Aggregate Fluctuations and the Role of Trade Credit*

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Abstract

This paper studies how trade credit affects aggregate fluctuations in a dynamic, general equilibrium model where heterogeneous entrepreneurs choose their lending and borrowing of trade credit in the presence of financial frictions. The model incorporates two forces through which trade credit affects the aggregate economy. First, trade credit helps channel funds from financially-unconstrained to constrained firms. Second, in the face of financial market distress, suppliers reduce trade credit lending, further tightening their customers' borrowing constraints. While the first channel helps mitigate the impact of financial shocks, the second channel amplifies it. When calibrated to match the magnitude of the financial shock during the Great Recession, our model shows that the drop in trade credit can account for a sizable share of the decline in output. The dynamics of trade credit following productivity shocks differ from that following financial shocks. Under productivity shocks, trade credit does not have a significant impact on the aggregate output fluctuations.

JEL classification: E32, E44, L23, L14

Keywords: Trade credit, firm heterogeneity, financial crisis, financial frictions.

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1 Introduction

Financial shocks are often associated with severe contractions in real economic activity. Most academic research studying the real impact of financial shocks has abstracted from trade credit—suppliers' lending of inputs to their customers, despite its importance as a source of financing for firms.[1] In 2006, total trade credit liabilities (accounts payable) of the non-financial corporate sector were approximately the same size as its monthly gross value-added output, and in the same sector, approximately 70 percent of the decrease in short-term liabilities during the 2007–09 financial crisis was attributable to trade credit. In this paper, we seek to understand the role of trade credit in the transmission of financial shocks to the real economy.

The existing literature documented that trade credit plays a "redistributive" role during periods of tight credit, passing funds from more liquid firms to less liquid firms (Meltzer, 1960 and Nilsen, 2002). This fact seems to suggest that trade credit could help mitigate the impacts of financial shocks. However, on the aggregate level, trade credit does not appear to increase during monetary and credit contractions (Gertler and Gilchrist, 1993). Indeed, during the Asian financial crisis and the 2007–09 global financial crisis, aggregate trade credit declined in both absolute terms and relative to output (Love et al., 2007).

In fact, even during normal times, trade credit serves as a substitute source of financing when firms' access to the traditional financial market is limited. The prior literature has explored this financial motive of trade credit (see Schwartz, 1974 and Petersen and Rajan, 1997) and the empirical evidence in this paper lends further support to this theory. Using a sample of Compustat firms, we document substantial heterogeneity in firms' choice of trade credit, with financially-advantaged firms—old, large firms and firms that rely less on external financing—being net lenders of trade credit and disadvantaged firms net borrowers.

Motivated by these stylized facts, we build a model of trade credit with two important

[1] As of 2009, trade credit liabilities (accounts payable) was the second-largest liabilities for the US non-financial businesses (Murfin and Njoroge, 2015).

features 1) firm heterogeneity in financial constraints and 2) interaction between trade credit and firms' access to the financial market. The model features a roundabout production where the final good can be used as consumption, investment, or intermediate inputs. There is a continuum of entrepreneurs who differ by their wealth and productivity, which creates heterogeneity in their financial constraints. Entrepreneurs choose bank credit, their borrowing of trade credit (accounts payable), and lending of trade credit (accounts receivable) simultaneously, subject to a working capital constraint. Trade credit and bank credit coexist, and trade credit flows—together with intermediate input goods—from relatively unconstrained to constrained entrepreneurs. The process also creates collateral (accounts receivable), which can be used by the lenders of trade credit to obtain bank loans. Hence, trade credit redistributes credit across entrepreneurs with different degrees of financial frictions and increases the overall level of credit in the economy.

We model the financial crisis as a negative shock to firms' collateral constraints. A negative financial shock makes entrepreneurs more constrained and lowers the collateral value of their receivables. Therefore, entrepreneurs reduce their trade credit lending, further tightening the other entrepreneurs' financial constraints in equilibrium. The spillover effect through endogenous changes in the provision of trade credit could lead to an amplification of original shock. Note that the redistributive channel of trade credit is still operative beneath the aggregate dynamics—trade credit still flows from relatively unconstrained entrepreneurs to the constrained ones. However, there are fewer unconstrained entrepreneurs in equilibrium, and hence the supply of trade credit is reduced.

To quantify the role of trade credit facing a financial shock, we first calibrate our model's steady-state to match the U.S. economy. The collateral value of wealth and accounts receivable are respectively pinned down by the size of credit market liabilities and accounts payable. Using the calibrated model, we simulate the 2007–09 financial crisis by introducing a shock process to the collateral constraints, such that the model (upon impact) delivers the same magnitude decrease in credit market liabilities in the data. Following the shock, the percentage decline in trade credit is almost twice as large as that of output, suggesting that firms need to rely less on trade credit to finance their working capital. When applied to the counterfactual economy without trade credit, the same shock process generates a decrease in output that is 16 percent smaller than the benchmark economy. This shows that while the trade credit channel improves credit allocation, it also makes the economy more susceptible to financial shocks.

In contrast, the benchmark and the counterfactual economies show no perceptible differences following a negative TFP shock. We show that trade credit moves very little relative to output following productivity shocks, which might explain why it does not play a significant role. This result is consistent with findings in Khan and Thomas (2013) and Zetlin-Jones and Shourideh (2017), where they show that a model with heterogeneous producers and a fixed collateral constraint does not significantly amplify the impacts of productivity shocks. Through the lenses of this model, financial and productivity shocks generate different dynamics of trade credit that could help identify shocks over the business cycle.

Lastly, in analyzing the role played by trade credit during financial shocks, the key mechanism generated in the model is the endogenous changes in trade credit choices when the firms' access to the financial market is tightened. We provide some evidence to support this mechanism by exploiting the dispersion of banks' health after the Lehman crisis as an exogenous variation to firms' access to financing (see Chodorow-Reich, 2014). We find that, compared with firms with lower pre-crisis exposure to Lehman, firms with higher exposure reduced their lending of trade credit and increased their borrowing of trade credit, which is consistent with the model prediction.

There exists a long theoretical and empirical literature on trade credit (see Cuñat and Garcia-Appendini, 2012 for a recent review). Theoretically, our paper builds on the insight that the existence of trade credit reflects a particular comparative advantage of suppliers in lending inputs to their customers compared with financial intermediaries. The sources of the comparative advantage explored in the literature include information advantage (Biais and Gollier, 1997), liquidation advantage in default (Fabbri and Menichini, 2010) and less severe moral hazard problem (Burkart and Ellingsen, 2004 and Cuñat, 2007). In the model, we make a similar assumption as in Burkart and Ellingsen (2004) that firms can default on bank credit, but suppliers can perfectly enforce trade credit.

Empirically, our paper belongs to and contributes to the literature that emphasizes the financial motive of firms' choice of trade credit (see Meltzer, 1960, Schwartz, 1974, and Nilsen, 2002). While these papers study the redistribution channel of trade credit in the context of monetary or credit contractions, other papers, including ours, argue that this channel is also present during normal times (Petersen and Rajan, 1997, Cull et al., 2009 and Fisman and Love, 2003). There also exists ample evidence of severe trade credit contraction when suppliers face financial distress. For example, Love et al. (2007) show that during the Asian financial crisis, after a temporary increase in trade credit, there was a pronounced decline in trade credit that lasted for several years.

We introduce trade credit into a quantitative dynamic general equilibrium model with firm heterogeneity. It builds upon seminal papers such as Buera and Moll (2015), Buera et al. (2015), Khan and Thomas (2013), and Zetlin-Jones and Shourideh (2017). Our model extends the working capital constraint in Jermann and Quadrini (2012) by incorporating a trade credit component. Previous papers such as Zetlin-Jones and Shourideh (2017) examine how shocks originated in the financial sector affect the real economy and calibrate their model to match firms' net liability, a part of which is trade credit. We model trade credit separately from the other type of liabilities (i.e., bank credit in our model). Importantly, by incorporating trade credit, the model captures the endogenous responses of trade credit to the exogenous shocks in the financial market. We also show that this transmission mechanism is quantitatively significant.

Since the flow of trade credit is accompanied by the transaction of intermediate inputs, it is also closely related to the economy's input-output structure. An early empirical work by Raddatz (2010) shows that higher cross-industry correlation in output is associated with trade credit usage along the input-output chain. Kalemli-Ozcan et al. (2014) build on Kim and Shin (2012), where trade credit helps sustain long production chains that are more productive than short ones, and show that financial shocks are amplified because longer production chains are less viable during financial crises. Bigio and La'O (2020) show that the input-output network can amplify the financial distortions in a model with a fixed working capital constraint. Altinoglu (2018), Luo (2020), and Reischer (2019) extend the framework to include endogenous changes in trade credit in response to financial shocks. Our paper complements this strand of literature by exploring the role played by trade credit in the presence of firm heterogeneity.

The rest of the paper is organized as follows: section 2 presents the empirical motivation for the model, section 3 describes the model, defines the recursive competitive equilibrium, and characterize entrepreneurs' trade credit choices, section 4 provides a quantitative analysis of the model, section 5 provides additional evidence for the model mechanism, and section 6 concludes.

2 Empirical motivation

In this section, we study firms' choice of trade credit in the cross-section, focusing on the correlation between financial constraints and trade credit choices. Section 2.1 discusses the data and section 2.2 presents the results.

2.1 Data description

We construct our sample of firms using the North America database at the quarterly frequency for 2000-2007. We drop all firms in the financial sector (SIC 60-69), as well as the wholesale and the retail sector (SIC 50-59).

Following the literature, we use accounts receivable (AR) to measure a firms' gross lending of trade credit to other firms, accounts payable (AP) to measure gross borrowing of trade credit from other firms, and net accounts receivable (net AR=AR-AP) to measure net lending of trade credit. We then normalize AR, AP and net AR by sales to adjust for the size, which gives us the three variables for trade credit in the empirical exercise: $\frac{AR}{sales}$, $\frac{AP}{sales}$ and $\frac{net\ AR}{sales}$.[2]

We focus on several firm characteristics that are known to be associated with financial constraints. The first one is firm age, which the literature shows a strong predictor of financial constraints. We follow the literature and construct age for firms in Compustat using three different methods: 1) firms' first appearance in the dataset with a non-missing closing price, 2) firms' IPO date, and 3) founding dates for firms going public in the U.S. during 1975-2018 by Jay Ritter. The results are similar with the three measures, and we report here the results using the first measure. Another firm characteristics that is known to be correlated with financial constraints is firm size measured using total asset (Almeida and Campello, 2007).

Perhaps a more direct measure of financial friction is firms' reliance on external financing. Rajan and Zingales (1998) define an industry's reliance on external financing as the difference between investment and cash generated from operation. Gomes (2001) shows that firms' reliance on external financing is informative of the severity of financial constraints. In his model, the most productive firms use costly external financing to finance their capital expenditure while less productive firms can finance their capital expenditure entirely with internal funds. We follow Gomes (2001) to construct firms' reliance on external financing as capital expenditure minus available funds (cash flow net of dividend payment). We then normalize external financing by total fixed assets (extfin/k) and designated firms as *borrowers* if their capital expenditure exceeds their available funds (extfin>0).

We trim the bottom and top 1 percent of the variables that we take from Compustat directly: AR, AP, net AR, capital expenditure, available funds, and total fixed assets. We then trim the bottom and top 5 percent of the ratios we constructed: AR/sales, AP/sales, net AR/sales, and extfin/k.

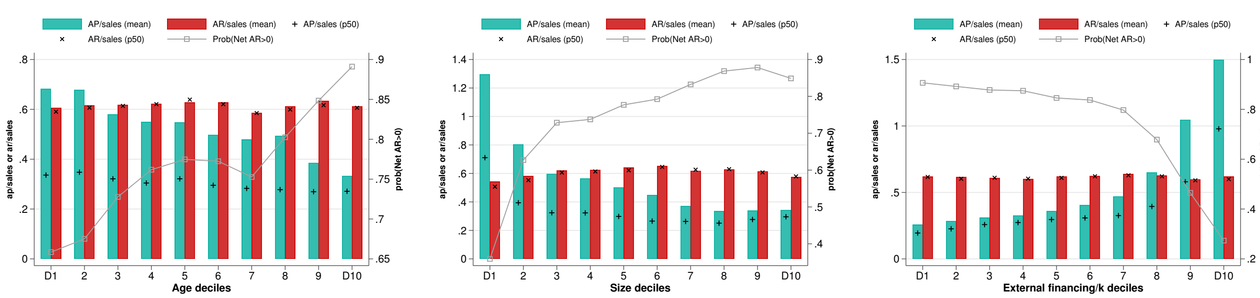
[2] Alternatively, we could normalize AP by the cost of goods sold (cogs). The results using AP/cogs are similar to the ones using AP/sales.

2.2 Trade credit and financial frictions

Figure 1 plots the correlation between trade credit choices, measured by AR/sales, AP/sales, and the probability of being a net trade credit lender (net AR>0), and firm characteristics associated with financial constraints. Panel (a) shows that young firms, on average, borrow more trade credit from their suppliers (i.e. AP/Sales), although they do not lend less trade credit to their customers (i.e. AR/Sales) than older firms. The probability of being a net trade credit lender (net AR>0) thus increases with firm age. Panel (b) shows a similar pattern for small firms versus large firms, where AP/sales declines with firm size while AR/sales stays relatively constant. Therefore large firms are more likely to be net trade credit lenders than small firms.[3] Lastly, firms that rely more on external financing also borrow more trade credit (higher AP/sales) and are less likely to be net trade credit lenders (panel c).

Figure 1: **Trade credit by age, size and reliance on external financing**

(a) age (b) size (c) reliance on external financing



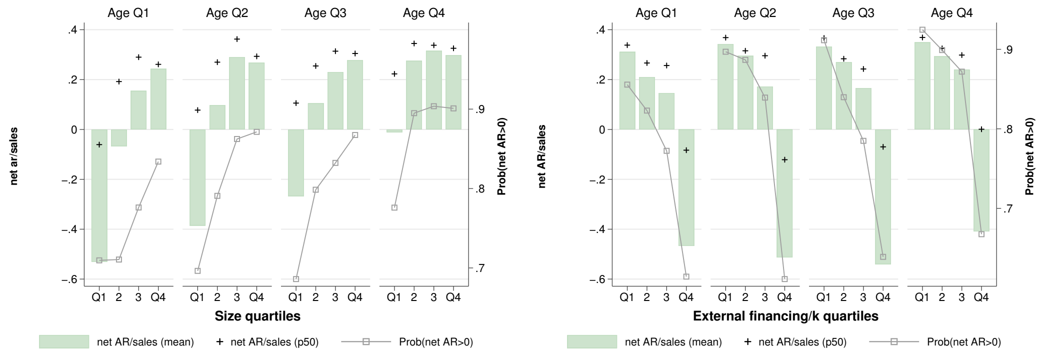
Notes: The sample includes all but wholesale, retail, and financial firms in the Compustat dataset for the period 2000-2007. The figures plot the choice of trade credit over age (left), firm size (middle) and reliance on external financing (right). The bars (+ or x) represent the mean (median) AP/sale and AR/sales. The gray line shows the probability of being a net trade credit lender (prob(net AR>0)) in each decile.

Figure 2 shows that even within the same age or size category, firms that are subject to more financial constraints borrow more trade credit. Panel (a) shows that, within each

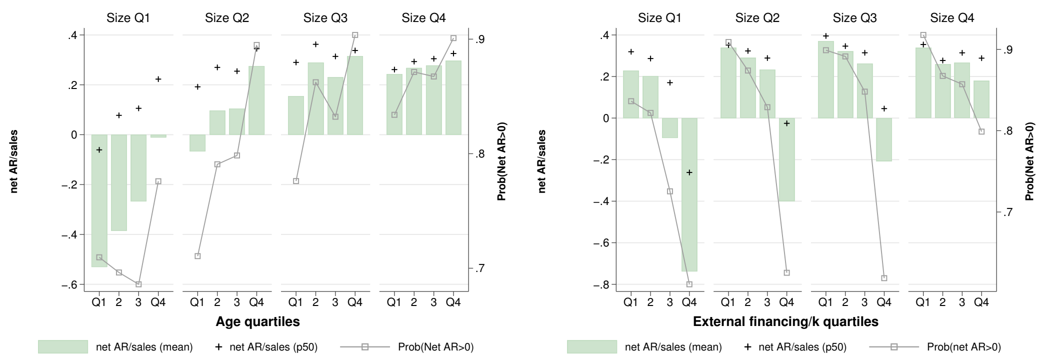
[3] Murfin and Njoroge (2015) shows, using a sample of retail firms that, the borrowing of trade credit (AP/sales) declines with firm size except for the largest two deciles of firms. That is, there exists a U-shaped relationship between AP/sales and firm size (Figure 1 of the paper). While we do see a similar, albeit less prominent, pattern among the retail sector firms in Compustat (Figure D.1 in the appendix), this pattern does not hold among the non-retail Compustat firms.

Figure 2: **Net AR within each age or size quartile**

(a) within each age quartile



(b) within each size quartile



Notes: The sample includes all but wholesale, retail, and financial firms in the Compustat dataset for the period 2000-2007. The figures plot net AR/sales (bars and +) and the probability of being a net trade credit lender (gray lines) within each quartile of age or size distribution. Panel (a) plots net AR over firm size (left) or reliance on external financing (right) within each age quartile. Panel (b) plots net AR over firm age (left) or reliance on external financing (right) within each size quartile. A similar plot for AR/sales and AP/sales can be found in Appendix Figure D.2.

quartile of the firm age distribution, smaller firms and firms that rely more on external financing are more likely to be net trade credit borrowers. Similarly, within the same size quartile, net lending of trade credit increases with firm age and declines with reliance on external financing (panel b).[4]

To control for industry-specific characteristics of trade credit practice, in Table 1, we estimate the correlation between firm age, size, and borrower status with trade credit choices

[4]As shown in the Appendix Figure D.2, this pattern is driven mostly by AP/sales.

with a set of sector and year fixed effects. The empirical specification is as follows:

$$y_{it} = \alpha_1 log(age)_{it} + \alpha_2 log(total\ asset)_{it} + \alpha_3 borrower_{it} + \phi_s + \varphi_t + \epsilon_{it}, \quad (1)$$

where y_{it} is one of the three measures of trade credit of firm i in year t—AP/sales, AR/sales and a dummy variable indicating this firm is a net trade credit lender $I_{net\ AR>0}$. The explanatory variables include the logarithms of firm age and total assets as well as a dummy variable indicating whether this firm is a borrower (i.e. external financing>0).

We find that the documented pattern is robust to the inclusion of the additional controls. While age and firm size have a negative and significant correlation with the size of AP/Sales, borrowers have a significantly higher AP/sales compared with non-borrowers (column 1-3). These firm characteristics, however, do not have a significant or statistically meaningful correlation with AR/sales (column 4-6), which is consistent with the patterns documented in the previous figures. More specifically, the estimated coefficients for AR/sales are insignificant for firm age and their magnitude is about 1/10 of the estimated coefficients for AP/sales. Lastly, the probability of being a net trade credit lender increases significantly with firm age and size. It is also significantly lower for borrowers (column 7-9).[5]

Table 1: **Trade credit and firm characteristics**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
log(age+1)	-0.136***	-0.0938***	-0.0756***	0.00859	0.00586	0.00819	0.0860***	0.0656***	0.0574***
	(0.0140)	(0.0134)	(0.0129)	(0.00552)	(0.00553)	(0.00552)	(0.00892)	(0.00867)	(0.00846)
log(total asset)		-0.0944***	-0.0793***		0.00626***	0.00833***		0.0490***	0.0420***
		(0.00565)	(0.00554)		(0.00174)	(0.00177)		(0.00304)	(0.00304)
borrower			0.234***			0.0324***			-0.111***
			(0.0137)			(0.00617)			(0.00971)
Dependent variable	AP/Sales	AP/Sales	AP/Sales	AR/Sales	AR/Sales	AR/Sales	$I_{NetAR>0}$	$I_{NetAR>0}$	$I_{NetAR>0}$
Sector FE, year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	29013	28942	28942	28982	28930	28930	28944	28891	28891
AR2	0.0662	0.144	0.164	0.0842	0.0873	0.0908	0.109	0.176	0.191

Notes: The table contains regression results from specification 1. The sample includes all but wholesale, retail, and financial firms in the Compustat dataset for the period 2000-2007. All regressions include a set of 2-digit sic sector and year fixed effects. Standard errors are clustered at the firm-level.

[5]The results do not change significantly if we control for inventory/sales and ROA. Appendix Table D.1 shows the regression of net AR/sales with these additional controls.

Our results show that among the Compustat firms, the choice of AR is much less sensitive to financial frictions than AP.[6] One possible explanation is the good access to accounts receivable financing instruments enjoyed by public firms. Accounts receivable financing is a type of agreement where firms receive financing in relation to their accounts receivable. It can be structured in various ways on the basis of loans (general credit and accounts receivable secured debt) and asset sales (factoring).[7] Without accounts receivable financing, lending one dollar of trade credit reduces the cash flow available to the lending firm by one dollar. However, if the lending firm can use the accounts receivable as collateral for a bank loan or sell the accounts receivable to a factor, the lending firm can provide trade credit to its customers without contributing as much of its own liquidity. Therefore, even constrained firms can often afford to provide trade credit to their customers.[8]

Discussion

Several other papers have also provided evidence to support the financial motive theory of trade credit using different datasets with key takeaways similar to ours. Compared with our Compustat sample, trade credit choices do exhibit certain differences in these datasets. As an example, the lending of trade credit—the choice of AR—does not vary significantly across firms in our Compustat sample. In contrast, Petersen and Rajan (1997) show that AR/sales increases with firm age and size in the Survey of Small Business Finance dataset. While we document that the borrowing of trade credit (AP) declines with firm age, Cuñat (2007) finds that trade credit increases in the early years of firms' life cycle (<5 years old)

[6] Note that financial frictions could still be an important determinant of AR for the non-Compustat firms. For example, Petersen and Rajan (1997) document that AR/sales increases with firm age and size among firms in the Survey of Small Business Finance dataset.

[7] For example, the Thomson Reuters DealScan data on loans issued in the syndicated loan market indicate that accounts receivable financing is quantitatively important. For example, of all the secured loan facilities opened during 2004–06, 46.3 percent are collateralized by accounts receivable. Accounts receivable has the highest advancing rate at 87 percent, which is much higher than "inventory of all kinds" (59 percent) and "property, plant, and equipment" (29 percent).

[8] If the advance rate of accounts receivable is x percent, lending one dollar of trade credit means a $1 - \frac{x}{100}$ dollar loss of liquidity. If the advance rate of accounts receivable is 100 percent, there is no liquidity loss when firms lend trade credit.

and decreases in the later years using a sample of UK firms. The initial increases with age is attributed to the time needed to build the buyer-supplier relationship. Despite these small differences, we view that our evidence, combined with the findings in these papers, is consistent with financial frictions being a crucial factor determining firms' trade credit choice. As a caveat, our analysis misses certain aspects of trade credit choices for young and small firms. However, Compustat firms are arguably more relevant quantitatively since the aggregate economic dynamics are driven mostly by large firms.

Our paper also abstracts from non-financial motives of trade credit, which are shown to be operative, especially among the largest firms and retailers. Using a sample of retailers and their suppliers, Murfin and Njoroge (2015) show that the borrowing of trade credit (AP/sales) declines with firm size, except for the largest two deciles of firms. These largest buyers use a substantial amount of trade credit from their small suppliers.[9] Similarly, Klapper et al. (2012) document that large buyers tend to get long trade credit terms from smaller suppliers. Both papers argue that these patterns are consistent with a non-financial motive to countervail frictions between suppliers and their buyers related to product quality. Another important non-financial motive often discussed in the literature is market power. Fabbri and Klapper (2016) show that suppliers with weaker bargaining power towards their customers are more likely to extend trade credit. As a caveat to our analysis, we choose to focus on the financial motives that we view as particularly important and relevant, especially given the empirical patterns documented in this section.

3 Model

This section builds a model with heterogeneous entrepreneurs and financial frictions to generate the cross-sectional correlation between financial constraints and trade credit choices,

[9] In Appendix Figure D.1, we replicate the result in Murfin and Njoroge (2015) using retail firms in Compustat. There are some evidence, albeit less significant than Murfin and Njoroge (2015), showing that AP/sales declines with firm size, except for the largest two deciles of retail-sector firms. However, we find that this pattern does not hold for non-retail firms (see Figure 1). As shown in Figure 1, AP/sales decreases monotonically with firm size.

as documented in the data. Firms in the model are different in two dimensions: productivity and wealth, and they choose the amount of bank credit and trade credit optimally. This productivity-wealth domain maps into firms with varying degrees of financial constraints, determining entrepreneurs' trade credit choices.

Sections 3.1 and 3.2 describe the economic environment and production technology. Section 3.3 discusses the financial frictions that lead to the coexistence of bank credit and trade credit as a means of financing working capital, which is where our model diverges from the standard model. We define the recursive competitive equilibrium in section 3.4. In section 3.5, we characterize the entrepreneurs' optimal choice of trade credit in the cross-section and when facing financial and TFP shocks theoretically.

3.1 Economic environment

Time is discrete with an infinite horizon. There is only one type of good that is used for consumption, investment and intermediate inputs. It is produced by a measure 1 of heterogeneous entrepreneurs using capital, labor and intermediate inputs. The entrepreneurs differ from each other by wealth (a) and productivity (z).

There is a measure N of homogeneous workers, who provide labor and consume. They do not have access to the asset markets; i.e., they are "hand-to-mouth."

The banking sector is perfectly competitive, with a representative bank making zero profit.

3.2 Preferences, endowments, and production technology

The preferences of workers are time separable, with instantaneous utility function $u(c_t^h, h_t)$

$$U^h(c^h, h) = \sum_t \beta^t u(c_t^h, h_t),$$

where β is the discount factor, c_t^h is consumption and h_t is labor provided by the households.

The preferences of entrepreneurs are time separable with instantaneous utility function of $log(c_t)$. The expected utility of the entrepreneur can be written as

$$U^e(c) = \mathbb{E}\sum_t \beta^t log(c_t),$$

where the expectation is taken over the stochastic processes of productivity z and wealth a.

Entrepreneurs operate a decreasing return to scale production technology ($\mu < 1$) that transforms capital, labor, and intermediate inputs into the final good, such that

$$y = Az((k^\alpha l^{1-\alpha})^{1-\chi} x^\chi)^\mu, \tag{2}$$

where A is the aggregate TFP of the economy and z is idiosyncratic productivity that follows an exogenous AR(1) process.[10]

Since the production technology is decreasing returns to scale, there is an optimal production scale for a given productivity z.

3.3 Financing production

In this section, we discuss the financial frictions that lead to the coexistence of bank credit and trade credit and derive the working capital constraints faced by the entrepreneurs.

Similar to Buera et al. (2015), entrepreneurs rent capital k at an interest rate r from a capital rental market and receive a return ra on their wealth.[11] Following Jermann and Quadrini (2012), we assume that entrepreneurs need to fund all outflows in advance and thus must take out an intra-temporal loan m. Since this is an intra-temporal loan and the representative bank earns zero profit, the equilibrium interest rate on the intra-temporal loan is zero.

[10] The economy admits an aggregate value-added production function $Y = \bar{A}K^{\frac{\alpha(1-\chi)\mu}{1-\chi\mu}} L^{\frac{(1-\alpha)(1-\chi)\mu}{1-\chi\mu}}$. In the absence of financial frictions, $\bar{A}$ is a function of A and the exogenous stationary distribution of z.

[11] In net, the entrepreneurs' interest payment is $r(k-a)$. This setup is equivalent to allowing entrepreneurs to own their capital k and borrow an inter-temporal loan d at interest rate r, in which wealth (net worth) is $a = k - d$ and the interest payment is $rd = r(k-a)$.

Timing

At the beginning of each period, entrepreneurs carry over from the previous period their wealth a. After the idiosyncratic productivity shock z is realized, entrepreneurs choose their current period production (k, l, x), their borrowing and lending of trade credit (AR, AP), their current period consumption (c), and their next period wealth (a').

Based on these choices, entrepreneurs obtain the required intra-temporal working capital bank loan, production occurs, and entrepreneurs and workers consume and save. At that point, entrepreneurs decide whether to default on their bank loans. If an entrepreneur decides to default, a renegotiation process occurs between the entrepreneur and the bank, with the ultimate settlement determined by the bank's expected proceeds from liquidating the entrepreneur's collateral. After the bank loan is settled, trade credit is repaid, and the entrepreneurs carry their wealth a' into the next period. The timing is summarized in Figure 3.

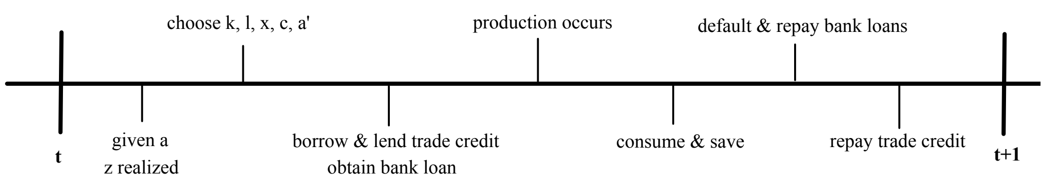


Figure 3: **Timing**

Financial frictions and bank loan limits

The fundamental financial friction in the economy is the bank's limited enforcement over the repayment of bank loans. Upon default, the bank can liquidate the entrepreneur's collateral, and, with some probability, the liquidation will be successful and the bank will recover the full value of the collateral. In equilibrium, entrepreneurs will simply make a take-it-or-leave-it offer equal to the expected liquidation value of the collateral to the bank. This gives rise to a bank loan borrowing constraint as a function of the collateral value of the entrepreneur's assets, which will ensure no default in equilibrium. Let m be the size of the intra-temporal bank loan of the intermediate and final goods entrepreneurs, respectively. We can write the bank loan limits as the following

$$m \leq \gamma_1 a' + \gamma_2 AR, \tag{3}$$

where γ_1 and γ_2 are the probability of liquidating wealth a' and accounts receivable AR upon the entrepreneur's default.

The term $\gamma_2 AR$ on the right hand side of the bank loan limit (inequality 3) intends to capture the usage of accounts receivable financing. Accounts receivable financing is a type of agreement where firms receive financing in relation to their accounts receivable. As documented by Mian and Smith (1992), accounts receivable financing can be structured in various ways on the basis of loans (general credit and accounts receivable secured debt) and asset sales (factoring). Here we model accounts receivable financing as a loan collateralized by AR.

The existence of accounts receivable financing changes the nature of trade credit. Without accounts receivable financing, trade credit serves merely as a redistribution channel, redirecting credit from firms with access to financing to those without. With the help of accounts receivable financing, a collateralizable or resalable asset (accounts receivable) is created whenever firms lend trade credit to their customers. Through the process of collateral creation, accounts receivable financing increases the collective access to bank credit for both trade credit lenders and borrowers.

Trade credit

Building on the idea from the literature that trade credit exists because inputs suppliers have a comparative advantage, compared with the bank, in lending inputs to their customers, we assume entrepreneurs have perfect enforcement over the repayment of trade credit similar to the assumptions used in Burkart and Ellingsen (2004).

There is a Walrasian market for the good and trade credit. r^{tc} is the trade credit interest rate. Entrepreneurs supply to this market their output $y = Az((k^{\alpha}l^{1-\alpha})^{1-\chi}x^{\chi})^{\mu}$ and a trade credit loan of size $AR \in [0, y]$. They also purchase intermediate good of value x and borrow trade credit of size $AP \in [0, x]$. At the end of the period, they expect to collect a payment of $y - x + r^{tc}(AR - AP)$ from the market. Households purchase good for consumption from this market and they always pay on the spot.

The budget constraints of the entrepreneurs in the presence of trade credit can be written as

$$\begin{aligned} c + a' &= (1+r)a + Az((k^{\alpha}l^{1-\alpha})^{1-\chi}x^{\chi})^{\mu} \\ &\quad -(r+\delta)k - wl - x + r^{tc}(AR - AP). \end{aligned} \tag{4}$$

Working capital constraint

Similar to Jermann and Quadrini (2012), the outflows must be financed intra-temporarily by bank loans m, such that

$$m = a' - a + c + r(k - a) + \delta k + wl + x + AR - AP.$$

Using the budget constraints of the entrepreneurs (equation 4), we can rewrite the size of the intra-temporal bank loan as

$$m = Az((k^{\alpha}l^{1-\alpha})^{1-\chi}x^{\chi})^{\mu} + (1 + r^{tc})(AR - AP).$$

Therefore, the working capital constraints faced by the entrepreneurs are:

$$Az((k^{\alpha}l^{1-\alpha})^{1-\chi}x^{\chi})^{\mu} + (1 + r^{tc})(AR - AP) \leq \gamma_1 a' + \gamma_2 AR, \tag{5}$$

Equation 5 shows that, in the presence of trade credit activities, the entrepreneurs' needs for intra-temporal loans increase by $(1 + r^{tc})(AR - AP)$, while their bank loan limit increases by $\gamma_2 AR$.

Discussion

In modeling trade credit, our primary goal is to capture the impact of trade credit on entrepreneurs' liquidity positions and hence we abstract from many other aspects of trade credit, one of which is trade credit default risk. Admittedly, trade credit default plays an important role in propagating financial shocks, especially when it triggers a chain of default (Kiyotaki and Moore, 1997, Boissay and Gropp, 2007, and Jacobson and von Schedvin, 2015).

Ideally, we would like to incorporate trade credit default risk into the current setting. However, there are two facts regarding trade credit default that make it difficult to separate it from liquidity loss. First, in practice, firms often employ specific policies to manage their accounts receivable so that they do not need to bear the default risk.[12] With the help of these policies, firms transform the risk of default into a loss in liquidity with certainty. Second, trade credit default often means a delay of payment later than the pre-agreed dates. In very rare cases, it means non-payment because the customer becomes insolvent (see Boissay and Gropp, 2007). In the former case, a delay in payment does not hurt an unconstrained entrepreneur by much; only the constrained ones suffer from liquidity loss—this is a mechanism already present in this model. Furthermore, as shown later, the model is calibrated to match the quarterly data, longer than the usual trade credit terms (30 days). Thus, the calibrated model is likely to have captured the majority of the default activities in the data.

[12] These policies include: non-recourse factoring, establishing a captive finance subsidiary, or purchasing credit risk insurance (see Mian and Smith, 1992).

3.4 Recursive competitive equilibrium

In this section, we present the problem of the workers and the entrepreneurs and define recursive competitive equilibrium.

The problem of the workers is stationary. It can be written simply as follows:

$$\max_{c^h,h} c^h - \psi\frac{h^{1+\theta}}{1+\theta},\ s.t.\ c^h = wh. \tag{6}$$

Let $V(a,z)$ be the value function of the entrepreneurs with state variables (a,z). They choose inputs of production (k,l,x), accounts receivable (AR), accounts payable (AP) consumption (c), and next period wealth (a'). The choices are subject to a budget constraint (equation 8) and a working capital constraint (inequality 9). We also require that entrepreneurs' wealth be non-negative. The value function of the entrepreneur can be written recursively as follows:

$$V(a,z) = \max_{c,k,l,x,AR,AP,a'} log(c) + \beta\mathbb{E}_{z'}V(a',z'), \tag{7}$$

$$s.t.\quad c + a' = (1+r)a + Az((k^{\alpha}l^{1-\alpha})^{1-\chi}x^{\chi})^{\mu} - (r+\delta)k - wl - x$$

$$+r^{tc}(AR - AP), \tag{8}$$

$$Az((k^{\alpha}l^{1-\alpha})^{1-\chi}x^{\chi})^{\mu} + (1+r^{tc})(AR - AP) \leq \gamma_1 a' + \gamma_2 AR, \tag{9}$$

$$0 \leq AR \leq Az((k^{\alpha}l^{1-\alpha})^{1-\chi}x^{\chi})^{\mu}, 0 \leq AP \leq x,$$

$$a' \geq 0.$$

Definition 1. (Recursive competitive equilibrium) The recursive competitive equilibrium consists of interest rate of rental capital r, wage rate w, trade credit interest rate r^{tc}; value function of the entrepreneurs $V(a,z)$; policy functions $c(a,z)$, $k(a,z)$, $l(a,z)$, $x(a,z)$, $AR(a,z)$, $AP(a,z)$ and $a'(a,z)$; consumption and hours of the workers (c^h,h); and the CDF of the stationary distribution $\Phi(a,z)$, such that

1. Given prices, the value functions and policy functions solve the entrepreneurs' problem

7.

2. Given prices, the consumption and hours of the workers solve the workers' problem 6.

3. Labor market clears

$$\int l(a,z)d\Phi(a,z) = N \cdot h.$$

4. Rental capital market clears

$$\int k(a,z)d\Phi(a,z) = \int ad\Phi(a,z).$$

5. Trade credit market clears

$$\int AR(a,z)\Phi(a,z) \quad = \quad \int AP(a,z)d\Phi(a,z).$$

6. Good market clears

$$\int y(a,z)d\Phi(a,z) = N \cdot c^h + \int [c(a,z) + \delta k(a,z) + x(a,z)]\Phi(a,z).$$

3.5 Trade credit decisions

In this section, we characterize entrepreneurs' choice of trade credit conditional on their state variables a and productivity z. Section 3.5.1 analyzes trade credit choices of the heterogeneous entrepreneurs in the cross-section. We then derive comparative statistics following a tightening in the working capital constraint and a decline in aggregate productivity (section 3.5.2).

3.5.1 Trade credit in the cross section

In this section, we show that entrepreneurs' optimal choice of trade credit follows simple cut-off rules. Before presenting the propositions, we first derive the first-order-conditions

(FOCs) of the entrepreneurs' problem and provide some intuitions based on the FOCs.

Denote $F(k,l,x) = ((k^{\alpha}l^{1-\alpha})^{1-\chi}x^{\chi})^{\mu}$ as the production function. The Lagrangian of the entrepreneurs' problem can be written as,

$$\begin{aligned}\mathcal{L} &= log((1+r)a + AzF(k,l,x) - (r+\delta)k - wl - x + r^{tc}(AR - AP) - a') \\ &\quad +\beta\mathbb{E}_{z'}V(a',z') + \mu(\gamma_1 a' + \gamma_2 AR - AzF(k,l,x) - (1+r^{tc})(AR - AP)) \\ &\quad +\chi_1(AzF(k,l,x) - AR) + \chi_2 AR \\ &\quad +\chi_3(x - AP) + \chi_4 AP \\ &\quad +\tau a'.\end{aligned}$$

where μ, $\chi_1, \chi_2, \chi_3, \chi_4$ and τ are the corresponding Lagrangian multipliers for the working capital constraint, the constraints on the size of AR and AP, as well as the non-negative wealth constraint, respectively.

We derive the FOCs as the following:

$$k: \quad AzF_k = \frac{r+\delta}{1-c\mu+c\chi_1}, \tag{10}$$

$$l: \quad AzF_l = \frac{w}{1-c\mu+c\chi_1}, \tag{11}$$

$$x: \quad AzF_x = \frac{1-c\chi_3}{1-c\mu+c\chi_1}, \tag{12}$$

$$AR: \quad r^{tc} = c\mu(1+r^{tc}-\gamma_2) + c\chi_1 - c\chi_2, \tag{13}$$

$$AP: \quad r^{tc} = c\mu(1+r^{tc}) - c\chi_3 + c\chi_4, \tag{14}$$

$$a': \quad \frac{1}{c} = \beta\mathbb{E}_{z'}V_{a'}(a',z') + \mu\gamma_1 + \tau. \tag{15}$$

These FOCs have to hold together with the complementary slackness conditions of the Lagrangian multipliers and inequalities (omitted here). Furthermore, using the Envelope theorem, we derive the Euler Equation as

$$\frac{1}{c} = \beta\mathbb{E}_{z'}\frac{1}{c'}(1+r') + \mu\gamma_1 + \tau. \tag{16}$$

Intuitively, the Lagrangian multiplier μ of the working capital constraint represents the shadow value of cash flows. The shadow value μ increases with the degree of financial constraints faced by the entrepreneurs. Given the productivity level z, μ decreases with wealth a. In fact, there exists a cut-off value $\underline{b}(z)$ of entrepreneur's wealth, above which the entrepreneur is not constrained ($\mu = 0$) and below which the entrepreneur is constrained ($\mu > 0$).

Next, we turn to the choices of trade credit. According to the FOC w.r.t AR (equation 13), the marginal benefit of lending AR is the interest rate r^{tc} while the marginal cost is the loss in cash flow $(1 + r^{tc} - \gamma_2)$ multiplier by the shadow value of cash flow μ adjusted by the marginal utility. Similarly, there exists a threshold value for wealth—we denote it as $\underline{AR}(z)$—above which the marginal benefit of lending trade credit exceeds marginal cost and the entrepreneurs start to choose a positive AR. The similar intuition applies to the choice of AP using equation 14: we can show that there exists a threshold value for wealth, $\underline{AP}(z)$, below which the entrepreneurs choose a positive AP and above which $AP = 0$.

We formalize the results in the following proposition:

Proposition 2. *There exist three cut-off functions $\underline{b}(z)$, $\underline{AR}(z)$, and $\underline{AP}(z)$ such that, for the entrepreneurs with wealth a and productivity z,*

1. The working capital constraint is binding if and only if $a \leq \underline{b}(z)$.
2. The choice of accounts receivable $AR > 0$ if $a \geq \underline{AR}(z)$, and $AR = 0$ if $a < \underline{AR}(z)$.
3. The choice of accounts payable $AP = 0$ if $a > \underline{AP}(z)$, and $AP > 0$ if $a \leq \underline{AP}(z)$.

Proof. See Appendix B.1. □

In fact, for any given z, we can rank the three wealth thresholds in the previous proposition. Intuitively, the three thresholds of wealth in the previous proposition have a one-to-one mapping with three values of μ: $\mu = 0$ for $\underline{b}(z)$, $\mu = \frac{r^{tc}}{c(1+r^{tc}-\gamma_2)}$ for $\underline{AR}(z)$ and $\mu = \frac{r^{tc}}{c(1+r^{tc})}$

for $\underline{AP}(z)$.[13] Since given z, μ decreases with the wealth of the entrepreneurs, the ranking of the three wealth thresholds is just the reverse of the ranking of their corresponding μs. In sum:

Proposition 3. *If the trade credit interest rate $r^{tc} \geq 0$, the following inequality holds for any z*

$$\underline{AR}(z) \leq \underline{AP}(z) \leq \underline{b}(z).$$

Proof. See Appendix B.2. □

Figure 4 is a graphic illustration of the cut-off property of trade credit choices (Proposition 2 and 3). If the trade credit interest rate is strictly positive and $\gamma_2 \in (0, 1]$, all unconstrained and some constrained entrepreneurs lend trade credit to their customers, and only the very constrained entrepreneurs borrow trade credit from their suppliers. Some entrepreneurs borrow and lend trade credit simultaneously.[14]

3.5.2 Trade credit following a negative financial and TFP shock

In this section, we first characterize the changes in trade credit choices in the face of a negative financial shock in a partial-equilibrium setting.

During a negative financial shock, the collateral value of assets drops. On average, the entrepreneurs are more likely to be financially constrained. They borrow more trade credit from their suppliers and lend less trade credit to their customers. The threshold functions for trade credit shift upwards. The following proposition summarizes the results:

Proposition 4. *Given prices, if $\tilde{\gamma}_2 < \gamma_2$, $\frac{\widetilde{AR}(a,z)}{\widetilde{y}(a,z)} \leq \frac{AR(a,z)}{y(a,z)}$ and $\frac{\widetilde{AP}(a,z)}{\widetilde{x}(a,z)} \geq \frac{AP(a,z)}{x(a,z)}$. The threshold functions move upwards, that is, $\underline{\widetilde{AP}}(z) \geq \underline{AP}(z)$, and $\underline{\widetilde{AR}}(z) \geq \underline{AR}(z)$ for any z.*

Proof. See Appendix B.3. □

[13] Using equation 13 and 14, we obtain μ corresponding to the threshold $\underline{AR}(z)$ and $\underline{AP}(z)$ by letting $\chi_1 = \chi_2 = 0$ and $\chi_3 = \chi_4 = 0$. The ranking of the three μ is $0 \leq \frac{r^{tc}}{c(1+r^{tc})} \leq \frac{r^{tc}}{c(1+r^{tc}-\gamma_2)}$ if $r^{tc} \geq 0$.

[14] More specifically, for a given z, if $\gamma_2 > 0$, then $\underline{AR}(z) < \underline{AP}(z)$ holds with strict inequality. The entrepreneur (a, z) would borrow and lend trade credit simultaneously if $a \in (\underline{AR}(z), \underline{AP}(z))$.

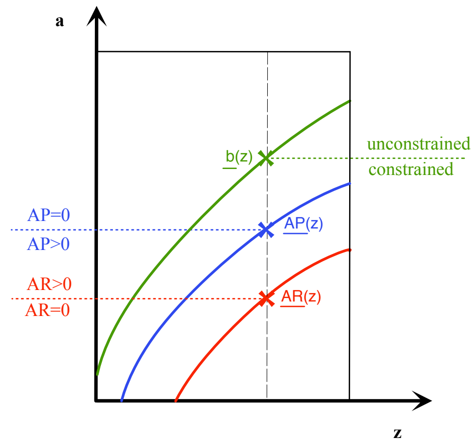


Figure 4: **The cut-off property of trade credit choices**

Notes: This figure shows the cut-off property of trade credit choices for the entrepreneurs. The three threshold functions $\underline{b}(z)$ (green), $\underline{AP}(z)$ (blue) and $\underline{AR}(z)$ (red) intersect with the vertical line at three points, which are the threshold value of wealth that separate constrained entrepreneurs from unconstrained ones, entrepreneurs who borrow trade credit and those who do not, and entrepreneurs who lend trade credit and those who do not, respectively.

Interestingly, the changes in trade credit are different following a negative TFP shock. Following a negative TFP shock, the optimal scale of production is lower, which relaxes the financial constraints faced by the entrepreneurs. Therefore they increase the trade credit lending to customers and reduces the borrowing of trade credit from their suppliers. The threshold functions shift downwards. The results are summarized in the following proposition.

Proposition 5. *Given prices, if* $\tilde{A} < A$, $\frac{\widetilde{AR}(a,z)}{\widetilde{y}(a,z)} \geq \frac{AR(a,z)}{y(a,z)}$ *and* $\frac{\widetilde{AP}(a,z)}{\widetilde{x}(a,z)} \leq \frac{AP(a,z)}{x(a,z)}$ *for any* (a, z). *The threshold functions shift downwards, that is,* $\underline{\widetilde{AP}}(z) \leq \underline{AP}(z)$, *and* $\underline{\widetilde{AR}}(z) \leq \underline{AR}(z)$ *for any* z.

Proof. See Appendix B.4. □

The key takeaway from Proposition 4 and 5 is the different response to negative financial and TFP shocks. Although both propositions are obtained under a partial-equilibrium setting, they have interesting implications on the movement of trade credit interest rate in the general equilibrium. In response to a negative financial shock, the supply of trade credit declines and the demand for trade credit surges. In equilibrium, this leads to an increase in trade credit interest rate. On the contrary, in the face of a negative TFP shock, supply of trade credit increases while the demand for trade credit declines, which puts downward pressure on the trade credit interest rate. In the next section, we further explore the dynamics of trade credit in a general equilibrium setting.

In addition, Proposition 4 predicts that entrepreneurs subject to more severe shocks would cut back their lending of trade credit (i.e. AR) and increase their borrowing of trade credit (i.e. AP) relative to entrepreneurs less exposed to the shock.[15] Note that this prediction speaks to entrepreneurs' differential responses, not the absolute changes in trade credit. For example, if there is a contraction in aggregate AR and AP during a financial crisis, we are likely to see that both AR and AP decrease, but firms that are hit harder by the crisis would cut back their lending more and reduce their borrowing less. In section 5, we test this prediction by comparing the trade credit changes across firm groups with different exposure to financial shocks.

4 Quantitative analysis

In this section, we provide a quantitative analysis of trade credit using the model. We first discuss the calibration strategy and some quantitative properties of the calibrated model in section 4.1. We then use the calibrated model to quantify the role of trade credit during the 2007–09 financial crisis (sections 4.2) and under productivity shocks (section 4.3).

4.1 Calibration strategy and results

Following Jermann and Quadrini (2012), each period in the model corresponds to one quarter. Since many data moments are only available at the annual frequency, calibrating the model

[15]To understand this prediction, consider two groups of ex-ante identical entrepreneurs with only one group experiencing a negative financial shock. In a partial equilibrium setting, the unaffected group's trade credit choices stay unchanged, whereas the threshold functions shift upwards for the affected group of entrepreneurs. Therefore, the affected group, as a whole, lends less trade credit to their customers and borrows more trade credit from their suppliers.

requires a temporal aggregation of the variables. For the stock variables such as capital and labor, we take the average of the quarterly variables to construct the annual variables. For the flow variables such as profit and output, we take the sum of the quarterly variables to construct annual variables.

The workers' utility function has the GHH form (Greenwood et al., 1988). We pick $\theta = 0.5$, which gives a Frisch elasticity of 2 and is well within the standard range of macro estimates (Chetty et al., 2011 and Keane and Rogerson, 2012). The disutility of providing labor, ψ, is calibrated such that 30 percent of workers' time is spent working, i.e., $h = 0.3$. Entrepreneurs' instantaneous utility function is in log form. We calibrate the discount factor β of entrepreneurs to match an annual interest rate of 4 percent. Since the share of entrepreneurs in the data is around 10 percent and the measure of entrepreneurs in the model is 1, we set the workers' measure at $N = 9$.

We fix the capital share $\alpha = 1/3$ in the production function. Consequently, the labor share is 2/3. Following Jones (2011), we fix χ so that the input's share in aggregate output is 0.43. The capital depreciation rate δ is chosen to be 0.025 so the annual depreciation rate of capital is approximately 10 percent. Following Buera et al. (2011), we calibrate the scale parameters (μ) to match the earnings share of the top 5 percent of individuals.

The idiosyncratic productivity process follows an AR(1) log-normal process, $logz_{it} = \rho_z logz_{it-1} + \sigma_z \epsilon_{it}$ where $\epsilon_{it} \sim \mathcal{N}(0, 1)$. We choose ρ_z and σ_z so that our model reproduces two moments documented in the literature: 1) the s.d. of annual employment growth of 0.38 documented by Davis et al. (2007), and 2) the 1-year auto-correlation of annual profit rate documented by Gourio (2018) using Compustat. Depending on the sample and the specification, Gourio (2018) estimates that the auto-correlation ranges from 0.68 to 0.79.

The calibrated productivity process has a persistence of 0.92 and a s.d. of innovation of 0.14. Under this calibration, the s.d. of employment growth and the 1-year auto-correlation of the profit rate in the model are 0.38 and 0.76, respectively. The annualized productivity process has a persistence of 0.71 and a s.d. of 0.34. In comparison, Khan and Thomas (2013) calibrated an annual productivity process with a persistence of 0.657 and s.d. of 0.118 in the presence of capital adjustment cost. Our calibration is comparable to the estimated process in Imrohoroglu and Tuzel (2014) using Compustat data, which has a persistence of 0.70 and a s.d. of 0.375.

We pick γ_1, the collateral constraint on wealth a' to match the ratio of credit market liabilities to non-financial assets in the US non-financial corporate sector. Similar to Jermann and Quadrini (2012), credit market liability is the sum of "debt securities" and "loans" in the Flow of Funds dataset. Non-financial asset is also taken from the Flow of Funds and includes equipment, real estate, and intellectual property product (IPP). In 2006, the ratio of credit market liabilities to non-financial assets was 0.36.[16] Our calibration shows that $\gamma_1 = 0.38$ can match this target.

The collateral value of accounts receivable, γ_2, is chosen to match the aggregate AP to sales ratio of 0.32 in our benchmark Compustat sample. We use Compustat sample moment as the target because Murfin and Njoroge (2015) document that large firms in the retail sector often borrow a substantial amount of trade credit from their small suppliers—a pattern we do not see in the other sectors of the economy. By using our Compustat sample, which excludes retailers, and targeting AP rather than AR, we try to minimize the impact of large retail firms on our results. Our calibrates gives $\gamma_2 = 0.69$ and the ratio of AP to sales of 0.32. Under this calibration, the ratio of trade credit to debt is 0.24 in the model, which is lower than the ratio of trade credit to credit market liabilities in the US non-financial corporate sector (0.32). This means that our calibration is likely to have underestimated the aggregate importance of trade credit in the economy.

Another thing to note is that, in our Compustat sample (2000-2007), the aggregate AR to AP ratio is approximately 1.75, and the aggregate net AR to sale ratio is 0.25. This means that the public firms are a net lender of trade credit to the rest of the economy. On the other hand, since our model is a closed economy, the aggregate AR to AP ratio is 1, and

[16]These targets can also be found in the BEA Intergrated Macroeconomic Accounts Table S.5.

the aggregate net AR to sales ratio is 0. Because of this data limitation, our model cannot match the full distribution of the net AR/sales in the Compustat sample. The s.d. of net AR to sales ratio is 0.68 in the model, which is somewhat lower than the s.d. of 0.74 in the data. Table 2 presents a summary of the calibrated parameters, targets, and calibration results.[17]

Table 2: **Summary of calibration**

Parameter		Value	Target/Source	Data	Model
θ	inverse of Frisch elasticity	0.5	standard	-	-
α	capital share in production function	1/3	capital share of 1/3	-	-
χ	intermediate goods share	0.43	intermediate goods share of 0.43	-	-
N	measure of workers	9	share of entrepreneurs	10%	10%
ψ	disutility from working	1.9	hours	0.3	0.3
δ	depreciation rate	0.025	annual 10% depreciation rate	10%	10%
β	discount rate	0.94	annual 4% interest rate	4%	4%
μ	scale parameter	0.9	top 5 percent earning share	0.3	0.3
ρ_z	persistence of productivity process	0.92	1-year autocorrelation of profit rate	[0.68,0.79]	0.76
σ_z	s.d. of the innovation in annual productivity process	0.14	s.d. of employment growth	0.38	0.38
γ_1	collateral value of wealth	0.38	credit market liabilities/nonfinancial assets	0.36	0.36
γ_2	collateral value of AR	0.69	accounts payable/sales	0.32	0.32

Notes: We take the share of entrepreneurs, and the top 5 percent earnings share from Buera et al. (2011). 1-year autocorrelation in profit rate follows the estimates in Gourio (2018). The s.d. of employment growth is estimated by Davis et al. (2007) for 2001. We take credit market liability from Flow of Funds Table L.103 line 23 and nonfinancial asset size from Flow of Funds Table B.103 line 2. Accounts payable to sales is computed as the total accounts payable divided by total sales in the Compustat sample.

In the data, trade credit interest rate is very difficult to measure and the literature is yet to give a widely accepted estimate for it. The common understanding is that trade credit is much more expensive than bank credit. Petersen and Rajan (1997) shows that the effective annual interest rate is around 43 percent for one of the most commonly used trade credit contracts in the retail sector. Costello (2014) uses Compustat to estimate the interest rate on trade credit by comparing firms' gross profit margin before and after the use of trade credit, and finds an annual interest rate of 12 to 16 percent. While our calibrated model is able to generate a rather high trade credit interest rate—the annualized trade credit interest rate is approximately 16 percent in the model, it is still at the lower end of the estimates in the data. This perhaps suggests there are other factors driving up the interest rate, such as the default risk.[18]

[17] The algorithm to solve the stationary equilibrium can be found in Appendix C.1.

[18] Boissay and Gropp (2007) documents, using French firm-level data, that the trade credit default to

Given that the calibration delivers a risk-free annual interest rate of 4% (1% at the quarterly frequency), a sizable spread exists between the two interest rates. The risk-free interest rate r is the price that clears the capital rental market. It also reflects the entrepreneur's willingness to substitute consumption inter-temporally, as shown in the Euler equation 16. The interest rate of trade credit, on the other hand, reflects the shadow value of liquidity for entrepreneurs. To see this, rewrite the FOC w.r.t. AR (equation 13) as $r^{tc} = \frac{\mu(1-\gamma_2)+(\chi_1+\chi_2)}{\frac{1}{c}-\mu}$. That is, r^{tc} increases when entrepreneurs are more constrained (higher μ) and when accounts receivable become less valuable as collateral (lower γ_2). Not surprisingly, these two interest rates differ and could potentially move in different directions with changes in economic fundamentals.

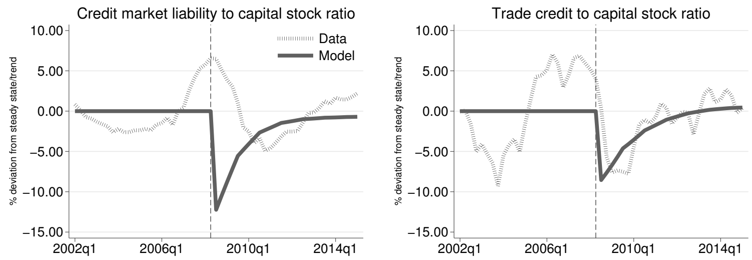
4.2 The 2007-09 financial crisis

Similar to the exercise in Khan and Thomas (2013) and Zetlin-Jones and Shourideh (2017), we introduce a shock to both collateral values—γ_1 and γ_2—so that the model generates a peak-to-trough decline in the ratio of credit market liabilities to the capital stock. The shock decays geometrically with a half-life of one year (four periods) to be consistent with the duration of the banking crisis in the advanced economies.[19]

The left panel of Figure 5 shows that, following an 8 percent decreases in the collateral values, the model generates a decrease in the ratio of credit market liabilities to the capital stock, closely matching the 11 percent decrease from peak to trough in the data. Also, panel (b) of Figure 5 shows that the decline in the ratio of trade credit to capital stock is approximately 9 percent, somewhat lower than the 13 percent decrease in the data. The

payable ratio is approximately 2 percent on average. If we take this default risk at face value, it seems that default risk is unlikely to generate the high trade credit interest rate on its own. Admittedly, default risk is perhaps much higher for small firms. According to Cuñat (2007), 46 percent of the firms in the Survey of Small Business Finance reported that they had made some payments after the due dates during the last year. However, it is difficult to translate this number into the actual cost faced by the suppliers. First, it is unclear what is the value of the delayed trade credit payment as a share of total trade credit. Second, as discussed in the model section, the cost of delay in the payment depends on whether the supplier is financially constrained.

[19]See Appendix C.2 for details on computing the transitional dynamics after the shock.

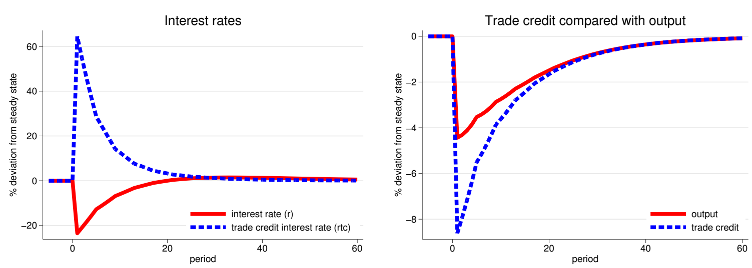


(a) (b)

Figure 5: **Dynamics of credit market liability and trade credit**

Notes: The data used in the above figures are for the U.S. non-financial corporate sector. Among them, credit market liability is taken from Flow of Funds Table L.103 line 23. Trade credit is calculated as the average of trade payable (line 30 of Flow of Funds Table L.103) and trade receivable (line 15 of Flow of Funds Table L.103). Capital stock is constructed as the sum of equipment (line 46 of Flow of Funds Table B.103), intellectual property products (IPP) (line 47 of Flow of Funds Table B.103), and nonresidential structural capital (line 51 of Flow of Funds Table B.103), all valued at historical prices. Both credit market liability and trade credit to capital stock ratio are HP-filtered with a smoothing parameter of 1,600, and the percentage derivation from trend is plotted in the figures. The corresponding model moments are normalized to 0 at $t = 0$. The dashed line corresponds to $t = 0$ in the model and 2008Q2 in the data.

vertical dash line marks 2008Q2, one quarter before the official bankruptcy of the Lehman Brothers. It also coincides with the peak of credit market liability to capital stock ratio.



(a) (b)

Figure 6: **Trade credit dynamics following the financial crisis**

Notes: Panel (a) plots the percentage change of interest rate r (red) and trade credit interest rate r^{tc} (blue) following the financial crisis in the model. Panel (b) plots the percentage change in total trade credit (blue) and value-added output (red) in the model.

Figure 6 plots the dynamics of trade credit. Consistent with the predictions of Proposition 4, the shift in the supply and demand of trade credit leads to an increase in the trade credit interest rate (panel a) and, under the calibrated parameters, a decrease of trade credit approximately twice as large as that of output (panel b). A direct consequence of these changes is that, as trade credit becomes costlier and scarcer during the financial crisis, some of the constrained entrepreneurs can no longer rely on their suppliers' trade credit to finance their production. Interestingly, the reduction in the demand for capital puts downward pressure on the real interest rate and widens the gap between the two interest rates (panel a).

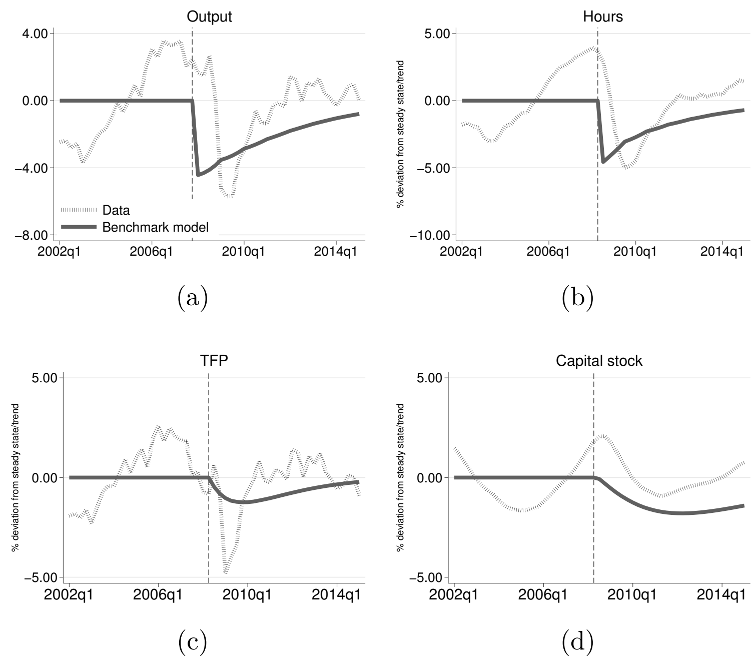


Figure 7: **Dynamics after the financial crisis**

Notes: The data used in the above figures are for the U.S. nonfinancial corporate sector. Among them, output (gross value added) is taken from NIPA Table 1.14 line 17. Data for hours worked is an index taken from Bureau of Labor Statistics Labor Productivity and Costs database (BLS code PRS88003033). Data for capital stock are constructed in the same way as Figure 5. TFP is then constructed as a Solow-type residual using output, hours, and capital stock. The corresponding model moments are normalized to 0 at $t = 0$. The dashed line corresponds to $t = 0$ in the model and 2008Q2 in the data.

Figure 7 shows that the model can generate a sizable recession following the crisis. Output decreases by 4.4 percent, slightly more than half of what we observe in the data. Hours decreases by 5 percent compared to a 9 percent decline in the data. The magnitude of the decrease in capital stock is similar in the data and the model. The model also generates a 1.2 percent decline in TFP. Note that although the official NBER recession starts from 2007Q4, the initial drop in output was small. In fact, the most significant decrease in all four series happened either in 2008Q3 or 2008Q4. The vertical dash line again marks 2008Q2, the same as in Figure 5.

Next, we provide further examination of the role played by trade credit by comparing the outcomes in the benchmark economy to a counterfactual economy without trade credit. The counterfactual economy is identical to the benchmark economy, except now bank credit is the only financing source. In Appendix Section A.1, we describe the counterfactual economy and define its recursive competitive equilibrium.

Not surprisingly, without trade credit, the counterfactual economy's output would be lower than that of the benchmark economy, ceteris paribus, and would react differently following aggregate shocks simply because the two economies start from different levels. Therefore, we first increase the collateral value of bank credit in the counterfactual economy so that the two economies produce the same output. In other words, we replace trade credit with bank credit in the counterfactual economy to reach the same output level as the benchmark economy. The calibration shows that this requires an increase in the collateral value of wealth in the counterfactual economy to $\tilde{\gamma}_1 = 0.56$.

Table 3: **Steady state: Benchmark vs. counterfactual economy**

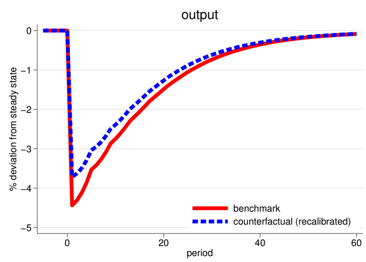
	γ_1	γ_2	interest rate	wage	output	capital	labor	TFP
			benchmark normalized = 1					
benchmark	0.38	0.69	1	1	1	1	1	1
counterfactual	0.56	—	1.11	1.01	1	0.99	1.01	0.98

Notes: This table compares the steady state aggregate outcomes between the benchmark and the counterfactual economy. The interest rate, wage, output, capital, labor and TFP are normalized such that the levels in the benchmark economy are 1.

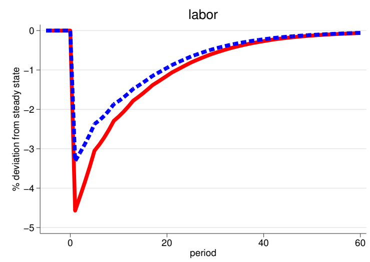
Table 3 summarizes the difference between the benchmark and the counterfactual economy under this calibration. Under this calibration, the percentage difference in aggregate labor, capital, and TFP between these two economies are all somewhere between 1 to 2 percent.[20] Admittedly, it is challenging to calibrate the two economies so that they are com-

[20] The difference in real interest rate is slightly higher than the rest of the variables. In an alternative calibration exercise, we increase the discounting factor β in the counterfactual economy to match the real interest rate's 1 percent target (quarterly). We find this alternative calibration gives very similar quantitative results.

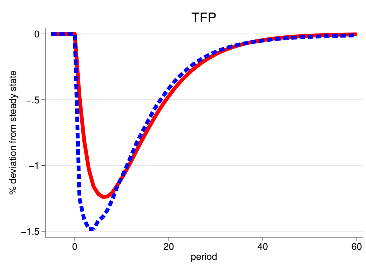
parable in all dimensions. Nevertheless, we view this as a useful exercise that helps illustrate the difference between two economies with and without trade credit.



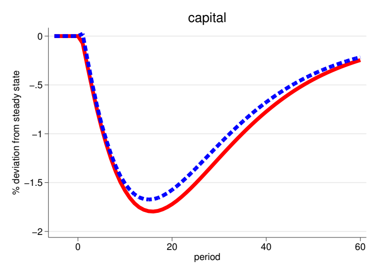
(a)



(b)



(c)



(d)

Figure 8: **Dynamics after the financial crisis: Benchmark vs. counterfactual**

Notes: The figures show the percentage changes in the aggregate economy in terms of output, hours, aggregate TFP, and capital stock after the financial crisis. The solid red lines represent the benchmark economy (with trade credit), while the dashed blue lines represent the counterfactual economy (without trade credit).

Figure 8 shows that the recession generated by the same shock—an 8 percent decreases in collateral value—is milder in the counterfactual economy than in the benchmark economy, with a total output reduction 0.7 percentage points smaller, or a 16 percent smaller decline than in the benchmark. The amplification effect stems mostly from a significantly larger decrease in labor inputs (hours) in the benchmark economy. Intuitively, consider an exogenous shock originated in the financial sector, leading to a tightening in firms' access to the financial market. On average, entrepreneurs become more constrained and cut back their supply of trade credit. This endogenous change in trade credit further tightens the other entrepreneurs' working capital constraints, which leads to a more significant decline in labor inputs in equilibrium. The fact that the shock has a more substantial impact on labor inputs than capital is familiar in the class of models with working capital constraints (see

Jermann and Quadrini, 2012).

Note that trade credit still flows from relatively unconstrained entrepreneurs to constrained ones beneath the aggregate dynamics. That is, the redistributive channel is still operative. However, since entrepreneurs are more constrained in equilibrium, the supply of trade credit is significantly reduced. The shock leads to a deterioration of allocative efficiency in both economies. But the decrease in TFP is slightly smaller in the benchmark economy, indicating that the reallocation is somewhat more favorable in the benchmark with trade credit relative to the counterfactual economy without trade credit.

4.3 Productivity shocks

Next, we examine the role of trade credit when the economy is hit with a negative productivity shock. Like Zetlin-Jones and Shourideh (2017), we consider the transitional dynamics following an unanticipated shock to the exogenous component of TFP, leading to a 1 percent decline in measured TFP in the benchmark model. The half-life of the shock is chosen to be one year (4 periods in the model).

The calibration shows that a decrease in TFP A by 0.6 percent in the benchmark economy can generate a 1 percent decrease in output. The solid red lines in Figure 9 show the impulse responses in the benchmark model following the shock. The response in aggregate output, capital, labor, and measured TFP all decline immediately and revert to steady-state level in the long-run. In the same figures, we also plot the corresponding impulse responses in the counterfactual economy (blue lines) following the same exogenous shock in TFP A. The close match between the series in the benchmark and the counterfactual economy reveals that the negative TFP shock does not have a perceptible impact on the role played by trade credit. Trade credit does not amplify the impacts of TFP shocks as it does to financial shocks.

We have explored, in theory, and a partial-equilibrium setting, the difference of trade credit choice in response to a negative financial shock and a negative TFP shock (Proposition

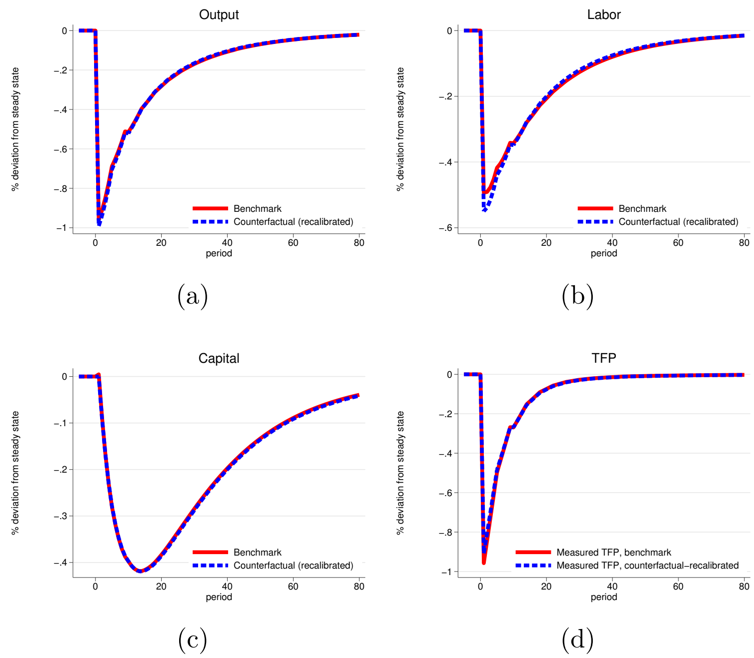


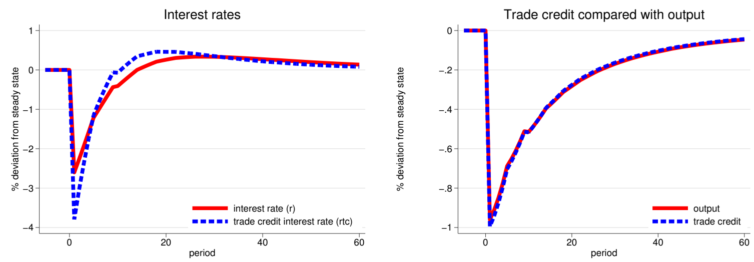
Figure 9: **Dynamics after TFP shock: Benchmark vs. counterfactural**

Notes: The figures show the percent deviation of output, capital, labor and TFP from the steady state following a negative TFP shock in the benchmark economy (solid red lines) and the counterfactual economy (blue dash lines)

4 and 5, respectively). We recall that in the partial equilibrium setting, under a negative TFP shock, entrepreneurs, on average, become less financially constrained. Hence, entrepreneurs increase their trade credit supply and lower their demand for trade credit. In Figure 10, we plot the dynamics of trade credit generated by the quantitative model. Following a negative TFP shock, the trade credit interest rate declines to clear the trade credit market, as shown in panel (a) of Figure 10. Simultaneously, the real interest rate r also decreases due to a decline in the demand for capital at a time of low productivity. In equilibrium, following the negative TFP shock, the reduction in trade credit is approximately the same magnitude as output (panel b). Intuitively, the role of trade credit, measured by the size of trade credit relative to the aggregate output, does not change significantly following a negative TFP shock.[21]

The different dynamics of trade credit under financial and productivity shocks can po-

[21]This result is also robust to smaller or larger TFP shocks, including a TFP shock with the same magnitude as what we observed during the Great Recession.



(a) (b)

Figure 10: **Trade credit dynamics following a negative TFP shock**

Notes: Panel (a) plots the percentage change of interest rate r (red) and trade credit interest rate r^{tc} (blue) following the negative TFP shock in the model. Panel (b) plots the percentage change in total trade credit (blue) and value-added output (red) following the negative TFP shock in the model.

tentially be used to help identify the drivers of business cycle fluctuations. Figure D.3 shows that, in the data, trade credit is strongly pro-cyclical and has a standard deviation more than twice as large as the standard deviation of GDP. This is consistent with the dynamics of trade credit under financial shocks and suggests that financial shocks are important drivers of the U.S. business cycle. Consequently, trade credit is likely to have played a role in amplifying financial shocks over the business cycle.

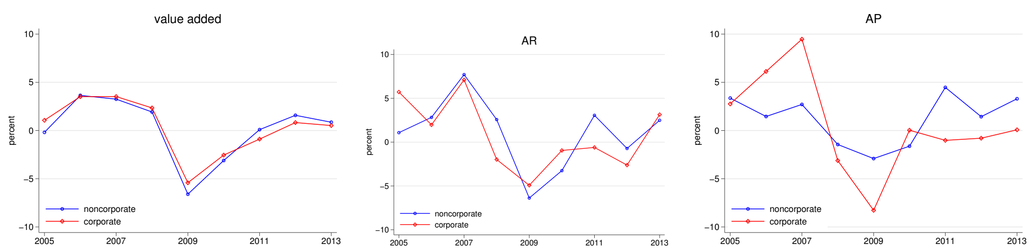
5 Additional evidence

In analyzing the role played by trade credit during financial shocks, the key mechanism of the model is the endogenous changes in trade credit choices when entrepreneurs' access to the financial market is tightened (see Proposition 4). The proposition predicts that, in the partial equilibrium (fixing prices), entrepreneurs subject to more severe shocks would cut back their lending of trade credit (i.e. AR) and increase their borrowing of trade credit (i.e. AP) relative to entrepreneurs less exposed to the shock. Importantly, this prediction speaks to entrepreneurs' differential responses, not the absolute changes in trade credit choices. Since there is a contraction in aggregate AR and AP during a financial crisis, we are likely to see that both AR and AP decrease, but firms that are hit harder by the crisis would cut back their lending of trade credit more and reduce their borrowing of trade credit less.

In this section, we examine if the data support the model prediction. The idea is to compare trade credit changes across firm groups with different exposure to financial shocks. In subsection 5.1, we investigate the different experiences between the US corporate and non-corporate sector during the 2007–09 financial crisis. In subsection 5.2, we exploit the variation in firms' exposure to the shock of Lehman Brothers in 2008.

5.1 Corporate versus non-corporate sector

During the 2007-09 financial crisis, the US economy experienced a significant contraction in its credit capacity. At a more disaggregated level, as documented by Buera et al. (2015), the shock faced by the non-corporate sector was more severe than the corporate sector.[22]



(a) Output (b) AR (c) AP

Figure 11: **Trade credit and output in the corporate and non-corporate sector**

Notes: Raw data are taken from BEA's integrated macroeconomic accounts for the United States. The time series plotted here are the percentage deviation from the HP trends for value-added output (panel a), accounts receivable (panel b), and accounts payable (panel c). Red lines are plotted using data from the corporate non-financial sector while blue lines are plotted using data from the non-corporate non-financial sector.

Figure 11 plots the HP-filtered time series of trade credit and value-added output in the corporate and non-corporate sector during the 2007–09 financial crisis. As shown in panel (a), both sectors experienced a significant decline in value-added output, which the peak-to-trough drop slightly higher in the non-corporate sector (10 percent) compared with the

[22]Starting from 2008Q4, there was a shape decline in the stock of credit market liabilities of the non-corporate sector and a milder one for the corporate sector. Buera et al. (2015) show that the difference between these two sectors was primarily due to the corporate sector's access to the bond market.

corporate sector (9 percent). The decline in AR is also similar in magnitude in these two sectors, as shown in panel (b). Moreover, the percentage decline in AR, at approximately 12 to 14 percent, was larger than that in value-added output, suggesting that AR decreased both in absolute terms and relative to output. Lastly, panel (c) shows a rather mild decrease in AP for the non-corporate sector and a sharp one for the corporate sector, consistent with the model prediction that AP's decline would be milder in the sector facing more severe financial contraction. In fact, relative to their respective output, the non-corporate sector increased, whereas the corporate sector cut back, the borrowing of trade credit from their suppliers (AP).

5.2 The Lehman shock

After the bankruptcy of Lehman Brothers, banks that co-syndicated with Lehman more on their loans reduced their lending to firms significantly (Ivashina and Scharfstein, 2010). We exploit the dispersion of banks' health after the Lehman crisis as an exogenous variation to firms' access to financing following Chodorow-Reich (2014). This identification strategy requires an assumption that firms and banks form relationships to overcome asymmetric information or moral hazard problems and that it is, therefore, costly for firms to switch to a new lender when their relationship bank is in financial distress.[23] Therefore, the financial health of a firm's pre-crisis lending partner provides an exogenous source of variation in their access to external financing during the crisis.[24]

5.2.1 Data description

We use a sample of Compustat firms that borrow from the syndicated loan market. Over the past several decades, the syndicated loan market has become one of the most important channels for large U.S. firms to obtain financing. The contraction in the syndicated

[23] See Sufi (2007) and Chodorow-Reich (2014) for discussions and evidence of this mechanism.

[24] Costello (2020) finds suppliers pass their liquidity shock to customers during the 2007-09 crisis by exploiting the cross-firm variation in the fraction of long-term debt coming due during the initial phase of the 2007–8 financial crisis.

loan market was severe during the 2007–09 financial crisis, with significant decreases in the number, size, and maturity of new credit facilities, as shown in Figure D.4. A more detailed discussion of the syndicated loan market during the 2007–09 financial crisis can be found in Ivashina and Scharfstein (2010).

We follow Sufi (2007) and Chodorow-Reich (2014) to construct the DealScan-Compustat sample of firms and their relationship banks. For the Compustat data, we follow the same treatment as in section 2. We first drop any observation (a loan facility) in the DealScan database that falls into one of the following categories: 1) the borrower was in the financial, insurance, retail, or wholesale trade sector, 2) the facility had multiple lead lenders, 3) the facility was not open during the period from January 1, 2004 to December 31, 2006, or 4) the lead lender was among the top 43 lenders as defined in Chodorow-Reich (2014). We then use the link table provided by Chava and Roberts (2008) to match each loan facility's lead lender in the DealScan database with the borrower from the Compustat database. If a firm had only one open facility from January 1, 2004, to December 31, 2006, we would define that facility's lead lender as its pre-crisis relationship bank. If a firm had multiple facilities during that period, we would define the newest facility's lead lender as its relationship bank.

The above process yields a panel of 605 firm-bank pairs over the period 2007Q1 to 2010Q4 at a quarterly frequency. The sample is a good representation of the universe of Compustat firms in terms of sectoral composition. However, the average DealScan-Compustat firm is eight times larger in total assets than that of the other Compustat firms. The DealScan-Compustat sample thus consists of the very largest U.S. firms with the best access to financing. For each firm-bank pair in the data, we measure their exposure to the Lehman shock using the fraction of banks syndication portfolio where Lehman Brothers had a lead role (the data is taken from Chodorow-Reich, 2014).

5.2.2 Results

We first divide firms into four quartiles by their pre-crisis exposure to Lehman. The left panel of Figure 12 shows that AR/Sales and AP/Sales were not significantly different across the four groups of firms before the Lehman bankruptcy (2008Q3). The right panel of Figure 12 shows the percentage change in the mean and the median of AR/Sales and AP/Sales after the Lehman bankruptcy relative to the levels before the bankruptcy.[25] Compared with firms with low exposure to Lehman, firms with a higher exposure reduced their borrowing of trade credit (AP/Sales) less and cut their lending of trade credit (AR/Sales) more. The decline in the average AP/Sales for the highest-exposure firms (Q4) was 0.7 percent, while the average AP/sales declined by 9.3 percent for the lowest-exposure firms (Q1). On the other hand, the highest-exposure firms cut their AR/sales by 6 percent, while the lowest exposure firms' AR/Sales even increased by 1.4 percent. In sum, Figure 12 confirms the model predictions regarding the differential reactions of trade credit choices across firms with different exposures to the Lehman shock.

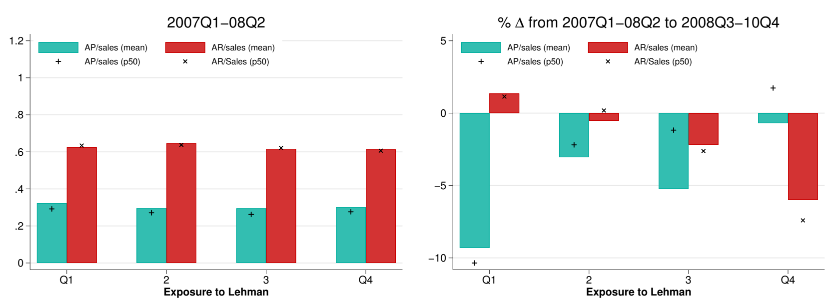


Figure 12: **Trade credit before and after Lehman shock, by exposure to Lehman**

Notes: This table presents percentage change in AR/sales and AP/sales from 2007Q1-2008Q3 to 2008Q4-2010Q4 by firms' exposure to Lehman through their relationship banks. The first quartile (Q1) are firms that have the lowest pre-bankruptcy exposure to Lehman. Consequently, the fourth quartile (Q4) are firms that have the highest pre-bankruptcy exposure to Lehman. The bars represent the mean of each quartile whereas the + and x represent the median.

Furthermore, Table 4 shows that this pattern holds for the average AP/sales and AR/sales

[25] Love et al. (2007) showed a pronounced decline in trade credit that lasted for several years during the Asian financial crisis. Like Love et al. (2007), we find that the decrease in trade credit activities lasted for at least two years after the Lehman bankruptcy. The pattern in the right panel of Figure 12 holds if we look at a shorter window after the Lehman shock.

and the 25th, 50th, and 75th percentile of the distribution. Importantly, Table 4 also shows an evident contraction in the overall trade credit activities. After the Lehman shock, the average AR/sales declined by 1.9 percent in the whole sample, while the average AP/sales fell by 4.6 percent. Since the contraction in AP was more significant than that in AR, as a whole, firms in our sample increased their net lending of trade credit during the Lehman shock. The fact that the Dealscan-Compustat firms increased their net lending of trade credit to the rest of the economy should not come as a surprise because they are a selective sample of very large and financially integrated firms.

Table 4: **Trade credit before and after Lehman shock, more moments**

panel A: AP/sales

Exposure to Lehman	2007Q1-08Q2				% △ from 2007Q1-08Q3 to 2008Q3-2010Q4 in			
	mean	p25	p50	p75	mean	p25	p50	p75
Q1 (lowest)	0.32	0.20	0.29	0.43	-9.31	-16.82	-10.35	-5.95
Q2	0.29	0.21	0.27	0.36	-3.05	-12.62	-2.19	-0.31
Q3	0.29	0.18	0.26	0.38	-5.11	-1.88	-1.12	-7.84
Q4 (highest)	0.30	0.18	0.28	0.40	-0.70	0.68	1.73	1.91
Total	0.30	0.19	0.27	0.39	-4.59	-7.17	-3.39	-4.12

panel B: AR/sales

Exposure to Lehman	2007Q1-08Q2				% △ from 2007Q1-08Q2 to 2008Q3-2010Q4 in			
	mean	p25	p50	p75	mean	p25	p50	p75
Q1 (lowest)	0.62	0.50	0.63	0.75	1.36	2.45	1.14	0.84
Q2	0.65	0.53	0.64	0.75	-0.53	-2.66	0.18	2.26
Q3	0.62	0.49	0.62	0.74	-2.33	-4.56	-2.64	-2.11
Q4 (highest)	0.61	0.50	0.61	0.71	-5.99	-6.88	-7.41	-4.80
Total	0.63	0.51	0.62	0.74	-1.90	-3.65	-2.38	-0.99

Notes: This table presents percentage change in AR/sales and AP/sales from 2007Q1-2008Q3 to 2008Q4-2010Q4 by firms' exposure to Lehman through their relationship banks. The first quartile (Q1) are firms that have the lowest pre-bankruptcy exposure to Lehman. Consequently, the fourth quartile (Q4) are firms that have the highest pre-bankruptcy exposure to Lehman.

A recent paper by Costello (2020) also documents how firms change their trade credit policies as a response to bank credit crunches. Using a novel dataset, Costello (2020) exploits the supplier-customer linkages and shows that firms pass on bank credit crunches to their customers by cutting back their lending of trade credit (AR), lending direct support to our model mechanism. Different from Costello (2020), the evidence provided in this section also speaks to firms' borrowing of trade credit (AP), another margin of trade credit adjustment present in the model.

6 Conclusion

In this paper, we show that trade credit—which exists because inputs suppliers have a comparative advantage over banks in lending to their customers—helps alleviate the misallocation of production factors. However, this channel is dependent on the suppliers' access to financing, including their ability to finance trade credit lending by borrowing against the resulting accounts receivable. In a financial crisis, their access to financing is disrupted, resulting in a decrease in trade credit lending, a reduction in the effectiveness of the trade credit reallocation channel, and an amplification of the original financial shock.

There are several extensions of the current framework that would help us better understand trade credit and its contribution to the aggregate economy. First, several aspects of trade credit currently missing in the model are worth exploring, such as trade credit default risk and imperfect substitutability between intermediate inputs. Second, the empirical evidence of trade credit clearly points out that "there are multiple, not mutually exclusive, rationales for extending trade credit" (see Klapper et al., 2012). A model incorporating all these rationales would be ideal for studying the aggregate and distributional effects of trade credit—disciplining such a model would require a representative sample of firms. Lastly, although the model is about domestic trade credit, it can be extended into a multi-country model to study international trade finance. We leave these topics for future research.

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Online Appendix

Not for Publication

A Model

A.1 Equilibrium definition of the counterfactual economy

The stationary equilibrium of the counterfactual economy without trade credit is defined as follows:

Definition 6. (Recursive competitive equilibrium of the counterfactual economy) The recursive competitive equilibrium consists of interest rate of rental capital r, wage rate w; value function of the entrepreneurs $V(a,z)$; policy functions $c(a,z)$, $k(a,z)$, $l(a,z)$, $x(a,z)$, and $a'(a,z)$; consumption and hours of the workers (c^h, h); and the CDF of the stationary distribution $\Phi(a,z)$, such that

1. Given prices, the value functions and policy functions solve the entrepreneurs' problem.

$$\begin{aligned} V(a,z) &= \max_{c,k,l,x,AR,AP,a'} log(c) + \beta \mathbb{E}_{z'} V(a',z'), \\ s.t. \quad & c + a' = (1+r)a + Az((k^{\alpha} l^{1-\alpha})^{1-\chi} x^{\chi})^{\mu} - (r+\delta)k - wl - x, \\ & Az((k^{\alpha} l^{1-\alpha})^{1-\chi} x^{\chi})^{\mu} \leq \gamma_1 a', \ a' \geq 0. \end{aligned}$$

2. Given prices, the consumption and hours of the workers solve the workers' problem.

3. Labor market clears

$$\int l(a,z) d\Phi(a,z) = N \cdot h.$$

4. Rental capital market clears

$$\int k(a,z) d\Phi(a,z) = \int a d\Phi(a,z).$$

5. Goods market clear

$$\int y(a,z)d\Phi(a,z) = N \cdot c^h + \int [c(a,z) + a'(a,z) - a + x(a,z)]\Phi(a,z).$$

B Proofs

In order to prove the propositions, we first lay out the optimization problem of the entrepreneurs and derive the first-order conditions (FOCs). The value function of the entrepreneurs is

$$\begin{aligned}
V(a,z) &= \max_{c,k,l,AR,AP,a'} log(c) + \beta\mathbb{E}_{z'}V(a',z') \\
s.t. \quad & c + a' = (1+r)a + Az((k^\alpha l^{1-\alpha})^{1-\chi}x^\chi)^\mu - (r+\delta)k - wl - x \\
& +r^{tc}(AR - AP), \qquad (17) \\
& Az((k^\alpha l^{1-\alpha})^{1-\chi}x^\chi)^\mu + (1+r^{tc})(AR - AP) \leq \gamma_1 a' + \gamma_2 AR, \qquad (18) \\
& 0 \leq AR \leq Az((k^\alpha l^{1-\alpha})^{1-\chi}x^\chi)^\mu, \\
& 0 \leq AP \leq x, \\
& a' \geq 0.
\end{aligned}$$

Denote $F(k,l,x) = ((k^\alpha l^{1-\alpha})^{1-\chi}x^\chi)^\mu$ as the production function. The Lagrangian of the problem can be written as,

$$\begin{aligned}
\mathcal{L} &= log((1+r)a + AzF(k,l,x) - (r+\delta)k - wl - x + r^{tc}(AR - AP) - a') \\
&+\beta\mathbb{E}_{z'}V(a',z') + \mu(\gamma_1 a' + \gamma_2 AR - AzF(k,l,x) - (1+r^{tc})(AR - AP)) \\
&+\chi_1(AzF(k,l,x) - AR) + \chi_2 AR \\
&+\chi_3(x - AP) + \chi_4 AP \\
&+\tau a'.
\end{aligned}$$

The FOCs are:

$$
\begin{aligned}
k: \quad & AzF_k = \frac{r+\delta}{1-c\mu+c\chi_1} && (19)\\
l: \quad & AzF_l = \frac{w}{1-c\mu+c\chi_1} && (20)\\
x: \quad & AzF_x = \frac{1-c\chi_3}{1-c\mu+c\chi_1} && (21)\\
AR: \quad & \frac{1}{c}r^{tc} = \mu(1+r^{tc}-\gamma_2)+\chi_1-\chi_2 && (22)\\
AP: \quad & \frac{1}{c}r^{tc} = \mu(1+r^{tc})-\chi_3+\chi_4 && (23)\\
a': \quad & \frac{1}{c} = \beta\mathbb{E}_{z'}V_{a'}(a',z')+\mu\gamma_1+\tau && (24)
\end{aligned}
$$

The envelope theorem is

$$V_a(a,z) = \frac{1}{c}(1+r)$$

That gives the Euler equation

$$\frac{1}{c} = \beta\mathbb{E}_{z'}\frac{1}{c'}(1+r')+\mu\gamma_1+\tau \tag{25}$$

In addition, according to the Kuhn-Tucker condition, the Lagrangian multipliers and the constraints have the following properties:

$$\mu \geq 0, \gamma_1 a' + \gamma_2 AR - AzF(k,l,x) - (1+r^{tc})(AR-AP) \geq 0,$$

$$\chi_1 \geq 0, pAzF(k,l,x) - AR \geq 0,$$

$$\chi_2 \geq 0, AR \geq 0,$$

$$\chi_3 \geq 0, x \geq AR,$$

$$\chi_4 \geq 0, AP \geq 0,$$

$$\tau \geq 0, a' \geq 0,$$

with complementary slackness.

According to Theorem 9.7 and 9.8 of Stokey and Lucas (1989), we know that given z, the value function $V(\cdot, z)$ is strictly increasing and strictly concave.[26] Before proceeding to the proofs of the propositions, we prove the monotonicity of the optimal policy function. To do this, we rewrite the value function as

$$\begin{aligned} V(a,z) &= \max_{c,a'} u((1+r)a + \pi(z,a') - a') + \beta \int_{z'} V(a',z') d\lambda(z',z) \\ s.t. &\quad a' \geq 0. \end{aligned} \tag{26}$$

where given a',

$$\begin{aligned} \pi(z,a') &= \max_{k,l,x,AR,AP} Az((k^{\alpha} l^{1-\alpha})^{1-\chi} x^{\chi})^{\mu} - (r+\delta)k - wl - x + r^{tc}(AR - AP) \\ s.t. &\quad Az((k^{\alpha} l^{1-\alpha})^{1-\chi} x^{\chi})^{\mu} + (1+r^{tc})(AR - AP) \leq \gamma_1 a' + \gamma_2 AR, \\ &\quad 0 \leq AR \leq Az((k^{\alpha} l^{1-\alpha})^{1-\chi} x^{\chi})^{\mu}, \\ &\quad 0 \leq AP \leq x. \end{aligned} \tag{27}$$

Lemma 7. *The value function $v(a,z)$ is supermodular in a and has increasing differences in (a,z). Given z, the policy functions $AR(a,z)$, $-AP(a,z)$ and $a'(a,z)$ increase in a.*

Proof. First we consider the optimization problem 27: given a', we intent to show that the optimal policy increase with a' using Theorem 2.8.1 from Topkis (1989). It is easy to verify that the feasibility set increases strictly with a'; therefore we only need to show that equation 2.8.1 from Topkis (1989) is satisfied.

Denote $W(k,l,x,AR,AP) = AzF(k,l,x) - (r+\delta)k - wl - x + (r^{tc}(AR - AP))$. Given

[26] Stokey, Nancy L. and Robert E. Lucas. 1989. *Recursive Methods in Economic Dynamics.* Harvard University Press.

any $\{k_1, l_1, x_1, AR_1, AP_1\}$ and $\{k_2, l_2, x_2, AR_2, AP_2\}$, we need to show that

$$\begin{aligned} & W(k_1, l_1, x_1, AR_1, AP_1) + W(k_2, l_2, x_1, AR_2, AP_2) \\ \leq \quad & W(k_1 \wedge k_2, l_1 \wedge l_2, x_1 \wedge x_2, AR_1 \wedge AR_2, AP_1 \wedge AP_2) + \\ & W(k_1 \vee \; k_2, l_1 \vee \; l_2, x_1 \vee x_2, AR_1 \vee AR_2, AP_1 \vee AP_2), \end{aligned}$$

which reduces to

$$\begin{aligned} & zAF(k_1, l_1, x_1) + zAF(k_2, l_2, x_2) \\ \leq \quad & zAF(k_1 \wedge k_2, l_1 \wedge l_2, x_1 \wedge x_2) + zAF(k_1 \vee k_2, l_1 \vee l_2, x_1 \vee x_2). \end{aligned}$$

This is straightforward to prove because function $F(\cdot, \cdot, \cdot)$ satisfy strictly increasing differences in its inputs. Following Theorem 2.8.1 of Topkis (1989), we know that the optimal policy increases with a'.

We follow Proposition 2 in Hopenhayn and Prescott (1992) to show the supermodularity of the value function and policy function $a'(a, z)$ increases with a. We need to verify the following three conditions using equations 26 and 27. First, $u((1 + r)a + \pi(z, a') - a')$ is supermodular in (a, a') and has increasing differences in (a, a') given any z. Second, the graph of the feasibility set $\{a'|a' \geq 0\}$ is a sublattice. Third, $\lambda(\cdot, z)$ is increasing in z with respect to the first order stochastic dominance. The second and third condition are straightforward in this case. We next need to show that the first condition holds, which is equivalent to showing $\frac{\partial^2 u}{\partial a \partial a'} \geq 0$.

$$\frac{\partial^2 u}{\partial a \partial a'} = u''(c)(1 + r)(\pi_{a'}(z, a') - 1).$$

Since $u''(\cdot) < 0$, it is sufficient to show that $\underline{\pi_{a'}(z, a') \leq 1}$.

Write the the Lagrangian of the problem 27 as

$$\begin{aligned}\mathcal{L} &= AzF(k,l,x)-(r+\delta)k-wl-x+r^{tc}(AR-AP)\\ &+\mu_1(\gamma_1 a'+\gamma_2 AR-AzF(k,l,x)-(1+r^{tc})(AR-AP))\\ &+\chi_1(AzF(k,l,x)-AR)+\chi_2 AR+\chi_3(x-AP)+\chi_4.\end{aligned}$$

Write the FOCs as

$$k: \quad AzF_k=\frac{r+\delta}{1-\mu_1+\chi_1} \tag{28}$$

$$l: \quad AzF_l=\frac{w}{1-\mu_1+\chi_1} \tag{29}$$

$$x: \quad AzF_x=\frac{1-\chi_3}{1-\mu_1+\chi_1} \tag{30}$$

$$AR: \quad r^{tc}=\mu(1+r^{tc}-\gamma_2)+\chi_1-\chi_2 \tag{31}$$

$$AP: \quad r^{tc}=\mu(1+r^{tc})-\chi_3+\chi_4 \tag{32}$$

There are two cases we need to investigate. The first one is if the borrowing constraint is not binding ($\mu_1(a',z)=0$)and the second one is if it is binding ($\mu_1(a',z)>0$).

(1) $\mu_1=0$

If $\mu_1=0$, from equation 31 and 32, we know that $\chi_1=r^{tc}$, $\chi_2=0$, $\chi_3=0$ and $\chi_4=r^{tc}$. Therefore equation 28, 29 and 30 become

$$\begin{aligned}k: &\quad AzF_k=\frac{r+\delta}{1+r^{tc}}\\ l: &\quad AzF_l=\frac{w}{1+r^{tc}}\\ x: &\quad AzF_x=\frac{1}{1+r^{tc}}\end{aligned}$$

Denote the solution to the above system of equations as k^*,l^*,x^* and the corresponding output $y^*=AzF(k^*,l^*,x^*)$. Because $x_1>0$ and $x_4>0$, the complementary slackness conditions imply that $AR = y^*$ and $AP = 0$. As a result, given z, $\pi(z, a')$ does not change with a', as a result, $\pi_{a'}(z, a') = 0$.

(2) $\mu_1 > 0$

If μ_1, we know that the borrowing constraint holds with equality. That is,

$$y + (1 + r^{tc})(AR - AP) = \gamma_1 a' + \gamma_2 AR \Longrightarrow y = \gamma_1 a' - (1 + r^{tc} - \gamma_2)AR + (1 + r^{tc})AP$$

Take above equation y back to $\pi(z, a')$, we can write the profit function as

$$\pi(z, a') = \gamma_1 a' - (1 - \gamma_2)AR + AP - (r + \delta)k - wl - x$$

Since we have shown that $\frac{dk}{da'} \geq 0, \frac{dl}{da'} \geq 0, \frac{dx}{da'} \geq 0$, $\frac{dAR}{da'} \geq 0$ and $\frac{dAP}{da'} \leq 0$, and because $\gamma_1 < 1$, we have $\pi_{a'}(z, a') < 1$. *Q.E.D.* □

B.1 Proof of Proposition 2

Cut-off for financial constraint Given z, define set $\mathbf{U}^z = \{a | \mu(a, z) = 0\}$. We intend to show that the set $\mathbf{U}^z$ is in the following form $(\underline{a}, \infty)$.[27] To do this, we first show that $\mathbf{U}^z$ has the following property: if $a \in \mathbf{U}^z$ and $\hat{a} > a$, then $\hat{a} \in \mathbf{U}^z$.

Let $a \in \mathbf{U}^z$. According to the definition of $\mathbf{U}^z$, we know that $\mu(a, z) = 0$. The complementary slackness condition then implies that for entrepreneur (a, z), the working capital constraint is not binding,

$$AzF(k, l, x) + (1 + r^{tc})(AR - AP) < \gamma_1 a' + \gamma_2 AR.$$

According to equation 22 and 23, $\mu = 0$ implies that $\chi_2 = 0$, $\chi_1 = \frac{1}{c} r^{tc}$, $\chi_3 = 0$ and

[27]This statement is equivalent to the first part of Proposition 2.

$\chi_4 = \frac{1}{c} r^{tc}$. Taking the value of μ, χ_1, χ_2 back into equations 19, 20 and 21, we get

$$\begin{aligned} k: \quad & AzF_k = \frac{r+\delta}{1+r^{tc}}, \\ l: \quad & AzF_l = \frac{w}{1+r^{tc}}, \\ x: \quad & AzF_x = \frac{1}{1+r^{tc}}. \end{aligned}$$

Since production function F is decreasing return to scale, there exist optimal k, l and x that solve the above system of three equations. Denote the solution as k^*, l^* and x^*. Since $\chi_1 > 0$ and $\chi_4 > 0$, the complementary slackness condition implies that $AR = AzF(k^*, l^*, x^*)$ and $AP = 0$.

Let $m = Az((k^\alpha l^{1-\alpha})^{1-\chi} x^\chi)^\lambda - (r+\delta)k - wl - x$, and the budget constraint 17 can be re-written as,

$$c + a' = (1+r)a + m.$$

It is clear that m is maximized when $k = k^*$, $l = l^*$, $x = x^*$, $AR = AzF(k^*, l^*, x^*)$ and $AP = 0$. In other words, entrepreneurs will always choose $k = k^*$, $l = l^*$, $x = x^*$, $AR = AzF(k^*, l^*, x^*)$ and $AP = 0$ if they are feasible under the working capital constraint (equation 18).

Consider the entrepreneur with productivity z and wealth $\hat{a} > a$. According to Lemma 7, $a'(\hat{a}, z) \geq a'(a, z)$. Therefore, since $k = k^*$, $l = l^*$, $x = x^*$, $AR = AzF(k^*, l^*, x^*)$ and $AP = 0$ are feasible for entrepreneur (a, z), they must be feasible for entrepreneur $(\hat{a}, z)$ as well. Following the above analysis, we know that entrepreneurs will choose $k = k^*$, $l = l^*$, $x = x^*$, $AR = AzF(k^*, l^*, x^*)$ and $AP = 0$, and the working capital constraint holds with strict inequality. Using the complementary slackness condition, this implies that $\mu(a', z) = 0$.

With the help of this property, we show that $\mathbf{U}^z$ is an interval. Suppose that it is not; then there exists $x < w < y$, such that $x, y \in \mathbf{U}^z$ but $w \notin \mathbf{U}^z$. This violates the property, since it means $x \in \mathbf{U}^z$, $w < x$, but $w \notin \mathbf{U}^z$. We can also show that $\mathbf{U}^z$ is unbounded from above. Suppose that it is not; then there exists $w \notin \mathbf{U}^z$ but $w > a$ for all $a \in \mathbf{U}^z$, which violates the property.

Cut-off for AR Define a set $\mathbf{H}^z = \{a | AR(a, z) > 0\}$. We show that $\mathbf{H}^z$ is in the form of $(\underline{a}, \infty)$. The proof is very similar. Essentially, we need to prove that the set $\mathbf{H}^z$ has the following property: if $a \in \mathbf{H}^z$ and $\hat{a} > a$, then $\hat{a} \in \mathbf{H}^z$. It is clear that this property holds since according to Lemma 7, $AR(a, z)$ is an increasing function in a. Therefore, for any $\hat{a} > a$, we have $AR(\hat{a}, z) \geq AR(a, z) > 0$.

Cut-off for AP Similarly, define a set $\mathbf{W}^z = \{a | AP(a, z) = 0\}$. We can show that $\mathbf{W}^z$ is in the form of $(\underline{a}, \infty)$. According to Lemma 7, $AP(a, z)$ is a decreasing function in a. Therefore for any $\hat{a} > a$, we have $0 \leq AP(\hat{a}, z) \leq AP(a, z) = 0$. As a result, $AP(\hat{a}, z) = 0$. *Q.E.D.*

B.2 Proof of Proposition 3

Proving this proposition is equivalent to showing that $\mathbf{U}^z \subseteq \mathbf{W}^z \subseteq \mathbf{H}^z$. We do it in two steps.

$\mathbf{U}^z \subseteq \mathbf{W}^z$ Take any $a \in \mathbf{U}^z$; we know that $\mu(a, z) = 0$ according to the definition of $\mathbf{U}^z$. According to equation 23, if $\mu(a, z) = 0$ then $\frac{1}{c(a,z)} r^{tc} = \chi_4(a, z) - \chi_3(a, z)$. Since $\frac{1}{c(a,z)} r^{tc} > 0$, it has to be the case that $\chi_4(a, z) = \frac{1}{c(a,z)} r^{tc}$ and $\chi_3(a, z) = 0$. Apply the complementary slackness condition, we know $AP(a, z) = 0$, which means $a \in \mathbf{W}^z$.

$\mathbf{W}^z \subseteq \mathbf{H}^z$ For any $a \in \mathbf{W}^z$, we know $AP(a, z) = 0$, thus the complementary slackness condition implies that $\chi_4(a, z) > 0$ and $\chi_3(a, z) = 0$. Therefore equation 23 implies $\frac{1}{c} r^{tc} > \mu(1 + r^{tc})$. As a result, $\frac{1}{c} r^{tc} > \mu(1 + r^{tc} - \gamma)$ because $\mu(a, z) \geq 0$. Take $\frac{1}{c} r^{tc} > \mu(1 + r^{tc} - \gamma)$

back to equation 22, we get $\chi_1(a,z) > 0$ and $\chi_2(a,z) = 0$. The complementary slackness condition implies that $AR(a,z) > 0$, which means $a \in \mathbf{H}^z$. *Q.E.D.*

B.3 Proof of Proposition 4

Let $\Gamma^{AR}(a,z) = AR(a,z)/y(a,z)$ and $\Gamma^{AP}(a,z) = AP(a,z)/x(a,z)$. We rewrite the budget constraint and the borrowing constraints as the following:

$$c + a' = (1+r)a + y - (r+\delta)k - wl - x + r^{tc}\Gamma^{AR}y - r^{tc}\Gamma^{AP}x$$
$$y + (1+r^{tc})(\Gamma^{AR}y - \Gamma^{AP}x) \leq \gamma_1 a' + \gamma_2\Gamma^{AR}y,$$

Replace a' in the second equation using the first equation, we get

$$\begin{aligned}&[\frac{1-\gamma_1}{\gamma_1}(1+r^{tc}\Gamma^{AR}) + \tau^{AR}\frac{1-\gamma_2}{\gamma_1}]AF(k,l,x)\\ &-[\frac{(1+r^{tc})\Gamma^{AP}}{\gamma_1} + (1+r^{tc}\Gamma^{AP})]x\\ &+(r+\delta)k + wl + c \leq (1+r)a.\end{aligned} \tag{33}$$

Any $\{k,l,x,c,\Gamma^{AR},\Gamma^{AP}\}$ that are feasible under $\tilde{\gamma}_2$ is also feasible under $\gamma_2 > \tilde{\gamma}_2$. Since we have shown that $V(a,z)$ is supermodular in a and has increasing differences in (a,z), it follows, according to the monotonicity theorem, that $\widetilde{\Gamma}^{AR}(a,z) \leq \Gamma^{AR}(a,z)$ and $\widetilde{\Gamma}^{AP}(a,z) \geq \Gamma^{AP}(a,z)$. According to the definition of the threshold functions, $\widetilde{\underline{AR}}(z) \geq \underline{AR}(z)$ and $\widetilde{\underline{AP}}(z) \geq \underline{AP}(z)$.

B.4 Proof of Proposition 5

The proof is similar to that of Proposition 4. Any $\{k,l,x,c,\Gamma^{AR},\Gamma^{AP}\}$ that satisfies equation 33 under A is also feasible under $\widetilde{A} < A$. As a result $\widetilde{\Gamma}^{AR}(a,z) \geq \Gamma^{AR}(a,z)$ and $\widetilde{\Gamma}^{AP}(a,z) \leq \Gamma^{AP}(a,z)$. According to the definition of the threshold functions, $\widetilde{\underline{AR}}(z) \leq \underline{AR}(z)$ and $\widetilde{\underline{AP}}(z) \leq \underline{AP}(z)$.

C Computation

In this section, we describe the algorithms for computing the benchmark model. Section C.1 contains the algorithms to compute the stationary equilibrium. Section C.2 contains the algorithms to compute the transitional dynamics. The algorithms to compute the counterfactual model are very similar to the benchmark model, only with different sets of FOCs, budget constraint, and working capital constraint. Hence they are omitted here.

C.1 Stationary equilibrium

- Guess equilibrium prices r, w, r^{tc}.
- Given the prices, solve the household problem.
- Given the prices, solve the entrepreneurs problem as follows:
  - Discretize the state space.
  - Guess policy function $c(a, z)$.
  - For each (a, z), assume that the entrepreneur is unconstrained, i.e., $\mu(a, z) = 0$. Solve for the system of equations that consists of FOCs and budget constraint.
  - Check whether the working capital constraint is satisfied with the solution to the above system of equations.
  - If the working capital constraint is not satisfied, it means that $\mu(a, z) > 0$ and working capital constraint holds with equality. Solve the system of equations that consists of FOCs, budget constraint, and working capital constraint (with equality).
  - Use the Euler equation to update the policy function $c(a, z)$ until it converges.
- Given any arbitrary distribution of (a, z), iterate using the policy functions derived above until a stationary distribution is reached.

- Generate the aggregate statistics of the three markets: capital, labor, =and trade credit market.
- Update (r, w, r^{tc}) until the markets clear simultaneously.

C.2 Transitional dynamics

To compute the transitional dynamics of the economy, we consider a transition path of $T = 100$ periods. The economy is at the initial stationary equilibrium level in period $t = 1$, and we assume that it converges back to the initial stationary equilibrium at period $t = T$.

- Guess a sequence of prices $\{r_t, w_t, r_t^{tc}\}_{t=2}^{T-1}$.
- Backward induction. For each $t = T - 1, T - 2, ..., 2$,
  - Discretize the state space.
  - Given prices, solve the household problem for period t.
  - Given prices, solve the entrepreneurs policy functions for period t.
    1. Guess $c_t(a, z)\mu_t(a, z) = 0$, solve the system of equations that consists of FOCs of period t, budget constraint, and Euler equations (with the next period policy function $c_{t+1}(a, z)$ known).
    2. Check whether the working capital constraint is satisfied under the above solution.
    3. If the working capital is not satisfied, $c_t(a, z)\mu_t(a, z) > 0$ and the working capital constraint holds with equality. Solve the system of equations that consists of FOCs of period t, budget constraint, Euler equations (with the next period policy function $c_{t+1}(a, z)$ known), and working capital constraint with equality.

- Forward induction. The first period stationary distribution $\Phi_1(a, z)$ is set to be the stationary equilibrium distribution. Using the policy functions for period $t = 2, ..., T-1$, compute the distribution along the transition path $\Phi_t(a, z)$.

- Generate aggregate statistics for the four markets in every period $t = 2, ..., T-1$ using the policy functions and the distributions.

- Update $\{r_t, w_t, r_t^{tc}\}_{t=2}^{T-1}$ until the four markets clear simultaneously in each period $t = 2, ..., T-1$.

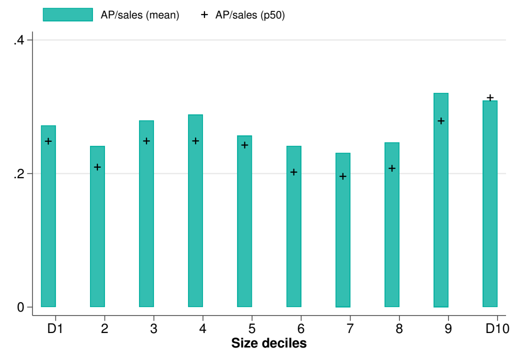
D Additional tables and figures

Table D.1: **Net AR and firm characteristics, controlling for inventory and ROA**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
log(age+1)	0.0318***	0.0220***	0.0173***	0.0158***	0.0149***	0.0143***	0.0550***	0.0526***	0.0498***
	(0.00317)	(0.00301)	(0.00293)	(0.00259)	(0.00260)	(0.00259)	(0.00686)	(0.00685)	(0.00686)
log(total asset)		0.0281***	0.0250***		0.00812***	0.00788***		0.0227***	0.0217***
		(0.00135)	(0.00131)		(0.00105)	(0.00105)		(0.00290)	(0.00290)
borrower			-0.0517***			-0.00841***			-0.0363***
			(0.00340)			(0.00304)			(0.00819)
inventory/sales	0.161***	0.190***	0.211***	0.164***	0.178***	0.181***	0.237***	0.274***	0.291***
	(0.0359)	(0.0337)	(0.0333)	(0.0300)	(0.0301)	(0.0303)	(0.0659)	(0.0657)	(0.0660)
ROA				0.203***	0.181***	0.177***	0.397***	0.336***	0.320***
				(0.00904)	(0.00935)	(0.00968)	(0.0137)	(0.0153)	(0.0156)
Dependent variable	net AR/Sales	net AR/Sales	net AR/Sales	net AR/Sales	net AR/Sales	net AR/Sales	$I\_NetAR > 0$	$I\_NetAR > 0$	$I\_NetAR > 0$
Sector FE, year FE	Y	Y	Y	Y	Y	Y			
N	14094	14052	14052	12688	12688	12688	12688	12688	12688
AR2	0.0870	0.181	0.194	0.265	0.271	0.271	0.248	0.258	0.259

Notes: The sample includes all but wholesale, retail, and financial firms in the Compustat dataset for the period 2000-2007. All regressions include a set of 2-digit sic sector and year fixed effects. Standard errors are clustered at the firm-level. ROA (return on assets) is defined as net income divided by total assets.

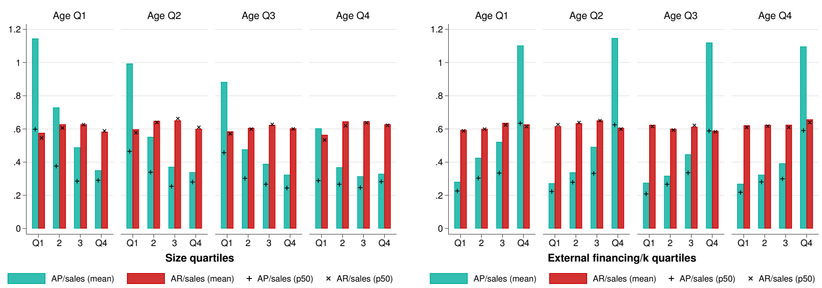
Figure D.1: **AP/sales by size in retail sector**



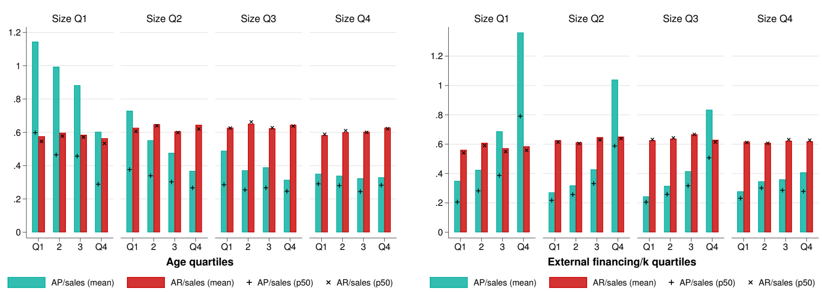
Notes: The sample includes retail-sector firms in the Compustat dataset for the period 2000-2007. The figure plots the average (bars) and median (+) of AP/sales over firm size.

Figure D.2: **AR and AP within each age/size quartile**

(a) Within each age quartile



(b) Within each size quartile



Notes: The sample includes all but wholesale, retail, and financial firms in the Compustat dataset for the period 2000-2007. The figures plot AP/sales and AR/sales within each quartile of age or size distribution. Panel (a) plots AR/sales or AP/sales over firm size (left) or reliance on external financing (right) within each age quartile. Panel (b) plots AR/sales or AP/sales over firm age (left) or reliance on external financing (right) within each size quartile.

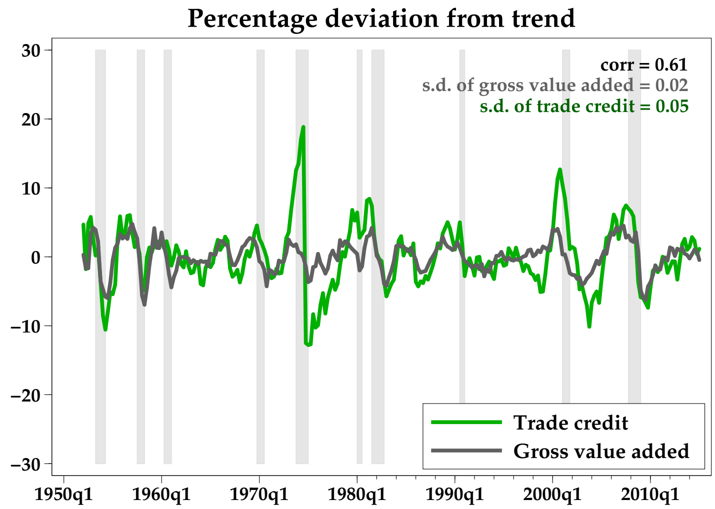


Figure D.3: **Trade credit over the U.S. business cycle**

Notes: The data are for the nonfinancial corporate sector. Gross value added is taken from NIPA Table 1.14 line 17. Trade credit is computed as the average of accounts receivable (line 15 of Flow of Funds Table L.103) and accounts payable (line 30 of Flow of Funds Table L.103). Both time series are HP-filtered with a smoothing parameter of 1,600.

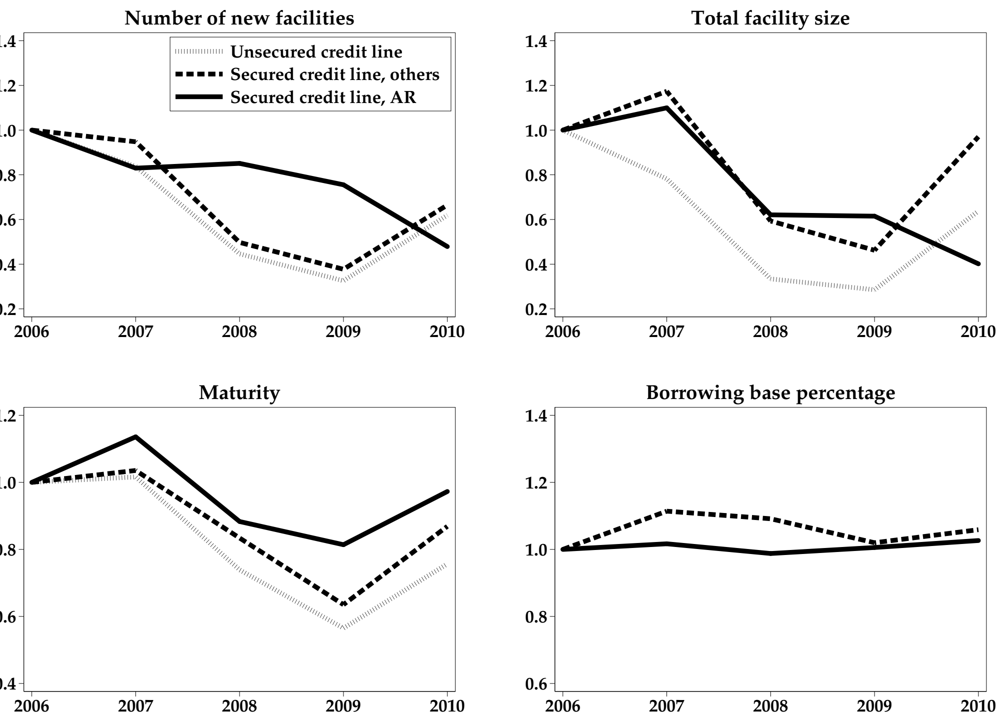


Figure D.4: **Characteristics of new credit line facilities**

Notes: We compute the characteristics of the newly opened credit line facilities of each year as the average of all credit line facilities that are opened in that year. The solid lines in these figures are credit line facilities that require accounts receivable as collateral. The dashed lines are credit line facilities that require other types of assets as collateral. The dotted lines are unsecured credit line facilities. The time series are normalized such that they are 1 in year 2006.