Cyclical Dynamics of Trade Credit with Production Networks

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VERY PRELIMINARY

Abstract

In this paper we show that in production and trade networks that characterize the Chinese economy there is an externality that (inefficiently) reduces the supply of trade credit from state-owned firms to private-owned firms. Furthermore, the externality becomes more severe in recessions. This implies that the response of trade credit to shocks displays excess sensitivity and amplifies macroeconomic shocks. The paper also studies policy interventions that encourage bank lending and finds that, in the context of the Chinese production and trade credit network, these policies may not be very effective in stimulating the real sector of the economy.

1 Introduction

In this paper we study the role of trade credit in production networks for economic growth and macroeconomic volatility, with special application to the Chinese economy. The study of trade credit is of special interest for China due to the particular structure of the financial and production systems. Although large state-owned enterprises have significant access to bank financing, the access of private-owned firms is more limited. As a result, many private-owned firms rely on trade credit from state-owned firms.

This structure generates an interesting financial network in which banks provide financing to state-owned firms, which in turn provide financing to private-owned firms with trade credit. This implies that trade credit decisions of state-owned firms play an important role for the transmission of macroeconomic shocks. For example, if state-owned firms choose to reduce trade credit to private firms in response to a negative shock, the macroeconomic impact of the shock would be amplified. The trade credit decisions of state-owned firms are also important for the transmission of stimulus policies targeted at bank loans: to the extent that higher lending from banks is not followed by an expansion of trade credit from state-owned firms to private firms, the macroeconomic impact of these policies would be limited.

The main motivation for studying how trade credit decisions affect the propagation of macroeconomic shocks comes from the empirical finding that trade credit in China is more volatile than bank credit. More importantly, we will show below that the pro-cyclical pattern of trade credit cannot be fully explained by the cyclical pattern of production.

To understand these patterns we develop a two-sector model with trade credit networks in which state-owned firms choose optimally the amount of credit supplied to private firms. The model generates over-reaction of trade credit to aggregate shocks, that is, state-owned firms reduce trade credit to private firms in response to a negative aggregate shock more than the contraction in sales. By doing so, they amplify the aggregate impact of the aggregate shock.

Trade credit over-reaction is a direct consequence of the externality associated with production and trade credit network. The externality derives from the fact that the choice to increase trade credit by an individual state-owned firm raises sales not only for the firm that provides credit but also for other firms. Since an individual firm cares only about its own sales, trade credit is under-supplied in equilibrium. More importantly, the externality becomes more severe when the economy is hit by a negative shock. This contributes to the over-sensitivity of trade credit to shocks, which in turn generates the amplification.

The paper also studies some possible policy interventions that could bring the economy closer to the socially optimal allocation, not only in the steady state but also in response to aggregate shocks. In particular, we consider a policy that subsidises bank loans. This is akin to a policy that encourages bank lending and could capture one of the pillars of the stimulus package adopted by China in response to the financial crisis. One of the surprising findings is that the subsidization of bank loans may not be effective in stimulating the economy and alleviating the effects of a negative shock. This is because, even if subsidies to bank loans increase lending to state-owned firms, these firms may not have an incentive to use the extra borrowed funds to increase trade credit. They may simply hoard the extra funds loaned from banks.

The organization of the paper is as follows. In the next Section 2 we provide empirical evidence about some of the key features of the cyclical property of trade credit in China. In Section 3 we present the model and characterize its properties. In Section 4 we derive the efficient allocation and compare it to the competitive allocation. Section 5 studies the business cycle properties of the model and Section 6 analyzes some of the policies that could improve the competitive allocation.

2 Empirical evidence

This section illustrates some of the cyclical features of trade credit in China using data for industrial enterprises from the National Bureau of Statistics of China, for the period 2001-2017. For years 2001-2006 and 2010-2017 data is available at a monthly frequency (with the exception of January) and for years 2007-2009 data is available at a quarterly frequency.

The main variables of interest are accounts receivable, value-added, and total liabilities for which we obtain annual growth rates (over the same month of the previous year) from the Main Indicators of Industrial Enterprises table. Since the table reports nominal values, real growth rates are obtained by subtracting the CPI inflation rate from the nominal growth rates. The real growth rates are then de-trended linearly.

The top section of Figure 1 plots the real growth rates of accounts receivable (trade credit) and value added, while the bottom section plots the difference between these two growth rates. Figure 2 plots the real growth rates of accounts receivable (trade credit) and the total liabilities of firms. The figures also indicates the main contractionary and expansionary phases during the sample period: (i) The 2001-2002 recession affected by the early 2000s contraction in developed economies; (ii) The 2003-2006 expansion that peaked in 2006; (iii) The 2007-2008 recession affected by the US sub-prime mortgage crisis; (iv) The 2009-2010 expansion associated with the 4 trillion stimulus package; (v) The 2010-2017 economic slowdown.

Figures 1 and 2 highlight three key patterns:

1. Trade finance is highly pro-cyclical, that is, its growth rate increases when the growth rate of the economy is high and decreases when the growth rate of the economy is low.

2. The cyclical variations of trade credit cannot be fully explained by fluctuations in production since the growth rate of trade credit is more volatile than the growth rate of value added. In fact, the bottom section of Figure 1 shows that the difference between the growth rate of trade credit and value added is highly pro-cyclical.

3. Trade credit is more volatile than firms' total liabilities. Figure 2 shows that, even though firms' borrowing from the financial sector is pro-cyclical, trade finance increases more during the expansionary phases than total debt. This is clearly shown by the bottom section of the figure which plots the difference between the growth rates of accounts receivable and total liabilities.

One of the goals of this paper is to understand these cyclical patterns. We do so by developing a network model that formalizes some of the salient features of the economic structure of China.

3 The model

An important feature of the Chinese economy is the coexistence of state-owned enterprises (SOE) and private-owned enterprises (POE). We formalize this structure by considering a two-sector model where the first sector is populated by state-owned enterprises and the second sector is populated by private-owned enterprises. SOEs and POEs differ in several dimensions meant to capture some key differences between these two types of firms. First, SOEs are on average bigger than POE. This is captured in the model by assuming that there is a finite number of SOEs (whose individual policies

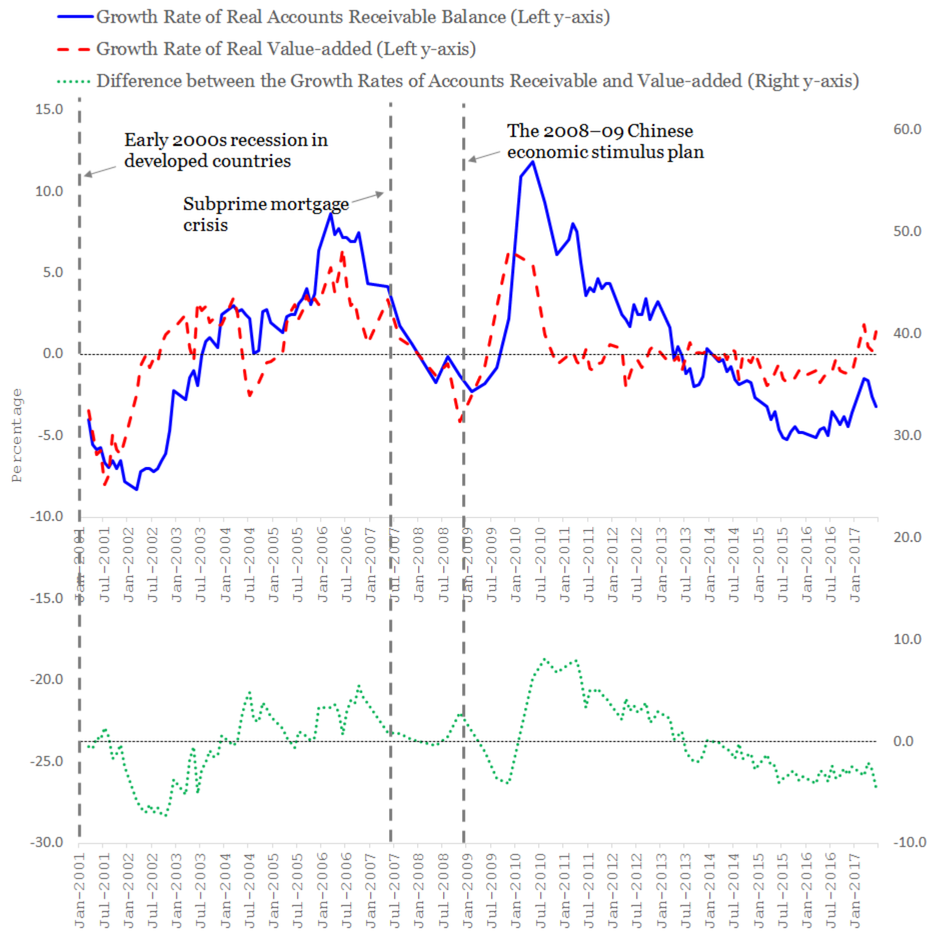

Figure 1: Growth Rates of Real Accounts Receivable and Real Value-added of All Firms

Notes: The upper panel shows the percentage changes of real accounts receivable balance (solid-blue) and real value-added (dashed-red) over the same month last year. The bottom panel shows the difference between them (dotted-green).

could have non-negligible general equilibrium effects) and a continuum of competitive POEs. Second, since SOEs have a stronger presence in more basic industries, that is, industries that are at the top of the production

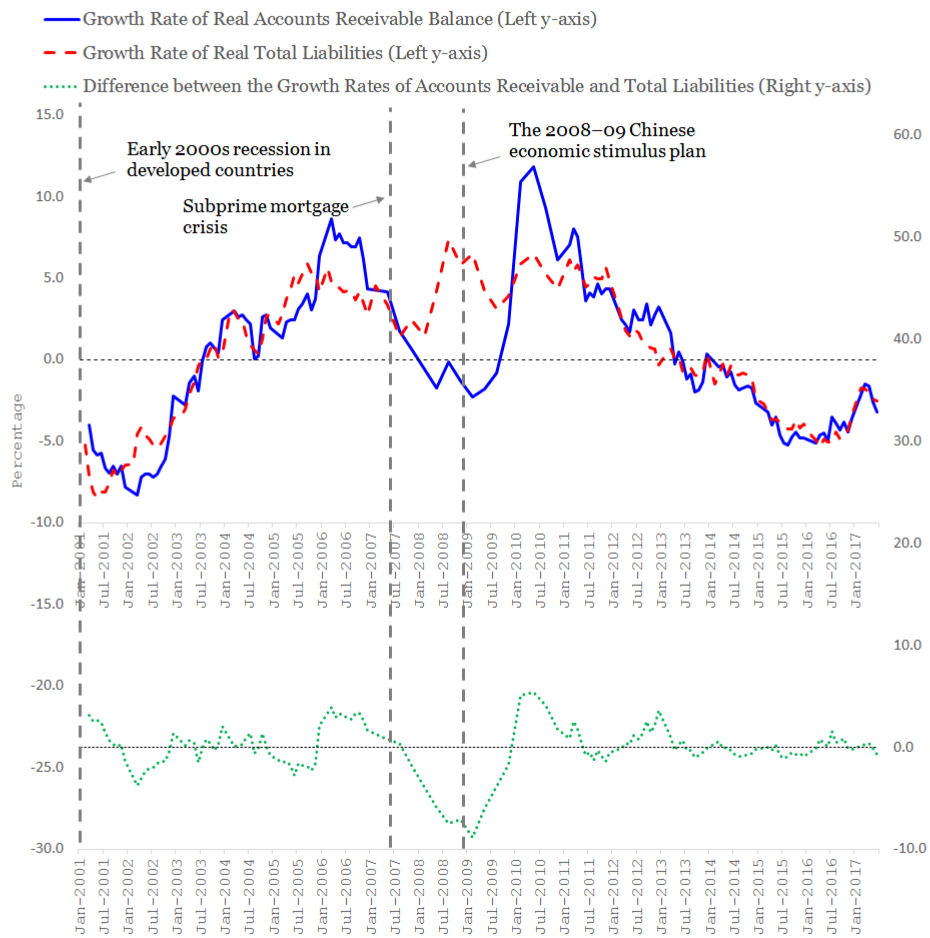

Figure 2: Growth Rates of Real Accounts Receivable and Real Total Liabilities

Notes: The upper panel shows the percentage changes of real account receivable balance (solid-blue) and real total liabilities (dashed-red) over the same month last year. The bottom panel shows the difference between them (dotted-green).

chain, we assume that SOEs are suppliers of intermediate goods to POEs.[1] This creates a production network that flows from SOEs to POEs. Third, since SOEs have stronger relationships with Chinese banks, which ultimately

[1]State-owned firms have a larger share of operation in sectors such as energy, mining, metal processing, and so on.

give them an advantage in accessing credit, we assume that SOEs face looser financial constrains than POE. Because of their privileged access to bank credit, SOEs are in a condition to provide (trade) credit to POEs, that is, private-owned firms borrow from state-owned firms.

Obviously, the structure of the Chinese economy is much more complex than formalized in the model. Nevertheless, we believe that the (highly stylized) formalization proposed in this paper helps us understand some of the key forces that characterize the nexus between the real and financial sectors in the Chinese economy and the importance of trade credit for the dynamics of the real economy.

Figure 3 provides a schematic illustration of the production network formalized in the model. There are N state-owned enterprises, each producing an intermediate input $i = 1, ..., N$. The intermediate inputs are sold to a continuum of competitive private-owned firms. Private firms use the intermediate inputs to produce a final good which we use as numeraire. There is only one period in the model and, therefore, the final good is used only for consumption.

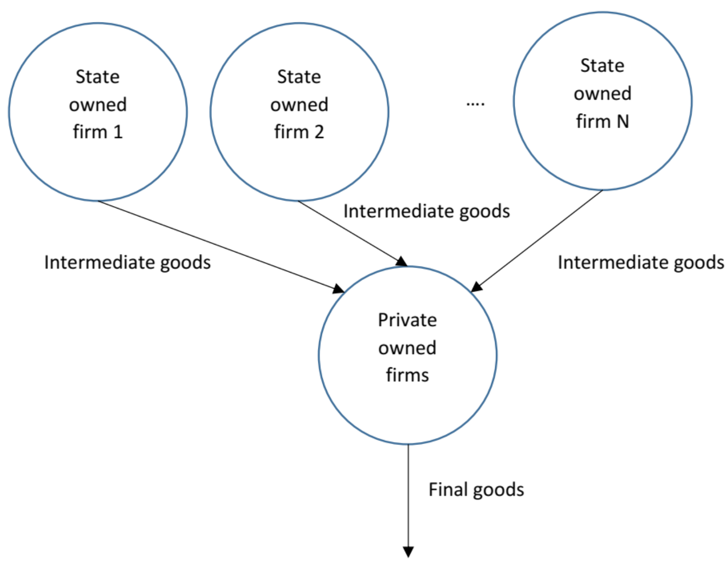

Figure 3: Structure of the Production Sector

3.1 Technology

There is a continuum of differentiated intermediate goods indexed by $i \in [0,1]$. Intermediate goods are produced by a finite number N of state-owned enterprises, identified by the index $j = 1,..,N$. Each state-owned firm produces a continuum of $1/N$ intermediate goods. So firm j produces intermediate goods of variety $i \in [(j-1)/N, j/N] \equiv \mathbf{I}_j$.

The production of intermediate goods implies an increasing cost measured in terms of the final good (numeraire). Denoting by x_i the quantity produced of intermediate good i, the total production cost for state-owned firm j is

$$\int_{i \in \mathbf{I}_j} c\left(x_i\right), \tag{1}$$

where $c(.)$ is strictly increasing and convex. Later we will specify this function as cost of labor.

There is a unitary mass of homogeneous and competitive private-owned firms that produce final goods by combining the intermediate goods produced by state-owned firms with the technology

$$y = \left(\sum_{j=1}^{N} \int_{i \in \mathbf{I}_j} x_i^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{2}$$

where x_i is the quantity of intermediate good i used as an input of production by a representative private firm and $\varepsilon > 1$ is the elasticity of substitution among intermediate goods.

3.2 Private-owned firms' problem

While state-owned firms have unrestricted access to financing from banks, bank financing of private-owned firms is limited by $\bar{b}$. Because of their limited access to external financing, private firms may have an incentive to borrow from state-owned firms (trade credit). However, trade credit is also bounded since SOEs require a down payment. We assume that private firms do not have own funds and, therefore, the down payments to state-owned firms need to be funded with bank loans.

Denote by ϕ_j the down payment required by state-owned firm j. The borrowing constraint for bank credit for the representative private firm is then given by

$$\sum_{j=1}^{N} \phi_j \int_{i \in \mathbf{I}_j} q_i x_i \leq \bar{b}. \tag{3}$$

The left-hand-side is the total financing from banks which must cover the total down payments to state-owned firms: Given the purchases of x_i units of intermediate good at price q_i from state-owned firm j, the representative private firm needs to make the down payment $\phi_j \int_{i \in \mathbf{I}_j} q_i x_i$. Since there are N state-owned firms, the total down payment is $\sum_{j=1}^{N} \phi_j \int_{i \in \mathbf{I}_j} q_i x_i$. This must be financed with loans from banks. Trade credit is the difference between the value of intermediate purchases and the down payments, that is, $\sum_{j=1}^{N}(1 - \phi_j) \int_{i \in \mathbf{I}_j} q_i x_i$.

The representative private firm chooses intermediate inputs x_i, $i \in [0, 1]$, to maximize profits,

$$\max_{\{x_i\}_{i \in [0,1]}} \quad y - \sum_{j=1}^{N} \int_{i \in \mathbf{I}_j} q_i x_i - r \sum_{j=1}^{N} \phi_j \int_{i \in \mathbf{I}_j} q_i x_i \tag{4}$$

subject to (2) and (3).

The firm maximizes the revenues from production, y, minus the cost of the intermediate inputs. This cost has two components. The first is the direct cost of purchasing the intermediate inputs while the second is the cost of financing the down payment with bank loans (which depends on the interest rate r charged by banks). The optimization problem is subject to the borrowing constraint imposed by banks.

The first order condition with respect to x_i is

$$\frac{\partial y}{\partial x_i} = \Big[1 + \phi_j (r + \lambda)\Big] q_i, \tag{5}$$

for all $i \in \mathbf{I}_j$ and $j = 1, .., N$. The variable λ is the Lagrange multiplier associated with the borrowing constraint on bank credit. This is the shadow price of liquidity for the private-owned firm and it is positive only if the constraint is binding.

For the analysis that follows we assume that $\bar{b}$ is sufficiently small so that the borrowing constraint is always binding in equilibrium and, therefore, $\lambda > 0$.

Using the first order condition (5) we derive the demand for intermediate good i as a function of q_i, ϕ_j, λ and y,

$$x_i = \frac{y}{[1+\phi_j(r+\lambda)]^{\varepsilon} q_i^{\varepsilon}}, \quad \textit{for } i \in \mathbf{I}_j, \ \textit{and} \ \ j = 1, 2, ..., N. \tag{6}$$

The demand function is the same as in the standard Dixit-Stiglitz monopolistic competition model except that the cost of purchasing the intermediate good i is augmented by the financing and shadow cost $\phi_j(r+\lambda)q_i$. In absence of down payment, that is, $\phi_j = 0$, the cost reduces to the price q_i and we obtain the standard demand function.

We can now use (6) to replace x_i in the production function (2) to obtain,

$$1 = \sum_{s=1}^{N} [1+\phi_s(r+\lambda)]^{1-\varepsilon} \int_{i \in \mathbf{I}_s} q_i^{1-\varepsilon}. \tag{7}$$

This defines the shadow price λ as a function of intermediate prices $\mathbf{Q} \equiv \{q_i\}_{i\in[0,1]}$ and down payments requirements $\mathbf{\Phi} = \{\phi_1, ..., \phi_N\}$ chosen by the N state-owned enterprises. Also, under the assumption that the borrowing constraint is binding, we can use (6) to replace x_i in the borrowing constraint (3) to obtain,

$$y = \frac{\bar{b}}{\sum_{s=1}^{N} \phi_s [1+\phi_s(r+\lambda)]^{-\varepsilon} \int_{i\in \mathbf{I}_s} q_i^{1-\varepsilon}}. \tag{8}$$

This equation defines final output y as a function of intermediate prices $\mathbf{Q} \equiv \{q_i\}_{i\in[0,1]}$, down payments requirements $\mathbf{\Phi} = \{\phi_1, ..., \phi_N\}$, and shadow price λ. Since equation (7) defines λ as a function of $\mathbf{Q}$ and $\mathbf{\Phi}$, final output is also a function of $\mathbf{Q}$ and $\mathbf{\Phi}$. The next step is to derive the prices of intermediate inputs and down payments which are chosen optimally by state-owned firms.

3.3 State-owned firms' optimization

State-owned firms have the financial capability of providing trade financing to private firms. Each state-owned firm chooses the faction of sales for which it provides trade credit while the remaining fraction, which we have denoted by ϕ_j, needs to be paid in advance by the purchasing firms. This is the down payment that private firms need to finance with banks at interest rate r. The remaining fraction is paid at the end of the period and for these payments there is no financial cost for the purchasing firms (although the prices chosen by state-owned firms may incorporate, implicitly, a financial cost).

Of course, lower down payments imply that state-owned firms need to finance production of the intermediate goods with banks at interest rate r. Thus, r is the opportunity cost of trade credit for state-owned firms.

We assume that a state-owned firm cannot differentiate the trade credit policy ϕ_j across goods and purchasing firms. Since there is a finite number of state-owned firms, this assumption implies that when a state-owned firm chooses ϕ_j, it takes into account the aggregate implications induced by this policy. On the other hand, the production and pricing policies are chosen ignoring the aggregate effects since the firm produces a continuum of intermediate goods.

In addition to the interest cost of financing trade credit, state owned firms incur a monitoring cost. To capture the idea that agency problems increase with the fraction of purchases funded with trade credit, we assume that the monitoring cost decreases with ϕ_j. To use a compact notation we define the down payment net of the monitoring cost as $g(\phi_j)x_i q_i$ where $g(0) < 0$, $g(1) = 1$, $g'(\phi_j) > 0$, $g''(\phi_j) < 0$.

State-owned firms set prices and down payment ratios taking as given the demand function from private firms and the policies of other state-owned firms (prices and down payments) as given. More specifically, state-owned firm j chooses q_i and ϕ_j to maximize,

$$\max_{\{q_i\}_{i\in\mathbf{I}_j},\phi_j} \quad \int_{i\in\mathbf{I}_j} q_i x_i - \int_{i\in\mathbf{I}_j} c\left(x_i\right) - r\Big[1-g(\phi_j)\Big]\int_{i\in\mathbf{I}_j} q_i x_i \tag{9}$$

subject to (6).

The first term in the objective function is the revenue from sales; the second term is the direct cost of production; the third term is the financial cost of production. The assumption is that the firm needs working capital that is equal to sales $x_i q_i$. Working capital can be funded with bank credit and the cost for interests is $x_i q_i r$. The firm can also fund working capital with down payments from its customers. This allows the state-owned firm to save on interests paid to banks but it also implies monitoring costs. The total savings from down payment ϕ_j are $rg(\phi_j)x_i q_i$. The saving on interests increases with ϕ_j because $g'(\phi_j) > 0$ but the rate of increase declines with ϕ_j because $g''(\phi_j) < 0$. This captures the idea that increasing the down payment rate is especially beneficial when ϕ_j is low because agency problems are more severe.

The problem solved by the state-owned firm is subject to the demand for its products, equation (6). The demand depends not only on its policies, $\mathbf{Q}_j$ and ϕ_j, but also on the policies of other state-owned firms through the shadow price λ. In fact, equation (7) shows that the shadow price λ is a function of $\mathbf{Q} = \{\mathbf{Q}_1, .., \mathbf{Q}_N\}$ and $\mathbf{\Phi} = \{\phi_1, ..., \phi_N\}$.

The strategic interaction between state-owned firms takes the form of a Nash game. Therefore, in solving the individual profit maximizing problem, each state-owned firm takes as given the policy instruments chosen by other state-owned firms, that is, prices and down payments. This allows us to derive the optimal response functions which we will then use to define the equilibrium.

The optimality conditions for the choice of prices and down payment can be derived by differentiating problem (9) with respect to q_i and ϕ_j. The resulting conditions are,

$$[q_i f(\phi_j) - c'(x_i)] \frac{\partial x_i}{\partial q_i} + f(\phi_j) x_i = 0 \tag{10}$$

$$\int_{i \in \mathbf{I}_j} \left[f(\phi_j) q_i - c'(x_i) \right] \frac{\partial x_i}{\partial \phi_j} + f'(\phi_j) \int_{i \in \mathbf{I}_j} q_i x_i = 0 \tag{11}$$

where we have defined the function $f(\phi_j) \equiv 1 - [1 - g(\phi_j)]r$ to simplify notations. This function depends only on ϕ_j and represents the unitary revenue net of the financial cost. For example, if the firm sells $s_j = \int_{i \in \mathbf{I}_j} q_i x_i$, the financial cost is $s_j(1 - g(\phi_j))r$. Thus the revenues net of the financial cost are $s_j[1 - (1 - g(\phi_j))r] = s_j f(\phi_j)$. Notice that $f(\phi_j)$ is strictly increasing in ϕ_j capturing the fact that higher down payments reduce the monitoring cost of trade credit. We assume that the elasticity of $f(\phi_j)$ with respect to ϕ_j, i.e., $\phi_j f'(\phi_j))/f(\phi_j)$, is decreasing with ϕ_j

3.4 Equilibrium

We focus on the symmetric equilibrium in which all state-owned firms choose the same prices and down payments. Denote by q^*, ϕ^*, x^*, y^* and λ^* the variables in the symmetric equilibrium. We can solve for these variables using (6), (7), (8), (10) and (11) as follows:

1. *Shadow price of liquidity.* In the symmetric equilibrium, (7) implies:

$$[1 + \phi^*(r + \lambda^*)]q^* = 1. \tag{12}$$

It says that the price of final goods, which is normalized to one, is proportional to the direct price of intermediate goods q^* augmented by the financial cost of production $\phi^*(r+\lambda^* q^*)$. The financial cost has two components: the direct interest cost r and the shadow price of liquidity captured by the lagrange multiplier λ.

2. *Output.* After imposing symmetry and using (12) to replace λ in (7) and (8), we obtain

$$y^* = x^* = \frac{\bar{b}}{\phi^* q^*}, \tag{13}$$

which says that the production scale of private firms is constrained by $\bar{b}$ and down payment ratio ϕ^*. If private firms were not liquidity constrained, they would have raised production scale until the marginal cost of producing intermediate goods is equal to one. Thus, the binding liquidity constraint allows trade finance to play an important role in determining y^*.

3. *Mark-up.* In the symmetric equilibrium, the first order condition for q_i, equation (10), implies:

$$q^* f(\phi^*) = \left(\frac{\varepsilon}{\varepsilon - 1}\right) c'(x^*), \tag{14}$$

which says that the marginal revenue of sales $q^* f(\phi^*)$ equals the marginal cost $c'()$, multiplied by the mark-up $\tilde{\theta} = \varepsilon/(\varepsilon - 1)$ as in the standard Dixit-Stiglitz monopolistic-competition model.

4. *Down-payment ratio.* By imposing symmetry and using (14), the first order condition for ϕ_j, equation (11), can be written as:

$$\varepsilon^{-1}\left[\frac{1}{N} + \varepsilon\left(\frac{N-1}{N}\right)(1 - q^*)\right] = \frac{\phi^* f'(\phi^*)}{f(\phi^*)}. \tag{15}$$

5. The equilibrium values of q^*, ϕ^*, x^*, y^* and λ^*, are derived using equations (12)-(15).

4 Trade finance externality

When a state-owned firm raises the down payment ratio ϕ_j, this reduces not only its own sales (internal effects) but also the sales of other firms (external effects). In this section, we analyze the internal and the external effects of changes in an individual state-owned firm's down payment ratio and the implications of trade finance externality for the production sector. We start by analyzing the internal and the external effects of trade finance in Section 4.1. In Section 4.2, we characterize the allocation in absence of trade finance externality, and show how the externality can lead to under provision of trade credit.

4.1 Internal and external effects of trade finance

A change in the down payment ratio of state-owned firm j, ϕ_j, can affect the private firms' demands for its products x_i, with $i \in \mathbf{I}_j$. We refer to this as *internal effect* of trade finance.

To analyze the internal effects of trade finance, we first note that the demand for intermediate good i, given by (6), is not only a function of q_i and ϕ_j but also a function of the production scale y and the shadow value of liquidity λ. Both y and λ are functions of prices and down payment ratios $\mathbf{Q}$ and $\mathbf{\Phi}$ (see (7) and (8)). Thus, a change in the down payment ratio of state-owned firm j, ϕ_j, can affect the demands for its own products directly and indirectly via y and λ.

The internal effects can be decomposed into three parts:

$$\underbrace{\frac{\partial x_i}{\partial \phi_j}}_{\textit{internal effect}} = \underbrace{\frac{\partial D_i}{\partial \phi_j}}_{\textit{relative cost}} + \underbrace{\frac{\partial D_i}{\partial \lambda}\frac{\partial \lambda}{\partial \phi_j}}_{\textit{liquidity reallocation}} + \underbrace{\frac{\partial D_i}{\partial y}\frac{\partial y}{\partial \phi_j}}_{\textit{production scale}}, \quad \textit{for } i \in \mathbf{I}_j. \tag{16}$$

Since the demand for a intermediate good depends not only on its own price and down payment ratio but also on aggregate production y and shadow price of liquidity λ, (see equation (6)), a change in the down payment ratio ϕ_j also affects the demands for other state-owned firms through y and λ. We refer to this as *external effect* of trade finance, which can be decomposed as

$$\underbrace{\frac{\partial x_i}{\partial \phi_j}}_{\textit{external effect}} = \underbrace{\frac{\partial D_i}{\partial \lambda}\frac{\partial \lambda}{\partial \phi_j}}_{\textit{liquidity reallocation}} + \underbrace{\frac{\partial D_i}{\partial y}\frac{\partial y}{\partial \phi_j}}_{\textit{production scale}}, \quad \textit{for } i \notin \mathbf{I}_j. \tag{17}$$

As shown in (16) and (17), changes in the down payment ratio of an individual state-owned firm can affect the demands for intermediate inputs not only for the firm that changes ϕ_j but also for other state-owned firms. The demand effects can be categorized in three types:

1. *Relative cost effect.* This is the direct impact of the change in down payment on its own demand, keeping y and λ fixed. Note that the cost to purchase a unit of intermediate good i is augmented by the financing and shadow cost, i.e., $\phi_j(r+\lambda)q_i$. Thus, an increase in ϕ_j raises the financing and shadow cost of purchasing x_i, which reduces the private firms' demands for x_i, as shown in equation (6).

2. *Liquidity reallocation effect.* This is the indirect impact of changes in the down payment ratio of a state-owned firm on the demands for all intermediate goods via λ. Recall that private firms finance their down payments using bank credit and the amount borrowed from banks by private firms is bounded by $\bar{b}$. When the liquidity constraint binds, increases in down payment ratios decrease the amounts of intermediate goods a private firm can buy with each dollar borrowed from banks, and thus the shadow value of liquidity, λ, decreases, i.e., $\partial\lambda/\partial\phi_j < 0$ (see equation (7)). Thus, the private firms' demands for all intermediate goods tend to rise as the shadow cost of purchasing intermediate goods drops, which shifts private firms' use of liquidity towards other intermediate goods, i.e., $\partial D_i/\partial\lambda < 0$, where $i \notin \mathbf{I}_j$, as shown in (6).

3. *Production scale effect.* This is the impact of changes in the down payment ratios on the demands for all the intermediate goods via y, i.e., $(\partial D_i/\partial y)(\partial y/\partial\phi_j)$, where $i \in [0,1]$. An increase in down payment ratio ϕ_j decreases the private firms' production scale, i.e., $\partial y/\partial\phi_j < 0$, as shown in (8). Thus, the private firms' demands for all the intermediate goods tend to drop as production scale decreases, i.e., $\partial D_i/\partial y > 0$, where $i \in [0.1]$, as shown in (6).

Proposition 1 *Suppose that at the symmetric equilibrium $\varepsilon(1-q^*) < 1$. Then, starting from this equilibrium, if we raise the down payment of an individual state-owned firm, the demands for the products of other state-owned firms decline, i.e., $\partial x_i/\partial\phi_j < 0$, for $i \notin \mathbf{I}_j$.*

Proof 1 *We first evaluate* $(\partial D_i/\partial\lambda)(\partial\lambda/\partial\phi_j)$ *and* $(\partial D_i/\partial y)(\partial y/\partial\phi_j)$ *at the symmetric equilibrium for* $i\in[0,1]$ *and obtain*

$$\left.\frac{\partial D_i}{\partial\lambda}\frac{\partial\lambda}{\partial\phi_j}\right|_{\mathbf{Q}=\mathbf{Q}^*,\boldsymbol{\Phi}=\boldsymbol{\Phi}^*} = \frac{\varepsilon}{N}\left(1-q^*\right)\frac{x^*}{\phi^*}, \tag{18}$$

$$\left.\frac{\partial D_\kappa}{\partial y}\frac{\partial y}{\partial\phi_j}\right|_{\mathbf{Q}=\mathbf{Q}^*,\boldsymbol{\Phi}=\boldsymbol{\Phi}^*} = -\frac{1}{N}\frac{x^*}{\phi^*}. \tag{19}$$

By using (18) and (19) in (17), we have that for $i\notin\mathbf{I}_j$,

$$\left.\frac{\partial x_i}{\partial\phi_j}\right|_{\mathbf{Q}=\mathbf{Q}^*,\boldsymbol{\Phi}=\boldsymbol{\Phi}^*} = \frac{\partial D_i}{\partial\lambda}\frac{\partial\lambda}{\partial\phi_j}+\frac{\partial D_i}{\partial y}\frac{\partial y}{\partial\phi_j} = \Big[\varepsilon(1-q^*)-1\Big]\frac{x^*}{N\phi^*}. \tag{20}$$

An increase the down payment ratio of state-owned firm j, ϕ_j, *tends to lower the demands for other state-owned firms' products via the production scale effects (equation (19)), and increase them via the liquidity reallocation effects (equation (18)), and the net external effect depends on the relative magnitudes of the two effects. Trade finance has positive externality only when* $\varepsilon(1-q^*)<1$. *In addition, the externality of trade finance tends to be positive when the substitutability between intermediate goods,* ε, *is small.*

Proposition 2 *At the symmetric equilibrium, the relative cost and the liquidity reallocation effects are purely redistributive, which do not affect the aggregate demand for intermediate goods.*

Proof 2 *By evaluating* $\partial D_i/\partial\phi_j$ *at the symmetric equilibrium for* $i\in\mathbf{I}_j$, *we have*

$$\left.\frac{\partial D_i}{\partial\phi_j}\right|_{\mathbf{Q}=\mathbf{Q}^*,\boldsymbol{\Phi}=\boldsymbol{\Phi}^*} = -\varepsilon\left(1-q^*\right)\frac{x^*}{\phi^*}. \tag{21}$$

Thus, the impact of ϕ_j *on the aggregate demand for intermediate goods can be decomposed as below*

$$\begin{aligned}\int_{i\in[0,1]}\left.\frac{\partial x_i}{\partial\phi_j}\right|_{\mathbf{Q}=\mathbf{Q}^*,\boldsymbol{\Phi}=\boldsymbol{\Phi}^*} &= \underbrace{\int_{i\in\mathbf{I}_j}\left.\frac{\partial D_i}{\partial\phi_j}\right|_{\mathbf{Q}=\mathbf{Q}^*,\boldsymbol{\Phi}=\boldsymbol{\Phi}^*}}_{\text{relative cost effects}} \\ &+ \underbrace{\int_{i\in[0,1]}\left.\frac{\partial D_i}{\partial\lambda}\frac{\partial\lambda}{\partial\phi_j}\right|_{\mathbf{Q}=\mathbf{Q}^*,\boldsymbol{\Phi}=\boldsymbol{\Phi}^*}}_{\text{liquidity reallocation effects}}\end{aligned}$$

$$+ \underbrace{\int_{i\in[0,1]} \frac{\partial D_i}{\partial y}\frac{\partial y}{\partial \phi_j}\bigg|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*}}_{\textit{production scale effects}} \tag{22}$$

Note that (21) and (18) imply

$$\int_{i\in\mathbf{I}_j} \frac{\partial D_i}{\partial \phi_j}\bigg|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*} + \int_{i\in[0,1]} \frac{\partial D_i}{\partial \lambda}\frac{\partial \lambda}{\partial \phi_j}\bigg|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*} = 0, \tag{23}$$

which indicates that the relative cost and the liquidity reallocation effects are purely redistributive and have no net effect on the aggregate demand. In addition, by using (19) in (22), we have

$$\int_{i\in[0,1]} \frac{\partial x_i}{\partial \phi_j}\bigg|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*} = -\frac{1}{N}\frac{x^*}{\phi^*}. \tag{24}$$

4.2 Centrally-planned trade finance

When the down payment ratios are determined by state-owned firms without coordination as in the benchmark economy characterized in Section 3, the benefits of trade finance may not be fully internalized as shown in Section 4. To study the socially optimal level of trade finance, we consider an alternative economy in which the down payment ratios and prices of intermediate goods by planner.

The planner can choose the prices $q_i \in \mathbf{I}_j$ and down payment ratios ϕ_j for all state-owned firms $j = 1, ..., N$, to maximize total profits. In doing so, however, it takes as given the demand functions from private firms. The planner's objective can then be written as

$$\max_{\{\{q_i\}_{i\in\mathbf{I}_j},\phi_j\}_{j=1}^N} \quad \sum_{j=1}^{N}\left\{\int_{i\in\mathbf{I}_j} q_i x_i - \int_{i\in\mathbf{I}_j} c\left(x_i\right) - r\Big[1-g(\phi_j)\Big]\int_{i\in\mathbf{I}_j} q_i x_i\right\} \tag{25}$$

subject to (6).

The first order condition for q_i is the same as that in the benchmark economy and takes the form (10). The first order condition for ϕ_j is

$$\sum_{j=1}^{N}\left\{\int_{i\in\mathbf{I}_j}\left[q_i f(\phi_j) - c'\left(x_i\right)\right]\frac{\partial x_i}{\partial \phi_j}\right\} + f'(\phi_j)\int_{i\in\mathbf{I}_j} q_i x_i = 0, \tag{26}$$

By comparing the above equation with the first order condition for ϕ_j in the benchmark economy (11), we can see that the planner internalizes the external effect described above.

We use superscript $*$ and subscript c to denote the variables for the symmetric planner's equilibrium. For example, we denote by q_c^* the price of intermediate good i. The variables q_c^*, ϕ_c^*, x_c^*, y_c^* and λ_c^* are determined by equations (6), (7), (8), (10) and (26). Note that the only difference between the planner's equilibrium and the competitive equilibrium is that the first order condition for ϕ_j is changed from (11) to (26), while all the other equilibrium conditions remain the same.

By imposing symmetry, the first order condition for ϕ_j can be written as

$$\frac{1}{\varepsilon} = \frac{\phi_c^* f'(\phi_c^*)}{f(\phi_c^*)}. \tag{27}$$

We then have the following result:

Proposition 3 *At the symmetric equilibrium of the benchmark economy, if $\varepsilon(1 - q^*) < 1$, trade finance is under provided, i.e., the down payment ratio is higher than its socially optimal level.*

Proof 3 *We compare the first order conditions for down payment ratios in the competitive economy and the planner's economy, that is, (15) and (27). If $\varepsilon(1 - q^*) < 1$ in the competitive symmetric equilibrium, trade finance has positive externality (see Proposition 1). Thus, the left-hand-side of (15) is smaller than the left-hand-side of (27). Since the right-hand-sides of (15) and (27) are decreasing in ϕ_j, it follows that $\phi^* > \phi_c^*$.*

5 Comparative statics

In this section we examine how the externality of trade finance varies with parameter values. To single out the effects of externality on trade finance, we compare the benchmark decentralized economy with the centralized planned economy. We then examine how the differences between the two economies vary with parameter values. In particular we characterize ho the trade credit externality varies with aggregate productivity (subsection 5.1), number of firms N (subsection 5.2) and intermediate goods substitutability ε (subsection 5.3).

To derive sharper analytical results we make the following assumption about the production cost function:

Assumption 1 *The cost of production takes the form*

$$c(x) = \left(\frac{\tau}{1+\alpha}\right) x^{1+\alpha}, \tag{28}$$

where $\tau > 0$ and $\alpha > 1$.

5.1 Productivity

Consider an exogenous increase in the cost of intermediate goods production, i.e., an increase in τ. When trade finance is centrally planned, the down payment ratio is determined by (27). Since this condition does not depend on τ, the down payment chosen by the planner is not affected by the productivity shock.

When the economy is de-centralized (benchmark model), the down payment ratio is determined by (15). As the production cost τ increases, the prices of intermediate goods rise. It then becomes less profitable for private firms to expand production. Thus, the borrowing constraint of private firms is less tight and the shadow price of liquidity λ drops. This also decreases the magnitudes of the relative cost effect and the reallocation cost effect (see (21) and (18)). Thus, an individual state-owned firm benefits less from trade finance and the equilibrium down payment ratio rises. This is stated formally in the next proposition.

Proposition 4 ***(amplification)*** *When production cost τ rises, in the de-centralized economy the down payment ratio ϕ^* increases while in the planned economy the down payment ratio ϕ_c^* does not change.*

Proof 4 *As the production cost τ increases, the prices of intermediate goods rise, which increase the left-hand-side of (15). Note that the right-hand-side of (15), which is the elasticity of $f(\phi_j)$ with respect to ϕ_j, is decreasing in ϕ_j. It follows that the equilibrium down payment ratio, ϕ^*, rises as the production cost parameter τ increases. See Appendix A for the detailed proof of the above proposition.*

Thus, the market reaction of trade credit amplifies the macroeconomic impact of the aggregate shock. This is further illustrated in Figure 4 which is based on a numerical example.

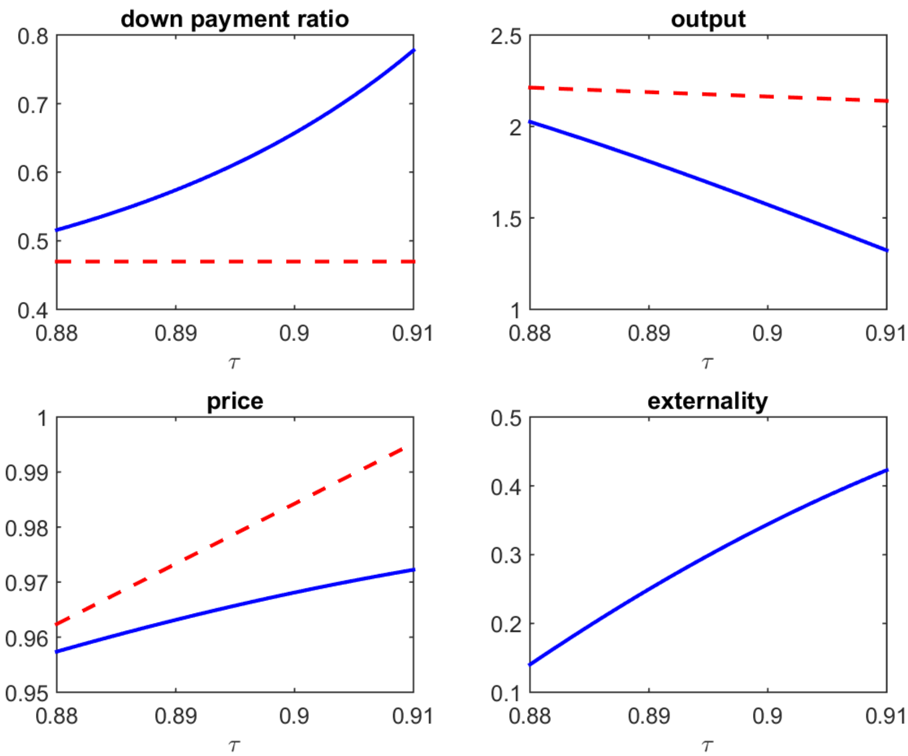

Figure 4: Exogenous increase in the cost of intermediate goods production τ (Solid-blue: market; Dashed-red: planner)

Notes: The above figure shows how the equilibrium down payment ratio ϕ^*, output y^*, price of intermediate goods q^* and the degree of externality change with the interested parameter, when the down payment ratio is market determined and centrally planned. The degree of externality is measured as the ratio of the external effects to the sum of the external and the internal effects of trade finance (see (16) and (17)). Parameter values are reported in Appendix B.

5.2 Number of firms

Consider an increase in the number of firms N. When trade finance is centrally chosen by the planner, the down payment ratio does not depend on N as we can see from equation (27). It follows that the down payment ratio ϕ_c^* does not change with τ. When trade finance is de-centralized, an increase in N implies that each firm internalizes less the benefits of trade finance and, as a result, the equilibrium down payment ratio rises.

Proposition 5 *(**number of firms**) When the number of firms N rises, the down payment ratio ϕ^* in the decentralized economy rises, while the down payment ϕ_c^* in the centrally planned economy remains the same.*

Proof 5 *See Appendix A.*

Figure 5 illustrates this property with a numerical example.

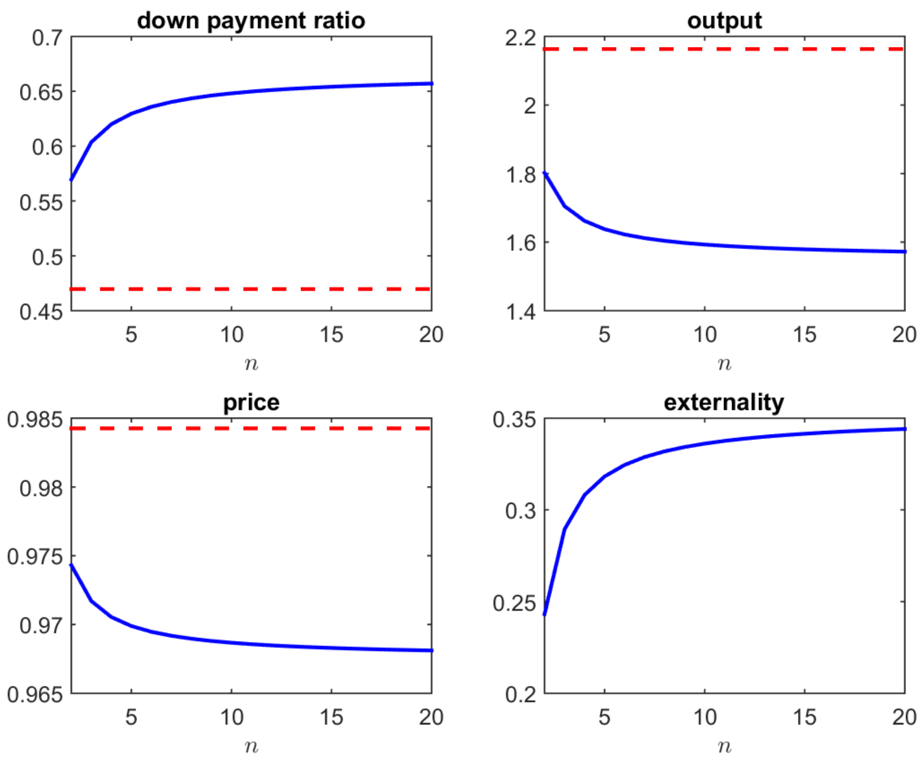

Figure 5: Increase in the number of firms N
(Solid-blue: market; Dashed-red: planned)

Notes: The above figure shows how the equilibrium down payment ratio ϕ^*, output y^*, price of intermediate goods q^* and the degree of externality change with the interested parameter, when the down payment ratio is market determined and centrally planned. The degree of externality is measured as the ratio of the external effects to the sum of the external and the internal effects of trade finance (see (16) and (17)). Parameter values are reported in Appendix B.

5.3 Intermediate inputs substitutability

Consider a rise in the intermediate inputs substitutability ε. The markup and thus the profit margin of monopolistic state-owned firms decreases with ε. When trade finance is centrally planned, the planner reduces trade finance and thus raises down payment ratio as the profit margin decreases. To see this, note that the left-hand-side of (27) decreases as ε increases while the right-hand-side decreases with ϕ_j. Thus, in the centrally planned economy the down payment ratio ϕ_c^* increases with ε.

In the decentralized economy, a rise in the substitutability ε may affect the equilibrium down payment ratio in two opposite ways. First, a higher substitutability between intermediate goods implies a lower complementarity, and thus, an increase in the sales of one intermediate good leads to less demands for other intermediate goods. As a result, the externality of trade finance tends to decrease. Second, the increase in ε decreases the monopolistic markup and the profit margin, which decreases the state-owned firms' incentive to expand sales. However, the former effect is larger than the later. Thus, the equilibrium down payment ration, ϕ^*, decreases with ε.

Proposition 6 ***(substitutability)*** *When the substitutability between intermediate goods ε rises, the decentralized down payment ratio ϕ^* decreases while the centralized down payment ratio ϕ_c^* increases.*

Proof 6 *See Appendix A.*

Figure 6 shows the role of ε with a numerical example.

5.4 Interest rate

State-owned firms under provide trade finance due to the externality as shown in Section 4. In the model, state-owned firms finance their working capital using both down payments and bank credit, and are assumed to be able to borrow any amount they wish from banks at the exogenously determined interest rate r. Therefore, lowering r reduces the opportunity cost of trade finance and helps raising the credit provided by state-owned firms to private firms.

Proposition 7 ***(interest rate)*** *When the interest rate r declines, the decentralized down payment ratio ϕ^* decreases.*

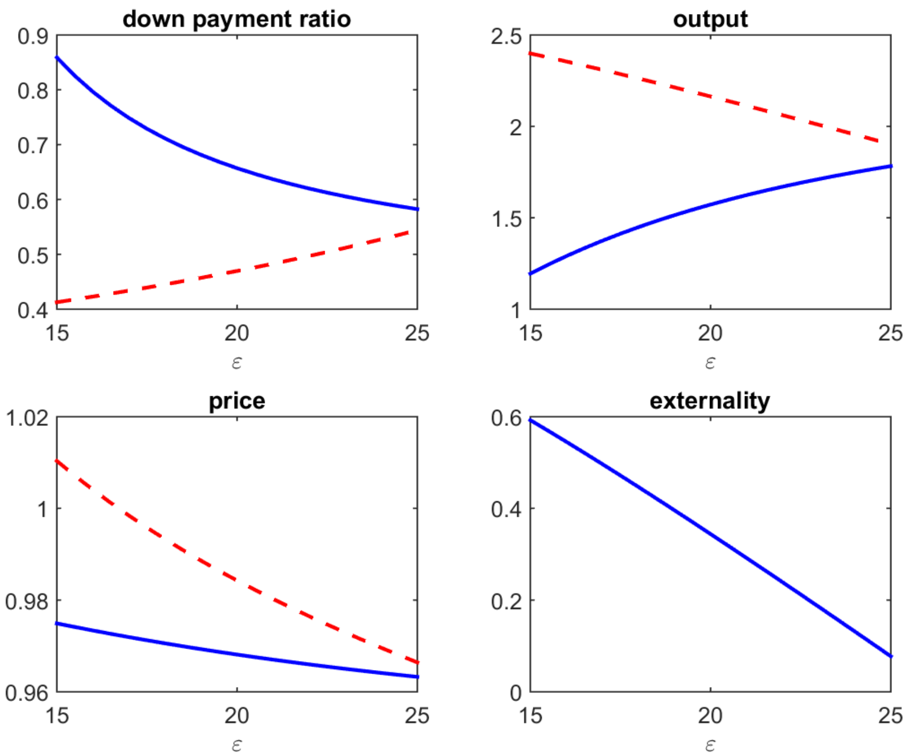

Figure 6: Increase in the substitutability ε
(Solid-blue: market; Dashed-red: planned)

Notes: The above figure shows how the equilibrium down payment ratio ϕ^*, output y^*, price of intermediate goods q^* and the degree of externality change with the interested parameter, when the down payment ratio is market determined and centrally planned. The degree of externality is measured as the ratio of the external effects to the sum of the external and the internal effects of trade finance (see (16) and (17)). Parameter values are reported in Appendix B.

Proof 7 *See Appendix A for the detailed proof of the above proposition.*

Figure 7 illustrates with an example how the equilibrium down payment ratio ϕ^* changes with r.

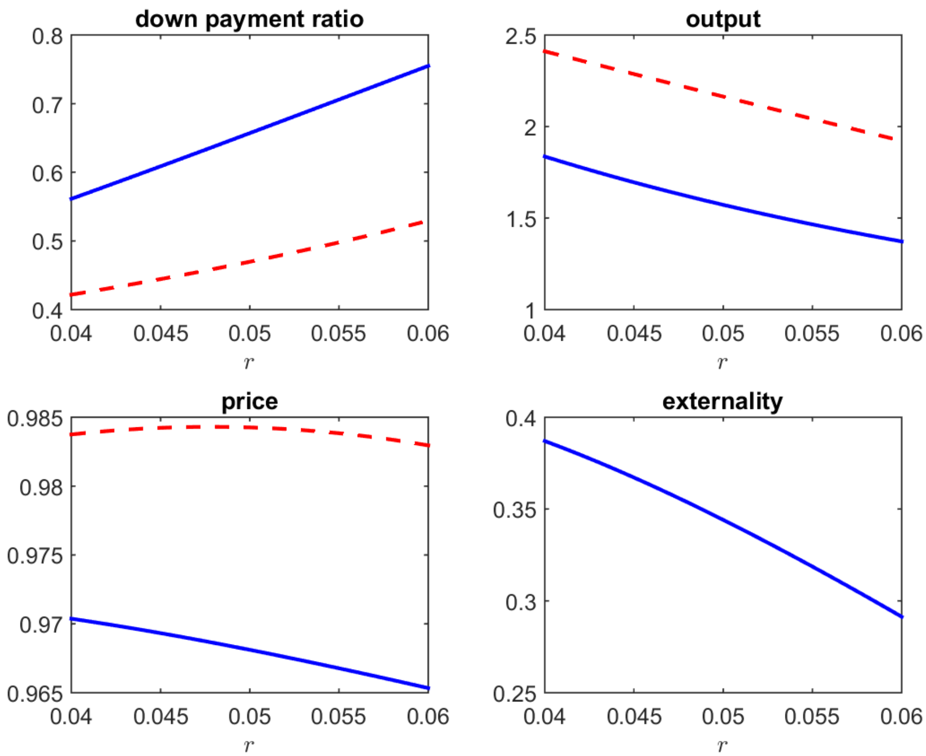

Figure 7: Increase in the interest rate r
(Solid-blue: market; Dashed-red: planned)

Notes: The above figure shows how the equilibrium down payment ratio ϕ^*, output y^*, price of intermediate goods q^* and the degree of externality change with the interested parameter, when the down payment ratio is market determined and centrally planned. The degree of externality is measured as the ratio of the external effects to the sum of the external and the internal effects of trade finance (see (16) and (17)). Parameter values are reported in Appendix B.

6 Policy implications

As shown in Section 4, state-owned firms may under provide trade finance due to externality. What policies can be implemented to correct for the inefficiency caused by the externality and increase trade finance? Lowering the return on the down payments can reduce the opportunity cost of trade finance and help raise the supply of trade credit. However, down payments received by state-owned firms can be used to make financial investments rather working capital financing. If the policy authority wants to encourage state-owned firms to lend more to private firms through trade credit, what would be the effective policy tool(s)?

To answer this question we extend the benchmark model constructed in Section 3 by assuming that state-owned firms can also invest in financial assets denoted by a_j. The flow of funds constraint at the beginning of the period for state-owned firm j is

$$g(\phi_j)\int_{i\in\mathbf{I}_j} x_i q_i + b_j^s = \int_{i\in\mathbf{I}_j} x_i q_i + a_j. \tag{29}$$

The first term on the left-hand-side is the down payment received from private firms and the second term is the loan received from banks. These funds are used to purchase working capital (the first term on the right-hand-side) and financial assets (the second term on the right-hand-side).

A further assumption is that bank loans to state-owned firms are also subject to a limit, that is,

$$b_j^s \leq \bar{b}^s, \tag{30}$$

and state-owned firms cannot go short on financial assets, that is,

$$a_j \geq 0. \tag{31}$$

State-owned firm j chooses q_i, ϕ_j, b_j^s, a_j, where $i \in \mathbf{I}_j$, to maximize its profits, while taking the demand function of private firms as given:

$$\max_{\{q_i\}_{i\in\mathbf{I}_j},\phi_j,b_j^s,a_j} \quad \int_{i\in\mathbf{I}_j} q_i x_i - \int_{i\in\mathbf{I}_j} c(x_i) + r_a a_j - r_b b_j^s$$

$$\text{subject to (6) and (29)} - \text{(31)}.$$

Let μ_r denote the Lagrangian multiplier associated with (29), which is the shadow value of pre-paid funds. Let μ_b and μ_a denote the Lagrangian multipliers associated with (30) and (31) respectively. Note that the first order conditions for q_i and ϕ_j are the same as those in the benchmark model (see (10) and (11)). However, the function $f(\phi_j)$ is now equal to

$$f(\phi_j) = 1 - [1 - g(\phi_j)]\mu_r. \tag{32}$$

Note also that the first order conditions for b_j^s and a_j are given by

$$-r_b + \mu_r - \mu_b = 0 \tag{33}$$

$$r_a - \mu_r + \mu_a = 0 \tag{34}$$

We assume that $\bar{b}^s$ is larger enough to meet the state-owned firm's needs for working capital financing, i.e., $\bar{b}^s > \int_{i \in \mathbf{I}_j} q_i x_i$ holds in equilibrium. Thus, (30) and (31) cannot both bind in equilibrium. However, if $r_b \neq r_a$, one of them must bind.

If $r_b > r_a$, state-owned firm j would borrow just enough to meet its working capital needs and choose $a_j = 0$. Thus, (30) does not bind while (31) binds. This implies that $\mu_b = 0$ and the shadow value of pre-paid funds μ_r is equal to the borrowing cost r_b.

If $r_b < r_a$, state-owned firm i borrows as much as possible to invest in the financial assets. Thus, (30) binds and (31) does not bind. In this case, $\mu_a = 0$ and the shadow value of pre-paid funds μ_r is equal to the return on financial investment r_a.

To summarize, the shadow value of pre-paid funds μ_r is always equal to the larger of r_b and r_v, that is, $\mu_r = \max\{r_b, r_v\}$.

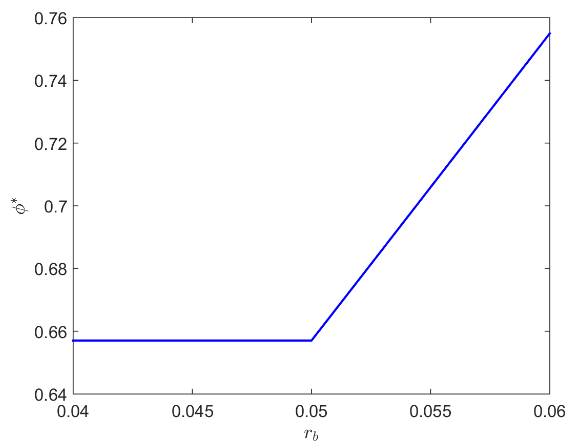

Figure 8: The impacts of r_b on the down payment ratio ϕ^*

Notes: Parameter values are reported in Appendix B. The rate of return of financial investment r_a is kept at 0.05.

An implication of the equilibrium characterization discussed above is that lowering the borrowing cost for state-owned firms does not necessarily raise trade finance. When the borrowing cost r_b is higher than the return of financial investment r_a, state-owned firms borrow just enough to meet their needs for working capital and do not make any financial investment. In this case, lower cist of borrowing reduces the down payment that state-owned require to private firms. This is because the cost of financing trade credit increases. However, when the borrowing cost r_b is below the return from financial investment r_a, state-owned firms would like to invest as much as possible in financial assets. In this case, they make more financial investments when they receive higher down payments from private firms. The opportunity cost of trade finance is pinned down by the return from financial investments, not the cost of borrowing r_b. In this case policies that encourage more lending to state-owned firms are not effective as a stimulus to the real economy.

Figure 8 gives an example of how the equilibrium down payment ratio ϕ^* vary with the borrowing cost r_b, while the return of financial investment r_a is kept fixed at 0.05.

7 Firm-level evidence

In addition to the aggregate evidence provided in Section 2, we present the firm-level evidence on the cyclical fluctuations of trade finance in this section. The firm-level data we use are from the annual surveys of manufacturing enterprises conducted by the National Bureau of Statistics of China, which are available for the period from 2006 to 2013. The database covers all state-owned enterprises and non-state-owned enterprises with annual sales of at least 5 million RMB, approximately US$750,000 in 2007.

We consider the following time varying fixed effects model:

$$y_{it} = c + \mu_i + \sum_{s=2007}^{2013} \alpha_s \cdot d_{st} + \beta_0 \cdot state_{it} + \sum_{s=2007}^{2013} \gamma_s \cdot d_{st} \cdot state_{it} + \sum_{k=1}^{n} \beta_k \cdot x_{kit} + \varepsilon_{it}, \tag{35}$$

where y_{it} is a measure for trade finance for firm i in year t, c is the nonrandom scalar intercept, μ_i represents time invariant unobservable individual-specific effects, d_{st} is the year dummy where $d_{st} = 1$ if $t = s$ and $d_{st} = 0$ otherwise, $state_{it}$ is an indicator equaling one if the firm is state-owned enterprise, and x_{kit} are the control variables. In order to control for other factors that can affect trade finance, such as, firms' capability to obtain credit from financial sector, we include three control variables (i.e., $x_{kit}, k = 1, 2, 3$) that are also employed in the related literature, including firm's age, profit-to-sales ratio, and interest rate.

Regression one: To control for the impacts of production scale on trade finance, we use the ratio of trade finance to output as the dependent variable.

Table 1: Ratio of Trade Finance to Output

This table reports estimates from panel regressions explaining firm-level yearly trade finance from 2006 to 2013. The dependent variable is *trade finance to output ratio*. *d2007 to d2013* are indicators equaling one if the year is which it indicates. *State* is an indicator equaling one if the firm is state-owned enterprise. *Age* is the age of firm. *Profit to sales ratio* is the ratio of profit to operating revenue. *Interest rate* is the ratio of interest payment to bank credit. ***, **, or * indicates that the coefficient estimate is significant at the 1%, 5%, or 10% level, respectively.

Ratio of Trade Finance to Output	(1)	(2)	(3)	(4)
d2007	-.0082***	-.0080***	-.0080***	-.0078***
d2008	-.0134***	-.0123***	-.0122***	-.0118***
d2009	.0030	.0035*	.0043**	.0048**
d2010	.0505***	.0510***	.0522***	.0526***
d2011	.0037	.0047	.0037	.0047
d2012	.0153***	.0163***	.0162***	.0173***
d2013	.0400***	.0410***	.0413	.0424***
State		-.0005	.0086	.0091
*State*d2007*			-.0021	-.0022
*State*d2008*			-.0182***	-.0180***
*State*d2009*			-.0201***	-.0205***
*State*d2010*			-.0253***	-.0256***
*State*d2011*			.0029	.0024
*State*d2012*			-.0151**	-.0155**
*State*d2013*			-.0225	-.0231
Age		-.0001		-.0001
Profit to sales		-.0205		-.0205
Interest rate		-.0080***		-.0080***
Constant	.1587***	.1611***	.1581***	.1605***
Firm Fixed Effects	Yes	Yes	Yes	Yes
R^2	0.1789	0.1789	0.1789	0.1789
No. of Obs.	221,359	221,292	221,359	221,292

Table 1:

Table 2: Ratio of Trade Finance to the Magnitude of Inter-firm Financing

This table reports estimates from panel regressions explaining firm-level yearly trade finance from 2006 to 2013. The dependent variable is *the ratio of trade finance to the magnitude of inter-firm financing, i.e., the sum of trade finance and trade credit*. *d2007 to d2013* are indicators equaling one if the year is which it indicates. *State* is an indicator equaling one if the firm is state-owned enterprise. *Age* is the age of firm. *Profit to sales ratio* is the ratio of profit to operating revenue. *Interest rate* is the ratio of interest payment to bank credit. ***, **, or * indicates that the coefficient estimate is significant at the 1%, 5%, or 10% level, respectively.

Trade finance / (trade finance + trade credit)	(1)	(2)	(3)	(4)
d2007	-.0010	-.0009	-.0002	-.0001
d2008	-.0033*	-.0028	-.0016	-.0011
d2009	.0076***	.0081***	.0103***	.0107***
d2010	.0819***	.0817***	.0843***	.0841***
d2011	.0082***	.0092***	.0128***	.0137***
d2012	.0130***	.0144***	.0178***	.0192***
d2013	.0089***	.0106***	.0139***	.0154***
State		.0118**	.0415***	.0420***
*State*d2007*			-.0092	-.0094
*State*d2008*			-.0215***	-.0226***
*State*d2009*			-.0364***	-.0370***
*State*d2010*			-.0324***	-.0328***
*State*d2011*			-.0713***	-.0724***
*State*d2012*			-.0766***	-.0774***
*State*d2013*			-.0878***	-.0885***
Age		-.0001		-.0001
Profit to sales		.0235*		.0231*
Interest rate		-.0240***		-.0242***
Constant	.5714***	.5714***	.5684***	.5695***
Firm Fixed Effects	Yes	Yes	Yes	Yes
R^2	0.5574	0.5583	0.5581	0.5590
No. of Obs.	220,559	220,491	220,559	220,491

Table 2:

The estimates of coefficients are reported in Table 1. As shown in the table, the year effects has cyclical pattern; it drops in 2008 and rise in 2010. Note that the cyclical pattern of trade finance are not merely the results of the fluctuations of firms' production scale, since we have already controlled for output. In addition, the amount of trade finance provided by state-owned firms drop relatively to that provided by non-state-owned firms after 2008.

Regression two: We use the ratio of trade finance to the magnitude of inter-firm financing as dependent variable, where the later is measured as the sum of firm's trade finance and trade credit. The estimates of coefficients are reported in Table 2. The results are similar as those obtained from regression one.

8 Conclusion

Chinese state-owned enterprises have much better access to bank loans than private firms. However, private firms can borrow from banks indirectly trough trade credit provided by state-owned firms. This paper shows that there exists an externality that reduces the equilibrium level of trade credit below its socially optimal level. Subsidizing bank credit to state-owned firms can lower their opportunity costs of providing trade credit. However, above a certain level, the subsidization of the bank loans to state-owned firms or the relaxation of their borrowing limit may become ineffective. We have also shown that the severity of trade finance externality varies endogenously with aggregate productivity and this amplifies the effects of aggregate shocks.

A Appendix A: derivations and proofs

A.1 Conditions for symmetric equilibrium

A.1.1 Equilibrium conditions

To derive the symmetric equilibrium conditions, we first note that the equilibrium conditions include the following equations.
First, the demand function for intermediate good i:

$$x_i = \frac{y}{[1+\phi_j(r+\lambda)]^{\varepsilon} q_i^{\varepsilon}} \equiv D_i(q_i, \phi_j, y, \lambda), \tag{36}$$

for $i \in I_j$, where $j = 1, 2, ..., N$, and y and λ are functions of $\mathbf{Q}$ and $\mathbf{\Phi}$ defined by the following equations:

$$1 = \sum_{\kappa=1}^{N} [1+\phi_\kappa(r+\lambda)]^{1-\varepsilon} \int_{i\in\mathbf{I}_\kappa} q_i^{1-\varepsilon}, \tag{37}$$

$$y = \frac{\bar{b}}{\sum_{\kappa=1}^{N} \phi_\kappa [1+\phi_\kappa(r+\lambda)]^{-\varepsilon} \left(\int_{i\in\mathbf{I}_\kappa} q_i^{1-\varepsilon}\right)}, \tag{38}$$

Second, the first order conditions for q_i and ϕ_j:

$$\left[q_i f(\phi_j) - c'\left(\int_{i\in\mathbf{I}_j} x_i\right)\right] \frac{\partial x_i}{\partial q_i} + f(\phi_j) x_i = 0, \tag{39}$$

and

$$f(\phi_j)\int_{i\in\mathbf{I}_j} q_i \frac{\partial x_i}{\partial \phi_j} - c'\left(\int_{i\in\mathbf{I}_j} x_i\right)\int_{i\in\mathbf{I}_j} \frac{\partial x_i}{\partial \phi_j} + f'(\phi_j)\int_{i\in\mathbf{I}_j} q_i x_i = 0, \tag{40}$$

A.1.2 Derivatives of x_i w.r.t. q_i and ϕ_j

The derivatives $\partial x_i/\partial q_i$ and $\partial x_i/\partial \phi_j$ can be written as

$$\frac{\partial x_i}{\partial q_i} = \frac{\partial D_i}{\partial q_i} + \frac{\partial D_i}{\partial y}\frac{\partial y}{\partial q_i} + \frac{\partial D_i}{\partial \lambda}\frac{\partial \lambda}{\partial q_i}, \tag{41}$$

$$\frac{\partial x_i}{\partial \phi_j} = \frac{\partial D_i}{\partial \phi_j} + \frac{\partial D_i}{\partial y}\frac{\partial y}{\partial \phi_j} + \frac{\partial D_i}{\partial \lambda}\frac{\partial \lambda}{\partial \phi_j}. \tag{42}$$

The derivatives of D_i with respect to q_i, ϕ_j, y and λ are given by

$$\frac{\partial D_i}{\partial q_i} = \frac{-\varepsilon y}{\left[1+\phi_j(r+\lambda)\right]^{\varepsilon} q_i^{1+\varepsilon}} \tag{43}$$

$$\frac{\partial D_i}{\partial \phi_j} = \frac{-\varepsilon y(r+\lambda)}{\left[1+\phi_j(r+\lambda)\right]^{1+\varepsilon} q_i^{\varepsilon}} \tag{44}$$

$$\frac{\partial D_i}{\partial y} = \frac{1}{\left[1+\phi_j(r+\lambda)\right]^{\varepsilon} q_i^{\varepsilon}} \tag{45}$$

$$\frac{\partial D_i}{\partial \lambda} = \frac{-\varepsilon y\phi_j}{\left[1+\phi_j(r+\lambda)\right]^{1+\varepsilon} q_i^{\varepsilon}} \tag{46}$$

To obtain $\partial\lambda/\partial q_i$ and $\partial\lambda/\partial\phi_j$ we use (37) which defines implicitly λ as a function of $\mathbf{Q}$ and $\mathbf{\Phi}$. Using the implicit function theorem we obtain

$$\frac{\partial \lambda}{\partial q_i} = 0 \tag{47}$$

$$\frac{\partial \lambda}{\partial \phi_j} = -\frac{(r+\lambda)\left[1+\phi_j(r+\lambda)\right]^{-\varepsilon}\int_{i\in\mathbf{I}_j} q_j^{1-\varepsilon}}{\sum_{\kappa=1}^{N}\phi_\kappa\left[1+\phi_\kappa(r+\lambda)\right]^{-\varepsilon}\int_{i\in\mathbf{I}_\kappa} q_\kappa^{1-\varepsilon}}. \tag{48}$$

To obtain $\partial y/\partial q_i$ and $\partial y/\partial\phi_j$, we first define

$$z(\mathbf{Q},\mathbf{\Phi},\lambda) = \sum_{\kappa=1}^{N}\phi_\kappa\left[1+\phi_\kappa(r+\lambda)\right]^{-\varepsilon}\left(\int_{i\in\mathbf{I}_\kappa} q_i^{1-\varepsilon}\right), \tag{49}$$

so that we can write (38) as:

$$y = \frac{\bar{b}}{z(\mathbf{Q},\mathbf{\Phi},\lambda)}. \tag{50}$$

The derivatives of y with respect to q_i and ϕ_j are given by

$$\frac{\partial y}{\partial q_i} = 0, \tag{51}$$

$$\frac{\partial y}{\partial \phi_j} = -\frac{\bar{b}}{z^2}\left(\frac{\partial z(\mathbf{Q},\mathbf{\Phi},\lambda)}{\partial \phi_j} + \frac{\partial z(\mathbf{Q},\mathbf{\Phi},\lambda)}{\partial \lambda}\frac{\partial \lambda}{\partial \phi_j}\right), \tag{52}$$

where

$$
\begin{aligned}
\frac{\partial z(\mathbf{Q},\mathbf{\Phi},\lambda)}{\partial \phi_j} &= \left[1-\varepsilon\frac{\phi_j(r+\lambda)}{1+\phi_j(r+\lambda)}\right][1+\phi_j(r+\lambda)]^{-\varepsilon}\int_{i\in\mathbf{I}_j} q_j^{1-\varepsilon}, \quad (53)\\
\frac{\partial z(\mathbf{Q},\mathbf{\Phi},\lambda)}{\partial \lambda} &= -\sum_{\kappa=1}^{N}\frac{\varepsilon\phi_\kappa^2}{[1+\phi_\kappa(r+\lambda)]^{1+\varepsilon}}\int_{i\in\mathbf{I}_\kappa} q_\kappa^{1-\varepsilon}, \quad (54)
\end{aligned}
$$

and $\partial\lambda/\partial\phi_j$ is given by (48).

A.1.3 Symmetric equilibrium

By imposing symmetric equilibrium on (36), (37), (38) and (49), we have

$$
\begin{aligned}
x^* &= \frac{y^*}{[1+\phi^*(r+\lambda^*)]^{\varepsilon}(q^*)^{\varepsilon}}, \quad (55)\\
q^* &= \frac{1}{1+\phi^*(r+\lambda^*)}, \quad (56)\\
y^* &= \frac{\bar{b}}{\phi^*[1+\phi^*(r+\lambda^*)]^{-\varepsilon}(q^*)^{1-\varepsilon}}, \quad (57)\\
z^* &= \phi^*[1+\phi^*(r+\lambda^*)]^{-\varepsilon}(q^*)^{1-\varepsilon}. \quad (58)
\end{aligned}
$$

By using (56) in the other three equations, we have

$$
\begin{aligned}
x^* &= y^* = \frac{\bar{b}}{\phi^* q^*}, \quad (59)\\
z^* &= \phi^* q^*. \quad (60)
\end{aligned}
$$

By evaluating (43), (44), (45), (46), (47), (48), (51), (52), (53) and (54), and using (56), (59) and (60) in the obtained equations, we have

$$
\begin{aligned}
\left.\frac{\partial D_i}{\partial q_i}\right|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*} &= -\varepsilon\frac{y^*}{q^*} \quad (61)\\
\left.\frac{\partial D_i}{\partial \phi_j}\right|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*} &= -\varepsilon\frac{y^*}{\phi^*}(1-q^*) \quad (62)\\
\left.\frac{\partial D_i}{\partial y}\right|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*} &= 1 \quad (63)
\end{aligned}
$$

$$\left.\frac{\partial D_i}{\partial \lambda}\right|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*} = -\varepsilon y^* \phi^* q^* \tag{64}$$

$$\left.\frac{\partial \lambda}{\partial q_i}\right|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*} = 0 \tag{65}$$

$$\left.\frac{\partial \lambda}{\partial \phi_j}\right|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*} = -\frac{r+\lambda^*}{N\phi^*} \tag{66}$$

$$\left.\frac{\partial y}{\partial q_i}\right|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*} = 0 \tag{67}$$

$$\left.\frac{\partial y}{\partial \phi_j}\right|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*} = -\frac{y^*}{N\phi^*} \tag{68}$$

$$\left.\frac{\partial z}{\partial \phi_j}\right|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*} = \frac{q^*\left[1-\varepsilon(1-q^*)\right]}{N} \tag{69}$$

$$\left.\frac{\partial z}{\partial \lambda}\right|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*} = -\varepsilon\left(\phi^* q^*\right)^2 \tag{70}$$

By using the above equations in (41) and (42), we have

$$\left.\frac{\partial x_i}{\partial q_i}\right|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*} = -\varepsilon\frac{y^*}{q^*} \tag{71}$$

$$\left.\frac{\partial x_i}{\partial \phi_j}\right|_{\mathbf{Q}=\mathbf{Q}^*,\mathbf{\Phi}=\mathbf{\Phi}^*} = -\frac{y^*}{\phi^*}\left[\frac{1}{N}+\varepsilon\left(\frac{N-1}{N}\right)(1-q^*)\right] \tag{72}$$

By evaluating (39) at the equilibrium point and using (71) in the obtained equation, we have

$$-\varepsilon\left[q^* f(\phi^*) - c'\left(\frac{y^*}{N}\right)\right]\frac{y^*}{q^*} + f(\phi^*)y^* = 0, \tag{73}$$

which implies

$$q^* f(\phi^*) = \left(\frac{\varepsilon}{\varepsilon-1}\right)c'\left(\frac{y^*}{N}\right). \tag{74}$$

By evaluating (40) at the equilibrium point and using (72) we obtain

$$\frac{1}{\varepsilon}\left[\frac{1}{N}+\varepsilon\left(\frac{N-1}{N}\right)(1-q^*)\right] = \frac{\phi^* f'(\phi^*)}{f(\phi^*)} \tag{75}$$

A.2 Proofs of Proposition 4 to 7

Note that by using (13) in (14) to eliminate x^*, we have

$$q^* f(\phi^*) = \left(\frac{\varepsilon}{\varepsilon - 1}\right) \tau^{1+\alpha} \left(\frac{\bar{b}}{\phi^* q^*}\right)^{\alpha}, \tag{76}$$

which implies

$$q^* = \tau \left(\frac{\varepsilon}{(\varepsilon - 1) f(\phi^*)}\right)^{\frac{1}{1+\alpha}} \left(\frac{\bar{b}}{\phi^*}\right)^{\frac{\alpha}{1+\alpha}}. \tag{77}$$

By using (77) in (15) to eliminate q^*, we obtain

$$\varepsilon^{-1} \left\{ \frac{1}{N} + \varepsilon \left(\frac{N-1}{N}\right) \left[1 - \tau \left(\frac{\varepsilon}{(\varepsilon - 1) f(\phi^*)}\right)^{\frac{1}{1+\alpha}} \left(\frac{\bar{b}}{\phi^*}\right)^{\frac{\alpha}{1+\alpha}} \right] \right\} = \frac{\phi^* f'(\phi^*)}{f(\phi^*)}. \tag{78}$$

Note that the left hand side of (78) is increasing in ϕ^* and the right hand side of (78) is decreasing in ϕ^*. Thus, if there exists an equilibrium, ϕ^* is uniquely determined.

1. An increase in τ shifts the LHS downward, and increases ϕ^*.
2. An increase in N shifts the LHS downward, and increases ϕ^*.
3. An increase in ε shifts the LHS upward, and lowers ϕ^*.
4. An increase in r shifts the RHS upward, and increases ϕ^*.

B Appendix B: Parameter values

Parameter	Value	Description
τ	0.9	scalar in cost function
α	0.01	elasticity of cost w.r.t. production scale, 1+α
r	0.05	interest rate
$\bar{b}$	1.0	maximum bank credit of private firms
ε	20	elasticity of substitution between intermediate goods
N	20	number of upstream firms in the sector i
Functions		
$c(.)$		$c(x) = (\tau/1+\alpha)\, x^{1+\alpha}$, for $x > 0$.
$g(.)$		$g(\phi) = 0.35 log(\phi - 0.3) + 1$, for $\phi \in (0.3, 1]$.

Table 3: Parameter values and function forms