Bank Loans, Trade Credit and Export Prices: Evidence from Exchange Rate Shocks in China*

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Abstract

This paper studies how the effects of exchange rate shocks on international prices (i.e., exchange rate pass-through) vary with trade credit. We put together a dataset that contains customs data and bank statements for the universe of Chinese exporters for the period 2001-2012. We start by documenting some stylized facts. First, exporters' international prices respond significantly less for products sold by exporters issuing more trade credit (more complete exchange rate pass-through). Second, the interests paid by exporters to domestic banks respond to exchange rate shocks. Third, we observe substantial complementarity between trade credit and bank loans. We introduce an open economy model of monopolistic competition in international markets with heterogeneous firms and domestic financial markets to explain these patterns. The mechanism is exporters can grant trade credits to the importers with the trade credit interest rate implicitly embedded in the exporting price. There is a trade credit premium channel: exchange rate shocks affect domestic banks' expectations of exporters' profits, and, in this way, impact interest rates (financial costs) offered to exporters and, in turn, the trade credit interest rate in the exporting price. Our findings and theory call for policy attention to firms' financial conditions when dealing with inflation through supply chains.

JEL Codes: *F31, F34, G32*

Keywords: *Exchange rate pass through, trade credit, financial constraints*

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1. Introduction

One fundamental question in international economics is why large movements in exchange rates have small effects on the prices of internationally traded goods (incomplete exchange rate pass-through). Recent literature has emphasized different mechanisms through which the exchange rate might affect export prices: import intensity (Amiti, Itskhoki and Konings, 2014), productivity (Atkeson and Burstein, 2008). At the same time, it has been shown financial constraints and trade credit affect firms' domestic pricing decisions (Gilchrist et al., 2017; Hardy, Saffie and Simonovska, 2022; Almut, Balleer; Nikolay, Hristov; Dominik, 2017; Kohn, Leibovici and Szkup, 2020). If this is the case, can financial constraints and trade credit also affect the international prices set by the firm? Can trade credit explain part of the heterogeneity in exchange rate pass-through?

This paper focuses on evaluating the effect of trade credit and bank loans on the pricing decisions of firms in international markets and on price dynamics when there is an exchange rate shock (i.e., exchange rate pass-through). To this end, we combine a rich dataset from China containing information on firms' balance sheets and export prices with a theoretical model of firm heterogeneity in a monopolistic competition framework that introduces financial markets in the home country and trade credit between exporters and importers. Our main finding is that trade credit and financial markets play a role in international price setting and in how these prices react to exchange rate shocks.

We begin our analysis by introducing a conceptual model of how trade credit could have an effect on the degree of exchange rate pass-through. The exporters are located in the home country and grant trade credit to importers from foreign countries. For this trade credit to be profit-maximizing for exporters, the importers need to pay an implicit interest rate embedded in the product price. As the trade credit interest rate reacts with changes in the exchange rate, it constitutes of a new mechanism determining exchange rate pass-through.

Based on our conceptual model, we use a dataset from China for the period 2000-2011 for our analysis. We combine three datasets into one panel: (i) a dataset of Chinese firms' balance sheets containing long term debt, trade credit, and interests costs, (ii) customs data which corresponds to transaction-level data for the universe of exports for China; and (iii) bilateral exchange rates from the International Monetary Fund.

Using this novel dataset, we document some stylized facts on Chinese export markets. First, we find export prices in producer currency react less to exchange rate shocks for an exporter with a higher ratio of trade credit (receivables) over sales than for an exporter with a lower ratio. In other words, firms issuing more trade credit have a more complete exchange rate pass-through to producer currency price. This effect is more predominant for devaluations.

Second, we find a negative correlation between interest costs paid by exporters to domestic banks (i.e., their bank loans) and changes in the exchange rates. As interest costs correspond to a *proxy* for the interest rate, our evidence suggests that domestic banks change the interest rate charged to exporters with changes in the exchange rate. This is because exchange rate fluctuations will make export prices more competitive in international markets.

Third, we find trade credit and bank loans are complements for exporting firms. For exporters to issue trade credit to their buyers, they need to rely on domestic banks to lend them money. This complementarity is heterogenous in the firm size: firms with higher market share have a stronger complementarity.

Motivated by these stylized facts, we develop an open economy model with three agents; exporters, importers, and domestic banks. Exporters and domestic banks are located in the home country while importers are the firms in foreign countries. The model has two key sections: the export market and the financial markets.

In the export market, the supply side corresponds to firms in a monopolistic competition framework. The novelty in this section is that we introduce both nominal exchange rates and trade credit. On the demand side for these exported products, we assume the importers can finance themselves by borrowing from their domestic banks and exporters.

In the financial market, the exporter borrows from domestic banks. The interest rate paid to these banks is endogenously set by the aggregate savings and borrowings levels in the home country. Given the average net worth of the exporter increases with an increase of the exchange rate (e.i., depreciation), the model is set such that the aggregate borrowing level reacts to changes in the exchange rate.

The first theoretical result of the model is that the equilibrium price depends on three terms: the variable markup, the marginal cost, and a financial term. The financial term is a function of the interest rate exporters get from domestic banks and the trade credit, measured as the ratio between the firm trade credit and sales. The higher the trade credit, the higher the price. The higher the domestic bank interest rate, the higher the price.

The second theoretical result is that the price response to exchange rate shocks varies with the trade credit level: firms that issue more trade credit relative to their sales level set prices that react less with changes in the exchange rate. This result is consistent with our empirical findings.

The mechanism behind these results is the following: exporters face lower financial costs from banks when the home currency depreciates, and this change of interest rate will pass on to trade credit implicit interest rate. In other words, as the firms sell in international markets, the expected sales/returns of exporting firms increase with home currency depreciation. On the other hand, domestic banks in a perfectly competitive framework maximize profits by choosing firm-specific interest rates given the firm's expected sales/returns. Bank loan interest rates are positively correlated with trade credit interest rates. Therefore, the trade credit interest rate decreases when the home currency depreciates.

We calibrate the model using the elasticities from the empirical part and matching several moments in our simulation to the data. In this way, we are able to retrieve the trade credit interest rate's elasticity with respect to the exchange rate which is the key elasticity governing the proposed mechanism. Knowing how the trade credit interest rate reacts to the exchange rate is crucial to determine how the financial system can encourage or discourage sales in the export markets.

After obtaining all the parameters from our calibration, we propose two counterfactuals. First, we evaluate the effects of lowering the costs of accessing trade credit for small exporting firms. Second, we explore what are the heterogeneous effects of targeting trade credits to industries with more comparative advantage.

Our paper contributes to three different strands of the literature. First, it contributes to the literature on the international pricing response to exchange rate changes. There is a big body of literature that focuses on different reasons why the exchange rate pass-through is incomplete, such as markup adjustment, local costs, or barriers to prices adjustment (Amiti, Itskhoki and Konings, 2014; Atkeson and Burstein, 2008; Campa and Goldberg, 2005; Gopinath, Itskhoki and Rigobon, 2010; Burstein and Gopinath, 2014; Auer and Schoenle, 2016; Berman, Martin and Mayer, 2012). This paper sheds light on an understudied source for incomplete exchange rate pass-through which is trade credit and bank loans. Together with this paper, Strasser (2013) explores the effects of credit constraints on exports responses to shocks in terms of prices and quantities in international markets. Our contribution to this literature corresponds to a theoretical model disentangling the mechanism through which trade credit and bank loans are connected and how this, in turn, affects the degree of exchange rate pass-through.

Second, our paper contributes to the literature relating firms' liquidity constraints and pricing decisions. Liquidity constraints can be divided into financial constraints related to domestic banks and trade credit. As regards bank loans, Gilchrist et al. (2017) shows that liquidity-constrained firms increased prices during the Great Recession in 2008, while unconstrained firms decreased prices. In contrast, Kim (2021) finds that a negative credit supply shock decreases output prices during the Lehman Brothers' failure. In terms of trade credit, Amberg, Jacobson and von Schedvin (2021) finds firms issuing more trade credit increased product prices significantly more during the Great Recession. All of this literature focuses on the domestic prices of firms, while our paper expands into the international markets and, at the same time, combines in a model both mechanisms of the trade credit one and the financial constraints related to bank loans.

Third, this study relates to the body of work on trade credit and liquidity propagation. On the one hand, Desai, Foley and Hines Jr (2016) shows US multinationals use trade credits to shift capital from low-tax places to high-tax places. On the other hand, Lin and Ye (2018) finds multinationals' trade credit provision for Chinese firms is significantly affected by global liquidity shocks. This paper connects trade credit and bank loans. We first exploit the variation of our data and find the relationship between the bank loan interests and trade credit. Then, our model identifies the theoretical connection behind this result.

This paper is organized as follows. Section 2 proposes a conceptual model of prices including trade credit. Section 3 corresponds to the data and some empirical findings. Section 4 presents a model that accounts for the empirical patterns and details a mechanism behind these patterns. In

Section 5, we calibrate the model. Section 6 proposes a counterfactual and Section 7 concludes.

2. A Conceptual Model

How do trade credits affect exchange rate pass-through? In this section, we use a simple conceptual model to answer this question. The conceptual model will guide our empirical regression and will be formalized in the theoretical model.

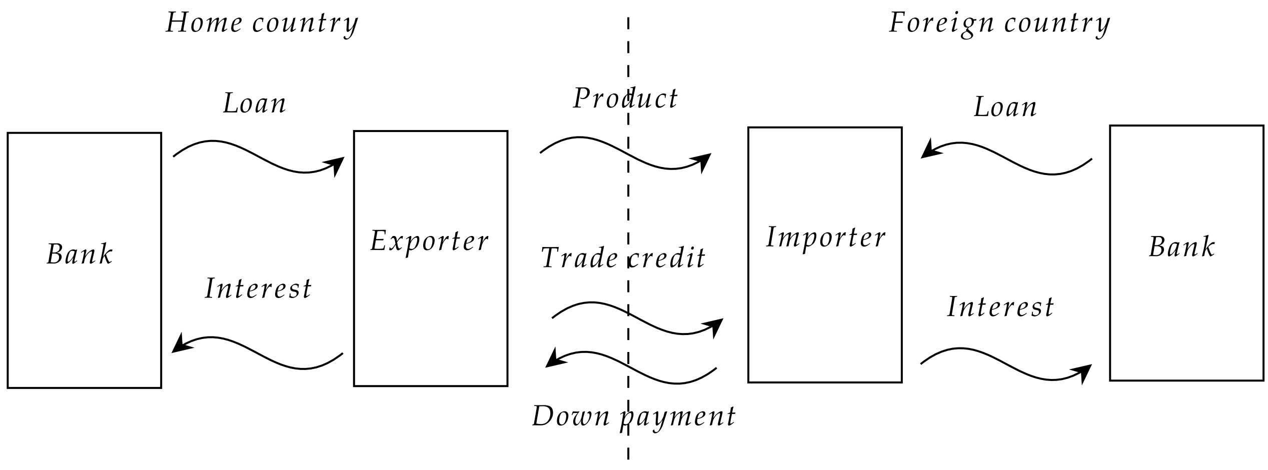


Figure 1: Trade and Financial Relationships

Notes: This figure provides an illustration of the trade and financial relationships of the economy. On the trade relationship, the exporter sells products to the importer and receives payments. The financial relationship between the export and the importer emerges when the exporter only requires a partial down payment and grants a trade credit to the importer. Both the exporter and the import can borrow from banks in their own countries.

Consider an exporter in the home country selling a product to a foreign buyer, or importer (Figure 1). The exporter sets the product price in the importer's currency, $P^* = P \times E$, where E is the exchange rate defined as exporter's currency/importer's currency and P is the price in the exporter currency. Suppose the price of the product is set with no trade credit being granted:

$$P^* = \frac{\varepsilon}{\varepsilon - 1} MC \times E^{-1} \tag{2.1}$$

where ε is the importer's demand elasticity; MC is the exporter's marginal cost in exporting country's currency unit [1]. From equation 2.1, we derive the following equation for the exchange rate pass-

[1]For this example, we use the standard setting with monopolistic competition and variable markups as in Atkeson and Burstein (2008)

through with no trade credits:

$$\frac{dp}{de} = \frac{d\mu}{de} + \frac{d(mc)}{de} \tag{2.2}$$

where $p = logP$, $\mu = \log \frac{\varepsilon}{\varepsilon - 1}$, $mc = \log MC$, and $e = logE$. Equation 2.2 summarizes two channels of the channels of incomplete exchange rate pass-through that have been studied in the literature: the markup response [2] ($\frac{d\mu}{de} > 0$) or the marginal cost response ($\frac{d(mc)}{de} > 0$) [3].

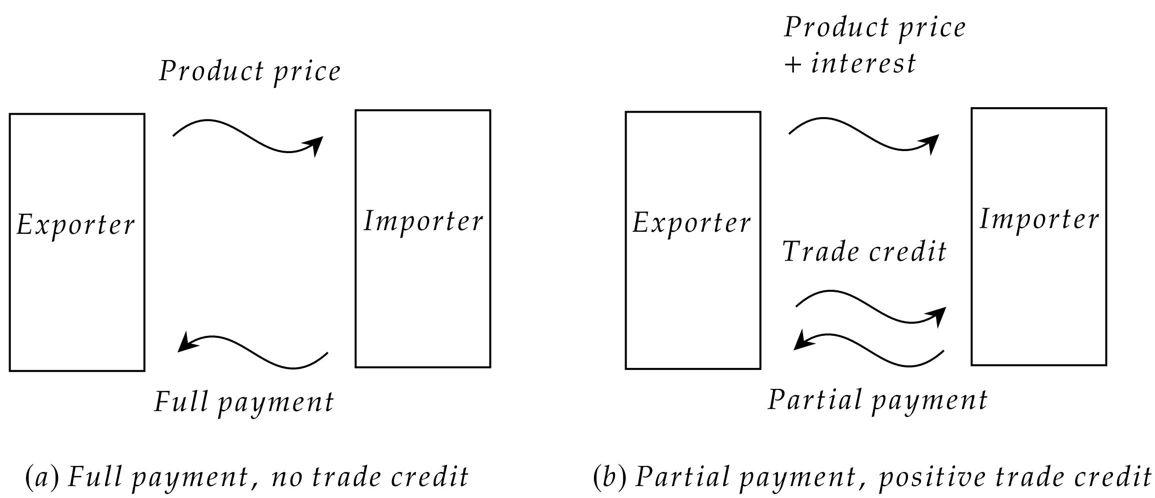


Figure 2: Trade Credit Utilization and the Exporting Price

Notes: Panel (a) illustrates the case where the exporter asks full payment and grants no trade credit. The observed exporting price is the product price. Panel (b) illustrates the case where the exporter asks partial payment and grants positive trade credits. The observed exporting price is the product price and an implicit interest rate (trade credit premium).

In this scenario, we introduce trade credit (Figure 2). Suppose the exporter allows the importer to pay for the products after a certain maturity period τ. That is, the exporter grants trade credit to the importer. Trade credit is desirable for the importer due to financial constraints. For example, an importer without cash could import inputs and sell final goods to consumers. After collecting cash from the consumers, the importer can pay the exporter back. However, as issuing trade credit is costly for the exporter, the importer needs to pay an implicit interest rate that is embedded in the product price. Following Amberg, Jacobson and von Schedvin (2021), we assume there is a trade-credit premium in the product price:

$$P^T = P \times exp(r\tau) \tag{2.3}$$

where r is the implicit annual interest rate of trade credit and τ is the maturity of the trade credit, in number of net days divided by 365.

[2]This channel assumes firms' have variable markups that vary via the response of the demand elasticity to exchange rate changes (Burstein and Gopinath, 2014)

[3]This channel is explored in studies such as Amiti, Itskhoki and Konings (2014); Berman, Martin and Mayer (2012)

With trade credit being granted, the exchange rate pass-through is:

$$\frac{dp^T}{de} = \frac{d\mu}{de} + \frac{d(mc)}{de} + \tau\frac{dr}{de} + r\frac{d\tau}{de} \tag{2.4}$$

In our empirical exercise, we focus on the role of $\tau\frac{dr}{de}$ in Equation 2.4. The variation of exchange rate pass-through across exporters could be explained by the different degrees of trade credit utilization and the adjustment of the implicit interest rate.

3. Data and relevant patterns

3.1 Data

Our sample of firms is drawn from two sources of data in China. First, we obtain the firm-level balance sheet data from the survey of Chinese manufacturing firms conducted by the National Bureau of Statistics of China. The survey covers more than 190,000 manufacturing firms' performance from 2000 to 2011. In this survey data, we are able to find the variables describing the firm's credit condition including trade credit (recorded on the balance sheet as account receivables), long-term debt, and interest costs. Together with this, we include variables that indicate the firm's size such as annual employment and sales. [4]

Second, we include a panel from customs that corresponds to the universe of Chinese trade transactions to 76 destination countries. It comprises data on trade values and trade prices for each transaction of a firm to a certain destination country in a given year. We merge the two datasets for the period 2000 to 2011 and construct the sample to conduct empirical analysis.[5]

In addition to the firm panel, we also use the annually averaged nominal bilateral exchange rates from IMF to construct the exchange rate shocks at the importing-country level. Figure 3 shows the bilateral exchange rate shocks fluctuation from the year 2000 to 2011. Before 2005, the Chinese government implemented a fixed exchange rate policy targeted at US dollars. As a result, there were no bilateral exchange rate shocks between China and US before 2005. Table 1 is the summary of the key variables we use in the empirical part.

[4] These variables are mainly used in the robustness checks.

[5] To avoid noise in the survey, we deleted unusual entries including negatives of key variables in the balance sheet and missing data.

Figure 3: Times Series of Change in Exchange Rates

Notes: This figure shows the exchange rates fluctuations from 2000 to 2011. In the vertical axis, the annual exchange rate is calculated as Chinese RMB per 1 unit of exporting destination's currency averaged from monthly data.

Table 1: Summary of Statistics

Variable	Mean	Std. dev.	Min	Max
Exporting prices	3351.702	332123.7	3.06e-06	1.63e+08
Export values	452078.1	1.08e+07	1	5.40e+09
Receivables	147343.2	1606957	1	5.28e+07
Interest costs	4144.873	50314.75	-707406	2821463
Sales	887535.5	6846421	56	1.92e+08
Employment	1068.278	5278.498	1	198971

Notes: This table summaries the data. The total observations in the sample are 5,773,343. The panel data is at the firm-product-destination-year level. The exporting prices and values are from transaction-level custom data. Receivables, interest costs, sales and employment are from the firm-level balance sheets. Part of the interest costs observations are negative because those firms received more interest income than the interest expenses they paid to creditors.

3.2 Stylized Facts

In this section, we establish basic facts about the role that trade credit plays in the exporters' market. We shed light on three relationships; the relationship between trade credit and bank loans, trade credit and export prices, and the exchange rate and bank loans.

3.2.1 Fact I: Larger trade credit share indicates more complete exchange rate pass-through

We begin by exploring how exporters that issue trade credit change their prices as a result of an exchange rate shock. Equation 3.1 shows our main specification.

$$\Delta p_{i,j,k,t} = \underbrace{[\alpha + \beta rec_{i,0}]}_{1-ERPT} \Delta e_{k,t} + n_{i,t} + \underbrace{\varphi_{j,k} + \varphi_t}_{Fixed\ Effects} + \varepsilon_{i,j,k,t} \tag{3.1}$$

where $\Delta p_{i,j,k,t}$ is the log change in price of good j denominated in producer-currency (Chinese RMB) from exporting firm i to destination country k at time t. $\Delta e_{k,t}$ is the log change of bilateral exchange rate (Chinese RMB per 1 unit of destination k's currency). An increase in $e_{k,t}$ corresponds to the depreciation of Chinese RMB relative to the destination-k currency. $rec_{i,0}$ is firm i's trade credit (receivables) over total sales in the first year of dataset. $n_{i,t}$ is log of employment of firm i at time t that captures remaining firm-level effects on ERPT. We also control for time fixed effects and product-destination fixed effects.

Since we are using the exporting prices, a complete exchange rate pass-through is when $\alpha + \beta rec_{i,t} = 0$. The coefficient β indicates to what extent firm-level trade credit changes the pass-through to exporting prices when there exist bilateral exchange rate shocks. Table 2 reports the regression results.

Column (1) shows the plain regression without controlling for trade credit shares. However, column (2) result shows that a 10% increase in trade credit share leads to a 1.24% higher exchange rate pass-through. The robustness check in columns (3)-(5) in which control for last-year trade credit share and employment demonstrate similar estimates of β. While a firm with no trade credit has a pass-through of 95.08% (= 1 - 0.0492), a firm with a 7% trade credit share (median) has a pass-through of 95.95% (= 1 - 0.0492 + 0.124$\cdot$ 0.07). The estimate of β indicates that firms with a larger share of trade credit relative to sales exhibit higher pass-through into destination-currency export prices.

Table 2: Regression Results

	(1)	(2)	(3)	(4)	(5)
	$\Delta p_{i,j,k,t}$	$\Delta p_{i,j,k,t}$	$\Delta p_{i,j,k,t}$	$\Delta p_{i,j,k,t}$	$\Delta p_{i,j,k,t}$
$\Delta e_{k,t}$	0.0314**	0.0492***	0.0281*	0.0497***	0.121***
	(0.0146)	(0.0176)	(0.0159)	(0.0176)	(0.0424)
$rec_{i,0}$		-0.00991**		-0.00778*	-0.00801*
		(0.00426)		(0.00412)	(0.00410)
$\Delta e_{k,t} \times rec_{i,0}$		-0.124***		-0.125***	-0.134***
		(0.0473)		(0.0476)	(0.0468)
$rec_{i,t-1}$			-0.000123*		
			(0.0000681)		
$\Delta e_{k,t} \times rec_{i,t-1}$			-0.00819***		
			(0.00264)		
$n_{i,t}$				0.00219***	0.00183***
				(0.000542)	(0.000574)
$\Delta e_{k,t} \times n_{i,t}$					-0.0111*
					(0.00588)
Product-destination FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Obs	1443809	1443809	1110858	1443809	1443809

Notes: This table reports the results of regression results from Equation 3.1 Standard errors are reported in parenthesis.* Significant at 10%.** Significant at 5%.*** Significant at 1%. All columns have year-level and product-destination-level fixed effect controls.

3.2.2 Fact II: Interest costs decrease in response to home currency depreciation

We ran Equation 3.2 to examine how firm's loan-related costs react to exchange rate shocks.

$$c_{i,t} = \alpha + \beta \Delta e_{i,t} + \varphi_i + \varphi_t + \varepsilon_{i,t} \tag{3.2}$$

where $c_{i,t}$ is the log finance costs or log interest costs of exporter i at time t. φ_i and φ_t are firm and time fixed effects. $\Delta e_{i,t}$ is the firm-level exchange rate shocks constructed as

$$\Delta e_{i,t} = \sum_{k \in \Omega_{i,t}} \Delta e_{k,t} \times \Gamma_{i,k,t}$$

where $\Gamma_{i,k,t}$ is the exporting share of firm i to destination k in period t. $\Omega_{i,t}$ is the a set of exporting countries of firm i in period t. The regression results are shown in Table 3.

Table 3: Regression Results

	(1)	(2)	(3)	(4)
	$c^F_{i,t}$	$c^I_{i,t}$	$c^F_{i,t}$	$c^I_{i,t}$
$\Delta e_{i,t}$	-0.339***	-0.566***	-0.158***	-0.149**
	(0.0919)	(0.0989)	(0.0575)	(0.0640)
Period	Yes	Yes	Yes	Yes
Firm	No	No	Yes	Yes
N	183118	183118	148458	148458

Notes: This table reports the results of regression results from Equation 3.2. Standard errors are reported in parenthesis.* Significant at 10%.** Significant at 5%.*** Significant at 1%.

Finance costs and interest cost can approximate firm's credit level and interest rate. Table 3 shows that when Chinese RMB depreciates, the loan-related costs decrease, which is in favor of what we discussed in the conceptual model. Home currency depreciation is at the advantage of exporting firms, who are expected to enlarge export. The higher profitability in the future enables them to borrow more loan from local bank at a lower cost because of lower default risks. As a result, the interest costs are lowered. This effect pass on to the implicit trade credit interest rate, indicating that exporters are willing to lend to downstream foreign firms at a lower cost.

We also run Equation 3.2 using trade credit share to examine if firms adjust their trade credit share upon exchange rate fluctuations. Table 4 shows that firm-level trade credit share does not response to exchange rate shocks generally, aligning with the assumption that trade credit value is exogenous in the determination of exchange rate pass-through mechanism.

Table 4: Regression Results

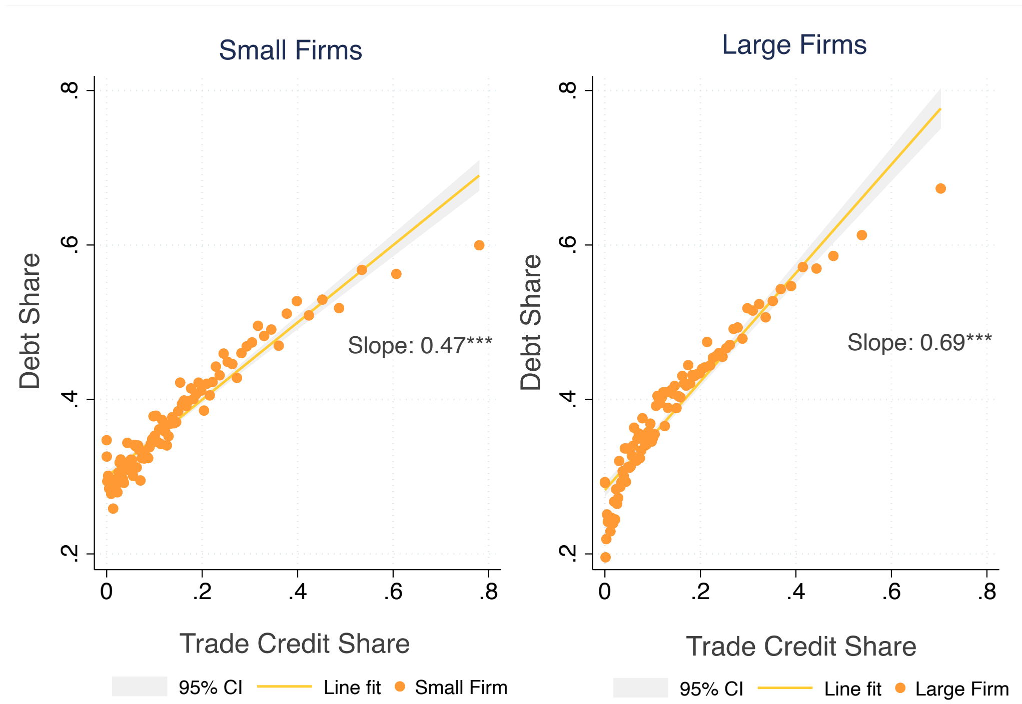
	(1)	(2)
	$rec_{i,t}$	$rec_{i,t}$
$\Delta e_{i,t}$	-0.0121	-0.00526
	(0.00636)	(0.00753)
Period	No	Yes
Firm	Yes	Yes
N	277919	277919

Notes: This table reports the results of regression results from Equation 3.2. Standard errors are reported in parenthesis.* Significant at 10%.** Significant at 5%.*** Significant at 1%.

3.2.3 Fact III: Higher trade credit is associated with higher bank loans

Not all Chinese exporters grant trade credit to their foreign buyers. One of the reasons for this is that trade credit is costly for the exporters given it poses a liquidity constraint. However, Chinese firms have access to a broad range of financial instruments that can mitigate or help cover the cost of trade credit. We explore the relationship between trade credit and bank loans for Chinese exporters [6].

Figure 4: Correlation between trade credit share and bank loans



Notes: This figure shows the relationship between trade credit and bank loans for small and big firms. In the vertical axis, the debt share corresponds to bank loans/sales and in the horizontal axis trade credit/sales.

Figure 4 illustrates the interplay between trade credit and bank loans. In both panels, the debt share is denoted as the ratio between bank loans and sales at the firm level. The trade credit share corresponds to the ratio between the trade credit and sales. The plot is a biscatter showing the relationship between these two variables for two types of firms: small firms and large firms.

The main takeaway is that the higher the trade credit granted by the exporter, the higher the debt that firm holds with the domestic banks. The intuition behind this finding is that exporters might face a financial constraint while offering trade credit and will solve it by taking loans from domestic banks.

Figure 4 also reveals the strength of the relationship between trade credit and bank loans varies with firm size. Small firms find it harder to substitute away granting trade credit with bank loans. A potential reason for this is small firms have less access to bank loans, while large firms might be automatically connected with banks willing to grant them credits. The lack of access could be translated into higher interests costs of bank loans

This fact corresponds to a key intuition for our theoretical model. It motivates the existence of

[6] Studies such as Hardy, Saffie and Simonovska (2022) analyze the relationship between these instruments but from the perspective of the firms receiving trade credit from their suppliers. In this paper, we shift the focus to the suppliers granting trade credit and how the extent of trade credit is related to their access and costs of bank loans.

a connection between domestic banks behavior with exporters' trade credit. In the Appendix, we include some more detailed statistics on the relationship between trade credit and other financial instruments.

4. Model

In this section, we formalize the idea using a theoretical model consistent with the data. The model captures a trade credit channel in exports price setting and a domestic financial market connected to this channel.

We develop a real small open economy model of monopolistic competition [7] in which exporters are located in the home country and importers correspond to foreign buyers. We introduce three key elements: trade credit, exchange rates and domestic banks.
To begin with, we allow exporters to issue trade credit. In this model, the importer pays for the product in two steps: (i) pays a portion of the price upfront (i.e., down payment), and (ii) pay the remaining portion when they receive the product (i.e., trade credit).[8]

Second, we introduce the nominal exchange rate. The exchange rate will connect prices charged by the exporters and prices received by the importers. The nominal exchange rate will be nontrivial for the choice of the equilibrium price, and will, in turn, affect how prices react to changes in the exchange rate. This will be the case even under the common assumption of constant markups and marginal cost for the exporter.

Third, we include financial markets into our model. Specifically, the importer and the exporter borrow from banks in their own countries. We assume the interest rate in the exporter's country is endogenously set by the domestic aggregate saving and borrowing levels [9], while the interest rate is exogenously set in the importer's country. This setting enables us to capture the interest rate response to exchange rate changes: when home currency depreciates, the aggregate export changes, leading to an change in the aggregate borrowing.

4.1 Model Setup

In the model, there are two countries: the exporting country and the importing country. In the exporting country j, there are N exporters indexed by $k = 1, ..., N$. Each exporter produces a unique intermediate input. In the importing country, there is a continuum of competitive firms. They import inputs from the exporters and combine the inputs to produce a final good.

There is one period in the model. In the following subsections we introduce the importer's and the exporter's problems together with details about the financial market.

[7] Our model takes as baseline standard models of monopolistic competition in trade (Krugman, 1980; Melitz, 2003)
[8] For the trade credit block, we follow Cun et al. (2022)
[9] We adopt this relationship from Tirole (2010)

4.2 Importer's Problem

In the importing country i, the representative importing firm is not endowed with any cash. Thus, to purchase inputs, she has to seek external financing. The external financing is assumed to be two-fold: on the one hand, the importer can borrow from a bank in the same country at an exogenous interest rate, r_i. The upper limit of bank loans (in importer's currency) is X_i^*. On the other hand, she can borrow trade credit from the exporter. As we discussed in the previous section, the exporter divides the full payment into a down payment and a trade credit. The down payment share is defined as $\phi(k)$ ($0 \leq \phi(k) \leq 1$), and the trade credit share in turn is defined as $1 - \phi(k)$. Since the importer has zero cash in hand, she has to borrow from the bank to fund for the down payment. We assume the down payment share $\phi(k)$ is exogenously given and is i.i.d. across exporters and importers [10]. The importer chooses quantity to import for each input, $Q_i(k)$.

The importer's maximization problem is:

$$\max_{\{Q_i(k)\}_{k\in J_i}} \left[\int_{k\in J_i} Q_i(k)^{\frac{\varepsilon-1}{\varepsilon}} dk\right]^{\frac{\varepsilon}{\varepsilon-1}} - \int_{k\in J_i} p_i^*(k) Q_i(k) dk - r_i \int_{k\in J_i} \phi(k) p_i^*(k) Q_i(k) dk \tag{4.1}$$

s.t.

$$\int_{k\in J_i} \phi(k) p_i^*(k) Q_i(k) dk \leq X_i^* \tag{4.2}$$

where J_i is the mass of inputs available to the importer in country i, $\phi(k)$ is the down payment share and r_i is the bank interest rate in the importer's country. $p_i^*(k)$ is the price of input k denominated in currency of importer's country.

Solving the problem, we obtain the equilibrium quantity

$$Q_i(k) = [1 + (r_i + \bar{\lambda})\phi(k)]^{-\varepsilon} (p_i^*(k))^{-\varepsilon} y_i \tag{4.3}$$

where $y_i \equiv \left[\int_{k\in J_i} Q_i(k)^{\frac{\varepsilon-1}{\varepsilon}} dk\right]^{\frac{\varepsilon}{\varepsilon-1}}$, $\bar{\lambda} = \lambda(P_i^*, y_i; \{\phi(k)\}_k, r, X_i)$ and $P_i^* = [\int_k p_i^*(k)^{1-\varepsilon} dk]^{\frac{1}{1-\varepsilon}}$.

4.3 Exporter's Problem

In the exporting country j, exporter k is not endowed with any cash. In order to finance labor payments, the exporter can either use the down payment provided by the importer or borrow from a bank in country j at an interest rate r_j. The interest rate is endogenously determined by the aggregate supply and demand in the financial market.

[10] This technique assumption enable us to separate shadow price from the price index in the importer problem.

A firm producing input k from country j faces the following problem:

$$\max_{p_i^*(k),b(k)} \quad p_i^*(k)eQ_i(k) - a(k)w_jQ_i(k) - fw_j - b(k)r_j \tag{4.4}$$

s.t.

$$Q_i(k) = [1 + (r + \bar{\lambda})\phi(k)]^{-\varepsilon}(p_i^*(k))^{-\varepsilon}y_i \tag{4.5}$$

$$\phi(k)p_i^*(k)eQ_i(k) + b(k) = a(k)w_jQ_i(k) + fw_j \tag{4.6}$$

where e is the exchange rate (exporter currency/ importer currency), f is the fixed costs, r_j is the bank interest rate in exporter's country and $b(k)$ is the borrowing from banks.

Solving for the problem, we have the equilibrium price in importing country's currency :

$$p_i^*(k) = e\frac{\varepsilon}{\varepsilon - 1}a(k)w_j\frac{1 + r_j}{1 + r_j\phi(k)} \tag{4.7}$$

Thus, the equilibrium price in the exporting country's currency is:

$$p_i(k) = \frac{\varepsilon}{\varepsilon - 1}a(k)w_j\frac{1 + r_j}{1 + r_j\phi(k)} \tag{4.8}$$

Note that the equilibrium price depends on different terms. First, it depends on the exporters' markup which is a function of the elasticity of demand, ε. Second, it depends on the marginal cost of production , $a(k)w_j$, corresponding to the hired labor multiplied by the wage. Third, the price depends on a novel trade credit term. This term is governed by r_j and $\phi(k)$. An increase in $\phi(k)$ (higher down payment, lower trade credit) leads to less "trade credit premium" in the price and in turn a lower product price. An increase in r_j leads to a higher product price, meaning a partial pass-through of financial cost into product price.

In the expression for the price the only term that depends on the exchange rate corresponds to the interest rate $r_j = r_j(e)$. In section 4.4 we characterize this relationship and explain the mechanism behind it.

From Equation 4.8, we compute the exchange rate pass-through:

$$\frac{\partial \log p_i(k)}{\partial \log e} = \frac{1 - \phi(k)}{(1 + r_j)(1 + r_j\phi(k))}\frac{\partial r_j}{\partial \log e} \tag{4.9}$$

From the equation above, it can be seen the exchange rate pass-through depends on the trade credit share $1 - \phi(k)$. When the trade credit share is higher, the first term $\frac{1-\phi(k)}{(1+\mu_k)(1+\mu_k\phi(k))}$ increases.

Our empirical results indicate $\frac{\partial r_j}{\partial \log e}$ is negative (i.e., the implicit interest rate decreases with the home currency depreciating). We attribute this finding to changes in the borrowing demand and this is formalized in Section 4.4. We formalize this in Proposition 1.

Proposition 1. *The pass-through of a bilateral exchange rate shock to the price decreases in the trade credit share, if* $\frac{\partial r_j}{\partial \log e} < 0$*:*

$$\frac{\partial^2 \log p_i(k)}{\partial \log e \partial \log \phi(k)} < 0$$

Proof. See Appendix for proof. □

4.4 A Model with Endogenous Interest Rate

We focus on the financial market in the exporting country j [11]. We drop the country notation in this section. Thus, the interest rate is denoted by r. Assume there is a saving function $S(r)$ which is increasing in r: higher interest rate, more savings[12].

Next, we introduce a borrowing relationship with moral hazard. There is a continuum of exporters who are risk-neutral. Each exporter owns a "machine" with different qualities: a high-quality machine provides high productivity and high net worth for the exporter. The net worth of a machine is denoted by A. A follows a continuous CDF $G(A|\theta)$ with support $[\underline{A}, \bar{A}]$ and PDF $g(A|\theta)$. θ is a parameter governing the quality distribution: an increase in θ indicates a first-order stochastic dominance shift of the distribution, leading to weakly increase in all machines' quality.

Every time an exporter wants to export to a certain import, she must initiate a project requiring a cost of I. The utility function of exporter is $U(c_0, c_1) = c_0 + c_1$. The exporters have limited liability. Thus, $c_1 \geq 0$[13].

An exporting project will succeed at the probability of p generating an income of $R > 0$. The income is verifiable to the investors. If the project fails, there is zero income. What governs the probability of success is the exporter's effort. If the exporter works, $p = p_H$; if she shirks, $p = p_L = p_H - \triangle p$ and she earns a private benefit $B > 0$. The private benefit is not verifiable to the investors and is counted into c_1: $G_\theta(A|\theta) < 0$. The timing is shown in Figure 5.

[11] We build this model based on Tirole (2010).

[12] As is shown in (Tirole, 2010), the saving function can be derived from certain investors' preferences. We abstract from that since the investors' behaviors are not our main focus.

[13] As is indicated by (Tirole, 2010), the exporter' utility is not crucial. That said, the exporter should be more patient than the investors so that the lending direction is from the investors to the exporters ($r > 0$).

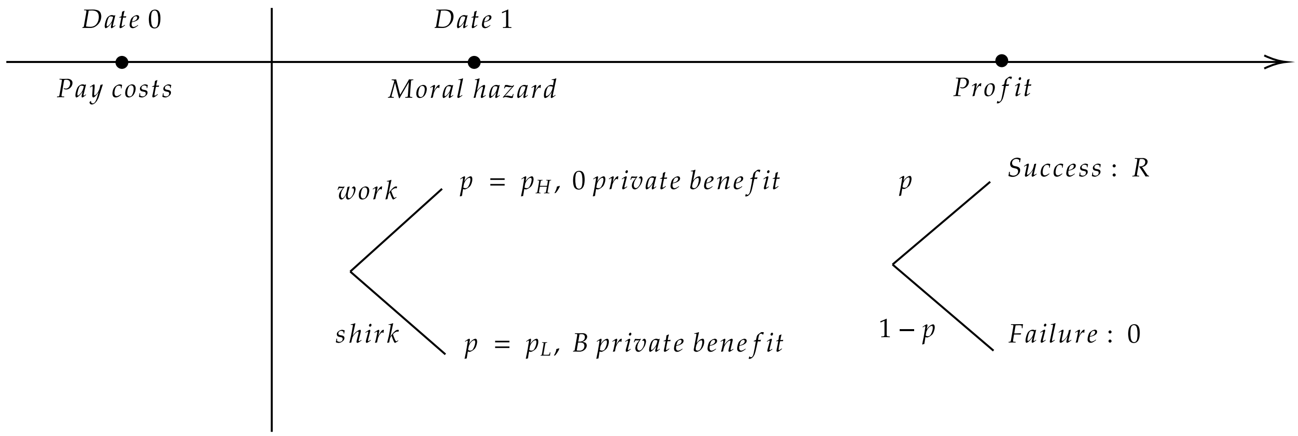


Figure 5: Model Timing

Notes: This figure provides an illustration of the model timing. In date 0, the exporter pays costs of production. In date 1, the exporter chooses between work and shirk. Working leads to a high success probability with no private benefit. Shirking leads to a low success probability with private benefit B. In the end, profit is realized with a success probability.

We assume the project's NPV is positive if and only if the exporter works:

$$p_H R > (1+r)I > p_L R + B \tag{4.10}$$

On the condition that the exporter get the fund, the optimal financial contract should be:

$$R = R_b + R_l \tag{4.11}$$

which specifies the allocation of the profit in the case of success between the exporter (R_b) and the investors (R_l). In the case of failure, both parties receive zero profit.

The incentive compatibility constraint is

$$(\triangle p)R_b \geq B. \tag{4.12}$$

The pledgeable income is

$$p_H(R - \frac{B}{\triangle p}) \tag{4.13}$$

which is the highest level of expected profit that can be pledged to the investors under the IC contriant.

If an exporter with a net worth A gets financing, the necessary and sufficient condition is

$$p_H(R - \frac{B}{\triangle p}) \geq (1+r)(I - A) \tag{4.14}$$

We define the cut-off level of net worth, $A^*(r)$:

$$p_H(R - \frac{B}{\triangle p}) = (1+r)(I - A^*(r)) \tag{4.15}$$

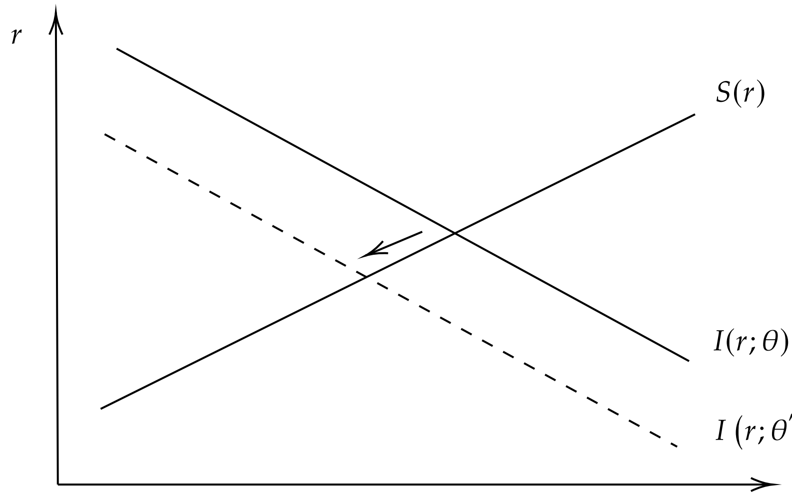


Figure 6: The Endogenous Interest Rate Change

Notes: This figure illustrates the financial market clear. Saving ($S(r)$) is upward sloping and borrowing ($I(r;\theta)$) is downward sloping. A change in θ could shift $I(r)$ inward, with equilibrium interest rate being lower.

The market clear condition in the financial market is:

$$I(r) = S(r) \tag{4.16}$$

where

$$I(r) \equiv \int_{A^*(r)}^{\bar{A}} (I - A) g(A|\theta) dA - \int_{\underline{A}}^{A^*(r)} A g(A) dA \tag{4.17}$$

$$= (1 - G(A^*(r)|\theta))I - A^e \tag{4.18}$$

where

$$A^e \equiv \int_{\underline{A}}^{\bar{A}} A g(A) dA \tag{4.19}$$

which is the average level of net worth of the exporters and also the average level of productivity of them.

Now we can discuss the comparative statics: when the home currency depreciates, how does the interest rate respond? The home currency depreciation leads to an increase in θ because it takes less costs for the exporters to produce in the foreign currency unit. It also means the exporters have higher net worth.

How does an increase in θ affect the total borrowing?

$$\frac{\partial I(A|\theta)}{\partial \theta} = -G_\theta(A^*(r))I - \frac{\partial A^e}{\partial \theta} \tag{4.20}$$

The equation suggests two effects:

First, $-G_\theta(A^*(r))I > 0$ indicates that more exporters are able to borrow. The borrowing curve shifts up. Second, $\frac{\partial A^e}{\partial \theta} > 0$ indicates the average net worth increases. The borrowing curve shifts down. The equilibrium interest rate depends on which effect dominates. When the second effect dominates, the interest rate decreases.

The intuition behind this mechanism is the following: when the home country is depreciated, firms increase their export both on the intensive and extensive margin. Given this increase in production, firms on the one hand need to pay more costs and on the other hand have more cash in hand. The cash effect dominates in this case, and firms with more cash in hand cause a decrease in the aggregate borrowing demand curve, decreasing the interest rate for bank loan. In this way, an increase in the exchange rate causes a decrease in the interest rate, that is, $\frac{\partial r_j}{\partial \log e} < 0$.

5. Conclusion

It is well-known financial factors play a key role in firms' price-setting behavior. In this paper, we explore this role in international markets. Mainly, we focus on the effect of trade credit on how export prices adjust exchange rate changes — exchange rate pass-through.

Our main finding is that financial frictions play a key role in exporting price setting. Exporters charge their foreign buyers a price that includes a trade credit premium corresponding to the trade credit they issue. Moreover, the prices of an exporter issuing a high ratio of trade credit to sales are less responsive to exchange rate shocks than the prices of an exporter with a low one. The mechanism behind this is that the implicit interest rate embedded in the exporting price endogenously responds to exchange rate changes. The higher degree of trade credit utilization the firm has, the more the exchange pass-through is affected by the implicit interest rate.

There are relevant policy implications that can be drawn from these findings. First, trade credit has a direct effect on price. That is firms, that can issue trade credit to their foreign buyers and in turn, borrow from domestic banks to sustain their liquidity and obtain some insurance against exchange rate shocks. Second, in a time of supply chain congestion, inflation, and dramatic exchange rate fluctuations, policymakers should pay attention to the financial conditions of the exporters and importers.

Given our findings some questions arise in related topics. For example, if exchange rate shocks have an effect on the interest costs domestic banks offer, do exporters' countries of destination have an effect on the financial system in a country? Another potential contribution could be to test the theory in other countries and in other time periods. Our model informs us that the interest rate could respond to the exchange rate in both directions depending on the productivity distribution of firms. It would be interesting to see the results in different economic contexts.

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6. Appendix

6.1 Solving the Importer's Problem

Now we can write the importer's maximization problem as:

$$\max_{\{Q_i(k)\}_{k\in J_i}} \left[\int_{k\in J_i} Q_i(k)^{\frac{\varepsilon-1}{\varepsilon}} dk\right]^{\frac{\varepsilon}{\varepsilon-1}} - \int_{k\in J_i} p_i^*(k)Q_i(k)dk - r_i \int_{k\in J_i} \phi(k)p_i^*(k)Q_i(k)dk \tag{6.1}$$

s.t.

$$\int_{k\in J_i} \phi(k)p_i^*(k)Q_i(k)dk \le X_i^* \tag{6.2}$$

where J_i is the mass of inputs available to the importer in country i. $\phi(k)$ is the down payment share and r_i is the bank interest rate in the importer's country. $p_i^*(k)$ is the price of input k denominated in currency of importer's country faced by importer i.

The Lagrangian:

$$L = \left[\int_{k\in J_i} Q_i(k)^{\frac{\varepsilon-1}{\varepsilon}} dk\right]^{\frac{\varepsilon}{\varepsilon-1}} - \int_{k\in J_i} p_i^*(k)Q_i(k)dk - r_i \int_{k\in J_i} \phi(k)p_i^*(k)Q_i(k)dk + \lambda[X_i - \int_{k\in J_i} \phi(k)p_i^*(k)Q_i(k)dk] \tag{6.3}$$

F.O.C. w.r.t. $Q_i(k)$:

$$\frac{\varepsilon}{\varepsilon-1}\left[\int_{k\in J_i} Q_i(k)^{\frac{\varepsilon-1}{\varepsilon}} dk\right]^{\frac{1}{\varepsilon-1}} \frac{\varepsilon-1}{\varepsilon} Q_i(k)^{\frac{-1}{\varepsilon}} - p_i^*(k) - r\phi(k)p_i^*(k) - \lambda\phi(k)p_i^*(k) = 0 \tag{6.4}$$

$$\left[\int_{k\in J_i} Q_i(k)^{\frac{\varepsilon-1}{\varepsilon}} dk\right]^{\frac{1}{\varepsilon-1}} Q_i(k)^{\frac{-1}{\varepsilon}} - (1 + (r+\lambda)\phi(k))p_i^*(k) = 0 \tag{6.5}$$

$$\left[\int_{k\in J_i} Q_i(k)^{\frac{\varepsilon-1}{\varepsilon}} dk\right]^{\frac{-\varepsilon}{\varepsilon-1}\times(\frac{-1}{\varepsilon})} Q_i(k)^{\frac{-1}{\varepsilon}} - (1 + (r+\lambda)\phi(k))p_i^*(k) = 0 \tag{6.6}$$

$$\left(\frac{Q_i(k)}{\left[\int_{k\in J_i} Q_i(k)^{\frac{\varepsilon-1}{\varepsilon}} dk\right]^{\frac{\varepsilon}{\varepsilon-1}}}\right)^{\frac{-1}{\varepsilon}} = (1 + (r+\lambda)\phi(k))p_i^*(k) \tag{6.7}$$

$$\left(\frac{Q_i(k)}{\left[\int_{k\in J_i} Q_i(k)^{\frac{\varepsilon-1}{\varepsilon}} dk\right]^{\frac{\varepsilon}{\varepsilon-1}}}\right) = (1+(r+\lambda)\phi(k))^{-\varepsilon}(p_i^*(k))^{-\varepsilon} \tag{6.8}$$

$$Q_i(k) = (1+(r+\lambda)\phi(k))^{-\varepsilon}(p_i^*(k))^{-\varepsilon} \times \left[\int_{k\in J_i} Q_i(k)^{\frac{\varepsilon-1}{\varepsilon}} dk\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{6.9}$$

Define

$$\tilde{\lambda}_k \equiv 1+(r+\lambda)\phi(k) \tag{6.10}$$

$$y_i \equiv \left[\int_{k\in J_i} Q_i(k)^{\frac{\varepsilon-1}{\varepsilon}} dk\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{6.11}$$

Then

$$Q_i(k) = \tilde{\lambda}_k^{-\varepsilon}(p_i^*(k))^{-\varepsilon} y_i \tag{6.12}$$

Put Equation 6.12 it into Equation 6.2, we have

$$\int_k \phi(k)p_i^*(k)[\tilde{\lambda}_k^{-\varepsilon}(p_i^*(k))^{-\varepsilon} y_i]dk = X_i \tag{6.13}$$

$$\int_k p_i^*(k)^{1-\varepsilon}\phi(k)\tilde{\lambda}_k^{-\varepsilon} y_i dk = X_i \tag{6.14}$$

Assume $\phi(k)$ is i.i.d. across exporters, then we have

$$(\int_k \phi(k)\tilde{\lambda}_k^{-\varepsilon} dk)(\int_k p_i^*(k)^{1-\varepsilon} y_i dk) = X_i \tag{6.15}$$

Define the price index

$$P_i^* = [\int_k p_i^*(k)^{1-\varepsilon} dk]^{\frac{1}{1-\varepsilon}} \tag{6.16}$$

Put Equation 6.16 into Equation 6.15, we have

$$(\int_k \phi(k)\tilde{\lambda}_k^{-\varepsilon} dk)(P_i^{*1-\varepsilon}) = X_i/y_i \tag{6.17}$$

which is

$$(\int_k \phi(k)[1+(r_i+\lambda)\phi(k)]^{-\varepsilon}dk)(P_i^{*1-\varepsilon}) = X_i/y_i \tag{6.18}$$

From Equation 6.18, we can implicitly solve for $\bar{\lambda} = \lambda(P_i^*, y_i; \{\phi(k)\}_k, r, X_i)$.

Assume there are a large number of exporters. Then $P_i^* = [\int_k p_i^*(k)^{1-\varepsilon}dk]^{\frac{1}{1-\varepsilon}}$ and $y_i \equiv \left[\int_{k\in J_i} Q_i(k)^{\frac{\varepsilon-1}{\varepsilon}}dk\right]^{\frac{\varepsilon}{\varepsilon-1}}$ are taken as given by the exporters when they choose prices. Thus, $\bar{\lambda} = \lambda(P_i^*, y_i; \{\phi(k)\}_k, r, X_i)$ is also taken as given.

Knowing that

$$Q_i(k) = \tilde{\lambda}_k^{-\varepsilon}(p_i^*(k))^{-\varepsilon}y_i \tag{6.19}$$

$$= [1+(r_i+\lambda)\phi(k)]^{-\varepsilon}(p_i^*(k))^{-\varepsilon}y_i \tag{6.20}$$

we have the equilibrium quantity

$$Q_i(k) = [1+(r_i+\bar{\lambda})\phi(k)]^{-\varepsilon}(p_i^*(k))^{-\varepsilon}y_i \tag{6.21}$$

6.2 Solving the Exporter's Problem

A firm producing product k from country j faces the following problem:

$$\max_{p_i^*(k),b(k)} \quad p_i^*(k)eQ_i(k) - a(k)w_jQ_i(k) - fw_j - b(k)r_j \tag{6.22}$$

s.t.

$$Q_i(k) = [1+(r+\bar{\lambda})\phi(k)]^{-\varepsilon}(p_i^*(k))^{-\varepsilon}y_i \tag{6.23}$$

$$\phi(k)p_i^*(k)eQ_i(k) + b(k) = a(k)w_jQ_i(k) + fw_j \tag{6.24}$$

where e is the exchange rate (exporter currency/ importer currency), f is the fixed costs, r_j is the bank interest rate in exporter's country and $b(k)$ is the borrowing from banks.

$$L = p_i^*(k)eQ_i(k) - a(k)w_jQ_i(k) - fw_i - b(k)r_j \tag{6.25}$$

$$+ \mu_k[\phi p_i^*(k)eQ_i(k) + b(k) - a(k)w_jQ_i(k) - fw_j] \tag{6.26}$$

$$= (1+\mu_k\phi(k))p_i^*(k)eQ_i(k) - (1+\mu_k)a(k)w_jQ_j(k) \tag{6.27}$$

$$- (1+\mu_k)fw_j - (r_j-\mu_k)b(k) - \mu_k fw_j \tag{6.28}$$

F.O.C.

$$\frac{\partial L}{\partial p_i^*(k)} = (1+\mu_k\phi(k))[eQ_i(k) + ep_i^*(k)\frac{\partial Q_i(k)}{\partial p_i^*(k)}] - (1+\mu_k)a(k)w_j\frac{\partial Q_i(k)}{\partial p_i^*(k)} = 0 \tag{6.29}$$

$$\frac{\partial L}{\partial b(k)} = \mu_k - r_j = 0 \tag{6.30}$$

Given $Q_i(k) = [1+(r+\bar{\lambda})\phi(k)]^{-\varepsilon}(p_i^*(k))^{-\varepsilon}y_i$ and $\frac{\partial Q_i(k)}{\partial p_i^*(k)} = -\varepsilon\frac{Q_i(k)}{p_i^*(k)}$

$$e(1+\mu_k\phi(k))[Q_i(k) + p_i^*(k)(-\varepsilon\frac{Q_i(k)}{p_i^*(k)})] - (1+\mu_k)a(k)w_j(-\varepsilon\frac{Q_i(k)}{p_i^*(k)}) = 0 \tag{6.31}$$

$$e(1+\mu_k\phi(k))(1-\varepsilon)Q_i(k) - (1+\mu_k)a(k)w_j(-\varepsilon\frac{Q_i(k)}{p_i^*(k)}) = 0 \tag{6.32}$$

$$e(1+\mu_k\phi(k))(1-\varepsilon) = (1+\mu_k)a(k)w_j(-\varepsilon\frac{1}{p_i^*(k)}) \tag{6.33}$$

$$p_i^*(k) = e^{-1}\frac{1+\mu_k}{1+\mu_k\phi(k)}a(k)w_j\frac{\varepsilon}{\varepsilon-1} \tag{6.34}$$

The other first order condition (Equation 6.30) shows that the shadow price equals to the market interest rate:

$$\mu_k = r_j \tag{6.35}$$

The equilibrium price is:

$$p_i^*(k) = e^{-1}\frac{1+r_j}{1+r_j\phi(k)}a(k)w_j\frac{\varepsilon}{\varepsilon-1} \tag{6.36}$$

Since $p_i = p_i^* \times e$, we have

$$p_i(k) = \frac{1+r_j}{1+r_j\phi(k)}a(k)w_j\frac{\varepsilon}{\varepsilon-1} \tag{6.37}$$

$$\tag{6.38}$$

$$\log p_i(k) = \log\left(1+r_j\right) - \log\left(1+r_j\phi(k)\right) + \log[a(k)w_j\frac{\varepsilon}{\varepsilon-1}] \tag{6.39}$$

$$\tag{6.40}$$

$$\frac{\partial \log p_i(k)}{\partial \log e} = \frac{1}{1+r_j}\frac{\partial r_j}{\partial \log e} - \frac{\phi(k)}{1+r_j\phi(k)}\frac{\partial r_j}{\partial \log e} \tag{6.41}$$

$$= (\frac{1}{1+r_j} - \frac{\phi(k)}{1+r_j\phi(k)})\frac{\partial r_j}{\partial log e} \tag{6.42}$$

$$= \frac{1-\phi(k)}{(1+r_j)(1+r_j\phi(k))}\frac{\partial r_j}{\partial \log e} \tag{6.43}$$