158 reported in Table 2 for actual data.

### 4.3 Exploring the mechanism and sensitivity analysis

In this section we explore through sensitivity analysis the main mechanism driving the result for leverage ratios. The essence of the capital structure choice is the tradeoff firms face between the benefits of equity versus bond issuance, when allocating overall firm value into these two components: bonds have the advantage of tax breaks, while equity provides collateral that relaxes the working capital constraint.

The presence of fixed costs of production in the working capital constraint implies that this tradeoff differs for firms of different size. Profits and hence overall firm value grow in proportion to the size of a firm's sales; however, the need for working capital grows less than proportionally with sales due to the fixed component. As a result, a larger firm can allocate a smaller fraction of firm value to equity to secure the working capital needed for production, and can allocate a larger share of firm value to bonds to reap the tax benefits. This mechanism helps explain higher leverage ratios for exporters: like the rest of the trade literature with heterogeneous firms and free entry, our model implies that exporting firms systematically tend to be more productive and larger, since only firms with sufficiently high productivity can afford to pay the one-time sunk cost of export entry.

The essential role in our mechanism played by the domestic fixed cost component is easily seen in panel 1 of Figure 2, which compares the leverage ratio from the benchmark calibration to that under the calibration where the fixed cost is eliminated ( $f^d$ =0). In the latter case, the leverage ratio among all non-exporters is uniform regardless of size, and similarly among all exporters. Within each group the uniform leverage ratio equals the value that would be the limit for large firms in that group. This implies that the presence of a fixed cost has a larger impact lowering the leverage ratio for small firms compared to large firms. This is because a fixed cost of a given size is larger relative to a small firm value, so the needs for working capital to finance the fixed production costs are large relative to firm value. For these small firms, a larger share of firm value needs to take the form of equity, rather than long-term bonds, to be used as collateral to secure these working capital loans. In sum, the presence of fixed costs implies a leverage ratio profile that starts lower for small firms, but rises with firm size. Under $f^d$ =0, the model loses most of its ability to replicate the empirical finding of higher average leverage of exporters: the ratio of average leverage of exporters to non-exporters falls to 1.012 -- still larger than unity, but smaller than the value of the benchmark calibration (1.073) or the empirical value (1.062).While it is a fundamental fact in corporate finance that larger firms tend to be more leveraged, no paper to our knowledge, either in trade or corporate finance, has used the presence of fixed costs as an explanation for this result.

Further enlarging the domestic fixed cost, without other change in parameter values of the benchmark setting, serves to strengthen our mechanism. The highest we are able to raise $f^d$ without implying negative leverage ratios for small firms implies fixed costs that are 4.8% of median firm sales. This calibration greatly amplifies the effect of firm size, so that the ratio of average leverage of exporters to non-exporters rises to 2.07. While impressive, this value exceeds the empirical fact we aim to explain.

Panel 2 of Figure 2 shows that including an additional fixed costs specific to export, of the same magnitude as domestic fixed cost ( $f^x = f^d$ ), implies the distribution of leverage across exporters has a lower starting point relative to the benchmark case, but that it has a steeper slope. The lower starting point, a drop in long-term leverage for the marginal exporter relative to a non-exporter of the closest size, results from the fact that additional needs for short-term working capital lower optimal leverage, as firms seek equity collateral to relax the short-term financial constraint. The steeper slope, a faster rise in leverage with firm size, comes from the fact that the export fixed cost, like the domestic fixed cost, becomes a smaller share of overall firm value for firms with larger sales. The effects of the lower starting level and steeper slope nearly cancel each other in this calibration, as the average leverage ratio of exporters is 1.061 that of non-exporters, a value only slightly reduced from the value in the benchmark calibration, and virtually equal to the ratio derived from the empirical sample.

Recall that an implication of our empirical finding is that while two-thirds of the higher leverage ratio of exporters is due to their larger size, the remaining one-third exists even after controlling for firm size. The calibrated model attributes the latter part of the empirical result to the parameter $\gamma^{xx}$, representing additional sources of collateral available to exporters not available to non-exporters. The logic is related to that of the size effect above. If exporters have additional sources of collateral, this would tend to reduce their reliance on equity for collateral, freeing them to respond to tax incentives to allocate a larger share of firm value to bonds rather than equity, hence a higher leverage ratio.

Panel 3 of Figure 2 indicates that the ability of the model to replicate this aspect of our empirical finding depends upon the ability to post export shipments as collateral ($\gamma^{xx}>0$). The solid line in panel 3 shows that when exporters have no special source of collateral ($\gamma^{xx}=0$), exporters all have a lower leverage ratio than non-exporters (the ratio of the average exporter leverage to non-exporter is 0.937). This results from the fact that the benchmark calibration implies exporters have greater needs for working capital ($\phi^{x}>\phi^{d}$), so they choose more equity as a share of firm value to secure the necessary working capital.

Even more informative is the dot-dashed line, which shows the case where exporters have neither special sources of collateral ($\gamma^{xx}=0$) nor special needs for working capital ($\phi^{x}=\phi^{d}$), compared to non-exporters. It now becomes clear that all exporters and non-exporters alike lie on the same curve: leverage rises in a concave fashion with firm sales alone; exporters have higher leverage just because they have more sales. The ratio of average exporter leverage to non-exporters is 1.060, which is lower than the empirical ratio. This shows that the model can explain the majority of exporter leverage with a standard trade model specification, without appealing to a special, additional source of exporter collateral. But without such an extra source of collateral, the best the model can do is place the exporters on the same leverage-size curve as non-exporters, not above it as implied by the regressions results.[26]

Panel 4 complements panel 3 by showing the case where a portion of domestic sales can be used as collateral, analogous to how export sales were used in the benchmark model. We augment the collateral constraint in equation (14) for non-exporters by adding $\gamma^{d}\frac{p_t^{nx}(z_i)y_t^{nx}(z_i)}{P_t}$, and for exporters by adding $\gamma^{d}\frac{p_t^{xd}(z_j)y_t^{xd}(z_i)}{P_t}$ as the additional collateral. The parameter $\gamma^{d}$ controls the share of domestic sales that can be used as collateral, and it is calibrated to the same value used for exports in the benchmark model ($\gamma^{d}=\gamma^{xx}$). The figure shows that use of domestic sales for collateral raises optimal leverage for all firms. But by putting domestic sales on equal footing with export sales, it eliminates the distinction between exporters and non-exporters that generated the positive jump in leverage for the

[26] We also experimented with a model specification that replaced exports sales with the sunk entry cost as collateral for exporters in equation (14). In addition to the disadvantage of double counting of collateral already included in firm equity (see discussion in section 3.3.1), this specification also implied that the benefit of export status is stronger for smaller exporters near the export margin, and becomes inconsequential for large exporters. It thus inverts the logic of the fixed costs in the working capital constraint, and hence negates the contribution of size to higher leverage among exporters.

marginal exporter in the benchmark model. As a result, it limits the ability of the model to explain the second empirical finding. It also dilutes the effect of size on leverage, which contributes to the ability of the model to explain the first empirical finding, how the larger size of exporters contributes to their higher leverage. Overall, as is clear in Figure 2 panel 4, the model no longer is consistent with the empirical finding that the average leverage of exporters is greater than that of non-exporters. The ratio of leverage for exporters to non-exporters is only 0.955. Experiments indicate an upper bound of $\gamma^{d} = 0.395 * \gamma^{xx}$ at which exporters cease to have a higher leverage ratio than non-exporters.

Panel 5 of Figure 2 shows results for an alternative calibration, based on Ruhl and Willis (2017), which emphasizes the role of repeated fixed export costs as a barrier to entry rather than a one-time sunk cost. We calibrate to the estimations in Ruhl and Willis (2017) by setting the ratio of fixed to sunk costs to be 1:10, when converted to final goods units.[27] We set the sunk cost to imply that 25.5% of firms export (also from Ruhl and Willis, 2017), implying $K^{EX} = 0.0998$ and $f^{x} = 0.0045$ (given that the steady state wage rate is 2.2). As a check, we note that the steady state solution implies that the ratio of sunk export cost to median firm sales is 0.502, which is close to the value of 0.590 estimated in Ruhl and Willis (2017). We then implement the calibration logic used in our benchmark model, choosing $\gamma^{xx}$ to match the average leverage ratio of exporters, implying a value of $\gamma^{xx} =$ 0.395 rather than 0.283 in the benchmark model. All other parameters remain unchanged.

The results shown in Panel 5 bear similarity to Panel 2, the other case with the $f^{x} > 0$: a positive fixed export cost shifts downward the leverage ratio of the marginal exporter relative to non-exporters, but it also raises the slope of the leverage ratio line with larger firm size. But in contrast with panel 2, the higher value of $\gamma^{xx}$ in panel 5 moderates the

[27] This ratio is taken from Table 4 of Ruhl and Willis (2017), from the row for their "extended model," which was Ruhl's concluding case with small sunk cost. In the table, the estimated value for sunk cost is 0.590 and that for fixed cost is 0.057, both measured as a fraction of median plant's sales.

downward shift in the curve for the marginal firm, so that the higher slope dominates and implies that the average leverage ratio among exporters is higher than that of non-exporters (with a ratio 1.063), thus replicating our empirical finding.[28]

### 4.4 Interpreting the mechanism for firms' financing strategy

We conclude this discussion of our main result by interpreting its implications for the tradeoff firms face between short-term and long-term debt. Given that the fixed cost implies the need for working capital grows less than proportionately with firm sales and hence firm value, one might have conjectured that a large firm would take advantage of this position to enjoy the benefit of a looser working capital constraint and scale up production closer to the unconstrained optimal level. One might even imagine that a sufficiently large firm would have enough firm value that the working capital constraint would no longer bind. But our main result shows that this will not occur; instead large and financially strong firms choose to reduce the share of equity in firm value, and thereby not relax the working capital constraint.

The underlying reason for the choice not to loosen the working capital constraint can be seen in the Euler equation arising from the capital structure optimality problem (Eq. 22), which indicates in steady state that $\xi\mu = (1/R - m)/m$. In this equation $\mu$ is the Lagrange multiplier on the working capital constraint and measures the degree of tightness, and it is common to all firms. Literally, it is the shadow value of one unit of equity as collateral, by relaxing the working capital constraint and allowing higher production and profits. So, multiplied by the collateral share parameter, $\xi$, the left-hand side of the Euler equation

[28] Additional experiments show that lowering the sunk export cost value tends to strengthen our model's main mechanism. If we lower $K^{EX}$ from 0.478 to 0.2, without other change in parameter values of the benchmark setting, the ratio of average leverage for exporters to that of non-exporters rises, from 1.073 in the benchmark model to 1.0895. The reason is that average leverage of non-exporters falls more than for exporters, because lower sunk cost allows more firms to export, reducing the average size and hence leverage of non-exporters.

measures the shadow value of one unit of equity as collateral. The right-hand side of the equation is the difference between the return on bonds and the household discount factor, which represents the tax benefit of bonds over equity. Of course, in a more standard model setting with no distinction between bonds and equity in terms of collateral value of equity or tax benefit of bonds, the Euler equation would require the interest rate equal the reciprocal of the stochastic discount factor; but in our setting the difference is the tax benefit of bonds. Note that in our model this difference on the right-hand side of the equation is constant for all firm productivity indexes, as it is determined by the marginal utilities of the households that supply both debt and equity financing. This implies that the tightness of the short-term borrowing constraint on the left-hand side of the equation is the same for all firms, regardless of size or export status.

This Euler condition is fundamental for generating our leverage ratio result. If one were to consider firms progressively higher in the productivity and size distribution, while hypothetically keeping capital structure fixed, the fixed cost component in working capital would imply that the working capital constraint becomes looser. But the Euler equation indicates it is not optimal for firms to let this outcome stand, but mandates an adjustment in capital structure to lower the share of equity relative to sales and hence firm value, which implies an increase in tightness of the working capital constraint to the same level as for all other firms. In other words, as firm size grows, the marginal benefit of equity as collateral falls, but the marginal cost in terms of lost tax benefits is constant.

## 5. Financial frictions as a barrier to exporter entry

This section discusses how endogenous capital structure alters the manner in which a standard financial constraint poses a barrier to export entry. Rather than constraining the scale of export sales and hence reducing the benefit of exporting, it tends to discourage entry by making it more difficult to finance the sunk cost of entry.

Consider an experiment in which policy aims to encourage exporting by mandating a lower collateral requirement for export activtiy (lower $\phi^x$ in our model). Figure 3 plots cross-sectional distributions for three values of $\phi^x$, ranging from the benchmark calibration of $\phi^x = 1$ down to the value applicable for domestic sales ($\phi^x = \phi^d = 0.53$). Panel 1 shows that as exporter working capital requirement is reduced, the average leverage ratio for exporting firms rises 13.6% (from 0.449 to 0.510). Exporting firms choose to trade away the benefit of a looser short-term working capital constraint in order to reap the tax benefits of more long-term debt.

Panels 2 and 3 show small effects of the policy on firm sales. While the figure plots three different lines for the three different values of $\phi^x$, these lines are nearly indistinguishable for total firm sales (exports plus domestic sales), and very close together for firm export sales. To be precise, if we track an individual firm that exports under all three cases (firm with productivity $z$ = 2.1867), the nearly halving in $\phi^x$ from 1 to 0.53 induces a rise in total sales by only 0.34%, and a rise in real export sales by 8.26%. Regarding economy-wide aggregates, overall exports and the number of exporting firms ($N^x$) both rise 11.2%. The changes in aggregate production and consumption are small, with aggregate production and consumption both rising just 0.01%.

One lesson from these simulation results is that lowering working capital requirements for exports in our model has large effects on firm capital structure but rather small effects on firm-level production. This conclusion is very similar to the finding in Jermann and Quadrini (2012) and Bergin et al. (2018a) for the case of a loosened working capital constraint due to a rise in the collateral value of assets ($\xi$ in our model). As explained in those papers, when firms are able to adjust the mix of debt and equity, it is optimal to alter the level of equity to nearly completely offset the change in its collateral value, thus nearly completely insulating the firm's ability to procure working capital and carry on production. The same logic applies here to a lower $\phi^x$ that otherwise would loosen the working capital constraint of exporters. There is still some effect raising firm exports, due to firms substituting between domestic sales and exports, given the lower relative financial cost, as emphasized in Kohn et al. (2016).

We are not able to run a counterfactual exercise by simulating a version of the model that excludes endogenous capital structure, as our use of the aggregation strategy of Melitz (2003) to deal with the distribution of heterogeneous firms depends upon this.[29] But one way to formulate a partial equilibrium counterfactual is to examine the working capital constraint when such capital structure adjustment is ruled out. Put simply, consider (14) with a fall in $\phi^x$, holding all else constant other than financing for export sales -- that is, $\phi^x w\, l^{xx}$. (In particular, rule out changes in equity value on the left hand side which could result from capital structure adjustment. One must hold constant domestic production, price and wage, as well as abstract from potential collateral value of export sales and export fixed costs by setting $\gamma^{xx}$=0, $f^x$=0). In this artificial case it becomes clear that a 47% reduction in $\phi^x$ from 1 to 0.53 requires an exactly offsetting reduction in labor costs expended on export production of 47%. The rise in firm export value by 8.26% for the survivor in our experiment with endogenous capital structure is clearly much smaller.

A second lesson from these quantitative results is that the rise in exports occurs at the extensive margin rather than the intensive margin, the average sales per firm.[30] Action

[29] Heterogeneous values of $\mu$ in addition to heterogeneous productivity in the pricing and output decisions would invalidate the Pareto distribution that permits analytical aggregation.
[30] If we run this experiment in an alternative version of our model that exogenously holds constant the share of exporting firms, by fixing the margins of domestic and export entry, the fall in aggregates exports is a similar 10.5%, but this occurs all at the intensive margin rather than extensive margin.

primarily at the extensive margin is consistent with the mechanism discussed in Bergin et al. (2018a) that links capital structure to entry, and which can be summarized in the present context by noting that capital structure directly affects firm value, and firm value comprises one side of the export entry equation (24). Intuitively, if one dollar of additional debt is issued to retire equity, that is, reallocated between the equity and bond components of equation (24), this capital restructuring lowers equity value by less than a dollar. The capital structure response raises firm value, the sum of equity plus debt, meaning that the range of firms has expanded that have firm value sufficient to justify export entry.

We conclude by briefly considering implications of our mechanism for a trade liberalization. Suppose a reduction in iceberg trade cost ( $\tau_x$ ) from the benchmark calibration of 0.16 to 0.10. Simulations indicate that aggregate trade rises at the extensive margin, with the value of aggregate trade and the number of exporters both rising 8.7%. The effect on the leverage ratio of exporters is minimal, rising only by 0.024 percent, reflecting a small fall in working capital needs to cover trade costs. The result differs from Kohn et al. (2016), which finds that a similar working capital financial constraint limits the expansion of trade at the extensive margin because new entrants have insufficient collateral to reap the benefits of scale. Our financial setup differs in two respects. First, firms can generate additional collateral by capital restructuring. And second, collateral takes the form of firm equity, the value of which rises automatically in response to changes in expectations for future export opportunities. The fact that capital structure does not need to adjust in our simulation indicates it is the latter mechanism that explains our large extensive margin response in steady state.

## 6. Conclusions

This paper adds to the literature studying the impact of finance on trade by studying the capital structure decision of exporters. We contribute a new empirical finding that exporters tend to be more leveraged than non-exporters in terms of long-term debt, as distinct from short-term debt. We contribute theoretically by showing how to marry a corporate finance model of capital structure, featuring an endogenous choice between equity and long-term debt, with a trade model featuring heterogeneous firms and export entry.

A lesson is that when capital structure is endogenous, it is generally optimal for firms to adjust the level of equity collateral to nearly fully offset any changes in the tightness of the short-term financial constraint. One implication is that larger firms that are financially stronger and have easier access to working capital should not use this advantage to reap the benefit of a relaxed working capital constraint by scaling up production closer to the unconstrained optimal; they instead should increase long-term leverage to cash in on its tax benefits, leaving the tightness of the working capital constraint unchanged. A second implication is that even if exporters tend to face higher working capital needs than non-exporters, optimal capital structure will adjust to augment equity collateral, thereby relaxing the tightness of the short-term financial constraint to be the same as non-exporters.

In general, we believe it is important for the literature to take into consideration how firm leverage is the endogenous product of an optimizing decision, and to consider the tradeoffs firms face between competing short-term and long-term financing needs. We show that this tradeoff has implications for steady state firm capital structure; future work may find it fruitful to explore its implications for the dynamics of firms' responses.

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Table 1. Summary Statistics

| | (1) total sample | (2) not exporting | (3) exporting | (4) newly exporting | (5) continuing exporting |
|---|---|---|---|---|---|
| means: | | | | | |
| log of size | 4.793 | 4.221 | 6.609 | 5.897 | 6.797 |
| Book Leverage ratio | 0.425 | 0.419 | 0.445 | 0.448 | 0.445 |
| Short-term borrowing to total assets | 0.054 | 0.055 | 0.047 | 0.046 | 0.047 |
| Long-term debt to total assets | 0.152 | 0.150 | 0.161 | 0.160 | 0.161 |
| Debt in current liabilities to total assets | 0.057 | 0.061 | 0.043 | 0.047 | 0.042 |
| Book debt minus short-term borrowing to total assets | 0.358 | 0.351 | 0.391 | 0.383 | 0.394 |
| standard deviation of size (within) | 0.855 | 0.810 | 0.554 | 0.504 | 0.517 |
| Observations | 74830 | 56909 | 17921 | 3738 | 14183 |

Note: we drop firms appearing only once in the sample.

Table 2: Panel Regressions

| | (1) Book Leverage ratio | (2) Short-term borrowing to total assets | (3) Long-term debt to total assets | (4) Debt in current liabilities to total assets | (5) Book debt minus short-term borrowing to total assets |
|---|---|---|---|---|---|
| Size | 0.0118*** | 0.00249 | 0.0132*** | 0.00124*** | 0.00797*** |
| | (0.000746) | (0.00189) | (0.000621) | (0.000358) | (0.00221) |
| Exporter | 0.0158*** | -0.00432 | 0.00473** | 0.00255* | 0.0219*** |
| | (0.00217) | (0.00467) | (0.00181) | (0.00104) | (0.00545) |
| N | 74641 | 24842 | 74618 | 74619 | 24842 |
| $R^2$ | 0.0464 | 0.0113 | 0.0465 | 0.0086 | 0.0584 |

Standard errors in parentheses. *** indicates statistical significance at the 1% level, ** 5%, and * 10%.

Figure 1. Benchmark model
cross-sectional distributions across firms

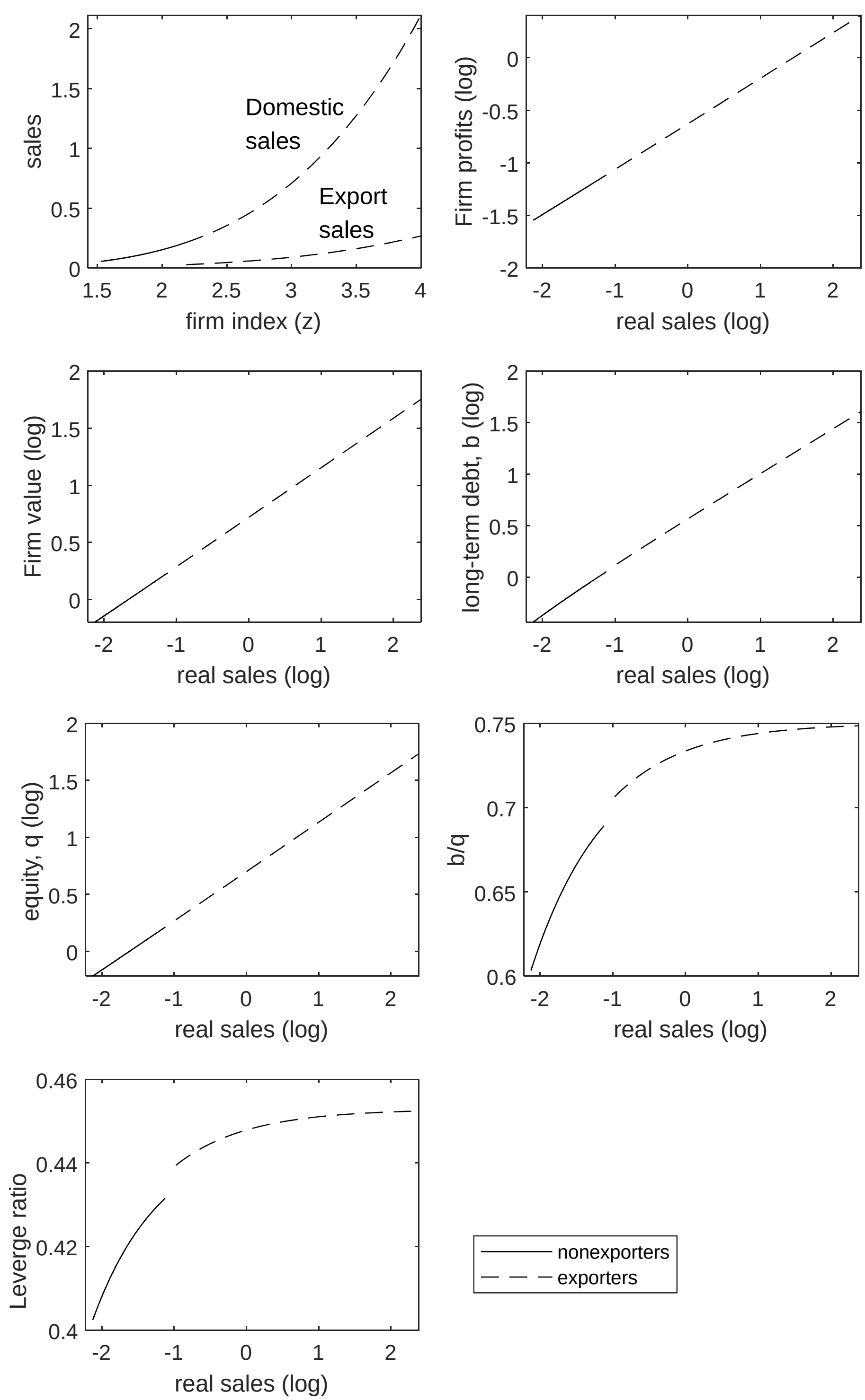


Figure 2: Sensitivity and Robustness:

Leverage ratio cross-sections for alternative model calibrations

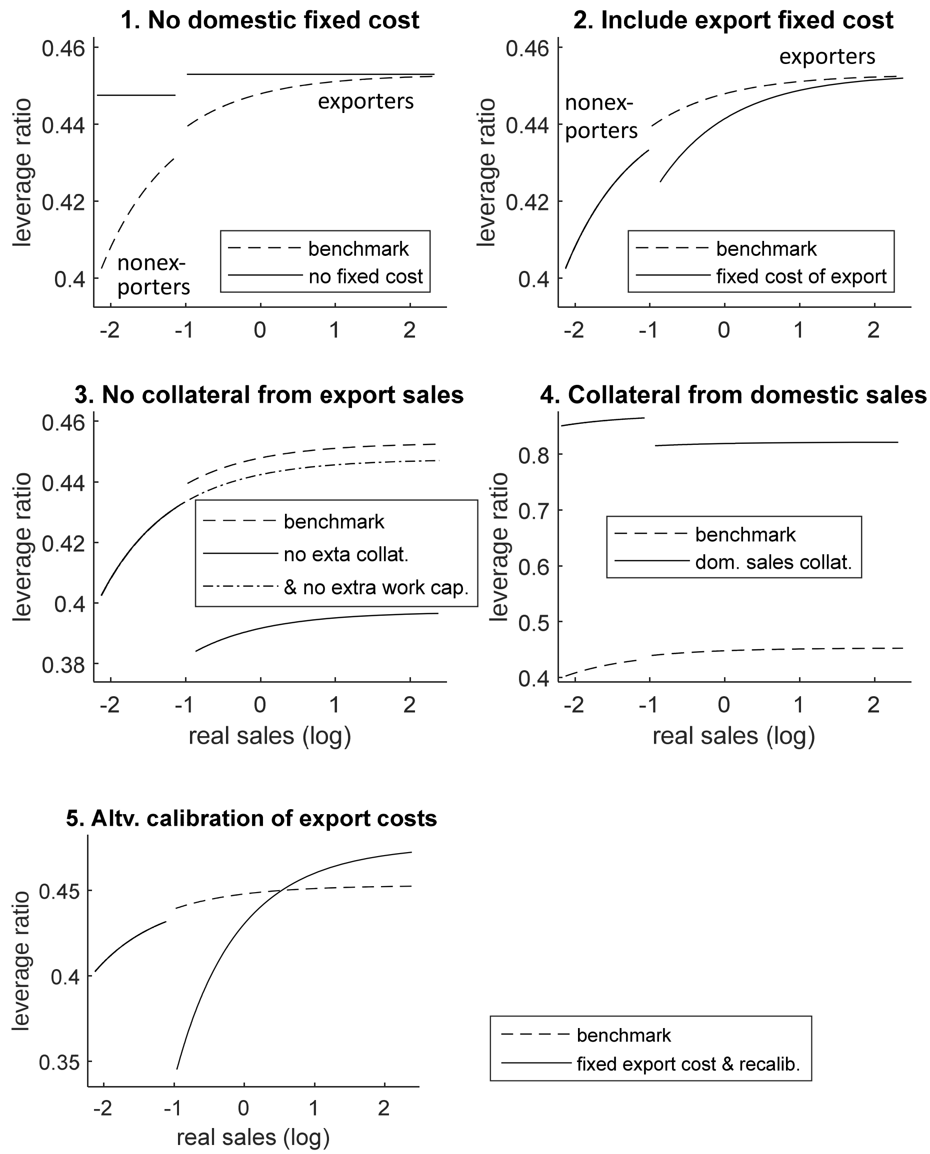
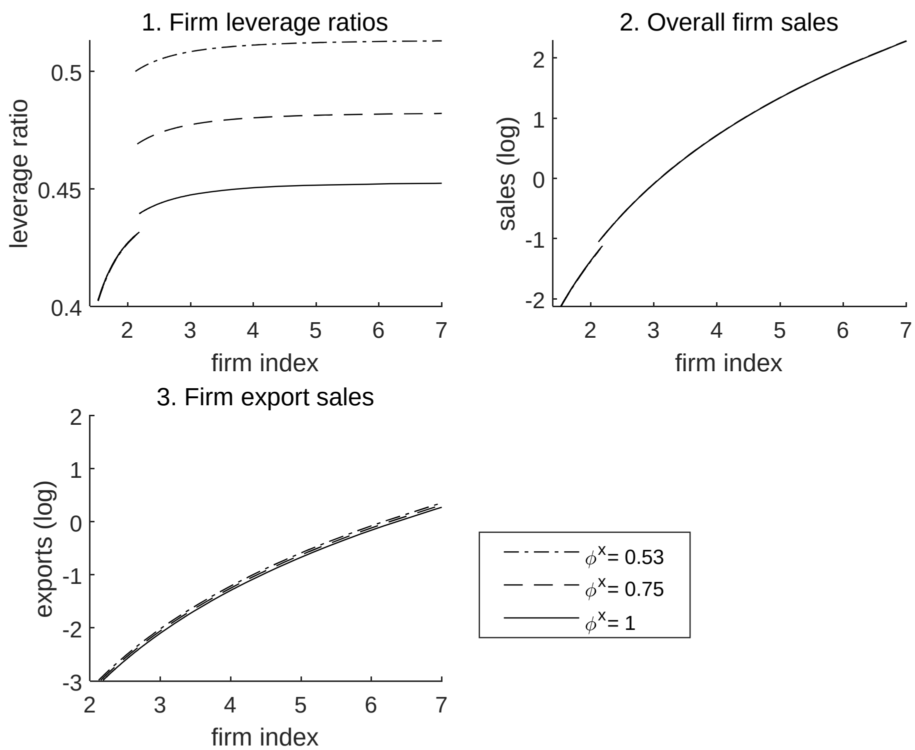


Figure 3: Alternative working capital requirements for exporters ($\phi^x$)



To be included as

**Supplementary Online Appendix for**

**"Trade and Firm Financing," by Bergin, Feng and Lin**

## Appendix 1: Full list of model equations and calibration

Appendix Table 1.1 Steady state model equations

| Equations: 66 | Variables: 66 |
|---|---|
| 1. Households<br>1) $C^{-\rho}w = \kappa L^{\psi}$<br>2) $\beta(1-\lambda) = \frac{1}{1+r}$<br>3) $\tilde{q} = \frac{\beta(1-\lambda)}{(1-\beta(1-\lambda))}\tilde{d}$ | $C$ $w$ $L$<br>$r$ $\tilde{d}$ $\tilde{q}$ |
| 2. Final Goods<br>4) $\tilde{Y}^{xx} = \left(\frac{\tilde{P}^{xx}}{P^*}\right)^{-\sigma} Y^*$<br>5) $\tilde{Y}^{nx} = \left(\frac{\tilde{P}^{nx}}{P}\right)^{-\sigma} Y$<br>6) $\tilde{Y}^{xd} = \left(\frac{\tilde{P}^{xd}}{P}\right)^{-\sigma} Y$<br>7) $Y^{x^*} = \left(\frac{P^{x^*}}{P}\right)^{-\sigma} Y$<br>8) $P^{1-\sigma} = \frac{N}{1\text{-}\lambda}\left(\tilde{P}^d\right)^{1-\sigma} + \left(p^{x^*}\right)^{1-\sigma}$<br>9) $\left(\tilde{P}^d\right)^{1-\sigma} = \frac{N^x}{N}\left(\tilde{P}^{xd}\right)^{1-\sigma} + \frac{N^{nx}}{N}\left(\tilde{P}^{nx}\right)^{1-\sigma}$ | $\tilde{Y}^{xx}$ $\tilde{P}^{xx}$<br>$Y^*$<br>$\tilde{Y}^{nx}$ $\tilde{P}^{nx}$<br>$Y$ $P$ $\tilde{Y}^{xd}$<br>$\tilde{P}^{xd}$ $Y^{x^*}$<br>$\tilde{P}^d$ $N$ $\tilde{Y}^d$<br>$N^x$ $N^{nx}$ |

| | |
|---|---|
| 10) $\tilde{Y}^{d} = \left(\frac{\tilde{P}^{d}}{P}\right)^{-\sigma} Y$ | |
| 3. Intermediate | $\tilde{V}^{nx}$ $\tilde{d}^{nx}$ |
| 3.1 Average Non-exporters | $\tilde{q}^{nx}$ $\tilde{l}^{nx}$ |
| 11) $\tilde{V}^{nx} = \tilde{d}^{nx} + \tilde{q}^{nx}$ | $\tilde{b}^{nx}$ $\tilde{\mu}$ |
| 12) $\tilde{q}^{nx} = \frac{\beta(1-\lambda)}{(1-\beta(1-\lambda))}\tilde{d}^{nx}$ | $R$ $\tilde{z}^{nx}$ |
| 13) $\tilde{b}^{nx} = \frac{R}{R-1}\left(\frac{\tilde{P}^{nx}\tilde{Y}^{nx}}{P} - w\,\tilde{l}^{nx} - w\,f^{d} - \tilde{d}^{nx}\right)$ | $z_x$ $z_d$ |
| 14) $R = 1 + r(1-\tau)$ | |
| 15) $\tilde{l}^{nx} = \frac{\tilde{y}^{nx}}{A\tilde{z}^{nx}}$ | |
| 16) $\xi\tilde{q}^{nx} = \phi^{d} w\left(\tilde{l}^{nx} + f^{d}\right)$ | |
| 17) $\tilde{\mu} = \frac{1/R - m}{\xi m}$ | |
| 18) $\frac{\tilde{P}^{nx}}{P} = \frac{\sigma}{\sigma-1}\frac{w}{A\,\tilde{z}^{nx}}\left(1+\phi^{d}\tilde{\mu}\right)$ | |
| 19) $\left(\tilde{z}^{nx}\right)^{\sigma-1} = \frac{\theta\left(z_x^{\sigma-\theta-1} - z_d^{\sigma-\theta-1}\right)}{(\sigma-\theta-1)\left(z_d^{-\theta} - z_x^{-\theta}\right)}$ | |
| 3.2Average exporter | $\tilde{V}^{x}$ $\tilde{d}^{x}$ |
| 20) $\tilde{V}^{x} = \tilde{d}^{x} + \tilde{q}^{x}$ | $\tilde{q}^{x}$ $\tilde{l}^{xd}$ |
| 21) $\tilde{q}^{x} = \frac{\beta(1-\lambda)}{(1-\beta(1-\lambda))}\tilde{d}^{x}$ | $\tilde{l}^{xx}$ $\tilde{b}^{x}$ |
| 22) $\tilde{b}^{x} = \frac{R}{R-1}\left[\frac{\tilde{P}^{xd}\tilde{Y}^{xd}}{P} + \frac{\tilde{P}^{xx}\tilde{Y}^{xx}}{P} - w\left(\tilde{L}^{xd} + \tilde{L}^{xx}\right) - w\left(f^{d} + f^{x}\right) - \tilde{d}^{x}\right]$ | $\tilde{z}^{x}$ $\tilde{l}^{x}$ |

23) $$\tilde{l}^{xd} = \frac{\tilde{y}^{xd}}{A\tilde{z}^{x}}$$

24) $$\tilde{l}^{xx} = \frac{\tilde{y}^{xx}}{A\tilde{z}^{x}\left(1\text{-}\tau_x\right)}$$

25) $$\tilde{l}^{x} = \tilde{l}^{xd} + \tilde{l}^{xx}$$

26) $$\xi \tilde{q}^{x} + \gamma^{xx}\frac{\tilde{p}^{xx}\tilde{y}^{xx}}{P} = \phi^{d}\left(w\tilde{l}^{xd} + w f^{d}\right) + \phi^{x}\left(w\tilde{l}^{xx} + w f^{x}\right)$$

27) $$\frac{\tilde{P}^{xd}}{P} = \frac{\sigma}{\sigma-1}\frac{w}{\tilde{z}^{x}}\left(1+\phi^{d}\tilde{\mu}\right)$$

28) $$\left(\tilde{z}^{x}\right)^{\sigma-1} = \frac{-\theta z_x^{\ \sigma-\theta-1}}{\left(\sigma-\theta-1\right)z_x^{\ -\theta}} = \frac{-\theta z_x^{\ \sigma-1}}{\sigma-\theta-1}$$

29) $$\frac{\tilde{P}^{xx}}{P} = \frac{\sigma}{\sigma-1}\frac{w_t}{A\,\tilde{z}^{x}\left(1-\tau_x\right)}\frac{1+\phi^{x}\tilde{\mu}}{1+\gamma^{xx}\tilde{\mu}}$$

### 3.3 Mass of New Entrants

30) $$V^{nx}\left(z_d\right) = d^{nx}\left(z_d\right) + q^{nx}\left(z_d\right)$$

31) $$b^{nx}\left(z_d\right) = \frac{R}{R-1}\left[\frac{p^{nx}\left(z_d\right)y^{nx}\left(z_d\right)}{p} - w\ \left(l^{nx}\left(z_d\right) + f^{d}\right) - d^{nx}\left(z_d\right)\right]$$

32) $$l^{nx}\left(z_d\right) = \frac{y^{nx}\left(z_d\right)}{A\,z_d}$$

33) $$y^{nx}\left(z_d\right) = \left(\frac{p^{nx}\left(z_d\right)}{P}\right)^{-\sigma} Y$$

34) $$q^{nx}\left(z_d\right) = \frac{\beta\ \left(1-\lambda\right)}{\left(1-\beta\ \left(1-\lambda\right)\right)} d^{nx}\left(z_d\right)$$

35) $$\xi q^{nx}\left(z_d\right) = \phi^{d} w\left(l^{nx}\left(z_d\right) + f^{d}\right)$$

$V^{nx}\left(z_d\right)$

$d^{nx}\left(z_d\right)$

$q^{nx}\left(z_d\right)$

$l^{nx}\left(z_d\right)$

$b^{nx}\left(z_d\right)$

$y^{nx}\left(z_d\right)$

$p^{nx}\left(z_d\right)$

36) $$\frac{p^{nx}\left(z_d\right)}{P}=\frac{\sigma}{\sigma-1}\frac{w}{A\,z_d}\left(1+\phi^d\mu\right),$$

37) $$\frac{p^{nx}\left(z_d\right)y^{nx}\left(z_d\right)}{P}-w\left(l^{nx}\left(z_d\right)+f^d\right)+\frac{b^{nx}\left(z_d\right)}{R}+q^{nx}\left(z_d\right)-K^E=0$$

3.4 marginal exporter

38) $$V^x\left(z_x\right)=d^x\left(z_x\right)+q^x\left(z_x\right)$$

39) $$b^x\left(z_x\right)=\frac{R}{R-1}\left[\frac{p^{xd}\left(z_x\right)y^{xd}\left(z_x\right)}{P}+\frac{p^{xx}\left(z_x\right)y^{xx}\left(z_x\right)}{P}-w\left(l^{xd}\left(z_x\right)+l^{xx}\left(z_x\right)\right)-w\left(f^d+f^x\right)-d^x\left(z_x\right)\right.$$

40) $$l^{xd}\left(z_x\right)=\frac{y^{xd}\left(z_x\right)}{A\,z_x}$$

41) $$l^{xx}\left(z_x\right)=\frac{y^{xx}\left(z_x\right)}{A\,z_x\left(1-\tau_x\right)}$$

42) $$y^{xd}\left(z_x\right)=\left(\frac{p^{xd}\left(z_x\right)}{P}\right)^{-\sigma}Y$$

43) $$y^{xx}\left(z_x\right)=\left(\frac{p^{xx}\left(z_x\right)}{P^*}\right)^{-\sigma}Y^*=\left(\frac{p^{xx}\left(z_x\right)}{P}\right)^{-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma}Y^*$$

44) $$\xi\,q^x\left(z_x\right)+\gamma^{xx}\frac{p^{xx}\left(z_x\right)y^{xx}\left(z_x\right)}{P}=\phi^d w\left(l^{xd}\left(z_x\right)+f^d\right)+\phi^x w\left(l^{xx}\left(z_x\right)+f^x\right)$$

45) $$\frac{p^{xd}\left(z_x\right)}{P}=\frac{\sigma}{\sigma-1}\frac{w}{A\,z_x}\left(1+\phi^d\mu\right)$$

46) $$\frac{p^{xx}\left(z_x\right)}{P}=\frac{\sigma}{\sigma-1}\frac{w}{A\,z_x}\frac{1+\phi^x\mu}{\left(1\text{-}\tau_x\right)\left(1+\gamma^{xx}\mu\right)}$$

47) $$q^x\left(z_x\right)=\frac{\beta\left(1-\lambda\right)}{\left(1-\beta\left(1-\lambda\right)\right)}d^x\left(z_x\right)$$

48) $$q^{nx}\left(z_x\right)=\frac{\beta\left(1-\lambda\right)}{\left(1-\beta\left(1-\lambda\right)\right)}d^{nx}\left(z_x\right)$$

$V^x\left(z_x\right)$

$d^x\left(z_x\right)$

$q^x\left(z_x\right)$

$p^{xd}\left(z_x\right)$

$y^{xd}\left(z_x\right)$

$p^{xx}\left(z_x\right)$

$y^{xx}\left(z_x\right)$

$b^x\left(z_x\right)$

$l^{xd}\left(z_x\right)$

$l^{xx}\left(z_x\right)$

$V^{nx}\left(z_x\right)$

| | |
|---|---|
| 49) $\frac{p^{nx}\left(z_x\right)}{P}=\frac{\sigma}{\sigma-1}\frac{w}{A\,z_x}\left(1+\phi^d\mu\right)$ | $d^{nx}\left(z_x\right)$<br>$q^{nx}\left(z_x\right)$ |
| 50) $d^{nx}\left(z_x\right)=\frac{p^{nx}\left(z_x\right)y^{nx}\left(z_x\right)}{P}-w\,l^{nx}\left(z_x\right)-b^{nx}\left(z_x\right)+\frac{b^{nx}\left(z_x\right)}{R}-w\ f^d$ | $p^{nx}\left(z_x\right)$ |
| 51) $V^{nx}\left(z_x\right)=d^{nx}\left(z_x\right)+q^{nx}\left(z_x\right)$ | $y^{nx}\left(z_x\right)$ |
| 52) $l^{nx}\left(z_x\right)=\frac{y^{nx}\left(z_x\right)}{A\,z_x}$ | $l^{nx}\left(z_x\right)$<br>$b^{nx}\left(z_x\right)$ |
| 53) $y^{nx}\left(z_x\right)=\left(\frac{p^{nx}\left(z_x\right)}{P}\right)^{-\sigma}Y$ | |
| 54) $\xi\,q^{nx}\left(z_x\right)=\phi^d w\ \left(l^{nx}\left(z_x\right)+f^d\right)$ | |
| 55) $\left(\frac{p^{xx}\left(z_x\right)y^{xx}\left(z_x\right)}{P}-w\,l^{xx}\left(z_x\right)-w\ f^x\right)+\frac{b^x\left(z_x\right)-b^{nx}\left(z_x\right)}{R}+\left(q^x\left(z_x\right)-q^{nx}\left(z_x\right)\right)=K$ | |
| 4. Aggregation | |
| 56) $\frac{N^x}{1-\lambda}\tilde{p}^{xx}\tilde{y}^{xx}=P^{X^*}Y^{X^*}$ | |
| 57) $Y\ =M_eK^E+Ne^xK^{EX}+C$ | |
| 58) $Ne{=}M_ep_{in}, with: p_{in}=1-G\left(z_d\right)=z_d^{-\theta}$ | |
| 59) $L\ =\frac{N^{nx}\tilde{l}^{\,nx}+N^x\left(\tilde{l}^{\,xd}+\tilde{l}^{\,xx}\right)+\left(N^{nx}+N^x\right)f^d+N^xf^x}{1-\lambda}$ | |
| 60) $1=\frac{N^{nx}}{N}+\frac{N^x}{N}$ | $Ne$<br>$Ne^x$ |
| 61) $\frac{N^x}{N}=\frac{1\text{-}G\left(z_x\right)}{1\text{-}G\left(z_d\right)}$ | $M_e$ |
| 62) $\frac{Ne}{N}=\frac{\lambda}{1\text{-}\lambda}$ | |
| 63) $\frac{Ne^x}{N^x}=\frac{\lambda}{1\text{-}\lambda}$ | |

| | |
|---|---|
| 64) $\tilde{d} = \frac{N^{nx}}{N}\tilde{d}^{nx} + \frac{N^{x}}{N}\tilde{d}^{x}$<br>65) $Y^* = 5Y$<br>66) $M_e$=0.05Y | |

Appendix Table 1.2 Benchmark model parameterization

| Description | | |
|---|---|---|
| | | From literature |
| Pareto distribution parameter | | $\theta = 3.8$ |
| Substitution elasticity in the consumption | | $\sigma = 3.8$ |
| Probability of death shock | | $\lambda = 0.005$ |
| Iceberg trade cost | | $\tau_X = 0.16$ |
| Tax benefit | | $\tau = 0.35$ |
| household discount factor | | $\beta = 0.96$ |
| household relative risk aversion | | $\rho = 2$ |
| Weight of labor disutility in utility function | | $\kappa = 3.409$ |
| Inverse of labor supply elasticity | | $\psi = 0.5$ |
| Working capital requirement, domestic sales | | $\phi^d = 0.53$ |
| Working capital requirement, export sales | | $\phi^x = 1$ |
| Rest-of-world income | | $Y^* = 5Y$ |
| Rest-of-world export price | | $P^{x*} = 1$ |
| Fixed costs (export production) | | $f^x = 0$ (0.0045) |
| Domestic Entry costs | | $K^E = 1$ |
| | To Match | Targeted Moments |
| Fixed costs (domestic production) | $f^d = 0.00073$ | Range in leverage ratio for non-exporting firms |
| Export Entry costs | $K^{EX} = 0.478$ (0.0998) | Share of firms engaging in export |
| Enforcement parameter for export sales | $\gamma^{xx} = 0.283$ (0. 395) | Average ratio of debt to collateral for exporters |
| Enforcement parameter | $\xi = 0.07$ | Average ratio of debt to collateral for all firms |
| Rest-of-world price level | $P^* = 0.198$ | share of exports in total sales |

## Appendix 2: Analytical results

This section presents analytical results to provide intuition for how the model explains the empirical finding. In particular, we focus on the analysis of the leverage ratio in steady-state, and examine how firm size and fixed costs affect the firms' external financing decision.

In the model, the leverage ratio of a firm is defined as $leverage(z_i) = \frac{total\ debt}{total\ asset}$ $= \frac{loan(z_i) + b(z_i)}{q(z_i) + loan(z_i) + b(z_i)}$. A little transformation implies that, $leverage(z_i) = \left( \frac{1}{LR(z_i) + SR(z_i)} + 1 \right)^{-1}$ where $LR(z_i) = \frac{b(z_i)}{q(z_i)}$ measures long-term leverage, and $SR(z_i) = \frac{Loan(z_i)}{q(z_i)}$ short-term leverage. Derivations detailed below show that the effect of productivity (and hence size) on the long-term leverage ratio of exporters and non-exporters are given by:

$$\frac{\partial LR^x(z_i)}{\partial z_i} = \frac{R}{R-1} \frac{1}{q^x(z_i)^2} \left( \frac{\sigma}{\sigma-1} \frac{w}{Az_i} \right)^{1-\sigma} \frac{\sigma-1}{z_i} \frac{w}{\xi} \left[ \begin{array}{l} \left(\phi^d f^d + \phi^x f^x\right) \left( \begin{array}{l} \left(1 - \frac{\sigma-1}{\sigma} \frac{1}{1+\phi^d \mu}\right) \left(1+\phi^d \mu\right)^{1-\sigma} Y \\ + \left(1 - \frac{\sigma-1}{\sigma} \frac{1+\gamma^{xx}\mu}{1+\phi^x \mu}\right) \left( \frac{1+\phi^x \mu}{(1\text{-}\tau_x)\left(1+\gamma^{xx}\mu\right)} \right)^{1-\sigma} \left( \frac{P}{P^*} \right)^{-\sigma} Y^* \end{array} \right) \\ + \left(f^d + f^x\right) \left( \begin{array}{l} \phi^d \frac{\sigma-1}{\sigma} \left(1+\phi^d \mu\right)^{-\sigma} Y \\ + \left( \phi^x \frac{\sigma-1}{\sigma} \frac{1+\gamma^{xx}\mu}{1+\phi^x \mu} - \gamma^{xx} \right) \left( \frac{1+\phi^x \mu}{(1\text{-}\tau_x)\left(1+\gamma^{xx}\mu\right)} \right)^{1-\sigma} \left( \frac{P}{P^*} \right)^{-\sigma} Y^* \end{array} \right) \end{array} \right],$$

$$\frac{\partial LR^{nx}(z_i)}{\partial z_i} = \frac{R}{R-1} \frac{1}{q^{nx}(z_i)^2} \left( \frac{\sigma}{\sigma-1} \frac{w\left(1+\phi^d \mu\right)}{Az_i} \right)^{1-\sigma} \frac{\sigma-1}{z_i} \frac{w}{\xi} f^d \phi^d Y.$$

Thus, $\frac{\partial LR^x(z_i)}{\partial z_i} > 0$ if $\sigma > 1$ and $\frac{\gamma^{xx}}{\phi^x} \leq \frac{\sigma-1}{\sigma} \frac{1+\gamma^{xx}\mu}{1+\phi^x \mu}$, where the last inequality places bounds on the effective price markup, inclusive of financing frictions but exclusive of the frictions from the ice-berg trade cost. And $\frac{\partial LR^{nx}(z_i)}{\partial z_i} > 0$ when $\sigma > 1$.

Additionally, we see from this result that in the absence of fixed costs to domestic and export markets, $f^d = f^x = 0$, the leverage ratio is the same for all exporters, regardless of productivity level. As with non-exporters, the presence of fixed costs of production are essential to deriving the result of a leverage ratio rising in firm size. However, for exporters, it is the sum of fixed costs of production and exporting that matter.

Similarly, for the short-term debt ratio of exporters and non-exporters:

$$\frac{\partial\left(SR^x(z_i)\right)}{\partial z_i}=\left(\frac{\sigma}{\sigma-1}\frac{w}{Az_i}\right)^{1-\sigma}\frac{\sigma-1}{z_i}\frac{1}{q^x(z_i)^2}\frac{w}{\xi}\left(\phi^d f^d+\phi^x f^x\right)\left(\frac{1+\gamma^{xx}\mu}{1+\phi^x\mu}\right)^{\sigma-1}(1-\tau_x)^{\sigma-1}\gamma^{xx}\left(\frac{P}{P^*}\right)^{-\sigma}Y^*, \qquad \frac{\partial\left(SR^{nx}(z_i)\right)}{\partial z_i}=0.$$

Thus, $\frac{\partial\left(SR^x(z_i)\right)}{\partial z_i}>0$ if $\sigma>1$. Again, we see from this result that in the absence of fixed costs to domestic and export markets, $f^d=f^x=0$, the short-term leverage ratio is the same for all exporters, regardless of productivity level.

**(1) Equity prices**

Given the enforcement constraints of the non-exporter and the exporter:

$$\xi q^{nx}(z_i)=\phi^d w\left(l^{nx}(z_i)+f^d\right), \text{ and}$$

$$\xi q^x(z_i)=\phi^d\left(wl^{xd}(z_i)+wf^d\right)+\phi^x\left(wl^{xx}(z_i)+wf^x\right)-\gamma^{xx}\frac{p^{xx}(z_i)y^{xx}(z_i)}{P},$$

we have the following derivatives of the equity price with respect to firm productivity for the non-exporter

$$\frac{\partial q^{nx}(z_i)}{\partial z_i}=\frac{\phi^d}{\xi}\left(\frac{\sigma}{\sigma-1}\left(1+\phi^d\mu\right)\right)^{-\sigma}Y\left(\frac{w}{Az_i}\right)^{1-\sigma}\left(\frac{\sigma-1}{z_i}\right), \text{ and} \qquad \text{(A.1)}$$

,

and for the exporter

$$\frac{\partial q^X(z_i)}{\partial z_i}=\frac{1}{\xi}\left(\frac{\sigma-1}{z_i}\right)\left(\frac{\sigma}{\sigma-1}\frac{w}{Az_i}\right)^{1-\sigma}\left(\begin{array}{l}\left(\phi^d\frac{\sigma-1}{\sigma}\frac{1}{1+\phi^d\mu}\right)\left(1+\phi^d\mu\right)^{1-\sigma}Y\\+\left(\phi^x\frac{\sigma-1}{\sigma}\left(\frac{1+\gamma^{xx}\mu}{1+\phi^x\mu}\right)-\gamma^{xx}\right)\left(\frac{1+\phi^x\mu}{(1-\tau_x)\left(1+\gamma^{xx}\mu\right)}\right)^{1-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma}Y^*\end{array}\right), \text{ and} \qquad \text{(A.2)}$$

by combing the production functions, Eq. (15), the pricing equations (19-21), and the market demand, Eqs. (8,9,11).

It can be seen that Eqs. (A.1) and (A.2) are the same if we drop the export component from the derivatives of the exporters. $\frac{\partial q^k(z_i)}{\partial z_i}>0$, $k=nx,x$, if $\sigma>2$ for non-exporters, and if $\sigma>2$ and $\frac{\gamma^{xx}}{\phi^x}\leq\frac{\sigma-1}{\sigma}\frac{1+\gamma^{xx}\mu}{1+\phi^x\mu}$ for exporters. So when the conditions are satisfied, rising firm productivity will increase firm equity value, and the effect is larger for firms with larger size from a given group.

For non-exporters, the impact of productivity on equity prices works through the component of variable production cost, by affecting labor demand, rather than the fixed component. When firm productivity rises, firm equity value increases more for larger firms than for smaller firms. This is because firm sales increase more for larger firms when the substitution elasticity across varieties is greater than 2 ($\sigma > 2$), as the higher productivity of larger firms allows them to charge lower prices, enjoying larger market demand, which can be seen from the pricing equation (19), and rising productivity further amplifies this advantage, allowing larger firms to procure an even larger market demand.

For exporters, the impact of productivity on equity prices works through three channels, the production cost for domestic sales, the production cost for export sales and the accounts receivable used as collateral. The first two channels raise firm equity value while the third one reduces it. This is because rising firm productivity is associated with rising sales in both domestic and foreign markets, and hence raises firm equity value. However, rising export sales provide a second type of collateral, that is, the accounts receivable, which reduces firms' reliance on equity as collateral.

The impact also relies on a few fundamental parameters, such as the external financing needs of working capital ($\phi^d, \phi^x$), the substitution elasticity across varieties ($\sigma$), the mean level of credit market condition ($\xi$), the reliance on accounts receivables as collateral ($\gamma^{xx}$) given the tightness of financial constraints ($\mu$), the aggregate market demand ($Y$), the wage level ($w$) and the aggregate technology level ($A$).

**(2) Bond position**

Given the dividend equations, (16-17),

$$b^{nx}(z_i) = \frac{R}{R-1}\left[\frac{p^{nx}(z_i)}{P} y^{nx}(z_i) - w\left(l^{nx}(z_i) + f^d\right) - d^{nx}\left(z_i\right)\right],$$

$$b^{x}(z_i) = \frac{R}{R-1}\left(\frac{p^{xd}(z_i)}{P} y^{xd}(z_i) + \frac{p^{xx}(z_i)}{P} y^{xx}(z_i) - w\left(l^{xd}(z_i) + l^{xx}(z_i) + f^d + f^x\right) - d^x\left(z_i\right)\right),$$

we have that

$$b^{nx}(z_i)=\frac{R}{R-1}\left[\frac{p^{nx}(z_i)}{P}y^{nx}(z_i)-\left(\frac{\xi}{\phi}+\frac{1-\beta(1-\lambda)}{\beta(1-\lambda)}\right)q^{nx}(z_i)\right], \text{ and}$$

$$b^{x}(z_i)=\frac{R}{R-1}\left(\left(1-\frac{\sigma-1}{\sigma}\frac{1}{1+\phi^d\mu}\right)\frac{p^{xd}(z_i)}{P}y^{xd}(z_i)+\left(1-\frac{\sigma-1}{\sigma}\frac{1+\gamma^{xx}\mu}{1+\phi^x\mu}\right)\frac{p^{xx}(z_i)y^{xx}(z_j)}{P}-w\left(f^d+f^x\right)-\left(\frac{1-\beta(1-\lambda)}{\beta(1-\lambda)}\right)q^{x}(z_i)\right),$$

by combining with the enforcement constraint, Eq. (14), the production functions, Eq. (15), the pricing equations (20)-(21), the market demand equations (9)-(11), the firm value function, Eq. (18). Note, the presence of trade credit and the asymmetric working capital requirements for exports in the enforcement constraint, prevent us from using the enforcement constraint of the exporters to substitute the production cost with firm equity value, as we did for the non-exporters.

Then taking the derivatives of bond position with respect to firm productivity, by combining with the pricing equation (19-21) and the market demand, Eq. (8-11), yields for the non-exporter

$$\frac{\partial b^{nx}(z_i)}{\partial z_i}=\frac{R}{R-1}\frac{\xi}{\phi^d}\left\{\frac{\sigma}{\sigma-1}\left(1+\phi^d\mu\right)-\left(1+\frac{1-\beta(1-\lambda)}{\beta(1-\lambda)}\frac{\phi^d}{\xi}\right)\right\}\frac{\partial q^{nx}(z_i)}{\partial z_i}, \text{ and} \tag{A.3}$$

and for the exporter

$$\frac{\partial b^{x}(z_i)}{\partial z_i}=\frac{R}{R-1}\frac{\sigma-1}{z_i}\left(\frac{w}{Az_i}\right)^{1-\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\left(\begin{array}{l}\left(\underbrace{1}_{dom\_sales}-\underbrace{\frac{\sigma-1}{\sigma}\frac{1}{1+\phi^d\mu}}_{dom\_var\_cost}-\underbrace{\frac{1-\beta(1-\lambda)}{\beta(1-\lambda)}\frac{\phi^d}{\xi}\frac{\sigma-1}{\sigma}\frac{1}{1+\phi^d\mu}}_{equiy\_Needs\_dom\_cost}\right)\left(1+\phi^d\mu\right)^{1-\sigma}Y\\ +\left\{\begin{array}{l}\left(\underbrace{1}_{\exp\_sales}-\underbrace{\frac{\sigma-1}{\sigma}\frac{1+\gamma^{xx}\mu}{1+\phi^x\mu}}_{\exp\_var\_cost}-\underbrace{\frac{1-\beta(1-\lambda)}{\beta(1-\lambda)}\frac{1}{\xi}\left(\phi^x\frac{\sigma-1}{\sigma}\left(\frac{1+\gamma^{xx}\mu}{1+\phi^x\mu}\right)-\gamma^{xx}\right)}_{equity\_needs\_exp\_cost}\right)\\ \left(\frac{1+\phi^x\mu}{(1-\tau_x)\left(1+\gamma^{xx}\mu\right)}\right)^{1-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma}Y^*\end{array}\right\}\end{array}\right). \tag{A.4}$$

For non-exporters, to ensure $\frac{\partial b^{nx}(z_i)}{\partial z_i}>0$, we need $\frac{\sigma}{\sigma-1}\left(1+\phi^d\mu\right)>1+\frac{1-\beta(1-\lambda)}{\beta(1-\lambda)}\frac{\phi^d}{\xi}$. This can be easily satisfied. Note, the left-hand-side, $\frac{\sigma}{\sigma-1}\left(1+\phi^d\mu\right)$, is the price mark-up, capturing the effect of changing $z_i$ on firm sales, while the right-hand-side captures the effect of changing $z_i$ on firm production costs (the $1$) plus the dividend payout costs (the $\frac{1-\beta(1-\lambda)}{\beta(1-\lambda)}\frac{\phi^d}{\xi}$). However, the complicated representations of the first- derivatives make us difficult to conclude the conditions that ensure $\frac{\partial b^{x}(z_i)}{\partial z_i} > 0$.

When both derivatives are positive for firms within a group, they imply that the larger the firm productivity is, the more the long-term debt the firm chooses. Additionally, when firm productivity rises, firm long-term debt positions will increase more for larger firms than for smaller firms from the same group, as long as firm sales increase more than its production costs plus dividend payouts, which is guaranteed as debt is cheaper than equity and preferred by firms. Further, we see that the impact on bond position is increasing with the impact on equity prices.

### (3) Long-term leverage (Debt-to-equity ratio)

Here we present the details to get Eq. (35) in the text. Given the definition of the long-term leverage ratio, $LR_1^k(z_i) = \frac{b^k(z_i)}{q^k(z_i)}, k = nx, x$, we have that for non-exporters

$$LR_1^{nx}(z_i) = \frac{R}{R-1}\left[\frac{\frac{p^{nx}(z_i)}{P}y^{nx}(z_i)}{q^{nx}(z_i)} - \left(\frac{\xi}{\phi} + \frac{1-\beta(1-\lambda)}{\beta(1-\lambda)}\right)\right],$$

which shows the effect of changing $z_i$ on the long-term debt-equity ratio is fully through the sales-equity ratio, $\frac{\frac{p^{nx}(z_i)}{P}y^{nx}(z_i)}{q^{nx}(z_i)}$. That is, $\frac{\partial LR_1^{nx}(z_i)}{\partial z_i} = \frac{R}{R-1}\frac{\partial\left(sales^{nx}(z_i)/q^{nx}(z_i)\right)}{\partial z_i}$. And for exporters

$$LR^{x}(z_i) = \frac{R}{R-1}\left[\left(1-\frac{\sigma-1}{\sigma}\frac{1}{1+\phi^d\mu}\right)\frac{sales^{xd}(z_i)}{q^{xd}(z_i)} + \left(1-\frac{\sigma-1}{\sigma}\frac{1+\gamma^{xx}\mu}{1+\phi^x\mu}\right)\frac{sales^{xx}(z_i)}{q^{x}(z_i)} - \frac{w\left(f^d+f^x\right)}{q^{x}(z_i)} - \left(\frac{1-\beta(1-\lambda)}{\beta(1-\lambda)}\right)\right].$$

which shows the effect of changing $z_i$ on the long-term debt-equity ratio is through the domestic sales-equity ratio, $\frac{sales^{xd}(z_i)}{q^{xd}(z_i)}$, the export sales-equity ratio, $\frac{sales^{xx}(z_i)}{q^{x}(z_i)}$, and the fixed costs-equity ratio, $\frac{w\left(f^d+f^x\right)}{q^{x}(z_i)}$.

A few steps of calculations show that for non-exporters

$$\frac{\partial LR^{nx}(z_i)}{\partial z_i}=\frac{R}{R-1}\frac{1}{q^{nx}(z_i)^2}\left(\frac{\sigma}{\sigma-1}\frac{w(1+\phi^d\mu)}{Az_i}\right)^{1-\sigma}\frac{\sigma-1}{z_i}\frac{w}{\xi}f^d\phi^d Y, \tag{A.5}$$

and for exporters

$$\frac{\partial LR^{x}(z_i)}{\partial z_i}=\frac{R}{R-1}\frac{1}{q^{x}(z_i)^2}\left(\frac{\sigma}{\sigma-1}\frac{w}{Az_i}\right)^{1-\sigma}\frac{\sigma-1}{z_i}\frac{w}{\xi}\left[\begin{array}{l}\left(\phi^d f^d+\phi^x f^x\right)\left(\begin{array}{l}\left(1-\frac{\sigma-1}{\sigma}\frac{1}{1+\phi^d\mu}\right)(1+\phi^d\mu)^{1-\sigma}Y\\+\left(1-\frac{\sigma-1}{\sigma}\frac{1+\gamma^{xx}\mu}{1+\phi^x\mu}\right)\left(\frac{1+\phi^x\mu}{(1\text{-}\tau_x)(1+\gamma^{xx}\mu)}\right)^{1-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma}Y^*\end{array}\right)\\+\left(f^d+f^x\right)\left(\begin{array}{l}\phi^d\frac{\sigma-1}{\sigma}(1+\phi^d\mu)^{-\sigma}Y\\+\left(\phi^x\frac{\sigma-1}{\sigma}\frac{1+\gamma^{xx}\mu}{1+\phi^x\mu}-\gamma^{xx}\right)\left(\frac{1+\phi^x\mu}{(1\text{-}\tau_x)(1+\gamma^{xx}\mu)}\right)^{1-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma}Y^*\end{array}\right)\end{array}\right]. \tag{A.6}$$

**(4) Short-term leverage (Intra-loan-to-equity ratio)**

Given $SR^k(z_i)=\frac{Loan^k(z_i)}{q^x(z_i)}$, $Loan(z_i)=\phi^d\left(w\,l^{xd}(z_i)+w\,f^d\right)$ for non-exporters, $Loan(z_i)=\phi^d\left(w\,l^{xd}(z_i)+w\,f^d\right)+\phi^x\left(w\,l^{xx}(z_i)+w\,f^x\right)$ for exporters, and the enforcement constraint Eq. (14), we have that for non-exporters

$$SR^{nx}(z_i)=\frac{1}{\xi},$$

and that for exporters,

$$SR^{x}(z_i)=\frac{\sigma-1}{\sigma}\frac{\phi^d}{1+\phi^d\mu}\frac{sales^{xd}(z_i)}{q^x(z_i)}+\phi^x\frac{\sigma-1}{\sigma}\frac{1+\gamma^{xx}\mu}{1+\phi^x\mu}\frac{sales^{xx}(z_i)}{q^x(z_i)}+\frac{\phi^d w\,f^d+\phi^x w\,f^X}{q^x(z_i)},$$

which shows the effect of changing $z_i$ on the short-term debt-equity ratio is through the domestic sales-equity ratio, $\frac{sales^{xd}(z_i)}{q^x(z_i)}$, the export sales-equity ratio, $\frac{sales^{xx}(z_i)}{q^x(z_i)}$, and the fixed costs-equity ratio, $\frac{w\left(f^d+f^x\right)}{q^x(z_i)}$.

For non-exporters, we see the short-term leverage ratio is constant, given by:

$$\frac{\partial\left(SR^{nx}(z_i)\right)}{\partial z_i}=0. \tag{A.7}$$

For exporters, a few steps of calculations show that

$$\frac{\partial\left(SR^{x}(z_i)\right)}{\partial z_i}=\left(\frac{\sigma}{\sigma-1}\frac{w}{Az_i}\right)^{1-\sigma}\frac{\sigma-1}{z_i}\frac{1}{q^x(z_i)^2}\frac{w}{\xi}\left(\phi^d f^d+\phi^x f^x\right)\left(\frac{1+\gamma^{xx}\mu}{1+\phi^x\mu}\right)^{\sigma-1}(1\text{-}\tau_x)^{\sigma-1}\left(\frac{P}{P^*}\right)^{-\sigma}Y^*\left(\frac{1+\gamma^{xx}\mu}{1+\phi^x\mu}\frac{\phi^x}{\sigma}+\gamma^{xx}\right). \tag{A.8}$$

**(5) Sales**

Combining the pricing equation (19) and the market demand, Eq. (8), we have the sales of a non-exporter:

$$sales^{nx}(z_i) = \frac{p^{nx}(z_i)}{P} y^{nx}(z_i) = \left( \frac{\sigma}{\sigma - 1} \frac{w}{Az_i} \left(1 + \phi^d \mu\right) \right)^{1-\sigma} Y \cdot$$

Taking the first-order derivative w.r.t. to $z_i$ then gives

$$\frac{\partial sales^{nx}(z_i)}{\partial z_i} = \frac{\sigma}{\sigma - 1} \left(1 + \phi^d \mu\right) \frac{\xi}{\phi^d} \frac{\partial q^{nx}(z_i)}{\partial z_i} \cdot \tag{A.9}$$

Eq.(A.9) shows that, first, sales is increasing in productivity when $\sigma > 1$, which is also the condition for equity price to increase in productivity; second, the marginal effect of productivity on firm sale for a non-exporter is linear in the marginal effect of productivity on its equity price.

In particular we find a linear relationship between the log level of sales and the log level of productivity,

$$\log\left(sales^{nx}\right) = (1 - \sigma) \log\left( \frac{\sigma}{\sigma - 1} \frac{w}{A} \left(1 + \phi^d \mu\right) \right) + \log(Y) + (\sigma - 1) \log(z_i),$$

which implies that

$$\frac{\partial \log\left(sales^{nx}(z_i)\right)}{\partial \log(z_i)} = (\sigma - 1),$$

given the aggregate market condition.

Similarly, given the sales of an exporter: $sales^{x}(z_i) = sales^{xd}(z_i) + sales^{xx}(z_i)$, $sales^{xd}(z_i) = \frac{p^{xd}(z_i)}{P} y^{xd}(z_i)$, and $sales^{xx}(z_i) = \frac{p^{xx}(z_i)}{P} y^{xx}(z_i)$, we have

$$\frac{\partial sales^{xd}(z_i)}{\partial z_i} = \frac{\sigma - 1}{z_i} \left( \frac{w}{Az_i} \right)^{1-\sigma} \left( \frac{\sigma}{\sigma - 1} \left(1 + \phi^d \mu\right) \right)^{1-\sigma} Y,$$

$$\frac{\partial sales^{xx}(z_i)}{\partial z_i} = \frac{\sigma - 1}{z_i} \left( \frac{w}{Az_i} \right)^{1-\sigma} \left( \frac{\sigma}{\sigma - 1} \frac{1 + \phi^x \mu}{(1\text{-}\tau_x)\left(1 + \gamma^{xx} \mu\right)} \right)^{1-\sigma} \left( \frac{P}{P^*} \right)^{-\sigma} Y^*, \text{ and}$$

$$\frac{\partial sales^{x}(z_i)}{\partial z_i} = \frac{\sigma - 1}{z_i} \left( \frac{w}{Az_i} \right)^{1-\sigma} \left( \frac{\sigma}{\sigma - 1} \right)^{1-\sigma} \left( \left(1 + \phi^d \mu\right)^{1-\sigma} Y_t + \left( \frac{1 + \phi^x \mu}{(1\text{-}\tau_x)\left(1 + \gamma^{xx} \mu\right)} \right)^{1-\sigma} \left( \frac{P}{P^*} \right)^{-\sigma} Y^* \right). \tag{A.10}$$

Note, the presence of the asymmetric working capital needs ($\phi^d \neq \phi^x$) and the reliance on trade credit ($\gamma^{xx} \neq 0$) does not allow us to represent $\frac{\partial sales^{x}(z_i)}{\partial z_i}$ as a function of $\frac{\partial q^{x}(z_i)}{\partial z_i}$ as we did for the non-exporter.

As for the non-exporter, we find a linear relationship between the log level of sales and the log level of productivity,

$$\log\left(sales^{x}\right)=(1-\sigma)\log\left(\frac{\sigma}{\sigma-1}\frac{w}{A}(1+\mu)\right)+\log\left(\left(1+\phi^{d}\mu\right)^{1-\sigma}Y+\left(\frac{1+\phi^{x}\mu}{(1\text{-}\tau_{x})\left(1+\gamma^{xx}\mu\right)}\right)^{1-\sigma}\left(\frac{P}{P^{*}}\right)^{-\sigma}Y^{*}\right)+(\sigma-1)\log\left(z_{i}\right),$$

$$\log\left(sales^{xd}\right)=(1-\sigma)\log\left(\frac{\sigma}{\sigma-1}\frac{w}{A}\left(1+\phi^{d}\mu\right)\right)+\log(Y)+(\sigma-1)\log\left(z_{i}\right),$$

$$\log\left(sales^{xx}\right)=(1-\sigma)\log\left(\frac{\sigma}{\sigma-1}\frac{w}{A}\right)+\log\left(\frac{1+\phi^{x}\mu}{(1\text{-}\tau_{x})\left(1+\gamma^{xx}\mu\right)}\left(\frac{P}{P^{*}}\right)^{-\sigma}Y^{*}\right)+(\sigma-1)\log\left(z_{i}\right),$$

which implies that $\frac{\partial\log\left(sales^{xd}\left(z_{i}\right)\right)}{\partial\log\left(z_{i}\right)}=\frac{\partial\log\left(sales^{xx}\left(z_{i}\right)\right)}{\partial\log\left(z_{i}\right)}=\frac{\partial\log\left(sales^{x}\left(z_{i}\right)\right)}{\partial\log\left(z_{i}\right)}=(\sigma-1)$.

## (6) Sales-equity ratio

From Eqs. (A.5)-(A.8), we see that the marginal effects of $z_i$ on the long- and short-term debt-equity ratios essentially rely on the sales-equity ratios. So here we show how changing productivity affects the sales-equity ratio formally.

Taking the first-order derivative of the sales-equity ratio w.r.t. $z_i$, we have

$$\frac{\partial\left(sales^{nx}(z_{i})/q^{nx}(z_{i})\right)}{\partial z_{i}}=\frac{\partial q^{nx}(z_{i})}{\partial z_{i}}\frac{1}{\left(q^{nx}(z_{i})\right)^{2}}\left(\frac{\dfrac{\partial sales^{nx}(z_{i})}{\partial z_{i}}}{\dfrac{\partial q^{nx}(z_{i})}{\partial z_{i}}}q^{nx}(z_{i})-sales^{nx}(z_{i})\right).$$

Given the marginal effect of productivity on equity price, Eq. (A.1), we have the following equation,

$$sales^{nx}(z_{i})=\frac{\partial q^{nx}\left(z_{i}\right)}{\partial z_{i}}\frac{\xi}{\phi^{d}}\frac{z_{i}}{\sigma-1}\frac{\sigma}{\sigma-1}\left(1+\phi^{d}\mu\right),$$

which, combining with the marginal effect of productivity on sales,

$$\frac{\partial sales^{nx}(z_{i})}{\partial z_{i}}=\frac{\sigma}{\sigma-1}\left(1+\phi^{d}\mu\right)\frac{\xi}{\phi^{d}}\frac{\partial q^{nx}\left(z_{i}\right)}{\partial z_{i}},$$

gives

$$\frac{\partial\left(sales^{nx}(z_{i})/q^{nx}(z_{i})\right)}{\partial z_{i}}=\frac{\partial q^{nx}(z_{i})}{\partial z_{i}}\frac{1}{\left(q^{nx}(z_{i})\right)^{2}}\frac{\sigma}{\sigma-1}\left(1+\phi^{d}\mu\right)\frac{\xi}{\phi^{d}}\left(q^{nx}(z_{i})-\frac{\partial q^{nx}\left(z_{i}\right)}{\partial z_{i}}\frac{z_{i}}{\sigma-1}\right).$$

Using the enforcement constraint, Eq. (14),

$$q^{nx}(z_i)=\frac{\phi^d}{\xi}\left(\frac{\sigma}{\sigma-1}\left(\frac{1+\phi^d\mu}{1+\gamma^{nx}\mu}\right)\right)^{-\sigma}Y\left(\frac{w}{Az_i}\right)^{1-\sigma}+\frac{\phi^d wf^d}{\xi}$$

and the marginal effect of productivity on equity price, Eq. (36),

$$\frac{\partial q^{nx}(z_i)}{\partial z_i}=\frac{\phi^d}{\xi}\left(\frac{\sigma}{\sigma-1}\left(1+\phi^d\mu\right)\right)^{-\sigma}Y\left(\frac{w}{Az_i}\right)^{1-\sigma}\left(\frac{\sigma-1}{z_i}\right),\text{ and}$$

$$q^{nx}(z_i)\text{-}\left(\frac{z_i}{\sigma-1}\right)\frac{\partial q^{nx}(z_i)}{\partial z_i}=\frac{\phi}{\xi}wf^d,$$

we have

$$\frac{\partial\left(sales^{nx}(z_i)/q^{nx}(z_i)\right)}{\partial z_i}=\frac{\partial q^{nx}(z_i)}{\partial z_i}\frac{1}{\left(q^{nx}(z_i)\right)^2}\frac{\sigma}{\sigma-1}\left(1+\phi^d\mu\right)wf^d. \tag{A.11}$$

For exporters, the domestic and export sales-equity ratios are respectively given by

$$\frac{sales^{xd}(z_i)}{q^x(z_i)}=\left(\frac{\sigma}{\sigma-1}\frac{w}{A}\right)^{1-\sigma}\left(1+\phi^d\mu\right)^{1-\sigma}Y\frac{(z_i)^{\sigma-1}}{q^x(z_i)},$$

and

$$\frac{sales^{xx}(z_i)}{q^x(z_i)}=\left(\frac{\sigma}{\sigma-1}\frac{w}{A}\right)^{1-\sigma}\left(\frac{1+\phi^x\mu}{(1\text{-}\tau_x)\left(1+\gamma^{xx}\mu\right)}\right)^{1-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma}Y^*\frac{(z_i)^{\sigma-1}}{q^x(z_i)}.$$

Taking the first-order derivative of these ratios w.r.t. $z_i$, we have

$$\frac{\partial\left(\frac{sales^{xd}(z_i)}{q^x(z_i)}\right)}{\partial z_i}=\frac{w}{\xi q^x(z_i)^2}\left(\phi^d f^d+\phi^x f^x\right)\left(\frac{\sigma}{\sigma-1}\frac{w}{Az_i}\right)^{1-\sigma}\frac{\sigma-1}{z_i}\left(1+\phi^d\mu\right)^{1-\sigma}Y,$$

and

$$\frac{\partial\left(\frac{sales^{xx}(z_i)}{q^x(z_i)}\right)}{\partial z_i}=\frac{w}{\xi q^x(z_i)^2}\left(\phi^d f^d+\phi^x f^x\right)\left(\frac{\sigma}{\sigma-1}\frac{w}{Az_i}\right)^{1-\sigma}\frac{\sigma-1}{z_i}\left(\frac{1+\phi^x\mu}{(1\text{-}\tau_x)\left(1+\gamma^{xx}\mu\right)}\right)^{1-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma}Y^*.$$

The marginal effect of $z_i$ on the total export sales-equity ratio is given correspondingly by

$$\frac{\partial\left(\frac{sales^{x}(z_i)}{q^x(z_i)}\right)}{\partial z_i}=\frac{w}{\xi q^x(z_i)^2}\frac{\sigma-1}{z_i}\left(\phi^d f^d+\phi^x f^x\right)\left(\frac{\sigma}{\sigma-1}\frac{w}{Az_i}\right)^{1-\sigma}\left(\left(1+\phi^d\mu\right)^{1-\sigma}Y+\left(\frac{1+\phi^x\mu}{(1\text{-}\tau_x)\left(1+\gamma^{xx}\mu\right)}\right)^{1-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma}Y^*\right). \tag{A.12}$$

Again, we see the presence of the asymmetric working capital needs ($\phi^d\neq\phi^x$) and the reliance on trade credit ($\gamma^{xx}\neq 0$) prevents us from representing $\frac{\partial sales^x(z_i)}{\partial z_i}$ as a function of

$\frac{\partial q^x(z_i)}{\partial z_i}$, as we did for the non-exporter.

**(7) Product quantity**

For non-exporters, combining the pricing equation (19) and the market demand, Eq. (8), we have that

$$y^{nx}(z_i)=\left(\frac{\sigma}{\sigma-1}\frac{w}{Az_i}\left(1+\phi^d\mu\right)\right)^{-\sigma}Y.$$

This implies

$$\frac{\partial y^{nx}(z_i)}{\partial z_i}=\frac{Az_i}{w}\frac{\sigma}{\sigma-1}\frac{\xi}{\phi}\frac{\partial q^{nx}(z_i)}{\partial z_i}. \tag{A.13}$$

A similar linearity is found in the relation between the log level of product quantity and the log level of productivity, given by

$$\log\left(y^{nx}(z_i)\right)=\log\left(\left(\frac{\sigma}{\sigma-1}\left(\frac{1+\phi^d\mu}{1+\gamma^{nx}\mu}\right)\frac{w}{A}\right)^{-\sigma}Y\right)+\sigma\log(z_i)$$

which implies

$$\frac{\partial\log\left(y^{nx}(z_i)\right)}{\partial\log(z_i)}=\sigma. \tag{A.14}$$

For exporters, combining the pricing equations (20)-(21) and the market demand, Eqs. (9) and (11), we have

$$\begin{aligned} y^x(z_i)&=y^{xd}(z_i)+\frac{1}{1\text{-}\tau_x}y^{xx}(z_i)\\ &=\left(\frac{\sigma}{\sigma-1}\frac{w}{A\,z_i}\left(1+\phi^d\mu\right)\right)^{-\sigma}Y_t+\frac{1}{1\text{-}\tau_x}\left(\frac{\sigma}{\sigma-1}\frac{w}{A\,z_i}\frac{1+\phi^x\mu}{(1\text{-}\tau_x)\left(1+\gamma^{xx}\mu\right)}\right)^{-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma}Y^*\end{aligned}.$$

This implies

$$\frac{\partial y^x(z_i)}{\partial z_i}=\frac{\sigma}{z_i}\left(\frac{\sigma}{\sigma-1}\frac{w}{Az_i}\right)^{-\sigma}\left(\left(1+\phi^d\mu\right)^{-\sigma}Y+\frac{1}{1\text{-}\tau_x}\left(\frac{1+\phi^x\mu}{(1\text{-}\tau_x)\left(1+\gamma^{xx}\mu\right)}\right)^{-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma}Y^*\right).$$

Further, we have

$$\log\left(y^x(z_i)\right)=(-\sigma)\log\left(\frac{\sigma}{\sigma-1}\frac{w}{A}\right)+\log\left(\begin{array}{l}\left(1+\phi^d\mu\right)^{-\sigma}Y\\ +\frac{1}{1\text{-}\tau_x}\left(\frac{1+\phi^x\mu}{(1\text{-}\tau_x)\left(1+\gamma^{xx}\mu\right)}\right)^{-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma}Y^*\end{array}\right)+\sigma\log(z_i)$$

and

$$\frac{\partial \log\left(y^x(z_i)\right)}{\partial \log(z_i)} = \sigma \cdot$$

### (8) Profit

For non-exporters, given $\pi^{nx}(z_i) = \frac{p^{nx}(z_i)}{P} y^{nx}(z_i) - \left(wl^{nx}(z_i) + wf^d\right)$, and combining the pricing equation (19) and the market demand, Eq. (8), and the enforcement constraint, Eq. (14), we have

$$\pi^{nx}(z_i) = sale^{nx}(z_i) - \frac{\xi\, q^{nx}(z_i)}{\phi^d}.$$

Taking the first-order derivative thus gives

$$\frac{\partial \pi^{nx}(z_i)}{\partial z_i} = \frac{\partial q^{nx}}{\partial z_i}\frac{\xi}{\phi^d}\left(\frac{\sigma}{\sigma-1}\left(1+\phi^d\mu\right)-1\right) \cdot \tag{A.15}$$

The first item in the bracket captures the rising sales effect associated with the rising $z_i$, while the second item captures the rising production cost associated with rising productivity.

For exporters, given $\pi^x(z_i) = \frac{p^{xd}(z_i)}{P} y^{xd}(z_i) + \frac{p^{xx}(z_i)}{P} y^{xx}(z_i)(1\text{-}\tau_x) - w\left(l^{xd}(z_i) + l^{xx}(z_i) + f^d + f^x\right)$,and combining the pricing equations (20)-(21) and the market demand, Eqs. (9) and (11), we have

$$\frac{\partial \pi^x(z_i)}{\partial z_i} = \frac{\sigma-1}{z_i}\left(\frac{w}{Az_i}\right)^{1-\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\left(\left(1-\frac{\sigma-1}{\sigma}\frac{1}{1+\phi^d\mu}\right)\left(1+\phi^d\mu\right)^{1-\sigma}Y + \left(1-\frac{\sigma-1}{\sigma}\left(\frac{1+\gamma^{xx}\mu}{1+\phi^x\mu}\right)\right)\left(\frac{1+\phi^x\mu}{(1\text{-}\tau_x)\left(1+\gamma^{xx}\mu\right)}\right)^{1-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma}Y^*\right) \cdot \tag{A.16}$$

### (9) Firm value

For non-exporters, given that $V^{nx}(z_i) = q^{nx}(z_i) + d^{nx}(z_i) = \left(1+\frac{1-\beta(1-\lambda)}{\beta(1-\lambda)}\right) q^{nx}(z_i)$, we have

$$\frac{\partial V^{nx}(z_i)}{\partial z_i} = \left(1+\frac{1-\beta(1-\lambda)}{\beta(1-\lambda)}\right)\frac{\partial q^{nx}(z_i)}{\partial z_i}.$$

For exporters, given that $V^x(z_i) = q^x(z_i) + d^x(z_i) = \left(1+\frac{1-\beta(1-\lambda)}{\beta(1-\lambda)}\right) q^x(z_i)$, we have

$$\frac{\partial V^x(z_i)}{\partial z_i} = \left(1+\frac{1-\beta(1-\lambda)}{\beta(1-\lambda)}\right)\frac{\partial q^x(z_i)}{\partial z_i}$$

### (10) Export intensity

We are also interested in studying how the productivity affects the export intensity. We consider two measures, one in terms of quantity, and the other in terms of sales.

In terms of quantity, we have the export intensity given by

$$\exp\_q\_ratio = \frac{y^{xx}(z_i)}{y^{xd}(z_i) + y^{xx}(z_i)}.$$

Combining with the market demand functions, Eqs. (9,11), and the pricing equations, Eqs. (20-21), we thus have

$$\exp\_q\_ratio = \frac{\left(\frac{1}{(1-\tau_x)}\frac{1+\phi^x\mu}{1+\gamma^{xx}\mu}\right)^{-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma} Y^*/Y}{\left(\frac{1}{(1-\tau_x)}\frac{1+\phi^x\mu}{1+\gamma^{xx}\mu}\right)^{-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma} Y^*/Y + \left(1+\phi^d\mu\right)^{-\sigma}} \tag{A.17}$$

In terms of sales, we have the export intensity given by

$$\exp\_sales\_ratio = \frac{sales^{xx}(z_i))}{sales^{xd}(z_i) + sales^{xx}(z_i)}.$$

Similarly, we have

$$\exp\_sales\_ratio = \frac{\left(\frac{1}{(1-\tau_x)}\frac{1+\phi^x\mu}{1+\gamma^{xx}\mu}\right)^{1-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma} Y^*/Y}{\left(\frac{1}{(1-\tau_x)}\frac{1+\phi^x\mu}{1+\gamma^{xx}\mu}\right)^{1-\sigma}\left(\frac{P}{P^*}\right)^{-\sigma} Y^*/Y + \left(1+\phi^d\mu\right)^{1-\sigma}} \tag{A.18}$$

From Eqs. (A.17-A.18), we see both measures of export intensity is independent of firm productivity.

## Appendix 3: A brief literature review of related empirical research

There is an extensive empirical literature studying how financial frictions influence international trade. A subset of this literature uses firm-level data from a variety of countries to provide evidence that firm financial health and financial market access increases export market participation (the extensive margin) and/or the scale of exports (the intensive margin).

For instance, using Belgian manufacturing firm data for the period of 1999 and 2007, Muûls (2015) finds that firms are more likely to be exporting or importing if they enjoy lower credit constraints and bankruptcy risk, and firms that have better credit rating export and import more on both the extensive and intensive margins. The paper uses a creditworthiness score constructed by a credit insurance company to measure the degree of firm financial constraint.

Using Italian manufacturing firm data, Minetti and Zhu (2011) find that "credit-rationed" firms are less likely to export and, credit rationing reduces exporters' foreign sales more strongly than on their domestic sales, especially for firms with short relationships with creditors and by firms with few creditors, and for firms operating in industries with high external financial dependence. The paper uses a firm-specific measure of credit rationing based on firms' responses to the survey.

Using French manufacturing firm data, Bellone, et al. (2010) find that firms enjoying better financial health are more likely to become exporters and to export more. In particular, they find that less constrained firms self-select into exporting and also shortens the time before firms decide to serve foreign customers, while foreign market penetration is not associated with easier access to external financial resources.

Berman and Héricourt (2010) work with a database covering firms in developing and emerging economies, and find that lower financial constraints have a positive impact on firms' export participation (the extensive margin), but better financial health neither increases the probability of remaining an exporter once the firm has entered, nor the size of exports (the intensive margin). Additionally, they find that productivity is a significant determinant of export entry decision only if the firm is financially unconstrained. The paper uses two financial ratios, the ratio of total debt over total assets and the ratio of cash flow over total assets, to measure firms' financial constraints.

Using a data set that matches exporters with the bank that provides them with trade finance, Amiti and Weinstein (2011) find that the health of financial institutions is an important determinant of firm-level export sales during crises, suggesting that Japanese banks transmitted financial shocks to exporters during the systemic crisis in the period of 1990 to 2010. The paper uses the market-to-book value to measure the health of a bank.

By comparing changes in exports of the same product and to the same destination by

Peruvian firms borrowing from banks differentially affected by capital-flow reversals during the 2008 financial crisis, Paravisini et al. (2015) find that credit shocks reduce continue exporting to a given product-destination market, but have no significant impact on entry or exit of firms. They conclude that credit shortages reduce exports through raising the variable cost of production, rather than the cost of financing sunk entry investments. They use the average foreign dependence of a firm's bank, weighted by the fraction of credit from each bank, as an instrument for the firm's exposure to the credit supply.

Using Chinese manufacturing firm level data in 2005, Manova, Wei, and Zhang (2015) show that foreign affiliates and joint ventures have better export performance than private domestic firms in financially more vulnerable sectors, which is stronger for destinations with higher trade costs and not driven by variation in firm size or by other sector determinants of FDI. To quantify firms' reliance on external finance, the paper uses industries' reliance on external finance as the main measure (see Rajan and Zingales (1998)).

The relevance of financial frictions in trade is also challenged. For instance, using a dataset of French manufacturing firms, Bricongne et al. (2012) show that most of the 2008–2009 trade collapse was due to the demand shock and to product characteristics. The trade adjustment is heterogeneous across firms. The effect on large firms has been mainly at the intensive margin, and has resulted in fewer products exported to destinations, while the effect on smaller exporters has been to reduce the number of destinations or to exit from the destination. Though financial constraints exacerbated the difficulties for financially constrained firms, this effect was quantitatively small since the share of credit constrained firms is small and their number has not increased hugely during the crisis. The paper uses payment incidents (defaults on credits) to measure a firm's financial constraint.

Similarly, using industry-level data of U.S. imports and exports, Levchenko, Lewis, and Tesar (2010) find little evidence that financial factors played a role in the collapse of U.S. trade.Blalock and Roy (2007) also find that, firms' perceptions of economic constraints differed little between new entrants and exiters after 1997 financial crisis.

Other empirical work uses sector-level or aggregate trade data to provide evidence that financial health affects export decisions. For instance, Manova (2008) shows that financial market imperfections severely restrict international trade flows. By exploiting the variation in financial development across countries and the variation in financial vulnerability across sectors, the paper finds that credit constraints limit firm entry into exporting and contract exporters' foreign sales, and financially developed economies export more in financially vulnerable sectors because they enter more markets, ship more products to each destination, and sell more of each product. The paper uses the Rajan and Zingales (1998)'s measure of external finance dependence to measure an industry's reliance on external finance.

Using data on monthly U.S. imports, Chor and Manova (2012) find that, countries with tighter credit markets exported less to the US during the peak of the crisis, which was especially pronounced in sectors that require extensive external financing, have limited access to trade credit, or have few collateralizable assets.

Using data from 160 developed and developing countries during 1970–2012, Iacovone and Zavacka (2019) analyze 147 banking crisis episodes, and find that during a banking crisis, the exports of sectors more dependent on external finance grow significantly less than other sectors, which holds robustly for sectors that depend on banking finance, but not for sectors that depend on interfirm finance (i.e., trade finance or trade credit).

Using product level data on exports to 12 European Union members and the U.S., Besedeš et al. (2014) show that credit constraints play a key role in early stages of exporting, but not in later stages. In particular, they find exports from more credit constrained and riskier exporters grow faster, and export growth rates decrease with duration and converge across countries. To measure credit constraint, they use industry level measures of asset tangibility and external finance dependence.

However, the literature also includes papers showing a relationship that runs the other direction, that exporting can improve firm financial health. Campa and Shaver (2002) find that Spanish manufacturing exporters' cash flows and capital investments are more stable than non-exporters', and exporting can help firms to reduce their financial constraints as investment is less sensitive to cash flow for the group of always-exporters compared to the group of never-exporters. They argue that this finding is consistent with the potential mechanism of diversification that, by exporting, firms sell in markets whose business cycles are not perfectly correlated and so can be expected to have more stable cash flows, and the mechanism of information advantage that, expectation of more stable cash flows provides greater assurances to external investors that the firm will be able to service its obligations, and hence exporting sends a signal about that exporters are more productive and has competitive advantage.

By working with a panel of UK manufacturing firms over the period 1993–2003, Greenaway et al (2007) shows that exporters exhibit better financial health than non-exporters, and this result is driven by the continuous exporters, not the starters which generally display low liquidity and high leverage, possibly due to the sunk costs which need to be met to enter export markets. They find strong evidence that participation in export markets improves firms' financial health, but no evidence in favor of the hypothesis of less constrained firms self-selecting into export activities. They define liquidity ratio as firm's current assets less current liabilities over total assets, and leverage ratio as firm's ratio of short-term debt to current assets. The higher its liquidity ratio and lower its leverage ratio, the better the firm's financial health.

Similarly, using a panel of UK firms over the period 1997–2002, Bridges and Guariglia (2008) find that lower collateral and higher leverage do result in higher failure probabilities, but only for purely domestic firms. They interpret this as evidence that global engagement shields firms from financial constraints.

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## Appendix 4: Additional empirical results and sample summary statistics

Appendix Table 4.1: Sample summary statistics by year

| year | number of firms | new entry | existing | exit |
|---|---|---|---|---|
| 1975 | 1589 | | | |
| 1976 | 1614 | 45 | 1569 | 20 |
| 1977 | 1578 | 62 | 1516 | 98 |
| 1978 | 1619 | 148 | 1471 | 107 |
| 1979 | 1691 | 175 | 1516 | 103 |
| 1980 | 1708 | 130 | 1578 | 113 |
| 1981 | 1861 | 249 | 1612 | 96 |
| 1982 | 1893 | 165 | 1728 | 133 |
| 1983 | 1988 | 215 | 1773 | 120 |
| 1984 | 1905 | 161 | 1744 | 244 |
| 1985 | 1865 | 162 | 1703 | 202 |
| 1986 | 1877 | 223 | 1654 | 211 |
| 1987 | 1957 | 256 | 1701 | 176 |
| 1988 | 1896 | 171 | 1725 | 232 |
| 1989 | 1818 | 146 | 1672 | 224 |
| 1990 | 1827 | 186 | 1641 | 177 |
| 1991 | 1782 | 169 | 1613 | 214 |
| 1992 | 1880 | 273 | 1607 | 175 |
| 1993 | 1940 | 309 | 1631 | 249 |
| 1994 | 2104 | 317 | 1787 | 153 |
| 1995 | 2228 | 329 | 1899 | 205 |
| 1996 | 2352 | 333 | 2019 | 209 |
| 1997 | 2369 | 265 | 2104 | 248 |
| 1998 | 2334 | 244 | 2090 | 279 |
| 1999 | 2215 | 226 | 1989 | 345 |
| 2000 | 2277 | 373 | 1904 | 311 |
| 2001 | 2154 | 224 | 1930 | 347 |
| 2002 | 2080 | 196 | 1884 | 270 |
| 2003 | 2048 | 203 | 1845 | 235 |
| 2004 | 2053 | 238 | 1815 | 233 |
| 2005 | 1986 | 201 | 1785 | 268 |

| | | | | |
|---|---|---|---|---|
| 2006 | 1943 | 225 | 1718 | 268 |
| 2007 | 1862 | 200 | 1662 | 281 |
| 2008 | 1659 | 146 | 1513 | 349 |
| 2009 | 1552 | 175 | 1377 | 282 |
| 2010 | 1584 | 230 | 1354 | 198 |
| 2011 | 1512 | 132 | 1380 | 204 |
| 2012 | 1403 | 117 | 1286 | 226 |
| 2013 | 1349 | 141 | 1208 | 195 |
| 2014 | 1289 | 88 | 1201 | 148 |

Shaded areas show periods of recession.

Appendix Table 4.2: Results from difference in means tests

| | Statistic | F(df1, | df2) | = F | Prob>F |
|---|---|---|---|---|---|
| Wilks' lambda | 0.9971 | 1.0 | 74828.0 | 220.15 | 0.0000 |
| Pillai's trace | 0.0029 | 1.0 | 74828.0 | 220.15 | 0.0000 |
| Lawley-Hotelling trace | 0.0029 | 1.0 | 74828.0 | 220.15 | 0.0000 |
| Roy's largest root | 0.0029 | 1.0 | 74828.0 | 220.15 | 0.0000 |

Appendix table 4.3: Panel Regressions with inventories

| | (1) Book Leverage ratio | (2) Short-term borrowing to total assets | (3) Long-term debt to total assets | (4) Debt in current liabilities to total assets | (5) Book debt minus short-term borrowing to total assets |
|---|---|---|---|---|---|
| size | -0.0001 | -0.0055 | 0.0103*** | -0.006*** | 0.0006 |
| | (0.0013) | (0.0040) | (0.0011) | (0.0007) | (0.0045) |
| exporter | 0.015*** | -0.00316 | 0.00290 | 0.00303* | 0.021** |
| | (0.0025) | (0.0066) | (0.0020) | (0.0012) | (0.0073) |
| inventories | 0.00199* | 0.0060* | 0.0057*** | 0.0064*** | -0.0035 |
| – finished goods | (0.0010) | (0.0028) | (0.0008) | (0.0005) | (0.0031) |
| N | 53521 | 17588 | 53498 | 53520 | 17588 |
| $R^2$ | 0.0042 | 0.0175 | 0.0506 | 0.0238 | 0.0017 |

Standard errors in parentheses. *** indicates statistical significance at the 1% level, ** 5%, and * 10%.

Appendix table 4.4: The correlation of working capital and XSGA (selling, general, and administrative expense)

| | (1) log of short-term borrowing | (2) log of debt in current liabilities |
|---|---|---|
| size | 0.3608*** | 0.3355*** |
| | (0.0431) | (0.0174) |
| exporter | 0.04824 | 0.1285*** |
| | (0.0385) | (0.0230) |
| Log of XSGA | 0.5239*** | 0.5230*** |
| | (0.0464) | (0.0194) |
| N | 16,466 | 57,759 |
| $R^2$ | 0.6291 | 0.5923 |

Standard errors in parentheses. *** indicates statistical significance at the 1% level, ** 5%, and * 10%.