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What Does Financial Crisis Tell Us About Exporter Behavior and Credit Reallocation?*

Yang Jiao Yi Wen

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Abstract

Using Japanese firm data covering the Japanese financial crisis in the early 1990s, we find that exporters' domestic sales declined more significantly than their foreign sales, which in turn declined more significantly than non-exporters' sales. This stylized fact provides a new litmus test for different theories proposed in the literature to explain the "great trade collapse" associated with the recent global financial crisis. In this paper we embed the Melitz's (2003) model into a tractable DSGE framework with incomplete financial markets and endogenous credit allocation to explain both the Japanese data and the "great trade collapse." The model highlights the role of credit reallocation between non-exporters and exporters as the main mechanism in explaining exporters' behaviors and trade collapse following a financial crisis.

Keywords: Credit Crunch, Credit Reallocation, Exporter Behavior, Financial Crisis, Heterogeneous Firms, Trade Collapse.

JEL codes: E22, E32, E44, F00, F10, F11, F41.

*This is a substantially revised version of an earlier working paper titled "Capital, Finance, and Trade Collapse," Jiao and Wen (2012). The views expressed here are only those of the individual authors and do not necessarily reflect the official positions of the Federal Reserve Bank of St. Louis, the Federal Reserve System, or the Board of Governors. Part of the work was done when Yang Jiao was a Ph.D. student at Columbia University and Postdoctoral Fellow at Dartmouth College. Yang Jiao, Fudan University. Yi Wen, Federal Reserve Bank of St. Louis. The usual disclaimer applies.

1 Introduction

It is now well known that one of the most striking aspects of the recent 2008 global financial crisis is the subsequent collapse in world trade, especially among developed countries with deeper financial markets. This decline in trade is so severe that it defies explanations based on standard trade models and is later referred to as the "great trade collapse" puzzle by the existing literature.[1] Figure 1 shows that the average cross-country decline in total trade volume (exports and imports, respectively) between 2008 and 2009 is 17% for the G7 countries (right panel), nearly 4 times larger than the average decline in these countries' gross domestic product (GDP, left panel).

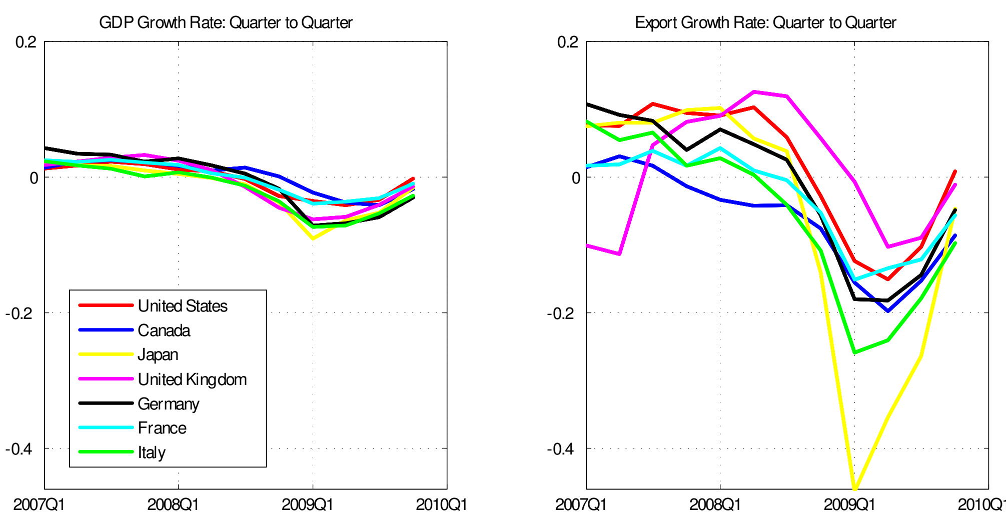

Figure 1: Declines in GDP and Export in the Global Financial Crises for G7 Countries

However, a severe trade collapse during a financial crisis is not a new phenomenon. Many countries that had financial crises also experienced a sharp contraction in trade volume relative to output. To quote Amiti and Weinstein (2011, p.1), "[A] striking feature of many financial crises is the collapse of exports relative to output."

[1]Ronci (2004) documents that in many countries that had financial crisis, trade volume contracted far more sharply and significantly than GDP. Also, using a measure of an international-trade wedge, Levchenko, Lewis, and Tesar (2010) show that the overall trade wedge during the recent financial crisis reached -40%, whereas the mean value of the wedge was only -1.6% in the Great Moderation period since 1983. They thus conclude that the recent trade collapse does represent a puzzle from the perspective of standard neoclassical business cycle models.

Why did trade volume decrease fare more severely than aggregate output during a financial crisis? Several strands of literature have been developed to explain the links between financial conditions and international trade.

First, such links have been studied empirically by many people. For example, Chor and Manova (2011) show that credit conditions have an important effect on trade. Their empirical findings based on monthly U.S. imports data suggest that countries experiencing higher interbank rates—and thus worse credit market conditions—tend to export less to the U.S. during the peak of the crisis. Amiti and Weinstein (2011) use a unique dataset, covering the Japanese financial crisis in the early 1990s, to demonstrate that the health of banks that provide external finance has a much larger effect on exports than on domestic sales. Raddatz (2008) shows there is greater comovement among sectors that have stronger trade-credit links. Iacovone and Zavacka (2009) demonstrate that in countries experiencing banking crises, exports fell systematically more in financially dependent industries. Using four different measures of credit constraints and a large dataset of Chinese firms, Egger and Kesina (2010) find a significant impact of firms' financial constraints on both the extensive margin and the intensive margin of firms' export activities; they estimate the impact of a one-standard-deviation increase in financial constraints on the extensive margin is at least half as strong as the same decrease in firms' productivity. Similarly, Minetti and Zhu (2011) also find a strong impact of credit rationing on both the extensive margin and the intensive margin of trade. They estimate that credit-rationed firms are 39% less likely to export and that credit rationing reduces firms' foreign sales by 38%.[2]

Second, theoretical models have been proposed to explain the great trade collapse. This segment of the literature believes that it is the weakening of aggregate demand (either foreign demand or domestic demand) during a financial crisis, or a sharp decline in total factor productivity (TFP) during the crisis, rather than the financial conditions per se, that caused the trade collapse. Hence, the theoretical literature mainly relies on non-financial shocks to explain the significantly larger decline in trade volume than GDP after 2008. For example, Alessandria, Kaboski, and Midrigan (2010) argue that aggregate productivity shocks can explain the great trade collapse when dynamic inventory adjustment is taken into account. Eaton et al. (2011) argue that demand shocks are the main driving force behind the trade collapse, while other shocks, such as current account shocks and trade friction shocks, have played only an insignificant role. Chen (2011) examines intermediate-goods trade under

[2]See Chen, Contessi, and Nicola (2012) for a survey on the recent literature on the relationship between international trade and access to finance.

demand shocks and show that demand shocks can generate large responses in trade volume. Bems, Johnson, and Yi (2010) argue that vertical linkages amplify demand disturbances on trade volume in an input-output framework—their verbal defense for the importance of demand shocks in the great trade collapse is that financial intermediation is severely affected during the crisis, reducing the economy's efficiency in transforming inputs into outputs and leading to reductions in overall productivity and demand; but the mechanism is not modeled in their work.

These important works have no doubt contributed to our understanding of the links between the business cycle and international trade, as well as the plausible causes of the great trade collapse. But a deeper theoretical question regarding the role of non-financial shocks is why aggregate demand (or aggregate TFP) changed simultaneously in different countries during the recent global financial crisis. What was coordinating these country-specific demand (supply) shocks? Another challenge to non-financial shock theories is explaining why this recent recession is more severe than the other recessions in the Great Moderation period—and particularly why the recent collapse in trade volume is far larger than that in GDP compared with historical recessions.[3]

To address these questions and to bring these two literatures together, we need a dynamic trade model that takes financial intermediation seriously. As Bems, Johnson, and Yi (2010, p.32) amply put: "[A] clearly preferred framework would be one that...digs deeper into the sources of shocks that drive the joint behavior of demand, output and trade," and "an even deeper methodology is one that marries a financial sector, as well as trade structure...to the framework."[4]

To answer this challenge put fourth by Bems, Johnson, and Yi (2010), this paper makes two contributions. First, we empirically document a new stylized fact that calls for a deeper understanding on the joint behavior of demand, output, and trade and their relationship with credit and financial intermediation. More specifically, we focus on the Japanese financial

[3] It seems that changes in aggregate demand and productivity in 2009 are the endogenous outcome of the 2008 financial crisis rather than the exogenous root cause of the crisis. In particular, why would a *domestic* TFP shock or demand shock trigger a disproportionately larger decline in total exports than GDP, given that exports demand is dictated by foreign countries' economic conditions? In other words, even if financial crises are contagious, it would be questionable to rely solely on non-financial shocks to explain the great trade collapse because changes in aggregate productivity and demand during the crisis period are endogenous—they are themselves the consequences of the financial crisis, not the root cause of the crisis.

[4] In particular, why would a domestic financial crisis trigger a disproportionately larger decline in total exports than GDP, given that exports demand is originated from other countries? Even if financial crises are contagious, it would be difficult to rely solely on non-financial shocks (such as aggregate productivity or aggregate demand shocks) to explain the great trade collapse because changes in aggregate productivity and demand during the crisis period are endogenous—they are themselves the consequences of the financial crisis, not the root of the crisis.

crisis in the early 1990s and its subsequent trade collapse—looking at the Japanese episode provides a clear advantage: Unlike the recent global recession, the Japanese trade collapse was not accompanied by external demand shocks to the Japanese economy. Using Japanese firm-level data covering the Japanese financial crisis period in the early 1990s, we find that the Japanese recession and trade collapse during the Japanese financial crisis are characterized by the following pattern of firm sales: Exporting firms' domestic sales declined more significantly than their foreign sales, which in turn declined more significantly than non-exporters' sales. This stylized fact is intriguing because it suggests that the Japanese trade collapse in the early 90s cannot be attributed to foreign demand shocks, which would imply a sharper drop in exporters' foreign sales than their domestic sales, nor solely to domestic demand shocks, which would result in a sharper drop in non-exporters' sales than exporters' foreign sales. Also, it cannot be explained by a negative shock to Japan's aggregate TFP because (similar to an aggregate domestic demand shock) such a shock would result in a sharper decline in non-exporters' sales than in exporters' foreign sales.[5] In addition, these stylized facts cast doubts on the conventional wisdom that firms' export activities are more financially dependent than selling at home—which would lead to a sharper drop in exporters' foreign sales than their domestic sales during a financial crisis, thus contradicting the stylized facts based on Japanese firm-level data.

Our second contribution is to build a tractable DSGE model of international trade with financial intermediation and credit-based trade structure to explain the Japanese firm-level experience in the early 1990s, while the model's predictions are also consistent with the great trade collapse after the 2008 global financial crisis. In our model, firms can choose to sell locally in domestic markets or abroad in foreign markets; however, endogenous credit arrangements among heterogeneous firms exist so that financial assets can be traded among firms, and firms must use capital as collateral to engage in borrowing under limited contract enforceability. Because of the additional operational costs involved in exports (a la Melitz, 2003), only high-productivity firms opt to export, and such firms will have a higher demand for working capital and outside credit to finance their activities than non-exporters. In addition, exporters also find it profitable to sell domestically due to the Melitz-type monopolistic competition structure and the lower market-participation costs at home. Since financial markets facilitate the flow of capital to where it is needed, the asymmetry in credit demand between exporters and non-exporters implies that financial shocks impeding the flow

[5]Xu (2018) uses data from the historical bank run in London around 1866 to show that bank failures lead to a substantial and persistent decline of exports in the region they serve. Her finding provides another piece of evidence that financial shocks significantly affect exports.

of credit have a greater impact on exporters than on non-exporters. Given that a domestic financial crisis endogenously affects domestic aggregate demand more significantly than foreign demand, exporters' domestic sales are expected to decline more sharply than their foreign sales. In the meantime, TFP declines endogenously and trade volume drops more significantly than GDP during the financial crisis.[6]

We also show that non-financial shocks, such as aggregate TFP shocks and aggregate demand shocks, cannot provide a fully satisfactory explanation for the stylized facts. For example, under a domestic TFP shock or a domestic demand shock, domestic firms' total sales would drop more than exporters' foreign sales.[7] On the other hand, under a foreign demand shock, exporters' foreign sales would drop more than their domestic sales. Neither implication is consistent with the Japanese firm-level data. Hence, our theoretical analysis suggests that the sharp decline in TFP or aggregate demand observed during a financial crisis is the endogenous outcome of the financial crisis, rather than the direct driving force of the trade collapse during the crisis.

Another immediate implication of our model is that deeper financial markets enhance aggregate productivity and international trade in the long run. Consequently, both GDP level and the trade volume-to-GDP ratio rise with financial development in our model. This explains why during the recent global financial crisis trade volume declined more for advanced countries than less developed countries—because advanced countries have deeper financial markets. This long-run relationship is also consistent with the empirical facts documented by the existing literature (e.g., see Manova, 2011).[8]

The rest of the paper is organized as follows. Section 2 documents the new stylized fact using firm-level data covering the Japanese financial crisis in the early 90s. Section 3

[6]In other words, since exporters are more productive than non-exporters, in normal times when the financial market is functioning properly, capital (or credit) will be channeled from low-productivity firms (in the domestic-goods sector) to high-productivity firms (in the export sector). This upward capital flow improves the efficiency of resource allocation and raises the level of aggregate productivity and output. However, the heavy reliance on external finance also makes exporters more vulnerable to financial shocks. Thus, during a financial crisis (say, due to the tightening of the borrowing limit), the upward flow of financial capital is hindered. Consequently, capital withdraws from the export sector and retreats to the domestic sector, causing a disproportionately larger drop in trade volume (e.g., exports) relative to aggregate income. In addition, since a domestic financial shock adversely affects domestic aggregate demand more than foreign aggregate demand, exporters' domestic sales decline more sharply than their foreign sales.

[7]As Almunia, Antras, Lopez-Rodriguez and Morales (2018) have argued, in the face of a domestic demand slump, exporters shift their sales from domestic markets to foreign markets. In our model, this is also the case in the sense that a negative aggregate demand shock induces exporters to shift their sales from domestic markets to foreign markets, resulting in a sharper decline in domestic sales than foreign sales. Nonetheless, non-exporters' sales would drop more than exporters' foreign sales because a domestic financial crisis has little impact on foreign countries' domestic demand.

[8]Leibovici (2018) builds a quantitative multi-industry model to study the cross-sector reallocation of trade shares under financial development. Our focus is within industry capital allocation between exporters and non-exporters. Moreover, our primary motivation is to explain the short-run fluctuations due to financial shocks rather than long-run equilibrium.

describes the set up of our theoretical model and solves firms' decision rules in closed form. Section 4 studies the aggregate implications of the model under financial and non-financial shocks, as well as long-run implications of financial development on international trade. Section 5 concludes the paper with remarks for future studies.

2 Japan's Financial Crisis

There are several reasons we focus on the Japanese financial crisis in the early 90s. First, Japan is a major exporter in the world, which has global implications, and its firms are well known to be bank-dependent. During that time, Japan's banking sector experienced significant contractions, which generated a credit crunch on firms. Second, this domestic credit supply shock is not accompanied by a global financial crisis, thus ruling out the possibility that a weak external demand played an important role in driving down Japan's export slump. Finally, the firm-level data enable us to separate Japanese firms' foreign sales from their domestic sales since most exporters also sell domestically.

After a long period of an asset bubble, Japanese asset prices peaked around 1989-1990 and started to fall afterward. Japanese banks' stock prices fell sharply in late 1991 and early 1992. Subsequently, Japanese exports collapsed in 1993 (see the left panel of Figure 2). During the trade collapse, Japan's total exports-to-GDP ratio dropped (blue line in the middle panel of Figure 2), as compared with the exports-to-GDP ratio in other G7 countries (green line in the same panel). Also, Japan's exports dropped more significantly than total domestic sales (right panel of Figure 2). These experiences are similar to what happened during the great trade collapse.

Japanese firm-level data reveal the same picture. We use data from the DBJ (Development Bank of Japan) database of unconsolidated corporate reports, which include Japan's listed firms' balance sheet information. Figure 3 (dashed green line) shows the growth rate of Japan's listed firms' total exports during the crisis period based on aggregated DBJ firm-level data (dashed green line). The exports growth of all firms is also plotted in Figure 3 (red solid line) to ensure that the information based on listed firms is representative.

Figure 4 shows the behavior of total sales of Japanese firms around the financial crisis, where the black line represents non-exporters' sales, the red line represents the exporters' foreign sales, and the green line represents the exporters' domestic sales. Clearly, the three time series behaved similarly before the crisis, with a similar growth rate; however, they suffered differently in terms of magnitude after the 1990 crisis (note: 1990 values are normalized

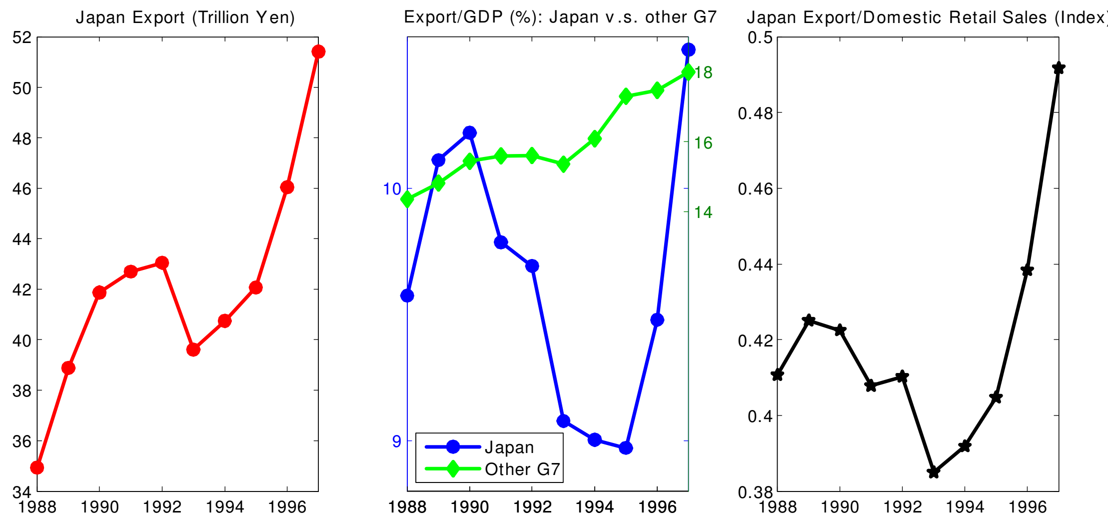

Figure 2: Japanese Export Collapse in 1993

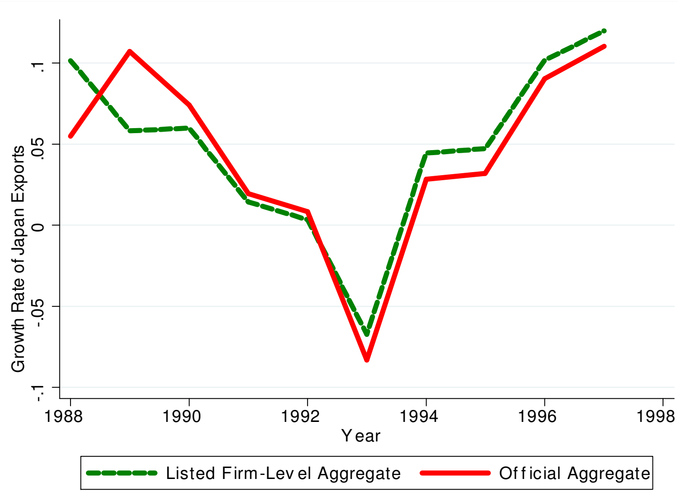

Figure 3: Export growth of listed firms (dashed line) and all firms (red line)

to 100). Specifically, the exporters' domestic sales dropped most significantly compared with their foreign sales, whereas the non-exporters' sales dropped the least significantly compared with the exporting firms' foreign and domestic sales in the middle of the financial crisis around 1993.

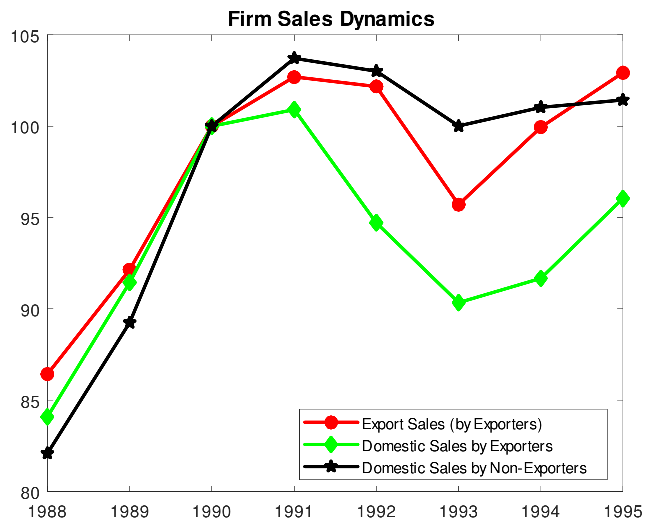

Figure 4: Exporters' foreign sales (red), exporters' domestic sales (green), and non-exporters' total sales (black)

If the aggregate export decline is mainly driven by the argument that exporting is more finance dependent than selling at home is, we should have observed the opposite. While we by no means argue that exporting is the same as selling at home in terms of financial dependence, the evidence shows that the importance of that argument in explaining aggregate dynamics might be limited.

To reveal that such heterogeneous behaviors between exporters and non-exporters have to do with firms' debt-credit positions, Figure 5 shows the debt level of the exporters and non-exporters (with 1990 normalized to 100). Clearly, the exporters' debt position experienced a dramatic decline after the crisis, as compared to non-exporters' debt position.[9]

To summarize, the Japanese financial crisis in 1990 triggered the same type of trade collapse as observed around the 2008 global financial crisis. However, the Japanese firm-level data also revealed that (i) not only did the exporters suffer more significantly than the non-exporters in terms of sales, but (ii) the exporters' domestic sales declined more than their foreign sales, and (iii) exporters' debt positions also deteriorated more significantly

[9] In the figure, debt position is computed as total liability minus (cash + deposit) minus loans receivables from their balance sheets.

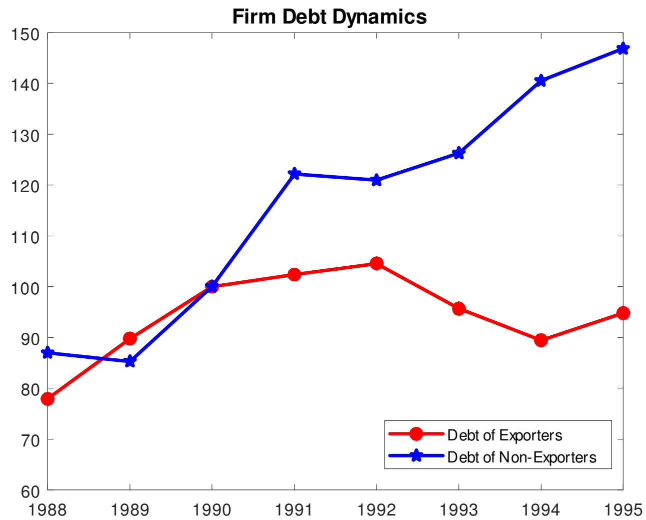

Figure 5: Japanese Firms' Debt-Credit Position

than non-exporters.

In what follows, we construct a small-open economy DSGE model of credit allocation (across exporting and non-exporting firms) to explain these stylized facts. We show that the excessive sensitivity of exporters to credit conditions holds the key for the great trade collapse after the 2008 financial crisis and the Japanese stylized fact—during booms, credit tends to flow from the non-exporting sector to the exporting sector; but such a healthy credit flow is severely interrupted and reversed during a recession caused by a financial crisis.

3 The Model

3.1 General Environment

The model consists of a home country and the rest of the world (ROW). In the home country there is a representative final-goods producer, a continuum of intermediate-goods producers, and a representative household.

The representative final-goods producer uses intermediate goods to produce the final output. The production technology is given by

$$Y_t = [\varphi(M_{ht})^{\frac{\mu-1}{\mu}} + (1-\varphi)(M_{ft})^{\frac{\mu-1}{\mu}}]^{\frac{\mu}{\mu-1}}, \tag{1}$$

where M_{ft} denotes a homogeneous imported foreign good and M_{ht} denotes an aggregation of domestically produced intermediate goods. The elasticity of substitution between the two types of goods is given by $\mu \geq 0$. The parameter φ captures the home bias in the final goods production.

There is a continuum of monopolistic intermediate-goods producing firms in the home country, each supplying a differentiated variety $i \in [0, 1]$. These products are aggregated according to the technology:

$$M_{ht} = \left[\int_0^1 [y_{it}^d]^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where y_{it}^d is the quantity of firm i's domestic supply and $\sigma > 1$ is the elasticity of substitution between these varieties. The price index of M_{ht} is given by

$$P_{ht} = \left[\int_0^1 [p_{it}^d]^{1-\sigma} \right]^{\frac{1}{1-\sigma}}. \tag{3}$$

The demand function for an individual firm i's good is

$$y_{it}^d = M_{ht} \left[\frac{p_{it}^d}{P_{ht}} \right]^{-\sigma}. \tag{4}$$

The demand function for a foreign intermediate good is

$$y_{it}^* = E_t^* (p_{it}^*)^{-\sigma}, \tag{5}$$

where E_t^* is the foreign aggregate demand taken as exogenously given by the home country.

Intermediate-goods firms produce output y_{it} by combining capital and labor according to the Cobb-Douglas production function,

$$y_{it} = (A_t z_{it} k_{it})^{\alpha} l_{it}^{1-\alpha}, \tag{6}$$

where A_t denotes aggregate productivity shock at home, which is common for all intermediate-goods firms; and z_{it} denotes a firm-specific productivity shock, which is assumed to be i.i.d across firms and time with the distribution $\Phi(z) = \Pr[z_i \leq z]$. Intermediate-goods firms can choose to sell their output either in the domestic market, abroad, or both. To export, a firm must pay a fixed cost f_e in terms of labor (as in Melitz, 2003; and Ghironi and Melitz, 2005).[10]

[10] We do not consider firm entry in this paper. Note that when we document the larger drop in total export sales compared with total domestic sales from Japan in a banking crisis, we indeed employ a balanced sample.

Heterogeneous productivity shocks imply that there exist aggregate efficiency gains by reallocating capital across firms. We assume there exists a domestic financial market through which firms can engage in risk-sharing via borrowing and lending capital across firms. The financial market can improve aggregate productive efficiency by allowing high-productivity firms to borrow and low-productivity firms to lend in a bond market.

The same logic applies to international trade with additional operational costs involved in exports. For example, a firm with high productivity may opt to issue debt and enter the foreign market by paying the fixed export costs, while a firm with low productivity may opt to sell locally and hold other firms' debt as an insurance device in the anticipation that future productivity may be high. However, because of limited contract enforcement, firms are borrowing constrained by their net worth. The details of the financial market structure is provided in Section 3.4.

3.2 Household's Problem

A representative household in the home country has a fixed endowment of time. The household chooses consumption C_t, hours worked H_t, and equity holdings for each firm i's share q_{it} ($i \in [0,1]$) to maximize lifetime utility,

$$\max_{\{C_t,H_t,q_{it}\}} \sum_{t=0}^{\infty} \beta^t \left[\zeta_t \log\left(C_t - \chi\frac{H_t^{1+\gamma}}{1+\gamma}\right)\right] \tag{7}$$

subject to the budget constraint,

$$P_t C_t + \int q_{it+1}(v_{it} - d_{it})di = W_t H_t + \int q_{it} v_{it} di, \tag{8}$$

where P_t is the final goods's price, W_t is the wage rate, d_{it} is the dividend payment from firm i, and v_{it} is firm i's value before dividends. ζ_t is a preference shock to capture exogenous changes in aggregate demand with a steady state value of 1.

Denoting Λ_t as the Lagrangian multiplier of the household budget constraint, the first-order conditions for $\{C_t, H_t, q_{it+1}\}$ are given, respectively, by

$$P_t \Lambda_t = \frac{\zeta_t}{C_t - \chi\frac{H_t^{1+\gamma}}{1+\gamma}} \tag{9}$$

$$\frac{W_t}{P_t} = \chi H_t^{\gamma} \tag{10}$$

$$v_{it} = d_{it} + \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t} v_{it+1}. \tag{11}$$

The last equation implies that firm i's value is given by the present value of future dividends:

$$v_{it} = E_t \sum_{s=0}^{\infty} \beta^s \frac{\Lambda_{t+s}}{\Lambda_t} d_{i,t+s}. \tag{12}$$

3.3 final-goods Firm's Problem

Denote the price of foreign-produced intermediate goods sold in the home country by P_f, which is taken as given by the home country. The objective function of the representative final-goods firm is to solve

$$\max_{M_{ht}, M_{ft}} \left(P_t Y_t - P_{ht} M_{ht} - P_f M_{ft}\right) \tag{13}$$

subject to equation (1). The demand functions for intermediate inputs are given by

$$\frac{Y_t}{M_{ht}} = \left(\frac{P_{ht}}{P_t} \frac{1}{\varphi}\right)^{\mu} \tag{14}$$

$$\frac{Y_t}{M_{ft}} = \left(\frac{P_f}{P_t} \frac{1}{1-\varphi}\right)^{\mu}. \tag{15}$$

The production function is constant return to scale, so the profit of the final-goods firm is zero,

$$P_t Y_t = P_{ht} M_{ht} + P_f M_{ft}. \tag{16}$$

3.4 Financial Market and Intermediate-goods Firm's Decision Rules

There is a bond market where intermediate-goods firms can engage in lending and borrowing capital by trading bonds. In a sense, the bond market serves as a competitive rental market for installed capital.[11] A firm can borrow the amount b_t in the bond market to augment its current capital stock at the beginning of period t, and pay back the loan at the end of period t with gross interest rate $1+r_t$. At the end of each period t, after paying dividends to households and debt to the lenders, a firm's net worth (net savings) in terms of final goodss is denoted by s_t, which can be used to finance the next-period's capital stock,

$$k_{t+1} = s_t + b_{t+1}, \tag{17}$$

[11] Our approach to financial intermediation and credit arrangement is related to the work of Wang and Wen (2009).

where b_{t+1} denotes new loans issued (funds borrowed) in the next period. Notice that we allow $b_{t+1} < 0$, implying that a firm can choose to be a lender.

The firm enters the next period $(t+1)$ with a random draw of productivity shock z_{t+1} in the beginning of $t+1$ before making production decisions. To help finance its capital stock in period $t+1$, the firm can borrow the amount b_{t+1} with the credit constraint,

$$b_{t+1} \leq \theta_{t+1} k_{t+1}, \tag{18}$$

where $\theta_{t+1} \in (0,1)$ is an indicator of financial conditions in period $t+1$. Equations (17) and (18) imply

$$b_{t+1} \leq \frac{\theta_{t+1}}{1-\theta_{t+1}} s_t, \tag{19}$$

where $\frac{\theta}{1-\theta}$ is the leverage ratio.

Upon the realization of z_{t+1}, a firm decides whether to (i) be an exporter serving both the domestic market and the foreign market (by paying a fixed cost to access the foreign market), or (ii) be a non-exporter serving only the domestic market. After production and sales, the firm pays off its debt $(1+r_{t+1})\, b_{t+1}$ (when $b < 0$, they receive interest payments from the financial market), gives dividends d_{t+1} to equity holders, and carries net worth s_{t+1} to the next period $t+2$; so on and so forth.

Denote x_t/P_t as a firm's maximum ex post real cash flow (measured in final goodss) after choosing production, making sales in its chosen markets, and paying wage bills and its debt $(1+r_t)\, b_t$, but before giving dividends. More specifically, depending on the firm's chosen market status (exporter or non-exporter), we have

$$\frac{x_t}{P_t} = \begin{cases} \max\left\{ \frac{(E_t^*)^{\frac{1}{\sigma}}}{P_t}[y_{it}^*]^{1-\frac{1}{\sigma}} + M_{ht}^{\frac{1}{\sigma}} \frac{P_{ht}}{P_t}[y_{it}^d]^{1-\frac{1}{\sigma}} - \frac{w_t}{P_t} l_t + (1-\delta)k_t - (1+r_t)b_t - \frac{W_t}{P_t} f_e \right\}, & \text{if exporting} \\ \max\left\{ M_{ht}^{\frac{1}{\sigma}} \frac{P_{ht}}{P_t}[y_{it}^d]^{1-\frac{1}{\sigma}} - \frac{w_t}{P_t} l_t + (1-\delta)k_t - (1+r_t)b_t \right\}, & \text{if not exporting} \end{cases}, \tag{20}$$

where the first row denotes an exporting firm's real cash flow, and the second row denotes a domestic firm's real cash flow. Note that for exporters, we have

$$y_{it}^* + y_{it}^d = (A_t z_t k_t)^{\alpha} l_t^{1-\alpha}, \tag{21}$$

and for domestic firms, we have

$$y_{it}^d = (A_t z_t k_t)^{\alpha} l_t^{1-\alpha}. \tag{22}$$

Denoting $E_t \equiv M_{ht} P_{ht}^{\sigma}$ and the parameter $\rho \equiv (1-\alpha)(1-\frac{1}{\sigma})$ for a domestic firm, its cash flow is given by

$$\frac{x_t}{P_t} = \left[\frac{E_t^{\frac{1}{\sigma}}}{P_t} (A_t z_t k_t)^{\alpha(1-\frac{1}{\sigma})} \right]^{\frac{1}{1-\rho}} (1-\rho)\rho^{\frac{\rho}{1-\rho}} \left(\frac{W_t}{P_t} \right)^{-\frac{\rho}{1-\rho}} + (1-\delta)k_t - (1+r_t)b_t, \tag{23}$$

and its optimal labor demand is

$$l_t = \left(\frac{\rho E_t^{\frac{1}{\sigma}} (A_t z_t k_t)^{\alpha(1-\frac{1}{\sigma})}}{W_t} \right)^{\frac{1}{1-\rho}}. \tag{24}$$

For an exporter, its cash flow is given by

$$\frac{x_t}{P_t} = \frac{(E_t + E_t^*)^{\frac{1}{\sigma}}}{P_t} y_{it}^{1-\frac{1}{\sigma}} - \frac{W_t}{P_t} l_t + (1-\delta)k_t - (1+r_t)b_t - \frac{W_t}{P_t} f_e \tag{25}$$

$$= \left[\frac{(E_t + E_t^*)^{\frac{1}{\sigma}}}{P_t} (A_t z_t k_t)^{\alpha(1-\frac{1}{\sigma})} \right]^{\frac{1}{1-\rho}} (1-\rho)\rho^{\frac{\rho}{1-\rho}} \left(\frac{W_t}{P_t} \right)^{-\frac{\rho}{1-\rho}} + (1-\delta)k_t - (1+r_t)b_t - \frac{W_t}{P_t} f_e, \tag{26}$$

and its optimal labor demand is

$$l_t = \left(\frac{\rho (E_t + E_t^*)^{\frac{1}{\sigma}} (A_t z_t k_t)^{\alpha(1-\frac{1}{\sigma})}}{W_t} \right)^{\frac{1}{1-\rho}}. \tag{27}$$

With these notations, an intermediate-good firm's dynamic saving problem (dividends policy) is to solve

$$\max E_0 \sum_{t=0}^{\infty} \beta^s \frac{\Lambda_t}{\Lambda_0} d_t \tag{28}$$

subject to

$$d_t = x_t - P_t s_t, \tag{29}$$

where the cash flow x_t is given by equations (23) and (26).

Proposition 1 *There exists an equilibrium in which the decision of s_t is independent of the history of each firm's cash flow and idiosyncratic shocks, $\{x_{t-j}, z_{t-j}\}_{j=0}^{t}$.*

Proof. Notice that (i) only x_{t+1} depends on s_t (through k_{t+1}), and (ii) only z_{t+1} can affect x_{t+1}. The first-order condition for s_t in the above problem is

$$P_t = \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t} \frac{\partial E[x_{t+1}]}{\partial s_t}, \tag{30}$$

where P_t is the marginal cost of saving one additional unit of cash flow (in terms of final goods) and the right-hand side is the expected future marginal returns to saving. Given that the future marginal product of capital is i.i.d, the expected future return to saving depends only on the distribution of z and hence is the same for all firms. So this optimal first-order condition ensures that the history of idiosyncratic shocks and cash flows, $\{z_{t-j}, x_{t-j}\}_{j=0}^{t}$, is irrelevant for the choice of s_t (because maximizing x_{t+1} is an intra-period problem and does not involve any dynamic considerations).[12] ■

Hence, in equilibrium all intermediate-goods firms will bring the same amount of savings (net worth) s_t to the next period. This means that a firm making more profit pays more dividends and that a firm making less profit pays proportionately less dividends, and all firms end up with the same net worth s_t when entering the next period $t+1$. This property greatly simplifies the model as it makes the distribution of firms' savings degenerate. Consequently, the model is analytically tractable despite a well-defined distribution of firms' capital stocks and debts. This is analogous to the trade-imbalance model of Wen (2011), where the objective function for an exporting firm is quasi-linear with the marginal cost of production independent of a firm's individual characteristics.

Next, we turn to the intraperiod optimal decisions of a firm in period $t+1$. It is easy to verify that the intraperiod objective of a firm is to maximize its cash flow x_{t+1} by choosing the capital stock k_{t+1}, labor demand l_{t+1}, the level of debt b_{t+1}, and the market status (i.e., whether to be an exporter or not) after observing the productivity shock z_{t+1}. That is, given the firm's last-period net worth s_t, the real interest rate r_{t+1}, the real wage $\frac{W_{t+1}}{P_{t+1}}$, and the aggregate demand (E_t, E_t^*), the intermediate-goods firm solves the following problem after the productivity shock z_{t+1} is realized:

$$\max_{\{k_{t+1}, l_{t+1}, b_{t+1}\}} x_{t+1} \tag{31}$$

[12] This is the consequence of the existence of a rental market.

subject to constraints (17), (18), and (20). Denoting

$$\lambda_t \equiv \frac{1}{1-\theta_t}, \tag{32}$$

then the borrowing constraint can be re-written as

$$k_t \leq \lambda_t s_{t-1}. \tag{33}$$

The optimal decision rules are characterized by two cutoffs for productivity shocks: a lower cutoff $\underline{Z}_t^*$ determining whether a firm borrows to bind its collateral constraint in the credit market, and a higher cutoff $\overline{Z}_t^*$ determining whether a firm is an exporter or a non-exporter. The most productive firms with $z_t \geq \overline{Z}_t^*$ will choose to be exporters and will borrow to their borrowing limits; the least productive firms with $z_t \leq \underline{Z}_t^*$ will choose to be non-exporters (there are both lenders and borrowers); and the rest will choose to serve domestic markets while being borrowers.

More specifically, for any domestic firm with $z_t \leq \underline{Z}_t^*$, its optimal capital stock is determined by the first-order condition with respect to k_t,

$$k_t^{1-\alpha(1-\frac{1}{\sigma})\frac{1}{1-\rho}} = \frac{\alpha(1-\frac{1}{\sigma})\rho^{\frac{\rho}{1-\rho}}}{r_t+\delta}\left(\frac{W_t}{P_t}\right)^{-\frac{\rho}{1-\rho}}\left[\frac{E_t^{\frac{1}{\sigma}}}{P_t}(A_t z_t)^{\alpha(1-\frac{1}{\sigma})}\right]^{\frac{1}{1-\rho}}, \tag{34}$$

and its borrowing constraint does not bind. For a domestic firm with $z_t \in (\underline{Z}_t^*, \underline{Z}_t^*)$, its borrowing constraint will be binding. The lower cutoff of productivity, $\underline{Z}_t^*$, is determined by the following equation

$$\left[\frac{E_t^{\frac{1}{\sigma}}}{P_t}(A_t \underline{Z}_t^*)^{\alpha(1-\frac{1}{\sigma})}\right]^{\frac{1}{1-\rho}}(1-\rho)\rho^{\frac{\rho}{1-\rho}}\left(\frac{W_t}{P_t}\right)^{-\frac{\rho}{1-\rho}}(\lambda_t s_{t-1})^{\alpha(1-\frac{1}{\sigma})\frac{1}{1-\rho}-1}\alpha(1-\frac{1}{\sigma})\frac{1}{1-\rho} = r_t+\delta, \tag{35}$$

where the left-hand side is the marginal value of capital of a firm with $z_t = \underline{Z}_t^*$ and the right-hand side is the marginal (user's) cost of capital facing the firm.

For an exporting firm, its borrowing constraint will be binding. The higher cutoff $\overline{Z}_t^*$ is determined by the equation

$$\left[\frac{(E_t+E_t^*)^{\frac{1}{\sigma}}}{P_t}\left(A_t\overline{Z}_t^*k_t\right)^{\alpha(1-\frac{1}{\sigma})}\right]^{\frac{1}{1-\rho}}(1-\rho)\,\rho^{\frac{\rho}{1-\rho}}\left(\frac{W_t}{P_t}\right)^{-\frac{\rho}{1-\rho}}-\frac{W_tf_e}{P_t}$$

$$=\left[\frac{(E_t)^{\frac{1}{\sigma}}}{P_t}\left(A_t\overline{Z}_t^*k_t\right)^{\alpha(1-\frac{1}{\sigma})}\right]^{\frac{1}{1-\rho}}(1-\rho)\,\rho^{\frac{\rho}{1-\rho}}\left(\frac{W_t}{P_t}\right)^{-\frac{\rho}{1-\rho}}. \tag{36}$$

where $k_t=\lambda_t s_{t-1}$, and the left-hand side is the gains when being an exporter while the right-hand side the gains when being a non-exporter. The gap between the gains is the fixed cost to export. That is, the higher cutoff is determined at the point where the firm opts to borrow to its borrowing limit and is indifferent between exporting and non-exporting.

Consequently, a domestic firm's output is

$$y_{it}=\left(\frac{\rho E_t^{\frac{1}{\sigma}}}{W_t}\right)^{\frac{1-\alpha}{1-\rho}}(A_tz_tk_t)^{\alpha\left[1+(1-\alpha)(1-\frac{1}{\sigma})\frac{1}{1-\rho}\right]}, \tag{37}$$

while an exporter's output is split into two parts with respect to two distinct markets (home and foreign):

$$y_{it}^d=\frac{E_t}{E_t+E_t^*}\left(\frac{\rho(E_t+E_t^*)^{\frac{1}{\sigma}}}{W_t}\right)^{\frac{1-\alpha}{1-\rho}}(A_tz_tk_t)^{\alpha[1+(1-\alpha)(1-\frac{1}{\sigma})\frac{1}{1-\rho}]}. \tag{38}$$

$$y_{it}^*=\frac{E_t^*}{E_t+E_t^*}\left(\frac{\rho(E_t+E_t^*)^{\frac{1}{\sigma}}}{W_t}\right)^{\frac{1-\alpha}{1-\rho}}(A_tz_tk_t)^{\alpha[1+(1-\alpha)(1-\frac{1}{\sigma})\frac{1}{1-\rho}]}. \tag{39}$$

The domestic firms' pricing is

$$p_{it}^d=\left(\frac{E_t}{y_{it}}\right)^{\frac{1}{\sigma}},$$

while exporters' pricing is

$$p_{it}^e=p_{it}^d=\left(\frac{E_t+E_t^*}{y_{it}}\right)^{\frac{1}{\sigma}}.$$

The domestic price index for home-produced intermediate goods is

$$p_{ht}=\left[\int_1^{\underline{Z}^*}[p_t^d(z)]^{1-\sigma}d\Phi(z)+\int_{\underline{Z}^*}^{\overline{Z}^*}[p_t^d(z)]^{1-\sigma}d\Phi(z)+\int_{\overline{Z}^*}^{+\infty}[p_t^d(z)]^{1-\sigma}d\Phi(z)\right]^{\frac{1}{1-\sigma}}. \tag{40}$$

Denoting $\kappa \equiv \alpha(1-\frac{1}{\sigma})\frac{1}{1-\rho}$, we have the following proposition:

Proposition 2 *The optimal cash flow x_{t+1} and decision rules for $\{l_{t+1}, k_{t+1}, b_{t+1}\}$ are given, respectively, by*

$$\frac{x_{t+1}}{P_{t+1}} = \begin{cases} \left\{ \left[\frac{E_{t+1}^{\frac{1}{\sigma}}}{P_{t+1}} (A_{t+1} z_{t+1})^{\alpha(1-\frac{1}{\sigma})} \right]^{\frac{1}{1-\rho}} (1-\rho)\rho^{\frac{\rho}{1-\rho}} \left(\frac{W_{t+1}}{P_{t+1}}\right)^{-\frac{\rho}{1-\rho}} \right\}^{\frac{1}{1-\kappa}} (1-\kappa)\kappa^{\frac{\kappa}{1-\kappa}} (r_{t+1}+\delta)^{-\frac{\kappa}{1-\kappa}} + (1+r_{t+1})s_t, \\ \left[\frac{E_{t+1}^{\frac{1}{\sigma}}}{P_{t+1}} (A_{t+1} z_{t+1})^{\alpha(1-\frac{1}{\sigma})} \right]^{\frac{1}{1-\rho}} (1-\rho)\rho^{\frac{\rho}{1-\rho}} \left(\frac{W_{t+1}}{P_{t+1}}\right)^{-\frac{\rho}{1-\rho}} (\lambda_{t+1}s_t)^{\kappa} - (r_{t+1}+\delta)\lambda_{t+1}s_t + (1+r_{t+1})s_t, \\ \left[\frac{(E_{t+1}+E_{t+1}^*)^{\frac{1}{\sigma}}}{P_{t+1}} (A_{t+1} z_{t+1})^{\alpha(1-\frac{1}{\sigma})} \right]^{\frac{1}{1-\rho}} (1-\rho)\rho^{\frac{\rho}{1-\rho}} \left(\frac{W_{t+1}}{P_{t+1}}\right)^{-\frac{\rho}{1-\rho}} (\lambda_{t+1}s_t)^{\kappa} - (r_{t+1}+\delta)\lambda_{t+1}s_t + (1+r_{t+1})s_t - \frac{W_t}{P_t} f_e, \end{cases} \tag{41}$$

$$l_{t+1} = \begin{cases} \left(\frac{\rho E_{t+1}^{\frac{1}{\sigma}} (A_{t+1} z_{t+1} k_{t+1})^{\alpha(1-\frac{1}{\sigma})}}{W_{t+1}} \right)^{\frac{1}{1-\rho}}, & \text{if } z_{t+1} \le \underline{Z}_{t+1}^* \\ \left(\frac{\rho E_{t+1}^{\frac{1}{\sigma}} (A_{t+1} z_{t+1} \lambda_{t+1} s_t)^{\alpha(1-\frac{1}{\sigma})}}{W_{t+1}} \right)^{\frac{1}{1-\rho}}, & \text{if } z_{t+1} \in \left(\underline{Z}_{t+1}^*, \overline{Z}_{t+1}^*\right) \\ \left(\frac{\rho (E_{t+1}+E_{t+1}^*)^{\frac{1}{\sigma}} (A_{t+1} z_{t+1} \lambda_{t+1} s_t)^{\alpha(1-\frac{1}{\sigma})}}{W_{t+1}} \right)^{\frac{1}{1-\rho}}, & \text{if } z_{t+1} \ge \overline{Z}_{t+1}^* \end{cases} \tag{42}$$

$$k_{t+1} = \begin{cases} \left[\frac{\alpha(1-\frac{1}{\sigma})\rho^{\frac{\rho}{1-\rho}}}{r_{t+1}+\delta} \left(\frac{W_{t+1}}{P_{t+1}}\right)^{-\frac{\rho}{1-\rho}} \left[\frac{E_{t+1}^{\frac{1}{\sigma}}}{P_{t+1}} (A_{t+1} z_{t+1})^{\alpha(1-\frac{1}{\sigma})} \right]^{\frac{1}{1-\rho}} \right]^{\frac{1}{1-\kappa}}, & \text{if } z_{t+1} \le \underline{Z}_{t+1}^* \\ \lambda_{t+1} s_t, & \text{if } z_{t+1} \in \left(\underline{Z}_{t+1}^*, \overline{Z}_{t+1}^*\right) \\ \lambda_{t+1} s_t, & \text{if } z_{t+1} \ge \overline{Z}_{t+1}^* \end{cases} \tag{43}$$

$$b_{t+1} = \begin{cases} k_{t+1} - s_t, & \text{if } z_{t+1} \le \underline{Z}_{t+1}^* \\ (\lambda_{t+1} - 1)s_t, & \text{if } z_{t+1} \in \left(\underline{Z}_{t+1}^*, \overline{Z}_{t+1}^*\right) \\ (\lambda_{t+1} - 1)s_t, & \text{if } z_{t+1} \ge \overline{Z}_{t+1}^* \end{cases}, \tag{44}$$

where the first cutoff $\underline{Z}_{t+1}^*$ determines whether a firm borrows to bind its borrowing constraint, and the second cutoff $\overline{Z}_{t+1}^*$ (the export cutoff) determines whether a firm exports or not.

Proof. See Appendix. ■

The above proposition shows the capital-reallocating role of the financial (bond) market. It allows the most-productive firms to borrow from the other firms to expand its scale of production, and the least-productive firms to save through the financial market (receiving positive returns above the marginal product of capital on their savings), and to reduce their scale of production.

Henceforth, we assume that productivity shocks z follow the Pareto distribution as in Melitz (2003):

$$\mathbf{\Phi}(z) = 1 - z^{-\eta}, \tag{45}$$

with support $z \in [1, \infty)$ and the shape parameter $\eta \geq 1$. The p.d.f. is then

$$\phi(z) = \eta z^{-\eta-1}. \tag{46}$$

By Proposition 2, we obtain a firm's expected cash flow (before the idiosyncratic productivity shock z_{t+1} is realized) as

$$E\left[x_{t+1}\right] = P_{t+1}(1+r_{t+1})s_t + P_{t+1}\frac{F_{1,t+1}}{\eta - \frac{\kappa}{1-\kappa}}(1 - \underline{Z}^{*}_{t+1}{}^{-\eta+\frac{\kappa}{1-\kappa}}) + P_{t+1}\frac{F_{2,t+1}}{\eta-\kappa}(\underline{Z}^{*}_{t+1}{}^{-\eta+\kappa} - \overline{Z}^{*}_{t+1}{}^{-\eta+\kappa})$$

$$+ P_{t+1}\frac{F_{3,t+1}}{\eta-\kappa}(\overline{Z}^{*}_{t+1}{}^{-\eta+\kappa} - 0) - P_{t+1}(r_{t+1}+\delta)\lambda_{t+1}s_t(\underline{Z}^{*}_{t+1}{}^{-\eta+\kappa} - 0), \tag{47}$$

where

$$F_{1,t+1} = \left\{\left[\frac{E_{t+1}^{\frac{1}{\sigma}}}{P_{t+1}}(A_{t+1})^{\alpha(1-\frac{1}{\sigma})}\right]^{\frac{1}{1-\rho}}(1-\rho)\rho^{\frac{\rho}{1-\rho}}\left(\frac{W_{t+1}}{P_{t+1}}\right)^{-\frac{\rho}{1-\rho}}\right\}^{\frac{1}{1-\kappa}}(1-\kappa)\kappa^{\frac{\kappa}{1-\kappa}}(r_{t+1}+\delta)^{-\frac{\kappa}{1-\kappa}} \tag{48}$$

$$F_{2,t+1} = \left\{\left[\frac{E_{t+1}^{\frac{1}{\sigma}}}{P_{t+1}}(A_{t+1})^{\alpha(1-\frac{1}{\sigma})}\right]^{\frac{1}{1-\rho}}(1-\rho)\rho^{\frac{\rho}{1-\rho}}\left(\frac{W_{t+1}}{P_{t+1}}\right)^{-\frac{\rho}{1-\rho}}\right\}(\lambda_{t+1}s_t)^{\kappa} \tag{49}$$

$$F_{3,t+1} = \left\{\left[\frac{(E_{t+1}+E^{*}_{t+1})^{\frac{1}{\sigma}}}{P_{t+1}}(A_{t+1})^{\alpha(1-\frac{1}{\sigma})}\right]^{\frac{1}{1-\rho}}(1-\rho)\rho^{\frac{\rho}{1-\rho}}\left(\frac{W_{t+1}}{P_{t+1}}\right)^{-\frac{\rho}{1-\rho}}\right\}(\lambda_{t+1}s_t)^{\kappa}. \tag{50}$$

The above expression for expected cash flow allows us to solve equation (30) analytically (note that the two cutoffs are related to s_t as well):

$$
\begin{aligned}
\frac{\partial E[x_{t+1}]}{\partial s_t} = & P_{t+1}(1+r_{t+1}) \\
& + \kappa P_{t+1}\frac{F_{2,t+1}}{\eta-\kappa}\frac{1}{s_t}({\underline{Z}^*_{t+1}}^{-\eta+\kappa} - {\overline{Z}^*_{t+1}}^{-\eta+\kappa}) \\
& + \kappa P_{t+1}\frac{F_{3,t+1}}{\eta-\kappa}\frac{1}{s_t}\overline{Z}^{*-\eta+\kappa}_{t+1} \\
& - P_{t+1}(r_{t+1}+\delta)\lambda_{t+1}\underline{Z}^{*-\eta+\kappa}_{t+1} \\
& + P_{t+1}\frac{F_{1,t+1}}{\eta-\frac{\kappa}{1-\kappa}}(\eta-\frac{\kappa}{1-\kappa})\frac{1-\kappa}{\kappa}\frac{1}{s_t}\underline{Z}^{*-\eta+\frac{\kappa}{1-\kappa}}_{t+1} \\
& + P_{t+1}\frac{F_{2,t+1}}{\eta-\kappa}({\underline{Z}^*_{t+1}}^{-\eta+\kappa}(-\eta+\kappa)\frac{1-\kappa}{\kappa}\frac{1}{s_t} + {\overline{Z}^*_{t+1}}^{-\eta+\kappa}(-\eta+\kappa)\frac{1}{s_t}) \\
& - P_{t+1}\frac{F_{3,t+1}}{\eta-\kappa}{\overline{Z}^*_{t+1}}^{-\eta+\kappa}(-\eta+\kappa)\frac{1}{s_t} - P_{t+1}(r_{t+1}+\delta)\lambda_{t+1}s_t(-\eta+\kappa)\frac{1-\kappa}{\kappa}\frac{1}{s_t}\underline{Z}^{*-\eta+\kappa}_{t+1}.
\end{aligned} \tag{51}
$$

3.5 Competitive Equilibrium

A competitive equilibrium is defined as the sequences of $\{s_{it}, x_{it}, b_{it}, l_{it}, k_{it}\}_{t=0}^{\infty}$, $\{C_t, H_t, q_{it}\}_{t=0}^{\infty}$, and $\{w_t, r_t, v_t, P_t, p_{ht}\}_{t=0}^{\infty}$ for all $i \in [0,1]$ such that

1. Intermediate-goods firms solve problems (28) and (31)
2. final-goodss firms solve problem (13)
3. The household solves problem (7)
4. All markets clear. The market clearing conditions include

(4.a) the equity market-clearing condition:

$$q_{i,t} = 1, \qquad i \in [0,1] \text{ and } t \geq 0, \tag{52}$$

(4.b) the labor market-clearing condition:

$$H_t = \int l_{it} di + f_e \int_{\overline{Z}^*_t}^{\infty} d\mathbf{\Phi}(x), \tag{53}$$

(4.c) the intermediate-goods market-clearing condition:

$$M_{ht}^{\frac{\sigma-1}{\sigma}} = \int_1^{\overline{Z}^*} y_{it}^{\frac{\sigma-1}{\sigma}} d\Phi(z) + \int_{\overline{Z}^*}^{\infty} y_{it}^{d\,\frac{\sigma-1}{\sigma}} d\Phi(z), \tag{54}$$

(4.d) the bond market-clearing condition:

$$\int b_{it} di = 0, \tag{55}$$

(4.e) the capital rental market-clearing condition:

$$K_{t+1} = s_t = S_t, \tag{56}$$

(4.f.) the final-goods market-clearing condition:

$$Y_t = C_t + K_{t+1} - (1-\delta)K_t. \tag{57}$$

Notice that when a domestic firm does not reach its borrowing limit, we have

$$l_t = \frac{\rho^{\frac{1}{1-\rho}} E_t^{\frac{1}{\sigma(1-\rho)}}}{W_t^{\frac{1}{1-\rho}}} \left(\frac{\alpha(1-\frac{1}{\sigma})\rho^{\frac{\rho}{1-\rho}}}{r_t+\delta} \right)^{\kappa} \left(\frac{W_t}{P_t}\right)^{-\frac{\rho}{1-\rho}\kappa} \left(\frac{E_t^{\frac{1}{\sigma}}}{P_t}\right)^{\frac{\kappa}{1-\kappa}} (A_t z_t)^{\frac{\kappa}{1-\kappa}},$$

so the labor market-clearing condition implies

$$H_t = \int_1^{\underline{Z}_t^*} \frac{\rho^{\frac{1}{1-\rho}} E_t^{\frac{1}{\sigma(1-\rho)}}}{W_t^{\frac{1}{1-\rho}}} \left(\frac{\alpha(1-\frac{1}{\sigma})\rho^{\frac{\rho}{1-\rho}}}{r_t+\delta} \right)^{\kappa} \left(\frac{W_t}{P_t}\right)^{-\frac{\rho}{1-\rho}\kappa} \left(\frac{E_t^{\frac{1}{\sigma}}}{P_t}\right)^{\frac{\kappa}{1-\kappa}} (A_t z_t)^{\frac{\kappa}{1-\kappa}} \phi(z)dz \tag{58}$$

$$+ \int_{\underline{Z}_t^*}^{\overline{Z}_t^*} \frac{\rho^{\frac{1}{1-\rho}} E_t^{\frac{1}{\sigma(1-\rho)}}}{W_t^{\frac{1}{1-\rho}}} (A_t \lambda_t s_{t-1} z_t)^{\kappa} \phi(z)dz + \int_{\overline{Z}_t^*}^{+\infty} \frac{\rho^{\frac{1}{1-\rho}} (E_t + E_t^*)^{\frac{1}{\sigma(1-\rho)}}}{W_t^{\frac{1}{1-\rho}}} (A_t \lambda_t s_{t-1} z_t)^{\kappa} \phi(z)dz \tag{59}$$

$$+ f_e \int_{\overline{Z}_t^*}^{\infty} d\mathbf{\Phi}(x); \tag{60}$$

and the bond market-clearing condition implies

$$\int_1^{\underline{Z}_t^*} \frac{\alpha(1-\frac{1}{\sigma})\rho^{\frac{\rho}{1-\rho}}}{r_t+\delta} \left(\frac{W_t}{P_t}\right)^{-\frac{\rho}{1-\rho}} \left(\frac{E_t^{\frac{1}{\sigma}}}{P_t}\right)^{\frac{1}{1-\kappa}} (A_t z_t)^{\frac{\kappa}{1-\kappa}} \phi(z)dz + (\int_{\underline{Z}_t^*}^{\infty} \phi(z)dz)\lambda_t s_{t-1} = s_{t-1};$$

and the balance of trade condition is given by

$$\int_{\overline{Z}_t^*}^{\infty} (E_t^*)^{\frac{1}{\sigma}} (y_{it}^e)^{1-\frac{1}{\sigma}} d\Phi(z) = P_f M_{ft}. \tag{61}$$

4 Aggregate Dynamics

4.1 Aggregation

Proposition 3 *Taking* $\{\lambda_t, A_t, E_t^*, \zeta_t\}_{t=0}^{\infty}$ *and the initial aggregate capital stock* $K_0 = S_{-1}$ *as given, the general equilibrium of the model is characterized by the sequences of 15 variables:* $\{E_t, \underline{Z}_t^*, r_t, \overline{Z}_t^*, C_t, \Lambda_t, M_{ht}, K_{t+1}, P_t, M_{ft}, p_{ht}, Y_t, w_t, H_t, S_t\}_{t=0}^{\infty}$*, which can be uniquely solved by the following system of 15 equations:*

$$E_t = M_{ht} p_{ht}^{\sigma}, \tag{62}$$

$$\frac{\alpha(1-\frac{1}{\sigma})\rho^{\frac{\rho}{1-\rho}}}{r_t+\delta}\left(\frac{W_t}{P_t}\right)^{-\frac{\rho}{1-\rho}}\left(\frac{E_t^{\frac{1}{\sigma}}}{P_t}\right)^{\frac{1}{1-\kappa}}\frac{(A_t)^{\frac{\kappa}{1-\kappa}}\eta}{\eta-\frac{\kappa}{1-\kappa}}(1-(\underline{Z}_t^*)^{\frac{\kappa}{1-\kappa}-\eta})+\underline{Z}_t^{*-\eta}\lambda_t s_{t-1}=s_{t-1}, \tag{63}$$

$$\left[\frac{E_t^{\frac{1}{\sigma}}}{P_t}(A_t\underline{Z}_t^*)^{\alpha(1-\frac{1}{\sigma})}\right]^{\frac{1}{1-\rho}}(1-\rho)\rho^{\frac{\rho}{1-\rho}}\left(\frac{W_t}{P_t}\right)^{-\frac{\rho}{1-\rho}}(\lambda_t s_{t-1})^{\alpha(1-\frac{1}{\sigma})\frac{1}{1-\rho}-1}\frac{\alpha(\frac{\sigma-1}{\sigma})}{1-\rho}=r_t+\delta, \tag{64}$$

$$\begin{aligned}&\left[\frac{(E_t+E_t^*)^{\frac{1}{\sigma}}}{P_t}(A_t\overline{Z}_t^*\lambda_t s_{t-1})^{\alpha(1-\frac{1}{\sigma})}\right]^{\frac{1}{1-\rho}}(1-\rho)\rho^{\frac{\rho}{1-\rho}}\left(\frac{W_t}{P_t}\right)^{-\frac{\rho}{1-\rho}}-\frac{W_t}{P_t}f_e\\ &=\left[\frac{(E_t)^{\frac{1}{\sigma}}}{P_t}(A_t\overline{Z}_t^*\lambda_t s_{t-1})^{\alpha(1-\frac{1}{\sigma})}\right]^{\frac{1}{1-\rho}}(1-\rho)\rho^{\frac{\rho}{1-\rho}}\left(\frac{W_t}{P_t}\right)^{-\frac{\rho}{1-\rho}},\end{aligned} \tag{65}$$

$$\begin{aligned}P_t=\beta E_t\frac{\Lambda_{t+1}}{\Lambda_t}\{&P_{t+1}(1+r_{t+1})+\kappa P_{t+1}\frac{F_{2,t+1}}{\eta-\kappa}\frac{1}{s_t}({\underline{Z}_{t+1}^*}^{-\eta+\kappa}-{\overline{Z}_{t+1}^*}^{-\eta+\kappa})\\ &+\kappa P_{t+1}\frac{F_{3,t+1}}{\eta-\kappa}\frac{1}{s_t}\overline{Z}_{t+1}^{*-\eta+\kappa}-P_{t+1}(r_{t+1}+\delta)\lambda_{t+1}\underline{Z}_{t+1}^{*-\eta+\kappa}\\ &+P_{t+1}\frac{F_{1,t+1}}{\eta-\frac{\kappa}{1-\kappa}}(\eta-\frac{\kappa}{1-\kappa})\frac{1-\kappa}{\kappa}\frac{1}{s_t}\underline{Z}_{t+1}^{*-\eta+\frac{\kappa}{1-\kappa}}\\ &+P_{t+1}\frac{F_{2,t+1}}{\eta-\kappa}({\underline{Z}_{t+1}^*}^{-\eta+\kappa}(-\eta+\kappa)\frac{1-\kappa}{\kappa}\frac{1}{s_t}+{\overline{Z}_{t+1}^*}^{-\eta+\kappa}(-\eta+\kappa)\frac{1}{s_t})\\ &-P_{t+1}\frac{F_{3,t+1}}{\eta-\kappa}{\overline{Z}_{t+1}^*}^{-\eta+\kappa}(-\eta+\kappa)\frac{1}{s_t}-P_{t+1}(r_{t+1}+\delta)\lambda_{t+1}s_t(-\eta+\kappa)\frac{1-\kappa}{\kappa}\frac{1}{s_t}\underline{Z}_{t+1}^{*-\eta+\kappa}\},\end{aligned} \tag{66}$$

$$\mathrm{M}_{ht}^{\frac{\sigma-1}{\sigma}} = \left(\frac{\rho E_t^{\frac{1}{\sigma}}}{W_t}\right)^{\frac{1-\alpha}{1-\rho}\frac{\sigma-1}{\sigma}} \Omega_t^{\frac{\alpha+(1-\alpha)\kappa}{1-\kappa}\frac{\sigma-1}{\sigma}} \frac{(\mathrm{A}_t)^{\frac{\alpha+(1-\alpha)\kappa}{1-\kappa}\frac{\sigma-1}{\sigma}}\eta}{\eta-\frac{\alpha+(1-\alpha)\kappa}{1-\kappa}\frac{\sigma-1}{\sigma}}(1\text{-}\underline{Z}_t^{*\frac{\alpha+(1-\alpha)\kappa}{1-\kappa}\frac{\sigma-1}{\sigma}-\eta})$$

$$+\left(\frac{\rho E_t^{\frac{1}{\sigma}}}{W_t}\right)^{\frac{1-\alpha}{1-\rho}\frac{\sigma-1}{\sigma}} \frac{(A_t\lambda_t s_{t-1})^{[\alpha+(1-\alpha)\kappa]\frac{\sigma-1}{\sigma}}\eta}{\eta-[\alpha+(1-\alpha)\kappa]\frac{\sigma-1}{\sigma}} \left(\underline{Z}_t^{*[\alpha+(1-\alpha)\kappa]\frac{\sigma-1}{\sigma}-\eta} - \overline{Z}_t^{*[\alpha+(1-\alpha)\kappa]\frac{\sigma-1}{\sigma}-\eta}\right)$$

$$+\frac{E_t}{E_t+E_t^*}\left(\frac{\rho(E_t+E_t^*)^{\frac{1}{\sigma}}}{W_t}\right)^{\frac{1-\alpha}{1-\rho}\frac{\sigma-1}{\sigma}} \frac{(A_t\lambda_t s_{t-1})^{[\alpha+(1-\alpha)\kappa]\frac{\sigma-1}{\sigma}}\eta}{\eta-[\alpha+(1-\alpha)\kappa]\frac{\sigma-1}{\sigma}}\overline{Z}_t^{*[\alpha+(1-\alpha)\kappa]\frac{\sigma-1}{\sigma}-\eta}, \quad (67)$$

$$Y_t = C_t + K_{t+1} - (1-\delta)K_t, \quad (68)$$

$$E_t^{*\frac{1}{\sigma}}\left[\frac{E_t^*}{E_t+E_t^*}\left(\frac{\rho(E_t+E_t^*)^{\frac{1}{\sigma}}}{W_t}\right)^{\frac{1-\alpha}{1-\rho}}(A_t\ \lambda_t s_{t-1})^{\alpha+(1-\alpha)\kappa}\right]^{1-\frac{1}{\sigma}} \frac{\eta\overline{Z}_t^{*(\alpha+(1-\alpha)\kappa)(1-\frac{1}{\sigma})-\eta}}{\eta-[\alpha+(1-\alpha)\kappa](1-\frac{1}{\sigma})}$$

$$= P_f M_{ft}, \quad (69)$$

$$\frac{Y_t}{M_{ft}} = \left(\frac{P_f}{P_t}\frac{1}{1-\varphi}\right)^{\mu}, \quad (70)$$

$$\frac{Y_t}{M_{ht}} = \left(\frac{P_{ht}}{P_t}\frac{1}{\varphi}\right)^{\mu}, \quad (71)$$

$$Y_t = \left[\varphi(M_{ht})^{\frac{\mu-1}{\mu}} + (1-\varphi)(M_{ft})^{\frac{\mu-1}{\mu}}\right]^{\frac{\mu}{\mu-1}}, \quad (72)$$

$$H_t = \frac{\rho^{\frac{1}{1-\rho}}E_t^{\frac{1}{\sigma(1-\rho)}}}{W_t^{\frac{1}{1-\rho}}}\left(\frac{\alpha(1-\frac{1}{\sigma})\rho^{\frac{\rho}{1-\rho}}}{r_t+\delta}\right)^{\kappa}\left(\frac{W_t}{P_t}\right)^{-\frac{\rho}{1-\rho}\kappa}\left(\frac{E_t^{\frac{1}{\sigma}}}{P_t}\right)^{\frac{\kappa}{1-\kappa}}\frac{(A_t)^{\frac{\kappa}{1-\kappa}}\eta}{\eta-\frac{\kappa}{1-\kappa}}(1-\underline{Z}_t^{*\frac{\kappa}{1-\kappa}-\eta})$$

$$+\frac{\rho^{\frac{1}{1-\rho}}E_t^{\frac{1}{\sigma(1-\rho)}}}{W_t^{\frac{1}{1-\rho}}}(A_t\lambda_t s_{t-1})^{\kappa}\frac{\eta}{\eta-\kappa}(\underline{Z}_t^{*\kappa-\eta}-\overline{Z}_t^{*\kappa-\eta})$$

$$+\frac{\rho^{\frac{1}{1-\rho}}(E_t+E_t^*)^{\frac{1}{\sigma(1-\rho)}}}{W_t^{\frac{1}{1-\rho}}}(A_t\lambda_t s_{t-1})^{\kappa}\frac{\eta}{\eta-\kappa}\overline{Z}_t^{*\kappa-\eta} + f_e\int_{\overline{Z}_t^*}^{\infty} d\mathbf{\Phi}(x), \quad (73)$$

$$\frac{W_t}{P_t} = \chi H_t^{\gamma}, \quad (74)$$

$$K_{t+1} = S_t, \quad (75)$$

$$P_t \Lambda_t = \frac{\zeta_t}{C_t - \chi \frac{H_t^{1+\gamma}}{1+\gamma}}; \tag{76}$$

where $\Omega_t \equiv \frac{\alpha(\frac{\sigma-1}{\sigma})\rho^{\frac{\rho}{1-\rho}}\left(\frac{W_t}{P_t}\right)^{-\frac{\rho}{1-\rho}}\left(\frac{E_t^{\frac{1}{\sigma}}}{P_t}\right)^{\frac{1}{1-\rho}}}{r_t+\delta}$.

Proof. See Appendix. ■

In the proposition, equation (62) is the definition of the domestic aggregate demand for intermediate goods, equation (63) is the bond market-clearing condition, equation (64) determines the cutoff for lending and borrowing, equation (65) determines the cutoff for exporting and non-exporting, equation (66) is the firm's optimal saving decision, equation (67) is the aggregation of domestic intermediate goods, equation (68) is the final-goods market-clearing condition, equation (69) is the trade-balance condition, equation (70) is the demand for foreign input in final-goods production, equation (71) is the demand for domestic input in final-goods production, equation (72) is the production function for producing domestic final goods, equation (73) is the labor market-clearing condition, equation (74) is the household labor supply, equation (75) is the market-clearing condition for capital goods, and finally, equation (76) is the household's intertemporal consumption decision.

4.2 Calibration

We calibrate our model to the Japanese economy during the sample period before 1990 at the quarterly frequency. We divide the parameters into two categories. One category is taken directly from external sources, and the other category is calibrated to match some key moments of the data.

The first category includes parameters $\{\delta, \sigma, \alpha, \eta, \mu, \gamma, \lambda_{ss}\}$, whose values are directly taken from the literature. Specifically, we set the capital depreciation rate $\delta = 0.025$; the elasticity of substitution between different domestic varieties $\sigma = 4$, which falls into the range of estimates from the existing literature; the capital share $\alpha = 0.42$, which is the average of estimates from Karabarbounis and Neiman (2014) and the Penn World Table; the Pareto shape parameter $\eta = 1.6$, which is consistent with Dekle, Jeong and Kiyotaki's (2014) calibration using Japanese firm-level data; the elasticity of substitution between home intermediate input and foreign intermediate input in final-goods production $\mu = 4$, in line with the existing literature; the elasticity of labor supply $1/\gamma$ is set to be $2/3$; the steady-state collateral constraint parameter $\lambda_{ss} = 3$ as our benchmark—Moll (2011) estimates that

λ is around 1 for India and 4.15 for United States, we take an intermediate value but closer to the U.S.; and finally, the aggregate foreign demand E^* is normalized to 1.0.

The second category contains parameters $\{\beta, \varphi, f_e, p_f, \chi\}$, which can be set to match some key moments of the Japanese data. We set $\beta = 0.995$ to target a steady-state quarterly interest rate of 1.5%. The home-bias parameter in final-goods production is set to 0.75 to match Japan's 14% export/GDP ratio in 1985. The remaining three parameters $\{f_e, p_f, \chi\}$ are set to match the fraction of hours worked $H = 0.15$, (household) consumption-to-GDP ratio 54%, and the fraction of exporters in all firms 0.5%; thus, $f_e = 2.1732$, $p_f = 0.2336$, and $\chi = 61.5274$.[13]

Table 1. Calibration

Parameters	Value	Explanation
δ	0.025	depreciation rate
σ	4	elast. of subs. btw. varieties
α	0.42	capital share
η	1.6	pareto shape parameter
μ	4	elast. of subs. btw. home & imported good
γ	1.5	1/elast. of labor supply
λ	3.0	collateral constraint
E^*	1.0	normalized aggregate foreign demand
β	0.995	quarterly interest rate of 1.5%
φ	0.75	targeted export/GDP = 13%
p_f	0.2336	targeted consumption/GDP = 54%
f_e	2.1732	targeted fraction of exporters = 0.5%
χ	61.5274	targeted labor supply = 0.15

4.3 Steady-State Analysis

We start with a steady-state analysis. Figure 6 shows the predicted relationship between financial development and four important indicators of economic performance: trade-to-GDP ratio (top-left panel), fraction of capital allocated to exporters (top-right panel), measured TFP (lower-left panel), and capital stock-to-GDP ratio (lower-right panel). It shows that financial development in our model (represented by the loan-to-value ratio θ) raises trade-to-GDP ratio, the amount of capital allocated to the export sector, and TFP, and it increases

[13] Tomiura (2007) uses a manufacturing survey for Japanese firms (only firms with fewer than 50 employees) and finds that around 6.3% of firms (out of 7,479 firms in the sample) are exporters. However, the manufacturing industry only accounts for less than 1/4 of Japan's GDP. The number of establishments in Japan is several million (for instance, this number is 5,911,038 in 2006, which gives us a lower bound estimate of 0.13% for the fraction of exporters in all firms). We choose 0.5% as a benchmark, but our results are robust when we set this number to other values around 0.5%.

consumption by lowering the stock of aggregate capital (thanks to the improved efficiency of capital). The underlying mechanism is that financial development allows capital in the economy to be allocated to the most-productive users (such as firms in the export sector which have higher productivity).

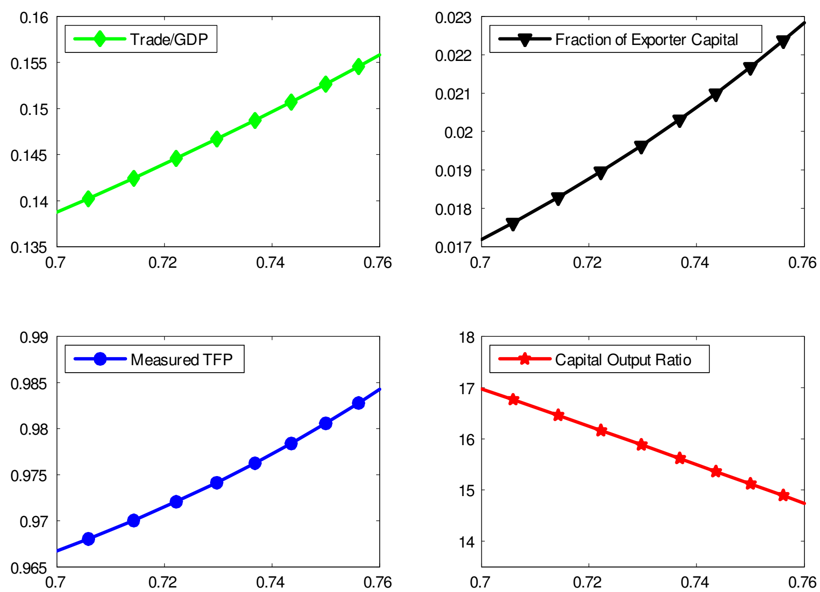

Figure 6: The Long-run Effects of Financial Development

4.4 Impulse Responses under Aggregate Shocks

Assume that the productivity shock A_t, the financial shock λ_t, the home aggregate demand shock ζ_t, and the foreign demand shock E_t^* all follow an AR(1) process with the same persistent parameter $\rho = 0.9$:

$$\log(A_{t+1}) - \log(A) = \rho(\log(A_t) - \log(A)) + \varepsilon_{A,t+1} \tag{77}$$

$$\log(\lambda_{t+1}) - \log(\lambda) = \rho(\log(\lambda_t) - \log(\lambda)) + \varepsilon_{\lambda,t+1} \tag{78}$$

$$\log(\zeta_{t+1}) - \log(\zeta) = \rho(\log(\zeta_t) - \log(\zeta)) + \varepsilon_{\zeta,t+1} \tag{79}$$

$$\log(E_{t+1}^*) - \log(E^*) = \rho(\log(E_t^*) - \log(E^*)) + \varepsilon_{E^*,t+1}. \tag{80}$$

The model's impulse responses to a shock (1% exogenous change) in A_t, λ_t, ζ_t, and E_t^* are presented, respectively, in columns 1-4 in Figure 7, where the first row is total exports, the second row is GDP, the third row is exports-to-GDP ratio, and the fourth row is the cutoff $\overline{Z}_t^*$. The figure shows that TFP shock (column 1) cannot explain the phenomenon of a trade collapse: Under a negative TFP shock, exports drop less significantly than GDP, thus the exports-to-GDP ratio rises instead of falls on impact. The key reason is that the cutoff (in the last row) does not increase significantly—suggesting that the number of exporters does not decrease sufficiently to trigger a sharp fall in total exports.

The home demand shock (column 3) is not able to generate a trade collapse either. After a shock to ζ_t, both GDP and exports decline, but exports drop less significantly than GDP, thus causing the export-to-GDP ratio to rise instead of fall during the crisis period. The key reason is again that the cutoff (in the last row) does not increase significantly—suggesting that the number of exporters does not decrease sufficiently to trigger a sharp fall in total exports.

However, under either a negative financial shock (column 2), or a negative foreign demand shock (column 4), the model can generate a trade collapse in the sense that exports drop more significantly than GDP, and the number of exporting firms declines, consistent with the great trade collapse after the 2008 financial crisis.

For example, under a negative one-standard-deviation shock to the loan-to-value ratio λ_t, the second column in Figure 7 shows that the drop in exports is far more severe than the drop in GDP: After a 1% decrease in the loan-to-value ratio, GDP drops by 0.2% and exports drop by 0.5%, which is more than twice as large as GDP; consequently, the exports-to-GDP ratio drops more than 0.2%. The last row shows that a key mechanism behind the trade collapse is the dramatic reduction in the number of exporting firms (since the cutoff $\overline{Z}_t^*$ rises sharply after the shock). These predictions are consistent with the 2008 financial crisis.

A similar prediction is made under a foreign demand shock, as shown in column 4 in Figure 7, where total exports drop more than twice as that of GDP, thus causing the exports-to-GDP ratio to drop significantly. Also, the cutoff increases significantly after the shock, implying that the number of exporting firms declines significantly, explaining the more severe drop in total exports than GDP.

Moreover, the Japanese firm-level data provide an additional litmus test to differentiate these different theories. The Japanese data show that although the exporters suffer more severely than the non-exporters, the exporting firms' domestic sales suffer more than their foreign sales. This stylized fact immediately rules out the foreign demand shock theory as it implies a more severe drop in exporters' foreign sales than their domestic sales.

This firm-level stylized fact also rejects the domestic demand shock theory: Under a

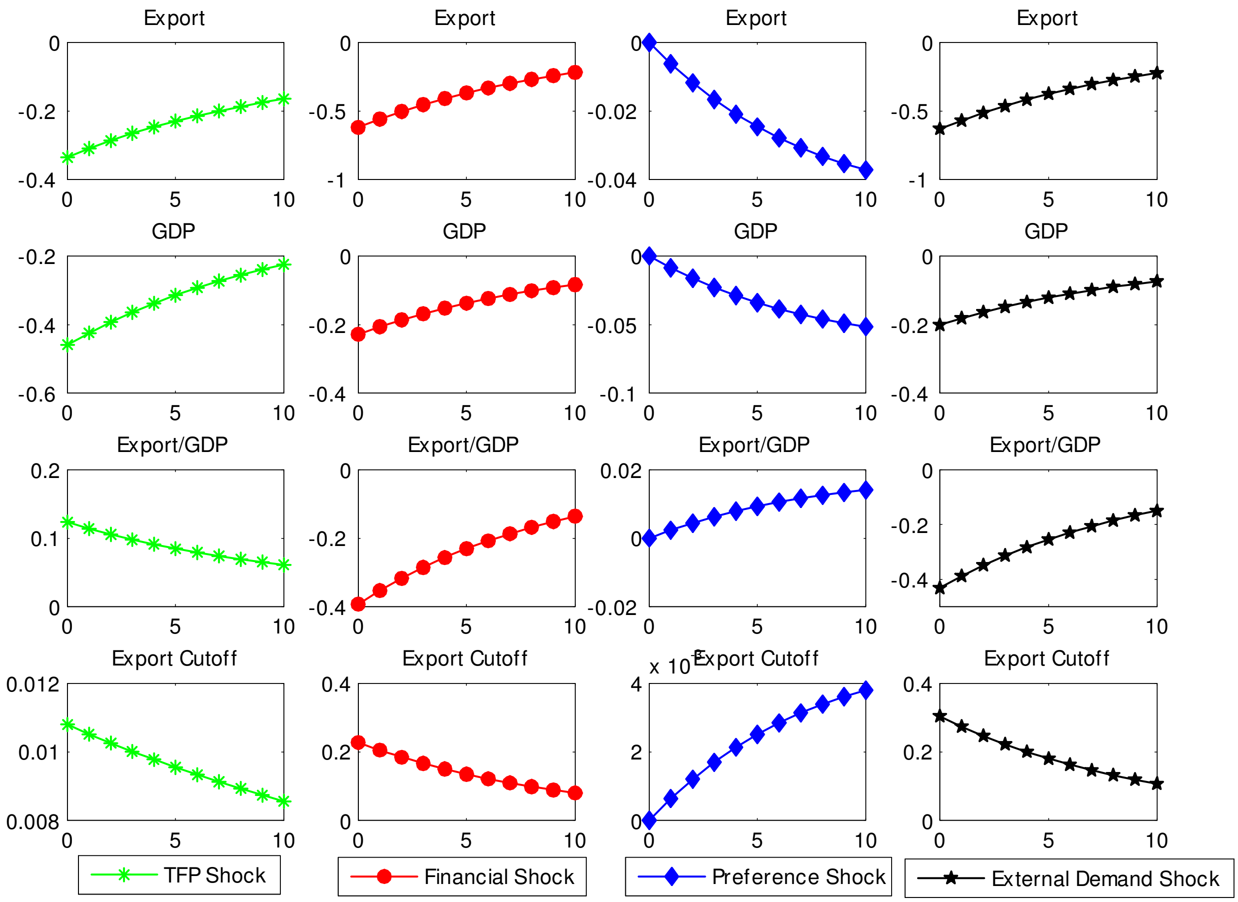

Figure 7: Export and GDP Dynamics under 4 Different Shocks

negative domestic demand shock, although it is likely that exporters' domestic sales may suffer more than non-exporters' sales, exporters' foreign sales cannot possibly drop more than non-exporters' sales. Indeed, the 4 panels in Figure 8 show the impulse responses of firm sales under the 4 aggregate shocks, where the top-left panel pertains to a TFP shock, the top-right panel to a financial shock, the lower-left panel to a home-demand shock, and the lower-right panel to a foreign-demand shock. In each panel, the green line represents exporters' domestic sales—which is supposed to decline the most to match the Japanese data; the red lines represents exporters' foreign sales—which is supposed to decline the second most to match the Japanese data; and the black line represents non-exporters' sales—which is supposed to decline the least to match the Japanese data. Clearly, only the impulse responses in the top-right panel under a financial shock perfectly match the order of firm sales revealed by the Japanese firm-level data.

Specifically, the top-right panel in Figure 8 shows that under a financial shock that

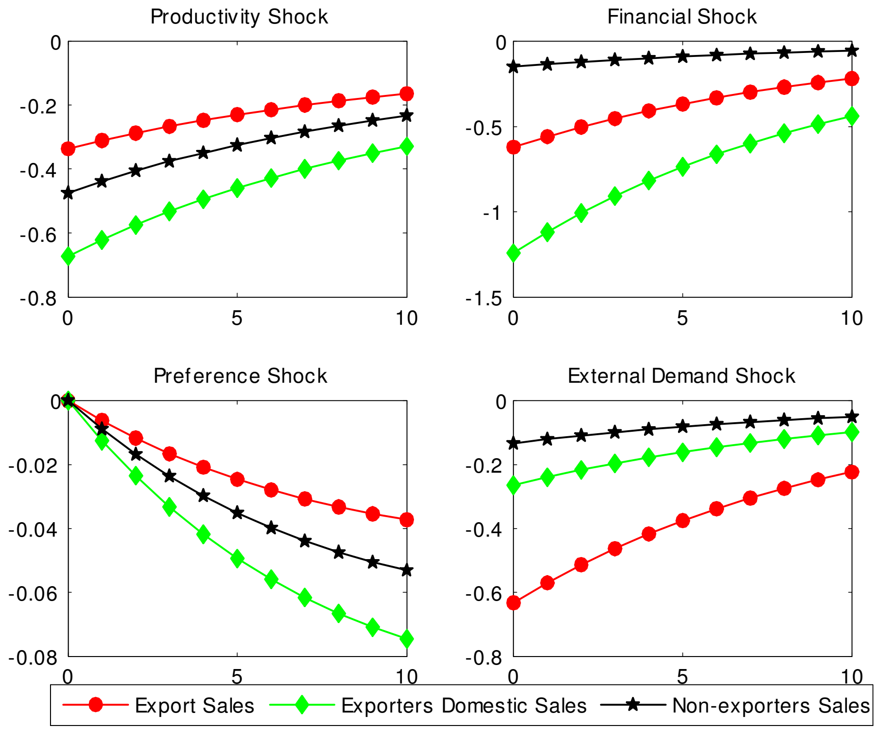

Figure 8: Sales Dynamics by Market and Firm Type under 4 Different Shocks

tightens all firms' borrowing limits, exporters' domestic sales (green line) drop the most significantly (about 1.2%), exporters' foreign sales (red) drop the second significantly (about 0.8%), and non-exporters' total sales (black) drop the least (about 0.2%). Such an order of magnitude is fully consistent with the Japanese firm experience.

However, under a TFP shock, non-exporters' sales drop more than exporters' foreign sales, inconsistent with the Japanese experience. Under a foreign-demand shock, exporters' foreign sales drop far more significantly than their domestic sales and non-exporters' sales, also inconsistent with the Japanese experience. Finally, under a domestic-demand shock, non-exporters' domestic sales drop far more significantly than exporters' foreign sales, also inconsistent with the Japanese experience.

5 Sensitivity Analysis

This section considers government-spending shocks as an alternative to home-demand shocks. For this purpose, we revise the market-clearing equation for final output to

$$Y_t = C_t + K_{t+1} - (1 - \delta)K_t + G_t,$$

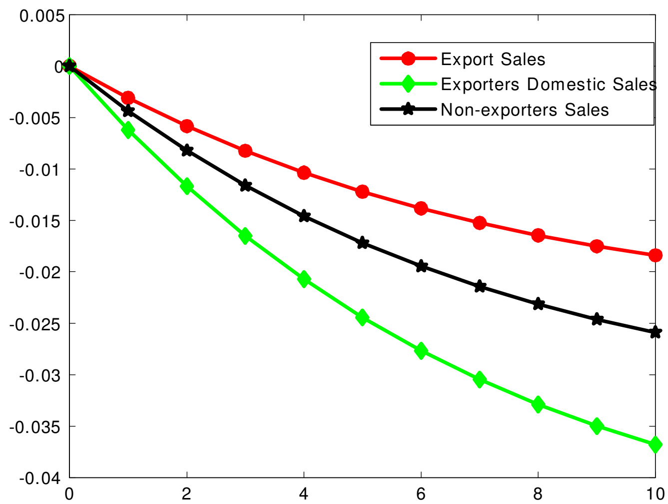

Figure 9: Sales Dynamics by Market and Firm Type under Government Spending Shock

where G_t denotes government spending. We re-calibrate the model by setting the steady-state government spending-to-GDP ratio G/Y to 14%, and assume the government spending shock follows an AR(1) process with persistence ρ,

$$\log(G_{t+1}) - \log(G) = \rho(\log(G_t) - \log(G)) + \varepsilon_{G,t+1}.$$

The impulse response of firm sales in the model to a 1% change in G_t is shown in Figure 9, which is very similar to the case under the domestic-preference shock; namely, non-exporters' sales drop more significantly than exporters' foreign sales, which is inconsistent with the Japanese firm data.

6 Conclusion

This paper makes two contributions. First, we document a new stylized fact about exporter behavior and trade collapse using Japanese firm data. The stylized fact shows that exporters' domestic sales are more volatile than their foreign sales, which in turn are more volatile than non-exporters' total sales during a domestically triggered financial crisis.

Second, we propose a dynamic international trade model with financial intermediation and credit reallocation across firms to explain the newly documented Japanese firm behaviors. The model is applied to examine the differential effects of financial and non-financial shocks on the economy. The results show that our model's implications are consistent with both the aggregate data and the firm-level data during a financial crisis if the key driving force of the crisis stems from a financial shock. In particular, our model lends support to financial shocks as the chief explanation for a trade collapse during a financial crisis, while non-financial shocks such as changes in aggregate demand and TFP will likely be the endogenous outcome of the financial crisis rather than the root cause of the trade collapse.

The mechanism is as follows: (i) Exporters are more productive and thus opt to enter the foreign market by paying a higher fixed cost; (ii) financial intermediation is able to channel capital from low-productive firms to high-productive firms, which means that exporters are able to rely more heavily on outside credits to finance their operations than non-exporters are and thus become more sensitive to financial conditions; (iii) consequently, a domestic financial crisis or credit crunch that hinders the healthy flow of funds from less-productive to more-productive firms will have a larger (asymmetric) effect on exporters than on non-exporters, as well as a larger effect on exporters' domestic sales than their foreign sales, resulting in a larger fall in trade volume than aggregate output and the correct ordering of changes in firm sales, consistent with the Japanese experience.

These predictions of our model thus offer a reasonable explanation for the newly documented Japanese firm behaviors after a domestic financial crisis, while still consistent with the great trade collapse observed after the 2008 global financial crisis.

Our model also shows that in the long run, countries with deeper financial markets are able to achieve higher measured TFP and output levels and a larger share of exports in GDP. Therefore, financial development appears to be a great source of "comparative advantage," enabling more firms to enter and stay in foreign markets, albeit making them more vulnerable to financial shocks.

Our model can be extended in many ways. For example, we can introduce persistent firm-level productivity differences across firms to capture the fact that firms change their export status infrequently.[14] We can also extend our model to a two-country framework, which is likely to enhance our results because a financial crisis in the home country reduces the demand for foreign goods, which can act as a demand shock to the foreign country's output (as emphasized by Eaton et al., 2011); a recession in the foreign country will then feed back to the home country, reinforcing the financial crisis. Thus, we expect that a two-country version of our model is able to explain the cross-country business-cycle comovements

[14] For example, based on highly disaggregated U.S. import data for 1972-2001, Besedes and Prusa (2006) found that trade duration is rather short lived, with a median of 2 to 4 years, and 67% of trade relationships hold only one year. Notice that in the original Melitz (2003) model, firms never change their export status once entering the foreign market unless hit by a death shock. Hence, our model is already a significant improvement over the Melitz model in accounting for the observed transition probability of exporters and non-exporters.

puzzle. Extensions such as these are left as our future projects.

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7 Appendix

7.1 Proof of Proposition 2

The uncontrained firms' capital demand is from equation (34). The constrained firms' capital is under the maximum possible debt. Labor demand follows from equation (24) by plugging in the capital demand. Equations (23) and (26) give the cash-flow expressions.

7.2 Proof of Proposition 3

Equation (62) is by definition. The bond market-clearing condition is

$$\int_1^{\underline{Z}_t^*} \frac{\alpha(1-\frac{1}{\sigma})\rho^{\frac{\rho}{1-\rho}}}{r_t+\delta}\left(\frac{W_t}{P_t}\right)^{-\frac{\rho}{1-\rho}}\left(\frac{E_t^{\frac{1}{\sigma}}}{P_t}\right)^{\frac{1}{1-\kappa}}(A_t z_t)^{\frac{\kappa}{1-\kappa}}\phi(z)dz + (\int_{\underline{Z}_t^*}^{\infty}\phi(z)dz)\lambda_t s_{t-1} = s_{t-1}.$$

Plugging in the Pareto distribution for idiosyncratic productivity z, we obtain that

$$\frac{\alpha(1-\frac{1}{\sigma})\rho^{\frac{\rho}{1-\rho}}}{r_t+\delta}\left(\frac{W_t}{P_t}\right)^{-\frac{\rho}{1-\rho}}\left(\frac{E_t^{\frac{1}{\sigma}}}{P_t}\right)^{\frac{1}{1-\kappa}}\frac{(A_t)^{\frac{\kappa}{1-\kappa}}\eta}{\eta-\frac{\kappa}{1-\kappa}}(1-(\underline{Z}_t^*)^{\frac{\kappa}{1-\kappa}-\eta}) + \underline{Z}_t^{*-\eta}\lambda_t s_{t-1} = s_{t-1},$$

which is equation (63). Equations (64) and (65) determine the two productivity cutoffs, copied from equations (35) and (36). Equation (66) is the firm saving decision previously derived. Equation (67) is the domestic intermediate-goods aggregation consisting of 3 parts: (i) unconstrained domestic firms' production; and (ii) constrained domestic firms' production, (iii) constrained exporters' production that goes to the domestic market. Equation (68) is the market-clearing condition for the final goods. Equation (69) is the balanced trade condition. Equations (70)-(72) are from the final goods producers' problem. Equation (73) is the labor market-clearing condition: Labor supply equals labor demand consisting of 4 parts: (i) unconstrained domestic firms' demand; (ii) constrained domestic firms' demand; (iii) constrained exporters' demand; and (iv) fixed cost to exports. Equation (74) is the labor supply function. Equation (75) means that firms save in the form of capital. Finally, equation (76) is the household consumption decision.