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Abstract

This paper investigates firm-level linkage between international finance and trade. Specifically, we present evidence that Korean firms rely more on financing in foreign currency if there is a positive export shock. We address the crucial endogeneity problem by capitalizing on South Korea's as well as its trading partners' demand shocks. We further show that global supply chains also play an important role as higher imported intermediate input shares induce lower foreign currency debt shares. Our findings point to a firm-level hedging channel and are pertinent to exchange rate policies that aim to reduce a (developing) country's vulnerability to exchange rate shocks.

Keywords: Trade Shocks, Debt Finance, Currency Composition, Exchange Rate Risk, Global Supply Chains

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1 Introduction

It has been widely acknowledged that the currency composition of corporate debt is important for both firm-level risk management and understanding the macroeconomic response to exchange rate fluctuations. This paper investigates how firms' currency composition of debt responds to international trade shocks, thereby linking international finance and trade. Our study is pertinent to policy discussions in emerging and developing economies, where corporate borrowings in foreign currency are pervasive and firms have limited hedging instruments.

In the theory section, we consider a firm that endogenously chooses its optimal currency composition of corporate debt. When the firm's objective function features risk aversion, which can be rationalized by financial frictions, the firm adopts operational hedge by raising the foreign currency debt share in response to a higher export revenue (or lower import cost) share.

We then use a proprietary firm-level dataset from South Korea to demonstrate the effect of trade shocks on firms' currency composition of debt. The dataset contains information on a wide range of firms – from small and medium enterprises to the largest firms in Korea – to portray a comprehensive landscape of foreign currency debts in Korea's corporate sector. South Korea is an ideal country for our study for the following reasons. First, during the period that we focus on (1999 - 2007), KRW (Korean won) did not have an international currency status and was rarely used as an invoicing currency in international trade. As a result, Korean firms' *export* revenue shares (in total revenue) were good approximations of their *foreign currency* revenue shares. In addition, South Korean firms' external borrowing was subject to the "original sin" (Eichengreen et al. (2005) and Frankel (2005)) of having most of their external debts denominated in foreign currencies.[1] Finally, due to strict regulations, Korean firms had limited access to financial instruments to hedge exchange rate risk.

[1] US dollar was used predominantly in both export invoicing and denomination of external debts.

To start, we illustrate a pattern that firms with a greater increase in their export shares during the period experienced a greater increase in their foreign currency debt shares. Although intuitive, this pattern falls short of establishing the causal effect of international trade shocks as it may suffer from the endogeneity issue. Specifically, time-varying firm characteristics, such as a firm hiring a foreign manager, may affect export and foreign currency debt shares simultaneously. It also admits a reverse causality interpretation where foreign credit supply shocks contribute to exporting.

As our strategy to address the endogenity problem, we construct an IV (instrument variable) to capture the exogenous changes in export shares at the firm level. Specifically, we rely on foreign industry-level demand shocks and domestic demand shocks, which can be regarded as exogenous to an individual firm, to identify exogenous variation in export shares. Relying on exogenous demand shocks, our IV mainly serves to eliminate two types of endogeneity. First, our IV can account for concomitant changes in firm unobservables (e.g., foreign manager) that may cause a spurious correlation. Second, the reverse causality problem, for instance, firms with access to foreign funds gaining export advantage, is also addressed.

We calculate foreign demand shocks at the industry level with the import growth rates (that exclude imports from South Korea) of all South Korea's international trading partners and calculate domestic demand shocks with South Korea's domestic absorption growth rate. We show that South Korea's actual industry-level export growths are well explained by our constructed foreign demand shocks. Moreover, our IV constructed in this way performs well in terms of predicting the actual changes in export shares at the firm level. Our IV regression results are consistent with our theory that firms seek operational hedge against exchange rate risk via adjusting their foreign currency debt shares. Specifically, we show that one percentage point increase in export share raises the foreign currency debt share by more than 0.10 percentage points.

Comprehensive robustness checks are performed to address potential concerns. First, we eliminate complexities from financial hedge by excluding firms with currency swaps or forwards (which are the major financial instruments to hedge foreign exchange risks), and show that the estimation results remain almost the same given that the fraction of firms that use financial hedge in South Korea is minuscule.[2] In addition, one can cast doubt on the exclusion restriction assumption of our instrument variable as some trading partners are also major lenders to South Korea. Then, it is possible that foreign demand shocks may be correlated with Korean firms' foreign currency debt shares, if, for instance, there are concomitant foreign credit supply shocks. We address this concern by constructing an alternative IV that excludes demand shocks from South Korea's major lending countries and find that our baseline results are still valid. Finally, we experiment with an alternative definition of foreign currency debt share using "net" foreign currency debt.[3] The estimation results are still consistent with our baseline results.

We seek further validation of our empirical results by exploring the historical change in South Korea's exchange rate regime. While South Korea adopted a freely floating exchange rate regime after the Asian financial crisis, its exchange rate regime was classified as a crawling peg and featured a less volatile exchange rate over a decade preceding the crisis (see Reinhart and Rogoff (2004)). Our new regression results using the data from 1988 to 1996 show that when South Korea had a less flexible exchange rate regime, the positive impact of export shares on foreign currency debt shares was much smaller (or became statistically insignificant). This placebo test suggests that firms had much less incentive to employ operational hedge when there were virtually no foreign exchange risk.

To gain a more comprehensive understanding of how firms behave as part of the global value chain, we extend our analysis to consider firms' imported intermediate inputs. We show theoretically that an increase in the import share (the share of imported

[2]Using Chilean firm data, Alfaro et al. (2021) find that large firms in international trade are more likely to hedge the exchange rate risk using currency derivatives. However, due to strict financial regulations in South Korea, we find that the overall use of currency derivatives is limited.

[3]Net debt is calculated by subtracting a company's total cash and cash equivalents from its total debt.

inputs in a firm's total input cost) will *decrease* the firm's foreign currency debt share.[4] We also instrument firms' import shares with South Korea's trading partners' supply shocks to address the endogeneity concerns. Consistent with our hypothesis, our IV regression results show that an increase in import shares *decreases* firms' foreign currency debt shares.

Related Literature. This paper is related to a recent strand of literature on the currency composition of corporate debt. Bruno and Shin (2017) and Huang et al. (2018) study the carry-trade motive, suggesting that a firm can find arbitrage opportunities of borrowing at a lower interest rate from foreign debt and lending to other domestic firms at a higher interest rate. Our paper emphasizes the role of international trade in determining the currency composition of debts. Maggiori et al. (2020) demonstrate that the currency denomination of firms' debt securities is biased towards creditor countries' currency. Salomao and Varela (2020) focus on the tradeoff between the lower borrowing cost and higher exchange rate risk exposure associated with foreign currency borrowing. As a key innovation of our paper, we complement the existing literature by further taking into account the linkage between foreign currency debt and firms' imports and exports.

While previous studies document a positive correlation between the issuance of foreign currency debt and exports (e.g., Allayannis et al. (2001), Kedia and Mozumdar (2003), and Kátay and Harasztosi (2017) among others), to the best of our knowledge, our paper is the first in the literature to address the endogeneity problem to study how currency composition of corporate debt responds to both import and export trade shocks.[5] Additionally, we bring new insights to the literature by investigating the role of *imports*, the understanding of which has been equally important given the rise of global value chains in recent decades (Johnson and Noguera, 2014).

[4] Our dataset does not contain direct information on firms' usage of foreign input, we propose a method to infer import shares with foreign and domestic currency account payables and South Korea's input-output tables.

[5] In a recent study, Lee and Wu (2021) demonstrate that the issuance of foreign currency loans has a connection with the currency composition of firms' assets. In the Appendix Table C.4, we additionally control for firms' foreign currency shares in their assets and find our main results remain robust.

This paper is also connected to an important strand of literature in international finance that studies the implications of foreign currency debt on emerging market economies.[6] This literature argues that given the currency mismatches on corporate balance sheets, there will be a significant real output loss when the value of local currency declines (e.g., Calvo and Reinhart (2002), Eichengreen et al. (2005), Frankel (2005), Kim et al. (2015), Du and Schreger (2016), Jiao (2019)). For example, Bruno and Shin (2020) focus on how foreign currency credit *supply* shocks impact firms' exports, whereas we study how trade shocks impact firms' foreign currency credit *demand*. Our study enriches the understanding of the types of firms that tend to borrow in foreign currencies and their operational hedge to mitigate the impact of exchange rate shocks.

The rest of the paper is organized as follows. We present our theoretical framework in Section 2. Section 3 describes our main dataset and provides the main empirical results. Section 4 incorporates global value chains into our analysis, and Section 5 concludes.

2 Theoretical Framework

We present a two-stage and two-currency model in which a firm in the home country determines the optimal currency composition of its debts with the knowledge of its export revenue and imported intermediate input shares. We refer to the home currency as the *local* currency. In the first stage, the firm chooses the optimal levels of debts in local and foreign currencies to finance its capital expenditure. In the second stage, the firm uses both labor and capital for production and earns domestic revenue in home currency and export revenue in foreign currency, respectively. Our theoretical framework delivers a sharp prediction that the firm's optimal share of foreign currency debt *increases* with its export share and *decreases* with its imported foreign intermediate input share.

[6] Relatedly, Allayannis and Weston (2001), Allayannis et al. (2003), Géczy et al. (1997), Jin and Jorion (2006) and Bartram et al. (2011) analyze the effect of using foreign currency derivatives on firm value.

2.1 Timing of Events

Consider a small open economy, in which "home" is a small country and the rest of the world is referred to as the "foreign" country. We describe the model from home country's perspective, and express the corresponding foreign variables with a superscript "$*$".

There are two stages in our baseline model. The first stage is the borrowing stage in which a home firm determines the level of debts in local and foreign currencies, and the second stage is the production stage in which the firm decides the optimal level of production. The firm's final products are sold in both home and foreign countries.

In the first stage, a firm in the home country finances its capital K with local currency debt b ($b \geq 0$) and foreign currency debt b^* ($b^* \geq 0$) according to

$$\frac{b}{1+r} + \frac{b^*}{1+r^*} = K, \tag{1}$$

where r and r^* are interest rates of local and foreign currency debts, respectively.[7]

At the beginning of the second stage, a level of exchange rate ξ is realized. Observing this, the firm decides its outputs in both domestic and foreign markets to maximize profit. The exchange rate ξ is expressed as the units of local currency per unit of foreign currency such that an increase in ξ means a *appreciation* of foreign currency. The total debt payment in the second stage is given by $b + \xi b^*$, in which ξb^* is the repayment of foreign currency debt converted into local currency. The profit of the firm is determined by its operating profit net of debt repayments. For simplicity, we assume that the firm's capital raised in the first stage fully depreciates after the second stage.

[7] In equation (1), we implicitly normalize the exchange rate (units of local currency per foreign currency) in the first stage as 1.

2.2 Demand and Production

Home consumers' demand for the firm's product is assumed to be $q = Ep^{-\eta}$, where E denotes the demand shifter for the home country, p denotes the price of the product, and η ($\eta > 1$ as estimated in Broda and Weinstein (2006)) is a parameter for demand elasticity. Similarly, we express the foreign demand for the firm's product as $q^* = E^* p^{*-\eta}$, where E^* is the demand shifter for the foreign country and p^* denotes the export price in the foreign country denominated in foreign currency.

Let Q denote the total output of the home firm in the second stage. The firm uses capital K, domestic input L and foreign intermediate input L^* to produce final goods under the following Cobb-Douglas production function

$$Q = \phi K^{1-\beta} \left(L^{1-\lambda} L^{*\lambda} \right)^{\beta}, \tag{2}$$

where ϕ denotes the productivity level of the firm, β ($0 < \beta < 1$) denotes the output elasticity with respect to non-capital inputs, and λ is the share of the foreign intermediate input among non-capital inputs. Total output Q is allocated between home and foreign markets according to $Q = q + q^*$, where q is the quantity sold in the home market and q^* is the quantity sold in the foreign market.

2.3 Production Stage

We present and solve the model in the backward order from the production stage. At the beginning of the production stage, the exchange rate shock ξ is realized. Given the level of capital K determined in the first stage and the realized level of exchange rate ξ, the firm chooses the quantities of goods to sell in home and foreign markets, denoted by q and q^*, respectively. For a given level of home wage w and foreign wage w^*, the firm's profit maximization problem in the second stage can be expressed as

$$\max_{q,q^*} pq + \xi p^* q^* - wL - \xi w^* L^* - (b + \xi b^*) \tag{3}$$

subject to the production function specified in equation (2). Since both b and b^* were already determined at the borrowing stage, they are taken as given in the production stage.[8]

In the expression (3), we multiply the export revenue from the foreign market and the cost of foreign intermediate inputs with exchange rate ξ for conversion into local currency, which reflects our assumption that both export revenue and foreign intermediate inputs are denominated in foreign currency. The assumption is supported by our observation (shown in Figure 3 and Figure 4) that almost all Korean exports and imports are denominated in foreign currencies (over 99%), with US dollar being the dominant one (around 85%).

We show in Appendix A.2 that using the first order condition with respect to q and q^*, we can express the "solved-out" profit of the firm as a function of debts and exchange rate shock as

$$\Pi(\xi, b, b^*) = \tilde{\Pi} \left(\phi K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}} \left\{\left[(1-\alpha) + \alpha \xi^{\eta}\right] \xi^{\lambda\beta(1-\eta)}\right\}^{\frac{1}{\beta+\eta(1-\beta)}} - (b + \xi b^*) \tag{4}$$

where $\tilde{\Pi}$ is a constant term and α is a parameter that represents the firm's export revenue share.[9] The expression in equation (4) shows that the firm's profit in the second stage

[8] An underlying assumption behind equation (3) is that firms can adjust their prices after the realization of foreign exchange shock. Recent empirical studies have shown that nominal stickiness has been important in explaining weak exchange rate pass-through (e.g., Gopinath and Itskhoki (2021)). In Appendix A.1, we demonstrate that our key theoretical predictions are robust to the introduction of nominal stickiness. Specifically, we derive a comparable closed-form expression for the foreign debt ratio under the alternative assumption.

[9] In specific, the constant term $\tilde{\Pi}$ can be expressed as

$$\tilde{\Pi} \equiv \left(1 - \frac{\eta - 1}{\eta}\beta\right) \left[\left(\frac{w}{1-\lambda}\right)^{1-\lambda} \left(\frac{w^*}{\lambda}\right)^{\lambda} \frac{1}{\beta} \frac{\eta}{\eta - 1}\right]^{\frac{\beta(1-\eta)}{\beta+\eta(1-\beta)}} \Gamma^{\frac{1}{\beta+\eta(1-\beta)}},$$

increases with respect to its productivity ϕ and capital K, although greater investment in K is associated with more debt repayments $(b + \xi b^*)$.

Crucially, equation (4) clearly shows that the firm's profit is subject to the exchange rate shock from two sources. First, an appreciation of the foreign currency increases the firm's export revenue through the term $\alpha\xi^{\eta}$. However, it also decreases the firm's overall profit by increasing the cost of foreign input through the term $\xi^{\lambda\beta(1-\eta)}$. In the next subsection, we describe the borrowing stage of our model in which the firm chooses the optimal level of debts b and b^* without knowing the realization of ξ.

2.4 Borrowing Stage

At the borrowing stage, the firm does not know the realization of the exchange rate, but understands its distribution property. The firm's borrowing decision is described by

$$\max_{b,b^*} \mathbb{E}_{\xi}(\Pi) - \frac{\gamma}{2}\mathrm{Var}_{\xi}(\Pi), \tag{5}$$

where the subscript ξ denotes that the expectation is taken over the random variable ξ and γ is a parameter for the extent of risk aversion of the firm.

In the main text, we adopt a "reduced-form" objective function in equation (5) for brevity of exposition. In Appendix A.3, we provide an extensive discussion that, even if the firm is inherently risk neutral, the mean-variance form of the objective function in (5) can be micro-founded by allowing the firm to operate for an extended period and introducing financial frictions that require the profit in the baseline model as the collateral for additional borrowing in the extended period.[10] In Appendix A.4, we also consider

$$\alpha \equiv \frac{E^*}{E + E^*}, \ \Gamma \equiv E + E^*$$

[10]Since it is beyond the scope of our paper to discuss the financial frictions that lead to an objective function that features risk-aversion, we refer readers to Appendix A.3 for a detailed discussion. Alternatively, one can simply assume that the firm in our model is inherently risk-averse.

an alternative specification in which the curvature of the firm's payoff emanates from the bond prices that take into account the endogenous default probability. The central message from the main text remains unchanged.

To derive a closed-form solution to the firm's optimal levels of debts, we assume that ξ follows a log-normal distribution $\xi \equiv \exp\{\sigma X\}$, where X follows a standard normal distribution and $\sigma (\sigma > 0)$ is the dispersion parameter for ξ. Conventionally, we approximate the profit function in equation (4) around $X = 0$ to the second order. In Appendix A.5, we show that the profit of the firm can be approximated by

$$
\begin{aligned}
\Pi(\xi, b, b^*) \approx & \tilde{\Pi} \left(\phi K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}} \left\{ 1 + \frac{\sigma}{\beta+\eta(1-\beta)} \left(\alpha\eta + \lambda\beta(1-\eta)\right) X \right. \\
& \left. + \frac{X^2}{2} \frac{\sigma^2}{\beta+\eta(1-\beta)} \left[\left(\frac{1}{\beta+\eta(1-\beta)} - 1 \right) \left(\alpha\eta + \lambda\beta(1-\eta)\right)^2 + \left(\alpha\eta^2 + 2\alpha\beta\lambda(1-\eta)\eta + \lambda^2\beta^2(1-\eta)^2\right) \right] \right\} \\
& - \left[b + b^*(1 + \sigma X + \frac{1}{2}\sigma^2 X^2) \right].
\end{aligned} \tag{6}
$$

In Appendix A.5, we further derive expressions for the expectation, $\mathbb{E}_\xi(\Pi)$, and the variance, $\text{Var}_\xi(\Pi)$, of the profit.[11] To solve for the optimal level of debts, we proceed with the following equivalent two-step optimization. In the first step, we solve the optimal level of foreign currency debt b^* for a given level of capital K; in the second step, we solve the optimal level of K.

The first order condition that maximizes the firm's objective function with respect to

[11] Appendix A.5 shows that the expectation and the variance of the firm profit in equation (6) can be expressed as

$$
\begin{aligned}
\mathbb{E}_\xi(\Pi(\xi, b, b^*)) = & \tilde{\Pi} \left(\phi K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}} \left\{ 1 + \frac{1}{2} \frac{\sigma^2}{\beta+\eta(1-\beta)} \left[\left(\frac{1}{\beta+\eta(1-\beta)} - 1 \right) \left(\alpha\eta + \lambda\beta(1-\eta)\right)^2 \right. \right. \\
& \left. \left. + \left(\alpha\eta^2 + 2\alpha\beta\lambda(1-\eta)\eta + \lambda^2\beta^2(1-\eta)^2\right) \right] \right\} - \left(b + \left(1 + \frac{1}{2}\sigma^2\right) b^* \right)
\end{aligned}
$$

$$
\text{Var}_\xi(\Pi(\xi, b, b^*)) = \left(\tilde{\Pi} \left(\phi K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}} \frac{\alpha\eta + \lambda\beta(1-\eta)}{\beta+\eta(1-\beta)} - b^* \right)^2 \sigma^2
$$

b^* given a level of K is

$$\frac{1+\frac{1}{2}\sigma^2-\frac{1+r}{1+r^*}}{\gamma\sigma^2}=\tilde{\Pi}\phi^{-\frac{1-\eta}{\beta+\eta(1-\beta)}}\frac{\alpha\eta+\lambda\beta(1-\eta)}{\beta+\eta(1-\beta)}K^{1-\frac{1}{\beta+\eta(1-\beta)}}-b^*. \tag{7}$$

Holding constant the left-hand side of equation (7), the optimal level of foreign currency debt b^* is increasing with respect to the firm's export share α, and is decreasing with respect to imported intermediate input share λ.

The left-hand side of equation (7) can be interpreted as the difference in the borrowing costs of two currencies (deviation from UIP, uncovered interest parity) discounted by $\gamma\sigma^2$. Specifically, the expected appreciation of the exchange rate is given by $1+\frac{1}{2}\sigma^2$, which adds to the borrowing cost in foreign currency. The second term in the numerator, $\frac{1+r}{1+r^*}$, is the relative interest rate between local and foreign currencies, which further contributes to the difference in borrowing costs between two currencies. The denominator in the left-hand side of equation (7) is $\gamma\sigma^2$, which reflects firms' risk aversion to volatility.

Let $\Sigma \equiv \frac{1+\frac{1}{2}\sigma^2-\frac{1+r}{1+r^*}}{\gamma\sigma^2}$ denote the left-hand side of equation (7), the extent of UIP deviation. We follow the findings in the international finance literature to determine the sign of Σ to be $\Sigma \leq 0$.[12] This occurs when the foreign interest rate is lower than the local interest rate after accounting for the expected appreciation of foreign currency. The effect of UIP deviation on the level of optimal foreign currency debt is easily observed from equation (7). When a lower foreign interest rate leads to greater UIP deviation, the home firm will increase the level of foreign currency debt, holding constant the level of capital.

We summarize the preceding discussion in the following proposition.

Proposition 1. *The optimal level of foreign currency debt for any given level of capital can be expressed as*

$$b^*=\tilde{\Pi}\left(\phi K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}}\frac{\alpha\eta+\lambda\beta(1-\eta)}{\beta+\eta(1-\beta)}-\Sigma.$$

[12] See Gilmore and Hayashi (2011) and Hassan (2013) for relevant discussions.

At the optimal level of foreign currency debt, the ex-ante variance of the firm's profit is a quadratic function with respect to the extent of UIP deviation:

$$\mathrm{Var}_{\xi}(\Pi) = \Sigma^2 \sigma^2. \tag{8}$$

When the UIP condition holds (i.e. $\Sigma = 0$), the firm eliminates ex-ante exchange rate risk in profit.

Proof. See Appendix A.6 for proofs. □

The second part of Proposition 1 states that the firm accepts volatility in its profit to the extent that there is UIP deviation. That is, the firm bears some uncertainty in profit as long as the foreign interest rate is lower than the local one. In the extreme case when there is no UIP deviation ($\Sigma = 0$), there is no difference in the borrowing costs of two currencies, and hence the firm will borrow exact amount of foreign currency debt to eliminate ex-ante volatility in its profit.

Despite being intuitive, Proposition 1 is not yet a full characterization of the firm's foreign currency debt share, since the amount of capital K is also endogenous. We use the expression of the optimal K in Appendix A.6 to characterize the optimal foreign currency debt share in the following proposition. To show the key intuition with a sharp analytical expression, we make two innocuous simplifications. First, we apply a first-order approximation to the expression of the optimal foreign currency debt share. We also assume that the UIP condition is satisfied, as allowing for its deviation does not yield much additional insights.[13]

Proposition 2. *Under the UIP condition and the first order approximation, the optimal share of foreign currency debt can be expressed as*

[13] In Appendix A.7, we show that the UIP deviation simply increases the optimal foreign currency debt share without much additional insights. In the empirical investigation, the UIP deviation is likely to be absorbed by the constant term in our regression since it has a common effect on all firms. In Appendix B, we show that the estimate of σ^2 is around 0.01, and thus it is safe to focus on the first order terms.

$$\frac{b^*}{(1+r^*)K} = \frac{(1+r)}{(1+r^*)} \frac{(\alpha\eta + \lambda\beta(1-\eta))}{(1-\beta)(\eta-1)} \tag{9}$$

which increases with the firm's export share α and decreases with the firm's imported intermediate input share λ.[14]

Proof. See Appendix A.6 for proofs. □

Proposition 2 states that the firm reduces the exchange rate volatility in its profit by raising the foreign currency debt share when the export share becomes higher. In the meantime, an increase in the imported intermediate input share lowers its optimal foreign currency debt share. Intuitively, the firm can adjust the ex-ante foreign currency debt share to reduce the foreign exchange risk in profit.

In our empirical exercise, we test the prediction of Proposition 2 with the KIS data, which provides rich information on firms' currency composition of debts. However, we note that the KIS data reports firm-level *exports*, but does not contain information on *imports*. Hence, we rely on the share of foreign currency account payables in total account payables along with the input-output table in Korea to approximate import shares at the firm-level.[15] As we acknowledge the measurement errors with the approximated import shares, we primarily build our empirical analysis around exports in Section 3. In Section 4, we utilize the constructed import data to examine the effects of both imports and exports.

[14]If the right hand side of equation (9) is larger than 1, then $\frac{b^*/(1+r^*)}{K}$ is set to 1 to guarantee that $b \geq 0$.

[15]We detail this procedure and the assumptions associated with this approach in Section 4.

3 Empirical Strategy and Estimation Results

3.1 Data Description

The main dataset used in our empirical analysis is the KIS (KIS-Value) data provided by the NICE Information Service Co.,Ltd.[16] Both listed and private firms with total assets over 12 billion won are required to report their financial statements every year to the Financial Services Commission in Korea.[17] Firms that do not meet these criteria can also voluntarily report their financial statements. As mentioned in Kim et al. (2015), a key advantage of KIS data is that it includes rich information on small firms, ensuring the empirical results to be relevant for a wide range of firms.

From the KIS data, we extract firms' information including annual total revenue, export revenue, total liabilities, liabilities in foreign currency, location and industry classifications.[18] We focus on the 1999-2007 period to rule out the impact from the Asian financial crisis in 1998 and the 2008-2009 Great Recession. Importantly, South Korea did not adopt a floating exchange rate regime until 1998, which created an incentive for firms to hedge foreign exchange rate risk. During and after the global financial crisis South Korea strengthened various capital control measures, which made it substantially more difficult for Korean firms to borrow funds in foreign currency (see Bruno and Shin (2014) and Ahn et al. (2019)). Thus, we posit that the period between 1999 and 2007 is ideal for our study.

In Figure 1, we compare the aggregate export values reported from the KIS data with the total South Korean export data from the UN COMTRADE (reported by South Korea

[16]NICE Information Service Co.,Ltd. was founded by the merging of National Information & Credit Evaluation Inc., and Korea Information Service, Inc. in November 2010.

[17]Alternatively, firms with total assets over 7 billion won and over 300 employees are also required to report audited financial statements.

[18]The original industry classification in the KIS data follows the 5-digit KSIC (Korea Standard Industry Classification) rev. 9. In order to match this with global international trade data, we merge the KSIC classification to the ISIC (International Standard Industry Classification) rev. 3. We focus on the manufacturing sector which is the major tradable sector in our analysis since our instrumental variable approach will rely on international trade data.

to the United Nations) database. We find that they track each other well, which suggests that firms in the KIS data account for almost all of Korean exports.[19]

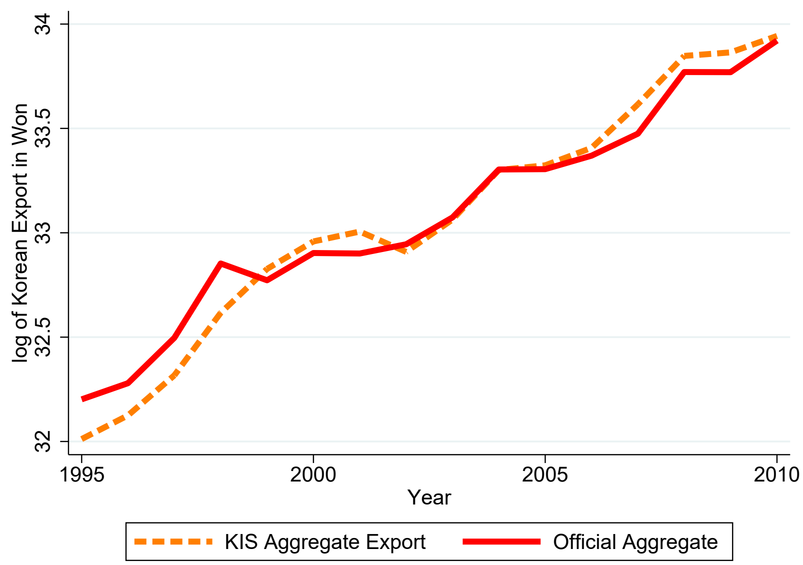
In Figure 2, we compare the aggregate foreign currency debts in the KIS data with the non-financial sector's total external debts (borrowing from foreign entities) provided by the official Korean Statistical Information Service. It is important to note that *foreign currency* debts are slightly different from the *external* debts from the official data, because not all external debts are denominated in foreign currencies. Moreover, the non-financial sector also includes households and NGOs that are not included in the KIS data. Nevertheless, we observe in Figure 2 that the aggregate foreign currency debt from the KIS data tracks South Korean non-financial sector's external debt reasonably well. This pattern is consistent with the notion of "original sin" that emerging and developing countries denominate most of their external debts in foreign currencies.

The KIS dataset includes firm-level export revenues but does not report their currency composition. However, using the aggregate data (see Figure 3), we confirm that Korean exports are almost entirely invoiced in foreign currencies and, in particular, the US dollar is the dominant one. This phenomenon is consistent with the growing literature on the use of dominant currencies in trade (e.g., Mukhin (2018), Gopinath et al. (2020)). Therefore, we argue that it is reasonable to proxy firms' foreign currency revenue shares with the shares of export sales in total sales.

In addition, we also employ the publicly available CEPII BACI database, which provides disaggregated annual data on bilateral trade flows for more than 5000 products and 200 countries. The product classification is at the Harmonized System (HS) 6-digit level and is built from the raw data directly reported by each country to the United Nations Statistical Division. This dataset enables us to construct trade shocks from South Korea's trading partners at the industry level. We convert the HS 6-digit product level data to the

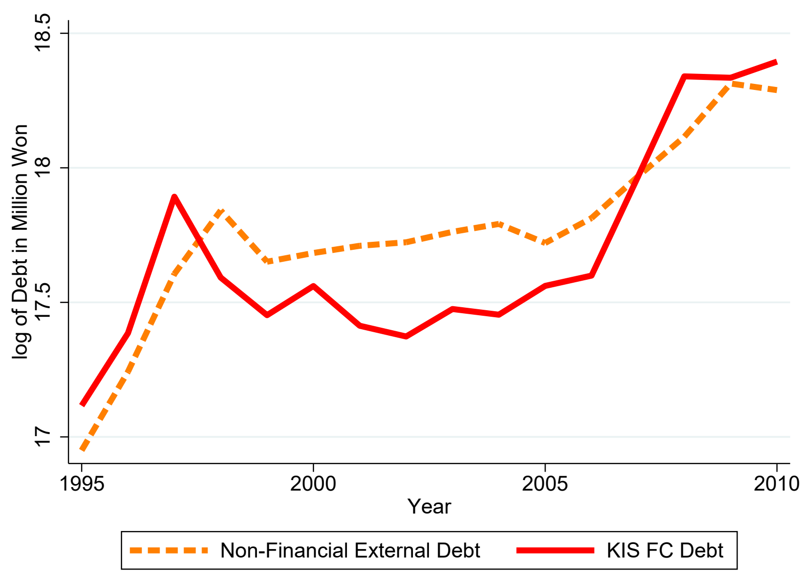
[19] The original UN COMTRADE database is recorded in USD (US dollar) and the KIS dataset is recorded in KRW (Korean won). We resolve this mismatch by using annual average exchange rates from the World Development Indicators database to convert the UN COMTRADE data to KRW.

Figure 1: Aggregate Korean Export: KIS v.s. UN COMTRADE Data



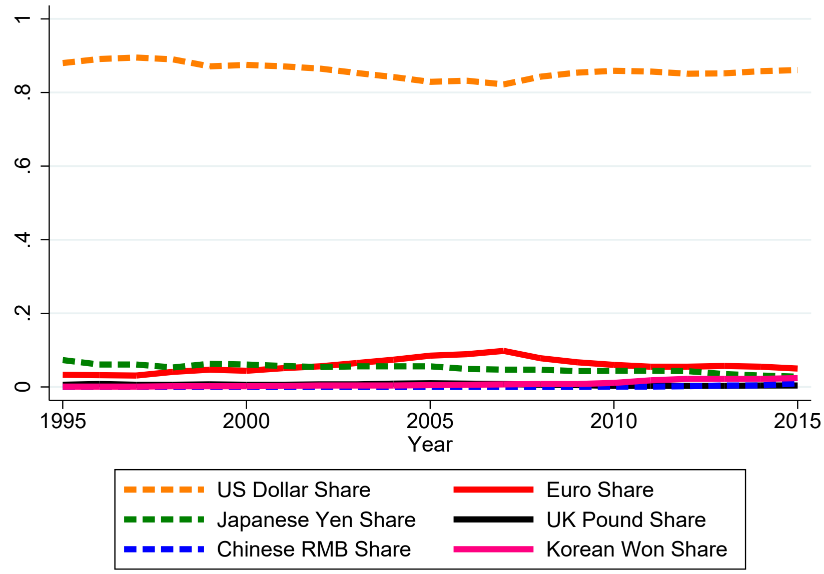
Notes: This figure compares the aggregate exports in the KIS dataset with that from the official UN COMTRADE.

Figure 2: Aggregate Korean Debt: KIS FC Debt and Official External Debt



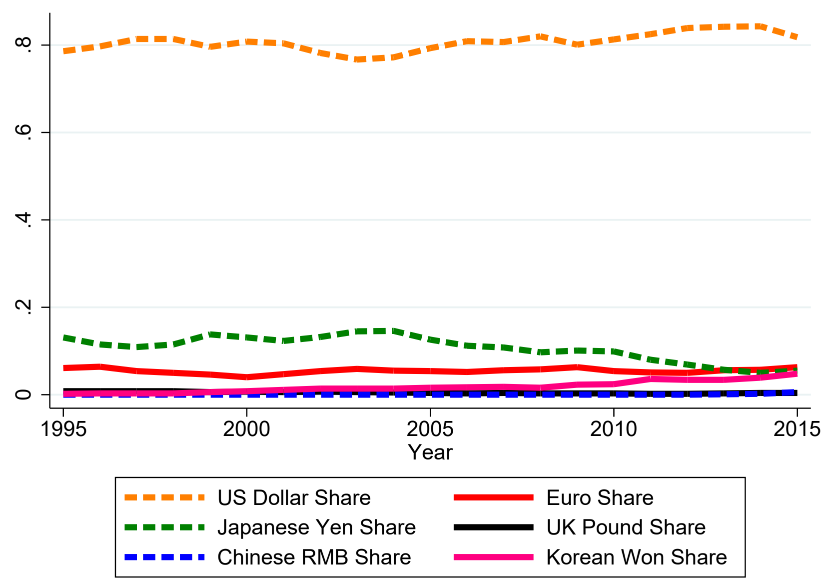
Notes: This figure compares the aggregate foreign currency debts from the KIS dataset with the official statistics (Korean Statistical Information Service) on the external debt of the non-financial sector.

Figure 3: Korean Export Currency Composition



Notes: This figure provides a breakdown of Korean export sales by settlement currencies. Data source: Bank of Korea.

Figure 4: Korean Import Currency Composition



Notes: This figure provides a breakdown of Korean import by settlement currencies. Data source: Bank of Korea.

ISIC 4-digit industry level by using the concordance table provided by the World Bank World Integrated Trade Solution (WITS).[20]

Our empirical strategy is to identify the effects of export shares on firms' foreign currency debt shares. The variable fc_share of firm i in year t is constructed as follows:

$$fc\_share_{it} = \frac{foreign\ currency\ debt_{it}}{total\ debt_{it}}, \tag{10}$$

where $foreign\ currency\ debt_{it}$ and $total\ debt_{it}$ denote firm i's debt in foreign currency and total debt in year t, respectively.[21] The key explanatory variable "export share" of firm i in year t is given by

$$ex\_share_{it} = \frac{export\ sales_{it}}{total\ sales_{it}}. \tag{11}$$

As the names suggest, $export\ sales_{it}$ and $total\ sales_{it}$ are the total export revenue and total revenue of firm i in year t, respectively.

Summary statistics reported in Panel A of Table 1 show that among the 4908 firms in 1999 in the dataset, the average foreign currency debt share is 4.9% (the sum of all KIS firms' foreign currency debt accounts for approximately 9% of their total debt in the same year) and the average export share is 7.3%. There are 1155 exporters and 1324 foreign currency borrowers, each accounting for around a quarter of our sample. We also report various conditional averages (not shown in Table 1) to understand the relation between exporting and borrowing in foreign currency. Conditional on exporting, the average export share is 31.04% and the average foreign currency debt share is 8.40%. Conditional on borrowing in foreign currency, the average foreign currency debt share is 18.49% and the average export share is 15.42%. These statistics imply a strong positive correlation between exporting and borrowing in foreign currency.[22]

[20]Concordance tables are available at wits.worldbank.org/product_concordance.html.

[21]Our definition of debt includes all of firms' liabilities but excludes account payables, because in our model, debt is used to entirely finance investments. However, our results are robust to including account payables in firms' debts.

[22]Table C.1 in the Appendix reports cross sectional regressions to illustrate this positive correlation.

Table 1: Summary Statistics

	obs.	mean	s.d.	min	max	p25	median	p75
Panel A: Year 1999								
foreign currency debt share	4902	0.049	0.127	0	0.956	0	0	0.012
export share	4908	0.073	0.192	0	1	0	0	0
export dummy	4908	0.235	0.424	0	1	0	0	0
Panel B: Long Difference 1999-2007								
Δ foreign currency debt share	4707	0.001	0.163	-0.956	0.900	0	0	0
Δ export share	4707	0.024	0.190	-0.999	1.000	0	0	0

Notes: This table displays the summary statistics of key variables in our empirical analysis. Obs. indicates the number of firms that report the relevant variables. S.d., p25 and p75 indicate the standard deviation, 25th and 75th percentile of the distributions, respectively. Data source: KIS.

3.2 Changes in Export Shares and Foreign Currency Debt Shares

As the first step of our empirical analysis, we estimate a long-difference regression model to examine the response of changes in foreign currency debt shares to changes in export shares. We study the changes in our key variables between 1999 and 2007, because South Korea adopted a floating exchange regime since 1998.[23] (See Reinhart and Rogoff (2004) on the exchange rate regime classifications) Compared with panel regressions, long-difference regressions allow us to capture relative bigger changes in both export and foreign currency debt shares and alleviate concerns with sluggish changes in variables. (As a robustness check, in Table C.3 of the Appendix C, we also provide a panel regression using the data between 1999 and 2007. Our preferred results in column (4) with the most stringent fixed effects indeed provide a much smaller point estimate than our benchmark long-difference results.) The main regression specification in long-difference is:

$$\Delta fc\_share_i = \alpha + \beta * \Delta ex\_share_i + \gamma X_i + \epsilon_i, \tag{12}$$

where Δ denotes the change of relevant variables between 1999 and 2007 and X_i are a set of covariates that include dummy variables indicating the firm's industry classification, main bank, location, year of establishment, whether the firm is listed on a stock exchange and whether the firm belongs to a chaebol.[24] The main bank dummy partially controls for unobserved credit-supply factors that may determine firms' foreign currency debt shares.[25] ϵ_i is the error term of the regression. The main coefficient of interest is β, which should be positive according to our theory.

Panel B of Table 1 shows the summary statistics of the long differences in foreign currency debt and export shares. The long difference strategy requires firms to exist in

[23] This regime change allows us to design a placebo test using the data prior to 1998. We provide the details and results of this test in Section 3.5.

[24] A South Korean chaebol is a family-owned business that typically has subsidiaries across diverse industries. Notable chaebols include Hyundai, Samsung, LG, and SK.

[25] The main bank of a firm is usually the largest lender of the firm and deals with most of the firm's transactions. See Amiti and Weinstein (2011) for a similar context in Japan.

Table 2: FC Debt and Export Share: Long Difference

	(1)	(2)	(3)
Dependent Variable: change in FC debt share			
change in export share	0.049***	0.042***	0.040***
	(0.010)	(0.011)	(0.011)
Industry FE	N	Y	Y
Location FE	N	N	Y
Founded Year FE	N	N	Y
Chaebol dummy	N	N	Y
Public firm dummy	N	N	Y
Main bank dummy	N	N	Y
Observations	4707	4707	4643
R^2	0.003	0.035	0.107

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table displays the relationship between the changes in foreign currency (FC) debt shares and that in export shares between 1999 and 2007. Standard errors are in parentheses. In columns (1) and (2), we cluster standard errors at the industry level and in column (3), standard errors are two-way clustered at the industry and location levels.

both 1999 and 2007 which leads to a smaller sample size. While the average changes in export and foreign currency debt shares are relatively small (0.024 and 0.01, respectively), there are wide variations across the firms as shown by much greater standard deviations of the changes in export (0.19) and foreign currency debt (0.16) shares.

We report the long-difference regression results in Table 2. In column (1), we do not include any controls and regress changes in foreign currency debt shares on changes in export shares. We estimate that 1 percentage point increase in export shares is associated with on average 0.049 percentage point increase in foreign currency debt shares. The positive estimate of the coefficient is consistent with our model prediction. In column (2), we include industry fixed effects and find that the point estimate remains positive and statistically significant. In column (3), we control for additional firm-level characteristics and find that the point estimate becomes smaller, but remains statistically significant.

Figure 5 shows a bin-scatter plot between the long difference relationship of export shares and foreign currency debt shares. The scatter plot reveals that the observations fall around the trend line, suggesting that the positive and significant coefficient estimates reported in Table 2 are not driven by outlier firms.

Although long-difference regressions can address endogeneity concerns associated with time-invariant unobserved firm characteristics, additional endogeneity problems can persist from time-varying firm characteristics or a correlation between export share and FC debt share caused by the exchange rate movement.[26] In addition, the reverse causality problem may also pose a major threat to identification.[27] In the following subsection, we address the remaining concerns by introducing our key identification strategy that exploits both the domestic demand shock in Korea and the external demand shocks from South Korea's trading partners to instrument changes in export shares.

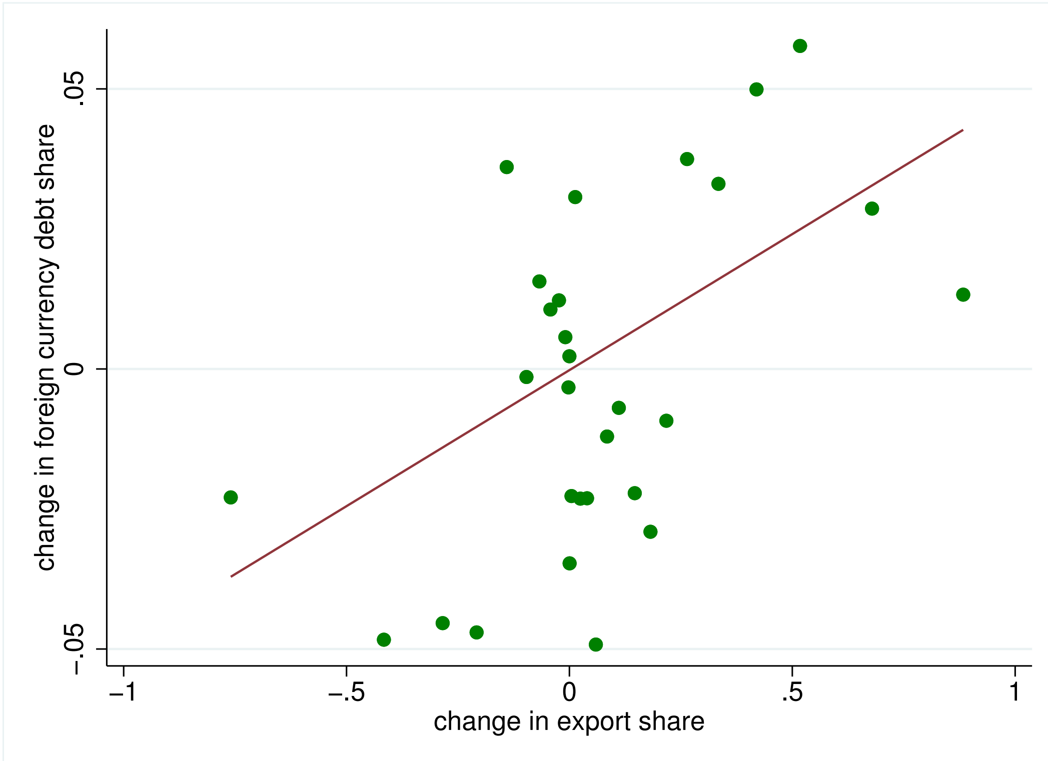
3.3 Demand Shocks as an Instrument

Firms' export shares are determined by both demand and supply side factors. Aggregate demand side factors (e.g., domestic or foreign demand shocks) are generally considered as exogenous to firms. Firm-level supply side factors (such as firm productivity and close connection to foreign firms), on the other hand, can be endogenous to firms' foreign currency debt shares. Our identification strategy uses foreign demand shocks to construct an instrument to capture the exogenous variation of firms' export shares.

[26]For example, if KRW appreciates against USD, holding constant the quantities of exports and debts, both export and FC debt shares will simultaneously decrease. However, our instrumental variable approach can address this problem, since foreign demand shocks for goods produced outside Korea can be regarded as uncorrelated with fluctuation in the value of KRW.

[27]For example, the dynamic trade-off discussed in Salomao and Varela (2020) shows that firms that borrow in foreign currency can grow faster, potentially expanding their activities abroad and generating higher export revenues. Our IV approach also addresses this reverse-causality concern.

Figure 5: Scatter Plot of the Long-Difference Patterns



Notes: This figure displays the relationship between the change in export share and the change in foreign currency debt share between 1999-2007 using a bin-scatter plot.

We first express the change in export share (from 1999 to 2007) for a firm i as

$$\Delta ex\_share_i = \frac{export\_sales_{i0} * (1 + g_{ei})}{export\_sales_{i0} * (1 + g_{ei}) + domestic\_sales_{i0} * (1 + g_{di})} - \frac{export\_sales_{i0}}{export\_sales_{i0} + domestic\_sales_{i0}}, \tag{13}$$

where g_{ei} is the growth rate in export sales, g_{di} is the growth rate of domestic sales and the subscript "0" indicates the initial year. Our identification strategy is to capture the exogenous variations in g_{ei} and g_{di} with instrumental variables.

In specific, we instrument g_{ei} of all firms in industry j with the industry-wide growth rate g_j^{IV}, which is constructed with South Korea's trading partners' (over 200 countries) imports from the rest of the world *except* South Korea. We calculate South Korea's external demand shocks from foreign markets in industry j as

$$g_j^{IV} = \sum_k s_{jk,0} * import\_growth_{jk}, \tag{14}$$

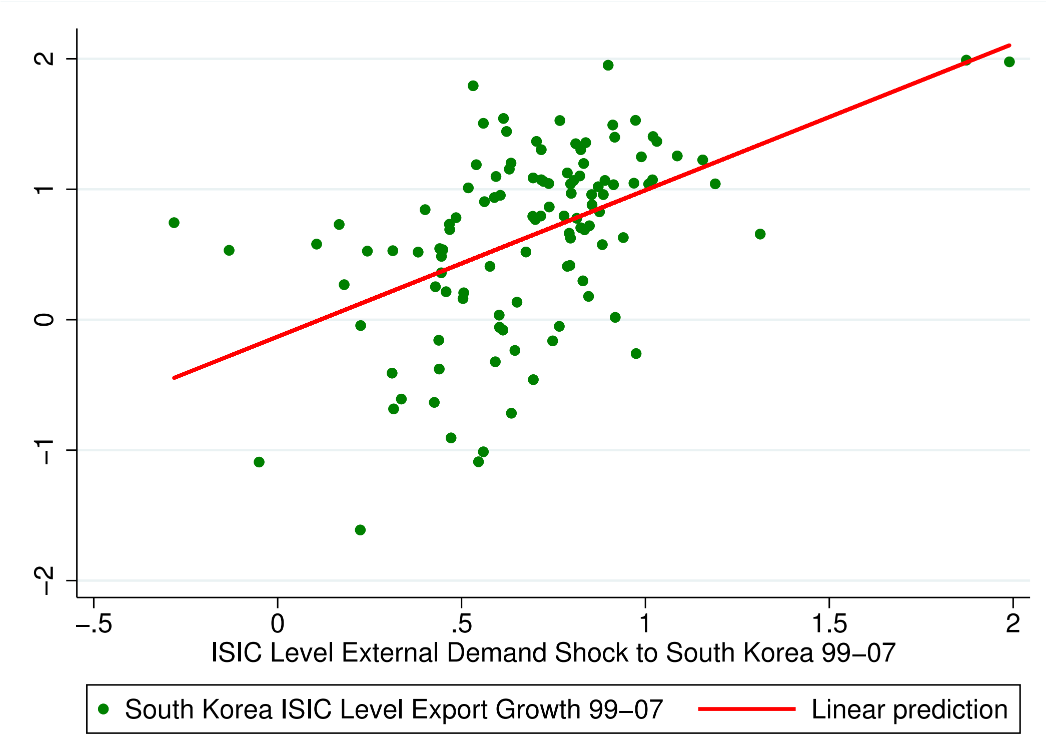
where $s_{jk,0} = \frac{export_{jk0}}{\sum_k export_{jk0}}$ with $export_{jk0}$ denoting South Korea's export sales to country k in industry j evaluated in the initial year 1999 (by construction, $\sum_k s_{jk,0} = 1$). $import\_growth_{jk}$ is country k's import growth rate from 1999 to 2007 from the rest of the world (excluding South Korea), and is computed as $import\_growth_{jk} = \frac{import_{jk,2007} - import_{jk,1999}}{(import_{jk,2007} + import_{jk,1999})/2}$, where we followed the growth formula provided by Levinsohn (1999) and Haltiwanger et al. (2013). This formula of the import growth rate has the advantage of accommodating values of zero in either 1999 or 2007 (but not both) and also mitigates the impact from outliers.

In Figure 6, we plot South Korea's actual industry-level export growths between 1999 and 2007 against our constructed external demand shocks g_j^{IV}. We estimate that the slope coefficient of the trend line is 1.122 with a robust standard error of 0.189, suggesting that South Korea's export growth rate at the industry level can be well explained by our external demand shocks.

Next, we instrument the domestic sales growth rate g_{di} using the growth rate of South Korea's aggregate domestic absorption (output-export+import) between 1999 and 2007 at the national level, denoted by z_d^{IV}. The choice of using national (instead of industry level) domestic absorption growth rate is to prevent the endogeneity concern that an industry-wide technological progress can potentially affect both export and foreign currency debt shares.

This leads us to our instrumental variable for the change in export share from year

Figure 6: External Demand Shocks and South Korea's Export Growth



Notes: This figure displays the relationship between Korean export growth rate from 1999 to 2007 and our constructed external demand shock at the industry level. Each dot represents an ISIC rev.3 4-digit industry. The slope in the figure is 1.122 (with robust standard error 0.189).

1999 to 2007 for a firm i in industry j , defined as:

$$\Delta ex\_share_i^{IV} = \frac{export\_sales_{i0} * (1 + g_j^{IV})}{export\_sales_{i0} * (1 + g_j^{IV}) + domestic\_sales_{i0} * (1 + z_d^{IV})} - \frac{export\_sales_{i0}}{export\_sales_{i0} + domestic\_sales_{i0}}, \tag{15}$$

where $export\_sales_{i0}$ and $domestic\_sales_{i0}$ are the 3-year average of sales from 1997 to 1999 in foreign and domestic markets, respectively. We refer to this instrumental variable as the "demand shock IV." It is important to note that despite being in the same industry, firms can have different values of the instrumental variable because of differences in their initial sales compositions. Appendix D provides additional discussions on the validity of the instrument. Guided by Goldsmith-Pinkham et al. (2020), we include additional control variables that potentially correlate with firms' initial export shares, including firm size, leverage ratio etc. in Table D.1.

Panel A in Table 3 presents the two-stage least square results using $\Delta ex\_share_i^{IV}$ as an instrument for the changes in export shares. In column (1), we account for industry fixed effects and estimate that 1 percentage point increase in export shares leads to 0.18 percentage point increase in foreign currency debt share and the estimated coefficient is statistically significant at 5% level. As we include more control variables such as location fixed effect, year of establishment fixed effect, chaebol, and public firm dummies in column (2), the point estimate remains statistically significant albeit with a smaller magnitude. Both point estimates appear to be two to three times larger than the OLS estimates presented in Table 2. This could arise from unobserved factors (to econometricians) that simultaneously increase (decrease) export shares while decrease (increase) foreign currency debt shares or from measurement errors that cause attenuation bias. In column (3), we present the reduced-form results from a regression of changes in foreign currency debt shares on the demand shock IV and find that the point estimate is also positive and statistically significant.

Table 3: Long Difference: IV Regression

	(1)	(2)	(3)
Panel A: Two-Stage Least Square			
Dependent Variable: change in FC debt share			
change in export share	0.182**	0.122**	
	(0.080)	(0.052)	
demand shock IV			0.216**
			(0.090)
Industry FE	Y	Y	Y
Location FE	N	Y	Y
Founded Year FE	N	Y	Y
Chaebol dummy	N	Y	Y
Public firm dummy	N	Y	Y
Main bank dummy	N	Y	Y
Observations	4558	4500	4500
R^2	-0.022	-0.008	0.108
	(1)	(2)	(3)
Panel B: First-Stage			
Dependent Variable: change in export share			
demand shock iv	1.268***	1.763***	
	(0.176)	(0.166)	
Industry FE	Y	Y	
Location FE	N	Y	
Founded Year FE	N	Y	
Chaebol dummy	N	Y	
Public firm dummy	N	Y	
Main bank dummy	N	Y	
Observations	4,564	4,500	
R^2	0.066	0.170	
Sanderson-Windmeijer F-stat	52.66	116.52	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the results of the instrumental variable approach to examine the causal effect of higher export share on higher foreign currency (FC) debt share among Korean firms between 1999 and 2007. Panel A shows the two-stage least square regression results and Panel B shows the first-stage regression results. Standard errors in parenthesis are clustered at the industry level in column (1) and are two-way clustered at the industry and location levels in column (2).

Panel B in Table 3 shows the first stage regression results, where we regress changes in export shares on the instrumental variable $\Delta ex\_share_i^{IV}$. From the two columns, we observe that the coefficient estimates remain positive and significant even after controlling for additional covariates. The F-statistics at the bottom of Panel B are 52.66 and 116.52, respectively, showing that our instrumental variable is robust.

3.4 Robustness Checks

In this subsection, we perform several robustness checks to demonstrate that our main regression results are not sensitive to: (1) excluding firms with financial hedge against exchange rate risk, (2) excluding major lending countries' demand shocks from the construction of the instrumental variable, and (3) using an alternative measure of debt that deducts firms' cash holdings.[28]

3.4.1 Hedging with Financial Instruments?

Our theoretical framework does not consider the use of financial instruments to hedge exchange rate risk. If firms have access to financial instruments, the positive link between foreign currency debt and export shares may become theoretically tenuous. We address this concern by exploiting the information on firms' currency swaps and forwards, which are generally considered as the major financial instruments used to hedge exchange rate risk (e.g., Du and Schreger (2016)).

In the KIS data, however, we note that the fraction of firms that use currency swaps and forwards are very low and never exceeds 4% in any year during our sample period. This observation is consistent with previous studies that have also documented a limited use of financial instruments against foreign exchange rate risk in South Korea. The first exchange to trade financial derivatives based on foreign exchange was established in Ko-

[28]In Table C.4 in Appendix C, we include additional control variables (firm size, leverage ratio and foreign currency asset share) and show the robustness of our main results.

Table 4: Dropping Firms with Currency Swap and Forward Holdings

	(1)	(2)	(3)	(4)
Dependent Variable:	change in FC debt share			
	Long Difference: OLS		Long Difference: IV	
change in export share	0.048***	0.048***	0.200***	0.154**
	(0.010)	(0.012)	(0.076)	(0.061)
Industry FE	Y	Y	Y	Y
Location FE	N	Y	N	Y
Founded Year FE	N	Y	N	Y
Chaebol dummy	N	Y	N	Y
Public firm dummy	N	Y	N	Y
Main bank dummy	N	Y	N	Y
Observations	4,348	4,285	4,207	4,149
R^2	0.033	0.106	-0.029	-0.012

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the relationship between foreign currency debt share and export share after dropping firms that hold currency swaps or forwards in any of years between 1999 and 2007. Standard errors in columns (1) and (3) are clustered at the industry level. Standard errors are two-way clustered at the industry and location levels in columns (2) and (4).

rea in 1999, and due to strict regulations, foreign exchange derivatives were not traded extensively (Baba and Shim, 2014).

We test the robustness of our results by excluding firms with any currency swaps or forwards during the period between 1999 and 2007 and report the estimates in Table 4. Columns (1) and (2) report the long difference analysis from 1999 to 2007, and columns (3) and (4) are the IV regression results. We find that the point estimates become even greater than our benchmark IV estimates and remain statistically significant.

3.4.2 Dropping Major Lenders' Demand Shocks

A valid instrument should satisfy the standard exclusion restriction that the instrumental variable Δex_share^{IV} does not affect changes in foreign currency debt shares directly. One concern is that demand shocks and credit supply shocks may be correlated. In specific, foreign credit supply shocks will increase both foreign demand and lending to Korean firms. This is well addressed by the alternative IV strategy in this subsection to drop the key lending countries from the construction of foreign demand shocks. This potentially impacts the validity of our identification strategy, because demand shocks in foreign countries can raise exporters' foreign currency debt shares through channels beyond what we have proposed.

We mitigate this concern by proposing an alternative way to construct demand shock IV, in which we exclude South Korea's major creditor countries' demand shocks (in equation (14)). Since South Korean firms typically do not borrow from remaining countries, this alternative IV overcomes the possible threat of identification mentioned above.

To this end, we use the aggregate data from the Bank for International Settlement (BIS) to identify South Korea's major lenders. In 2000, 79% of South Korea's foreign borrowings were from five developed economies: United States (26%), Japan (17%), France (13%), Germany (12%) and United Kingdom (11%).[29] These five countries' demand shocks are dropped from the construction process of g_j^{IV}, specified in equation (14).

We report the new results with this alternative demand shock IV in Table 5. The two-stage least squares point estimates in columns (1) and (2) of Panel A continue to be positive and statistically significant and their magnitudes are highly comparable to our benchmark estimates. In column (3) of Panel A, we perform a reduced-form regression in which we regress changes in foreign currency debt shares on the alternative demand shock IV and find that the reduced-form coefficient is positive and statistically significant. Panel B of Table 5 presents the first-stage regressions, and the F-statistics confirm that our alternative demand shock IV is not subject to weak IV concerns.

[29] These five countries continue to be the largest lenders to South Korea leading into 2007, in which they comprised more than 74% of foreign lending to South Korea in the dataset.

Table 5: Long Difference: Alternative Demand Shock IV without Major Lenders

	(1)	(2)	(3)
Panel A: Two-Stage Least Square			
Dependent Variable: change in FC debt share			
change in export share	0.190**	0.128**	
	(0.076)	(0.051)	
alter. demand shock IV			0.185**
			(0.072)
Industry FE	Y	Y	Y
Location FE	N	Y	Y
Founded Year FE	N	Y	Y
Chaebol dummy	N	Y	Y
Public firm dummy	N	Y	Y
Main bank dummy	N	Y	Y
Observations	4558	4500	4500
R^2	-0.025	-0.008	0.109

	(1)	(2)	(3)
Panel B: First-Stage			
Dependent Variable: change in export share			
alter. demand shock IV	1.038***	1.445***	
	(0.136)	(0.134)	
Industry FE	Y	Y	
Location FE	N	Y	
Founded Year FE	N	Y	
Chaebol dummy	N	Y	
Public firm dummy	N	Y	
Main bank dummy	N	Y	
Observations	4,564	4,500	
R^2	0.077	0.174	
Sanderson-Windmeijer F-stat	58.88	119.96	

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the IV regression results with the alternative IV (constructed without demand shocks from major lender countries – United States, Japan, France, Germany and United Kingdom) to examine the connection between the changes in foreign currency (FC) debt shares and the changes in export shares between 1999 and 2007. Panel A shows the two-stage least square regression results and Panel B shows the first-stage regression result. Standard errors are clustered at the industry level in column (1). Standard errors are two-way clustered at the industry and location levels in column (2).

3.4.3 Alternative Measure of Foreign Currency Debt Share

Firms often hold cash and cash-equivalent as a buffer against unexpected shocks. As a result, it is plausible that "net debt", defined as debt minus cash and cash equivalent assets, is more relevant when firms seek to hedge the exchange rate risk. In our empirical exercise, we define net foreign currency debt share as

$$fc\_debt\_share^{\text{net}} = \frac{\text{net debt in foreign currency}}{\text{net debt}}. \tag{16}$$

An important caveat is that this definition can produce negative $fc\_debt\_share^{\text{net}}$ in our data, if, for example, firms' cash holdings are larger than their debts. In a few extreme cases, we find that when the denominator (amount of net debt) is small, $fc\_debt\_share^{\text{net}}$ can become far outside the interval [0,1]. Such cases can produce impactful outliers and hence we drop observations (around 2 percent of the sample) whose $fc\_debt\_share^{\text{net}}$ is either negative or greater than 1.

We present the regression results using the net foreign currency debt shares as the dependent variable in Table 6. All columns show consistent results that firms with higher export shares exhibit higher foreign currency debt share. As shown in columns (3) and (4), we find that the coefficient estimates derived from IV regressions are greater in magnitude than our benchmark estimates, consistent with the notion that changes in net foreign currency debt shares are more responsive to trade shocks.

3.5 The Role of Exchange Rate Regime

As our analysis has shown, exchange rate risk is a key factor when firms determine the currency composition of their debts. Accordingly, we expect that when the exchange rate volatility is lower, firms' foreign currency debt shares become *less* responsive to export shares.

We test this hypothesis by taking advantage of South Korea's exchange rate regime

Table 6: Regression Results with Net Foreign Currency Debt Share

	(1)	(2)	(3)	(4)
Dependent Variable:	changes in net FC debt shares			
	Long Difference: OLS		Long Difference: IV	
change in export share	0.049**	0.045*	0.325***	0.172***
	(0.022)	(0.026)	(.106)	(0.069)
Industry FE	Y	Y	Y	Y
Location FE	N	Y	N	Y
Founded Year FE	N	Y	N	Y
Chaebol dummy	N	Y	N	Y
Public firm dummy	N	Y	N	Y
Main bank dummy	N	Y	N	Y
Observations	4,596	4,532	4,451	4,393
R^2	0.030	0.097	-0.063	-0.012

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the relationship between foreign currency debt share and export share where debt is redefined as the "net debt" (liability-cash holdings). Standard errors are clustered at the industry level in columns (1) and (3). Standard errors are two-way clustered at the industry and location levels in columns (2) and (4).

shift to implement a placebo test. For over a decade prior to 1997, South Korea's exchange rate regime was classified as a crawling peg (Reinhart and Rogoff (2004)), which featured low exchange rate volatility.[30] We follow the same IV approach in previous sections to implement the long-difference IV regressions with the KIS data between 1988 and 1996. To construct external demand shocks, we use the UN COMTRADE international trade data at the industry (SITC rev. 2) and country level.[31] We then construct the ISIC industry-level external demand shocks with the concordance table between SITC and ISIC provided by WITS.

Table 7 presents new regression results using data from 1988 to 1996. We confirm that regression results under various specifications lead to smaller and mostly insignificant point estimates. This is consistent with our expectation that lower exchange rate volatility reduces firms' incentives to adopt operational hedges via adjusting their foreign currency debt shares.[32]

4 Global Supply Chains and Currency Composition of Debt

Our analysis thus far has focused on the impact of exports on the currency composition of debts. We now extend the empirical analysis to account for firms' imported intermediate inputs. The rise of global value chain has been well documented in the recent literature (e.g. Johnson and Noguera (2012), Wang et al. (2017)). Nowadays, imported goods are not only used for final consumption, but are also widely used as intermediate inputs for production.

In this section, we investigate the role of firms' foreign intermediate input shares in determining foreign currency debt shares. Unfortunately, the KIS data does not contain

[30] See Figure C.2 for the historical exchange rate between KRW and US dollar since 1980s.

[31] CEPII BACI database does not include pre-1990 data, so we use the UN COMTRADE instead. The majority of countries did not adopt the Harmonized System until 1990.

[32] One concern is that before 1997, Korean firms may have limited access to foreign currency debt. However, we find that Korean non-financial sector's external debt/GDP in 1995 and 2005 are fairly comparable with a value of 5.4%.

Table 7: Periods with Lower Exchange Rate Risk 1988-1996

	(1)	(2)	(3)	(4)
Dependent Variable:	change in FC debt share			
	Long Difference: OLS		Long Difference: IV	
change in export share	0.029	0.024	0.105**	0.078
	(0.032)	(0.032)	(.040)	(.056)
Industry FE	Y	Y	Y	Y
Location FE	N	Y	N	Y
Founded Year FE	N	Y	N	Y
Chaebol dummy	N	Y	N	Y
Public firm dummy	N	Y	N	Y
Main bank dummy	N	Y	N	Y
Observations	1,046	982	1,014	960
R^2	0.111	0.280	-0.017	-0.009

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the relationship between foreign currency debt share and export share in the period 1988-1996 when the exchange rate regime in South Korea features less volatility than the post 1997 period. Standard errors are clustered at the industry level in columns (1) and (3). Standard errors are two-way clustered at the industry and location levels in columns (2) and (4).

information on firms' imported intermediate inputs. Instead, it has information on firms' account payables in foreign currency and local currency, respectively. In addition, there is also information on total labor cost and total intermediate input cost. We use these data series to infer firms' foreign intermediate input shares under reasonable assumptions that we describe below.

From the KIS data, we obtain total intermediate input cost at the firm level but do not know the share of intermediate inputs in domestic currency or that in foreign currencies. We assume that all imports are invoiced in foreign currency (see Figure 4 for the aggregate patterns) and domestic transactions are invoiced in KRW. However, since the account payable periods may differ between imported and domestic inputs, we make the assumption that, in each industry, firms have the same (relative) account payable periods for imported and domestic inputs. We rescale firms' account payables in each industry such that the share of total rescaled foreign currency account payables is equal to the share of foreign intermediate input in each industry. We obtain the latter from South Korea's input-output table in 1998 provided by Bank of Korea. For an industry j that consists of firms denoted by the index i, we introduce the industry-specific scaling parameter χ_j such that

$$\frac{\text{imported intermediate input}_j}{\text{imported intermediate input}_j + \text{domestic intermediate input}_j} = \frac{\sum_i \text{FC account payable}_i * \chi_j}{\sum_i \text{FC account payable}_i * \chi_j + \sum_i \text{LC account payable}_i} \tag{17}$$

where "FC" denotes foreign currencies and "LC" denotes the local currency. We obtain the shares on the left-hand side of the above equation from the input-output table and the data needed for the right-hand side from the KIS data.

With the scaling parameter χ_j for each industry, we calculate the amount of imported intermediate input and domestic intermediate input of each firm as

$$\text{imported intermediate input}_i = \text{total intermediate input}_i * \frac{\text{FC account payable}_i * \chi_j}{\text{FC account payable}_i * \chi_j + \text{LC account payable}_i}, \tag{18}$$

and

$$\text{domestic intermediate input}_i = \text{total intermediate input}_i - \text{imported intermediate input}_i. \tag{19}$$

The imported intermediate input share of a firm's total input is then

$$\text{import share}_i = \frac{\text{imported intermediate input}_i}{\text{imported intermediate input}_i + \text{domestic intermediate input}_i + \text{labor cost}_i}. \tag{20}$$

To construct an IV for the changes in import shares, we adopt an analogous method as with the changes in export shares. The change in the import share of a firm i in industry j can be decomposed as

$$\Delta im\_share_i = \frac{\text{imported input}_{i0} * (1 + h_{mi})}{\text{imported input}_{i0} * (1 + h_{mi}) + \text{domestic intermediate input}_{i0} * (1 + h_{di}) + \text{labor cost}_{i0} * (1 + h_{li})} - \frac{\text{imported intermediate input}_{i0}}{\text{imported intermediate input}_{i0} + \text{domestic intermediate input}_{i0} + \text{labor cost}_{i0}}, \tag{21}$$

where h_{mi} is the growth rate of the imported input, h_{di} is the growth rate of the domestic intermediate input, and h_{li} is the growth rate of domestic labor cost. The initial values of different components are denoted as imported input$_{i0}$, domestic intermediate input$_{i0}$, and employee cost$_{i0}$.

For h_{mi}, we use South Korea's trading partners' supply shocks in industry j's imported input to construct an instrument as

$$h_j^{IV} = \sum_n share_{jn,0} * export\_growth_n, \tag{22}$$

where $share_{jn,0}$ is industry j's import share from industry n that we obtain from the IO tables (by construction, $\sum_n share_{jn,0} = 1$) and $export\_growth_n$ denotes trading partners' export growth industry n to the rest of the world except South Korea. Here, $export\_growth_n$ is defined as $export\_growth_n \equiv \frac{exportshock_{n,2007} - exportshock_{n,1999}}{(exportshock_{n,2007} + exportshock_{n,1999})/2}$ with $exportshock_{n,t}$ being the weighted (the weight being Korea's import share from country k in industry n in 1999) average of trading partners' exports to the rest of the world in industry n in year t. For h_{di} and h_{li}, we employ South Korea's growth rates in the manufacturing sector's shipment values h_d^{IV} and labor cost h_l^{IV}. In summary, the instrumental variable for the change in import share is given by the following expression

$$\Delta im\_share_i^{IV} = \frac{\text{imported input}_{i0} * (1 + h_j^{IV})}{\text{imported input}_{i0} * (1 + h_j^{IV}) + \text{domestic intermediate input}_{i0} * (1 + h_d^{IV}) + \text{labor cost}_{i0} * (1 + h_l^{IV})} - \frac{\text{imported intermediate input}_{i0}}{\text{imported intermediate input}_{i0} + \text{domestic intermediate input}_{i0} + \text{labor cost}_{i0}}, \tag{23}$$

where imported input$_{i0}$, domestic intermediate input$_{i0}$ and employee cost$_{i0}$ are the 3-year average values for firm i from 1997 to 1999.

In Table 8, we report the extension of our main results with an additional explanatory variable "change in import share". In column (1), we report the OLS regression results. The coefficient estimate of the changes in import shares is negative but not statistically significant, and that of the changes in export shares continues to be positive and statistically significant.

As mentioned, the endogeneity problem may bias the OLS estimates. For instance, the changes in import shares can be driven by firms' access to foreign loans, which facilitates

Table 8: The Role of Global Supply Chain

	(1)	(2)	(3)	(4)
Dependent Variable:	change in FC debt share		change in export share	change in import share
	OLS	IV	OLS	OLS
		Two Stage LS	First Stage	
change in export share	0.046^{***}	0.133^{**}		
	(0.008)	(0.054)		
change in import share	-0.002	-0.194^{**}		
	(0.020)	(0.091)		
demand shock IV			1.594^{***}	-0.370^{*}
			(0.171)	(0.194)
supply shock IV			-0.030	0.949^{***}
			(0.070)	(0.273)
Industry FE	Y	Y	Y	Y
Location FE	Y	Y	Y	Y
Founded Year FE	Y	Y	Y	Y
Chaebol dummy	Y	Y	Y	Y
Public firm dummy	Y	Y	Y	Y
Main bank dummy	Y	Y	Y	Y
Observations	3987	3942	4043	3937
R^2	0.102	-0.067	0.148	0.136
Sanderson-Windmeijer F-stat			55.45	15.26

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the regression results of foreign currency debt shares on export shares and import shares. Standard errors in parenthesis are two-way clustered at the industry and location levels.

the use of foreign inputs and introduces a positive bias in the estimate. An additional concern is that measurement errors in our constructed import shares can cause attenuation bias. Such concerns can all be addressed with our import share IV, which takes advantage of foreign supply shocks.

In column (2), we report the IV regression results where both changes in export and import shares are instrumented with respective IVs. It shows that the point estimates for both coefficients are statistically significant and their signs are the same as the estimates in column (1). In particular, the results in column (2) suggest that 1 percentage point increase in (the change of) import share reduces foreign currency debt share by 0.19 percentage point. These results are consistent with our prediction that export shares increase firms' foreign currency debt shares, while the shares of imported intermediate inputs reduce them.

Columns (3) and (4) of Table 8 present the first stage regressions for the IV regression reported in column (2). The first takeaway is that both demand shock and supply shock IVs are positively correlated with changes in export and import shares, respectively. In addition, the F-statistics from the first stage regressions are 55.45 and 15.26 for export and import shares, respectively, showing that our IVs do not suffer from the weak IV problem. Overall, we view the results from Table 8 to be a key evidence that global supply chains play a crucial role in shaping firms' currency composition of debts.

5 Conclusion

This paper investigates the impact of international trade on firms' currency compositions of debts. We present a stylized theoretical framework to show that firms with higher export shares (foreign intermediate input shares) have greater (less) incentives to borrow in foreign currencies to hedge their profits against exchange rate risk. We validate our theoretical predictions by presenting a wide range of empirical evidence based on long difference regressions and IV regressions. We also document that the effect of export shares on foreign currency debt shares was less pronounced prior to the Asian financial crisis when Korea had a less flexible exchange rate regime, providing a placebo test for our main results. Finally, we extend our framework to account for the rise of global supply chains. Consistent with our expectation, we show that higher shares of foreign inputs lower firms' foreign currency debt shares.

Our results provide new evidence on the linkage between trade (dis)integration and financial (dis)integration and shed light on exchange rate policies in open economies where the use of foreign currency debt is pervasive. If firms endogenously hedge their exposure to foreign currency debt based on their international trade positions, movements in exchange rates can have a muted impact on their balance sheets, resulting in a lower aggregate output loss. Understanding the aggregate implication of this channel is left for future research.

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Online Appendix

(Not For Publication)

A Technical Appendix for the Theoretical Framework

A.1 Sticky Price Model

In Section 2 of the main text, we solved the model under the assumption that firms can freely set the output prices in both domestic and foreign markets. When demand features a constant elasticity, the optimal price for the firm is a constant markup over the marginal cost. Yet, recent literature shows that there can be nominal stickiness in firms' pricing behavior (e.g., Gopinath and Itskhoki (2021)). In this section of the appendix, we demonstrate that nominal stickiness does not place a central role in our analysis by analyzing a short run model in which the firm in question cannot adjust prices in both domestic and foreign markets.

When doemstic and foreign prices $\bar{p}$ and $\bar{p}^*$ are given and cannot be adjusted in the short run, the realized demand $\bar{q}$ and $\bar{q}^*$ are determined by the demand functions ($\bar{q} = E\bar{p}^{-\eta}$ and $\bar{q}^* = E^*\bar{p}^{*-\eta}$), and hence the total demand $\bar{Q} = \bar{q} + \bar{q}^*$. The firm maximizes its profit given the level of debts (b and b^*) and realized ξ as follows

$$\begin{aligned} &\max_{L,L^*} E\bar{p}^{1-\eta} + \xi E^*\bar{p}^{*1-\eta} - wL - \xi w^* L^* - (b + \xi b^*) \\ &\text{s.t. } \bar{Q} = \phi K^{1-\beta}(L^{1-\lambda}L^{*\lambda})^{\beta}. \end{aligned} \tag{A.1}$$

With the expression of L and L^* obtained from first order conditions, the solved-out profit of the firm can be expressed as

$$\Pi^s(b, b^*, \xi) = E\bar{p}^{1-\eta} + \xi E^*\bar{p}^{*1-\eta} - \left(\frac{\bar{Q}}{\phi}\right)^{\frac{1}{\beta}} \left(\frac{\xi w^*}{\lambda}\right)^{\lambda} \left(\frac{w}{1-\lambda}\right)^{1-\lambda} K^{\frac{\beta-1}{\beta}} - (b + \xi b^*). \tag{A.2}$$

This expression shows that when prices are sticky, the firm's demand for labor is determined by $\bar{Q}$, the quantity of production, which in turn is determined by the realized exchange shock ξ. Following the analysis in our main text, we suppose that the firm's objective function can be expressed as a mean-variance form in equation (5). To the second-order approximation, it can be shown that the firm's objective function can be expressed as

$$\begin{aligned}\mathbb{E}(\Pi) - \frac{\gamma}{2}\text{Var}(\Pi) =& E\bar{p}^{1-\eta} + \left(1+\frac{\sigma^2}{2}\right) E^*\bar{p}^{*1-\eta} - \left(1+\frac{\sigma^2\lambda^2}{2}\right)\bar{Q}^s \\ & - \left(b + \left(1+\frac{\sigma^2}{2}\right) b^*\right) - \frac{\gamma\sigma^2}{2}\left[E^*\bar{p}^{*1-\eta} - \bar{Q}^s\lambda - b^*\right]^2,\end{aligned} \tag{A.3}$$

where $\bar{Q}^s$ represents $\left(\frac{\bar{Q}}{\phi}\right)^{\frac{1}{\beta}}\left(\frac{w^*}{\lambda}\right)^{\lambda}\left(\frac{w}{1-\lambda}\right)^{1-\lambda} K^{\frac{\beta-1}{\beta}}$. Noting that $b = K(1+r) - \frac{1+r}{1+r^*}b^*$, the first order condition with respect to b^* can be expressed as

$$b^* = E^*\bar{p}^{*1-\eta} - \bar{Q}^s\lambda - \Sigma, \tag{A.4}$$

where Σ (following the definition in main text) denotes the extent of UIP deviation in favor of local currency debt. Equation (A.4) shows that the UIP plays a straightforward role of decreasing the level of foreign currency debt level at a given level of capital K. From equation (A.4), it is clear that when the foreign revenue share is high for the firm (a higher level of $E^*\bar{p}^{*1-\eta}$ for a given level of $\bar{Q}$), the firm's optimal share of foreign currency debt rises (a higher level of b^* for a given level of K).

With equation (A.4), the first order condition for K that maximizes the objective of the firm can be expressed (to the first-order approximation) as

$$K^{\frac{1}{\beta}} = \left(\frac{\bar{Q}}{\phi}\right)^{\frac{1}{\beta}}\left(\frac{w^*}{\lambda}\right)^{\lambda}\left(\frac{w}{1-\lambda}\right)^{1-\lambda}\frac{1-\beta}{\beta(1+r)}. \tag{A.5}$$

The expression for the share of foreign currency debt can be expressed as

$$\frac{b^*}{K} = \frac{\bar{p}^*\bar{q}^*}{\bar{q}+\bar{q}^*}\phi\left(\frac{\lambda}{w^*}\right)^{\lambda\beta}\left(\frac{1-\lambda}{w}\right)^{(1-\lambda)\beta}\left(\frac{\beta(1+r)}{1-\beta}\right)^{\beta} - \lambda\frac{\beta(1+r)}{1-\beta}. \tag{A.6}$$

Equation (A.6) suggests that the optimal level of foreign currency debt is a function of $\bar{p}$ and $\bar{p}^*$. To pin down this level, we make a reasonable assumption that $\bar{p}^*$ is set at the long-run equilibrium in which the level of capital can be adjusted. Intuitively, the long-run prices are determined by maximizing the economic profit

$$E\bar{p}^{1-\eta} + \left(1+\frac{\sigma^2}{2}\right) E^*\bar{p}^{*1-\eta} - \left[\beta\left(1+\frac{\sigma^2\lambda^2}{2}\right)+(1-\beta)\right]\left(\frac{\bar{Q}}{\phi}\right)\left(\frac{w}{\beta(1-\lambda)}\right)^{\beta(1-\lambda)}\left(\frac{w^*}{\beta\lambda}\right)^{\beta\lambda}\left(\frac{1+r}{1-\beta}\right)^{1-\beta}. \quad \text{(A.7)}$$

The corresponding long-run prices satisfy

$$\bar{p} = \left(1+\frac{\sigma^2}{2}\right)\bar{p}^* = \frac{\eta}{\eta-1}\frac{c}{\phi}, \quad \text{(A.8)}$$

where $c = \left[\beta\left(1+\frac{\sigma^2\lambda^2}{2}\right)+(1-\beta)\right]\left(\frac{w}{\beta(1-\lambda)}\right)^{\beta(1-\lambda)}\left(\frac{w^*}{\beta\lambda}\right)^{\beta\lambda}\left(\frac{1+r}{1-\beta}\right)^{1-\beta}$. With the expression for the long-run equilibrium prices, we can express the optimal foreign debt share in equation (A.6) (to the first-order approximation) as

$$\frac{b^*}{K} = \frac{\alpha\eta}{\eta-1} - \frac{\beta\lambda(1+r)}{1-\beta}, \quad \text{(A.9)}$$

where α is defined equally as in the main text. Analogous to equation (9), this equation shows that the optimal foreign currency debt share increases with the share of foreign currency revenue α and decreases with foreign input share λ.

A.2 Production Stage

The production function is given by:

$$Q = \phi K^{1-\beta}\left(L^{1-\lambda}L^{*\lambda}\right)^{\beta} \quad \text{(A.10)}$$

Let $\tilde{w}$ denote the price index of both local and foreign inputs.

$$\tilde{w} = \left(\frac{w}{1-\lambda}\right)^{1-\lambda}\left(\frac{\xi w^*}{\lambda}\right)^{\lambda}$$

The ideal composite of local and foreign inputs can be expressed as

$$\tilde{L} = L^{1-\lambda}L^{*\lambda}$$

The first order conditions with respect to q and q^* can be expressed as

$$\begin{aligned} \frac{\eta-1}{\eta}E^{\frac{1}{\eta}}q^{-\frac{1}{\eta}} - \left(\frac{\tilde{L}}{K}\right)^{1-\beta}\frac{\tilde{w}}{\beta\phi} &= 0 \\ \frac{\eta-1}{\eta}\xi E^{*\frac{1}{\eta}}q^{*^{-\frac{1}{\eta}}} - \left(\frac{\tilde{L}}{K}\right)^{1-\beta}\frac{\tilde{w}}{\beta\phi} &= 0. \end{aligned} \tag{A.11}$$

Using the two equations above, we obtain the following intuitive expression regarding the equilibrium ratio of output prices that the home firm will set in home and foreign markets

$$\xi p^* = p. \tag{A.12}$$

Equation (A.12) demonstrates that prices are equalized in home and foreign markets after prices are converted to the same currency. Next, we use equation (2) to express the equilibrium labor input as a function of the domestic output price

$$\tilde{L} = \left[\frac{Ep^{-\eta} + E^*\xi^\eta p^{-\eta}}{\phi K^{1-\beta}}\right]^{\frac{1}{\beta}}. \tag{A.13}$$

Combining the first order condition with respect to q in equations (A.11) and (A.13), we solve for the equilibrium domestic output price as

$$\begin{aligned} p^{1+\eta\frac{1-\beta}{\beta}} &= \tfrac{\eta}{\eta-1}\tfrac{\tilde{w}}{\beta\phi^{\frac{1}{\beta}}}K^{\frac{\beta-1}{\beta}}\left(E+E^*\xi^\eta\right)^{\frac{1-\beta}{\beta}} \\ &\equiv \tfrac{\eta}{\eta-1}\tfrac{\tilde{w}}{\beta\phi^{\frac{1}{\beta}}}K^{\frac{\beta-1}{\beta}}\Gamma^{\frac{1-\beta}{\beta}}\left(\alpha+(1-\alpha)\xi^\eta\right)^{\frac{1-\beta}{\beta}}, \end{aligned} \tag{A.14}$$

where we have introduced the following notations

$$\Gamma \equiv E + E^*$$

and

$$\alpha \equiv \frac{E^*}{E + E^*}.$$

The variable α can be seen as the current share of export revenue before the production stage.

We use equations (A.12) and (A.13) to express the profit as a function of p given b, b^* and ξ as follows

$$\Pi(p, b, b^*, \xi) = \Gamma\left[(1-\alpha) + \alpha\xi^\eta\right] p^{1-\eta} - \tilde{w}\Gamma^{\frac{1}{\beta}} \left[\frac{(1-\alpha)p^{-\eta} + \alpha\xi^\eta p^{-\eta}}{\phi K^{1-\beta}}\right]^{\frac{1}{\beta}} - (b + \xi b^*). \quad \text{(A.15)}$$

We then plug the equilibrium domestic price in equation (A.14) into equation (A.15) to obtain the profit of a firm as a function of debts and the realized exchange rate shock ξ

$$\begin{aligned}\Pi(b, b^*, \xi) =& \left(1 - \frac{\eta-1}{\eta}\beta\right)\left[\left(\frac{w}{1-\lambda}\right)^{1-\lambda}\left(\frac{w^*}{\lambda}\right)^{\lambda}\frac{\eta}{\beta(\eta-1)}\right]^{\frac{\beta(1-\eta)}{\beta+\eta(1-\beta)}}\Gamma^{\frac{1}{\beta+\eta(1-\beta)}}\left(\phi K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}} \\ &\times\left\{\left[(1-\alpha) + \alpha\xi^\eta\right]\xi^{\lambda\beta(1-\eta)}\right\}^{\frac{1}{\beta+\eta(1-\beta)}} - (b + \xi b^*) \\ \equiv& \tilde{\Pi}\left(\phi K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}}\left\{\left[(1-\alpha) + \alpha\xi^\eta\right]\xi^{\lambda\beta(1-\eta)}\right\}^{\frac{1}{\beta+\eta(1-\beta)}} - (b + \xi b^*)\end{aligned} \quad \text{(A.16)}$$

where we introduce a constant term $\tilde{\Pi}$ in the second line.[33]

A.3 Financial Frictions

In this section, we extend the baseline model by a period to demonstrate that the objective function in equation (5) can be rationalized by financial frictions that generate

[33] In specific, the constant term $\tilde{\Pi}$ can be expressed as

$$\tilde{\Pi} \equiv \left(1 - \frac{\eta-1}{\eta}\beta\right)\left[\left(\frac{w}{1-\lambda}\right)^{1-\lambda}\left(\frac{w^*}{\lambda}\right)^{\lambda}\frac{1}{\beta}\frac{\eta}{\eta-1}\right]^{\frac{\beta(1-\eta)}{\beta+\eta(1-\beta)}}\Gamma^{\frac{1}{\beta+\eta(1-\beta)}},$$

a collateral constraint in the extended period. Specifically, we suppose that firms live by another period in addition to the baseline model, and the firms have to use the profit in the baseline model as the collateral for borrowing in the extended period.

Let $\Pi_t(b_t, b_t^*, X_t)$ $(t \in \{1,2\})$ denote the profit of the firm in period t as a function of the borrowing decisions $\{b_t, b_t^*\}$ and the realization of exchange rate X_t. Note that we use $t = 1$ to indicate the profit in the baseline model and $t = 2$ to indicate the profit in the extended period. The borrowing stage that we described in the baseline model occurs at the beginning of each period before the exchange rate shock realizes in each period. We also assume that the capital from the first period is fully depreciated before the second stage.

A.3.1 Second Period

We describe and solve the model in a backward manner from the second stage. The collateral constraint is an inequality constraint that limits the capital invested in the second period to the profit in the first period multiplied by a multiplier κ, which is the maximum leverage of the firm under the financial frictions.

Conditional on the level of profit in the first period, the borrowing decision in the second period can be expressed as:

$$\begin{aligned} \max_{b_2, b_2^*} \quad & \mathbb{E}_{X_2}(\Pi_2) \\ \text{s.t.} \quad & K_2 = \tfrac{b_2}{1+r} + \tfrac{b_2^*}{1+r^*} \\ & K_2 \leq \kappa \cdot \Pi_1(b_1, b_1^*, X_1) \end{aligned} \tag{A.17}$$

A second-order approximation of the profit function can be expressed as (See Appendix A.5 for details)

$$\begin{aligned} \Pi_t \approx & \tilde{\Pi}\left(\phi K_t^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}} \left\{1 + \frac{\sigma}{\beta+\eta(1-\beta)}\left[\alpha\eta + \lambda\beta(1-\eta)\right] X_t \right. \\ & \left. + \frac{1}{2}\frac{\sigma^2}{\beta+\eta(1-\beta)}\left\{\frac{(\alpha\eta+\lambda\beta(1-\eta))^2}{\beta+\eta(1-\beta)} + \alpha\eta^2(1-\alpha)\right\} X_t^2\right\} - \left[b + \left(1 + \sigma X_t + \frac{\sigma^2}{2}X_t^2\right) b^*\right] \end{aligned} \tag{A.18}$$

The expectation of the profit function can be expressed as

$$\begin{aligned}\mathbb{E}_{\xi}(\Pi_t) =&\tilde{\Pi}\left(\phi K_t^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}}\left\{1+\frac{1}{2}\frac{\sigma^2}{\beta+\eta(1-\beta)}\left\{\frac{(\alpha\eta+\lambda\beta(1-\eta))^2}{\beta+\eta(1-\beta)}+\alpha\eta^2(1-\alpha)\right\}\right\}\\&-\left(b_t+\left(1+\frac{1}{2}\sigma^2\right)b_t^*\right)\end{aligned} \tag{A.19}$$

To proceed, we make two simplifying assumptions. First, the financial frictions constraint in equation (A.17) always binds. Second, the UIP (uncovered interest parity) condition holds. Under the UIP condition, the second term in equation (A.19) can be written as $b_t + b_t^* \left(1 + \frac{1}{2}\sigma^2\right) = (1 + r)K_t$, and thus K_t becomes a sufficient statistic for $\mathbb{E}_{X_t}(\Pi_t)$.

Under the second assumption, the expected profit can be expressed as a function of K_t and (conditional on K_t no longer relying on b_t and b_t^*. Specifically, the expectation of the profit can be expressed as

$$\begin{aligned}\mathbb{E}_{\xi}(\Pi_t) =&\tilde{\Pi}\left(\phi K_t^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}}\left\{1+\frac{1}{2}\frac{\sigma^2}{\beta+\eta(1-\beta)}\left\{\frac{(\alpha\eta+\lambda\beta(1-\eta))^2}{\beta+\eta(1-\beta)}+\alpha\eta^2(1-\alpha)\right\}\right\}\\&-(1+r)K_t\end{aligned} \tag{A.20}$$

As the expected profit in the second stage is a function of K_2 only, which in turn is constrained by the collateral constraint in equation (A.17), the solution to the firm's problem in equation (A.17) is simply the set of $\{b_2, b_2^*\}$ that satisfies both constraints in equation (A.17).

We intentionally keep the model simple in the extended period as our main focus in this section is to show that the firm's borrowing problem in the first period will feature risk aversion if the firm foresees the implications of the first-period profit on the extended period. Namely, we can make the firm's problem in the second stage non-trivial by introducing another extended period, but this does not provide further intuition. We move on to describe the firm's problem in the first period.

A.3.2 First Period

The firm's borrowing problem in the first period can be expressed as

$$\max_{b_1,b_1^*} \mathbb{E}_{X_1}\left(\Pi_1(b_1,b_1^*,X_1) + \frac{1}{1+r}\mathbb{E}_{X_2}\left(\Pi_2(b_2,b_2^*,X_2)\right)\right) \tag{A.21}$$

Let K^* denote the equilibrium level of capital in the second period. Using the expression of the expectation of the profit in equation (A.20), a second order approximation with respect to $\mathbb{E}_{X_2}(\Pi_2)$ around K^* leads to

$$\begin{aligned}
\mathbb{E}_{X_2}\left(\Pi_2\right) \approx\ & \mathcal{C}_0 + \left\{\tilde{\Pi}\phi^{\frac{\eta-1}{\beta+\eta(1-\beta)}} K^{*-\frac{1}{\beta+\eta(1-\beta)}}\Psi - (1+r)\right\} K_2 \\
& -\tfrac{1}{2}\tilde{\Pi}\phi^{\frac{\eta-1}{\beta+\eta(1-\beta)}} K^{*-\frac{1}{\beta+\eta(1-\beta)}-1}\Psi\left(K_2 - K^*\right)^2 \\
=\ & \mathcal{C}_0 + \left\{\tilde{\Pi}\phi^{\frac{\eta-1}{\beta+\eta(1-\beta)}} K^{*-\frac{1}{\beta+\eta(1-\beta)}}\Psi - (1+r)\right\} \kappa\Pi_1 \\
& -\tfrac{1}{2}\tilde{\Pi}\phi^{\frac{\eta-1}{\beta+\eta(1-\beta)}} K^{*-\frac{1}{\beta+\eta(1-\beta)}-1}\Psi\kappa^2\left(\Pi_1 - \Pi^*\right)^2
\end{aligned} \tag{A.22}$$

where $\mathcal{C}_0$ is a constant term that is irrelevant for the profit maximization problem, $\Psi \equiv \left\{1 + \frac{1}{2}\frac{\sigma^2}{\beta+\eta(1-\beta)}\left[\frac{(\alpha\eta+\lambda\beta(1-\eta))^2}{\beta+\eta(1-\beta)} + \alpha(1-\alpha)\eta^2\right]\right\}$. With equation (A.22), the profit maximization in equation (A.21) can be expressed as (after dropping constant terms and normalizing the coefficient of the first term)

$$\max_{b_1,b_1^*} \mathbb{E}_{X_1}\left(\Pi_1(b_1,b_1^*,X_1)\right) - \frac{\gamma}{2}\mathrm{Var}\left(\Pi_1(b_1,b_1^*,X_1)\right) \tag{A.23}$$

which is analogous to the objective function expressed in equation (5).

A.4 Endogenous Default Model

In our benchmark model, we abstract away from the firm's endogenous decision to default in the second stage for the sake of model tractability. In this subsection, we allow firms to default on their loans if their net worth becomes negative, and the loan prices at the borrowing stage take into account the subsequent probability of default. The model presented in this section is analogous to the one in Salomao and Varela (2020) with the additional feature that we account for the firm's revenue streams denominated in both home and foreign currencies.

At the borrowing stage, the firm raises local and foreign currency debts $(b, b^* \geq 0)$ to finance its physical capital K

$$qb + q^* b^* + K_0 = K, \tag{A.24}$$

where $K_0 \geq 0$ is the initial physical capital.

The firm chooses the optimal amount of b and b^* to maximize the firm value expressed as

$$E_{\phi,\xi}[\max\{\Pi(\phi, \xi, b, b^*), 0\}]$$

where

$$\Pi(\phi, \xi, b, b^*) = \tilde{\Pi} \left(\phi K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}} \left\{\left[(1-\alpha) + \alpha\xi^{\eta}\right] \xi^{\lambda\beta(1-\eta)}\right\}^{\frac{1}{\beta+\eta(1-\beta)}} - (b + \xi b^*). \tag{A.25}$$

Following Salomao and Varela (2020), we assume that the firm level productivity shock ϕ and the exchange rate shock ξ are independently distributed. At a given level of b, b^* and a realization of X $(= \log(\xi))$, we can characterize the level of productivity cutoff above which the firm will repay its debts:

$$\tilde{\phi} \equiv \left\{ \frac{b + (1+\sigma X) b^*}{\tilde{\Pi}\left[1 + \frac{\sigma\alpha\eta}{\beta+\eta(1-\beta)} X\right]} \right\}^{\frac{\beta+\eta(1-\beta)}{\eta-1}} \frac{1}{K^{1-\beta}} \tag{A.26}$$

The probability of debt solvency is given by $p = \Pr(\phi > \tilde{\phi})$, and the corresponding bond price in the borrowing stage is given by $q = p/(1+r)$ and $q^* = p/(1+r^*)$. Up to the first order approximation, the first order condition with b and b^* can be expressed as:

$$\begin{aligned} \frac{\mathrm{d}\mathbb{E}(V)}{\mathrm{d}b} = & \int_X \int_{\tilde{\phi}}^{\infty} \left\{ \tilde{\Pi}\phi^{\frac{\eta-1}{\beta+\eta(1-\beta)}} \left[1 + \frac{\sigma(\alpha\eta + \lambda\beta(1-\eta))}{\beta+\eta(1-\beta)} X\right] \frac{(1-\beta)(\eta-1)}{\beta+\eta(1-\beta)} K^{-\frac{1}{\beta+\eta(1-\beta)}} \frac{\mathrm{d}K}{\mathrm{d}b} - 1 \right\} f(\phi) h(X) d\phi dX \\ & - \int_X \left\{ \tilde{\Pi}\left(\tilde{\phi} K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}} \left[1 + \frac{\sigma(\alpha\eta + \lambda\beta(1-\eta))}{\beta+\eta(1-\beta)} X\right] - \left[b + (1+\sigma X) b^*\right] \right\} f(\tilde{\phi}) h(X) \frac{\mathrm{d}\tilde{\phi}}{\mathrm{d}b} dX \leq 0 \end{aligned} \tag{A.27}$$

$$\frac{\mathrm{d}\mathbb{E}\left(V\right)}{\mathrm{d}b^{*}} = \int_{X}\int_{\tilde{\phi}}^{\infty}\left\{\tilde{\Pi}\phi^{\frac{\eta-1}{\beta+\eta(1-\beta)}}\left[1+\frac{\sigma\left(\alpha\eta+\lambda\beta(1-\eta)\right)}{\beta+\eta(1-\beta)}X\right]\frac{(1-\beta)(\eta-1)}{\beta+\eta(1-\beta)}K^{-\frac{1}{\beta+\eta(1-\beta)}}\frac{\mathrm{d}K}{\mathrm{d}b^{*}}-(1+\sigma X)\right\}f(\phi)h(X)d\phi dX$$
$$-\int_{X}\left\{\tilde{\Pi}\left(\tilde{\phi}K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}}\left[1+\frac{\sigma\left(\alpha\eta+\lambda\beta(1-\eta)\right)}{\beta+\eta(1-\beta)}X\right]-\left[b+(1+\sigma X)b^{*}\right]\right\}f(\tilde{\phi})h(X)\frac{\mathrm{d}\tilde{\phi}}{\mathrm{d}b^{*}}dX \leq 0 \quad \text{(A.28)}$$

where $f(\phi)$ and $h(X)$ denote the probability density functions for ϕ and X, respectively. The inequality for both equations arise from the non-negativity constraints for b and b^{*}.

To understand the effects of α and λ on the optimal foreign debt ratio, it is useful to study $\frac{\mathrm{d}\mathbb{E}(V)}{\mathrm{d}b^{*}} - \frac{\mathrm{d}\mathbb{E}(V)}{\mathrm{d}b}$, since the increase in the difference suggests that the marginal benefit of issuing foreign currency debt increases vis-à-vis that of issuing local currency debt.

In specific,

$$\begin{aligned}\frac{\mathrm{d}\mathbb{E}\left(V\right)}{\mathrm{d}b^{*}}-\frac{\mathrm{d}\mathbb{E}\left(V\right)}{\mathrm{d}b} = & \underbrace{\int_{X}\int_{\tilde{\phi}}^{\infty}\left\{\tilde{\Pi}\phi^{\frac{\eta-1}{\beta+\eta(1-\beta)}}\left[1+\frac{\sigma\left(\alpha\eta+\lambda\beta(1-\eta)\right)}{\beta+\eta(1-\beta)}X\right]\frac{(1-\beta)(\eta-1)}{\beta+\eta(1-\beta)}K^{-\frac{1}{\beta+\eta(1-\beta)}}\left(\frac{\mathrm{d}K}{\mathrm{d}b^{*}}-\frac{\mathrm{d}K}{\mathrm{d}b}\right)\right\}f(\phi)h(X)d\phi dX}_{\text{marginal product of capital}\times\text{debt revenue}} \\ & \underbrace{-\int_{X}\int_{\tilde{\phi}}^{\infty}\sigma X f(\phi)h(X)d\phi dX}_{\text{debt repayment}} \\ & \underbrace{-\int_{X}\left\{\tilde{\Pi}\left(\tilde{\phi}K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}}\left[1+\frac{\sigma\left(\alpha\eta+\lambda\beta(1-\eta)\right)}{\beta+\eta(1-\beta)}X\right]-\left[b+(1+\sigma X)b^{*}\right]\right\}f(\tilde{\phi})h(X)\left(\frac{\mathrm{d}\tilde{\phi}}{\mathrm{d}b^{*}}-\frac{\mathrm{d}\tilde{\phi}}{\mathrm{d}b}\right)dX}_{\text{change in default cutoff}}\end{aligned} \quad \text{(A.29)}$$

The first term in equation (A.29) represents the difference of the firm's marginal operating profit between issuing an additional unit of foreign debt and local currency debt, *holding constant* the default cutoff $\tilde{\phi}$, and it is equal to the product of marginal debt revenue and the marginal product of capital. The second term is the firm's debt repayment *holding constant* the default cutoff, and the last term is the change in firm value due to the change in default productivity cutoff.

For the first term, notice that all components except for $\left(\frac{\mathrm{d}K}{\mathrm{d}b^{*}}-\frac{\mathrm{d}K}{\mathrm{d}b}\right)$ are the same for $\frac{\mathrm{d}\mathbb{E}(V)}{\mathrm{d}b^{*}}$ and $\frac{\mathrm{d}\mathbb{E}(V)}{\mathrm{d}b}$, and thus we analyze the sign of $\left(\frac{\mathrm{d}K}{\mathrm{d}b^{*}}-\frac{\mathrm{d}K}{\mathrm{d}b}\right)$. Using equation (A.24),

$$\left(\frac{\mathrm{d}K}{\mathrm{d}b^{*}}-\frac{\mathrm{d}K}{\mathrm{d}b}\right) = \left[E\left(\xi\right)\Sigma+1\right]\left(\frac{\mathrm{d}q}{\mathrm{d}b^{*}}-\frac{\mathrm{d}q}{\mathrm{d}b}\right)+\left[E\left(\xi\right)\Sigma-1\right]q \quad \text{(A.30)}$$

where $q = \frac{1}{1+r}\int_{X}\int_{\tilde{\phi}}^{\infty}f(\phi)h(X)d\phi dX$ and Σ captures the extent of UIP deviation and is defined in the main text as $\frac{1+r}{E(\xi)(1+r^*)}$. The derivatives of q with respect to b^* and b can be expressed as

$$\frac{\mathrm{d}q}{\mathrm{d}b} = -\frac{1}{1+r}\int_X f(\tilde{\phi})\frac{\mathrm{d}\tilde{\phi}}{\mathrm{d}b}h(X)dX$$

$$\frac{\mathrm{d}q}{\mathrm{d}b^*} = -\frac{1}{1+r}\int_X f(\tilde{\phi})\frac{\mathrm{d}\tilde{\phi}}{\mathrm{d}b}(1+\sigma X)h(X)dX$$

One can show that

$$\frac{\mathrm{d}q}{\mathrm{d}b^*} = \frac{\mathrm{d}q}{\mathrm{d}b} - \frac{\sigma}{1+r}\mathrm{Cov}\left(f(\tilde{\phi})\frac{\mathrm{d}\tilde{\phi}}{\mathrm{d}b}, X\right) \tag{A.31}$$

When the change in ϕ's probability density is not too extreme (i.e. the pdf of ϕ is not too skewed), it is possible to determine the sign of $\mathrm{Cov}(f(\tilde{\phi})\frac{\mathrm{d}\tilde{\phi}}{\mathrm{d}b}, X)$ to be negative based on equation (A.26). This implies

$$\frac{\mathrm{d}q}{\mathrm{d}b^*} > \frac{\mathrm{d}q}{\mathrm{d}b}, \tag{A.32}$$

and furthermore, one can show that

$$\frac{\mathrm{d}\left(\mathrm{d}q/\mathrm{d}b^* - \mathrm{d}q/\mathrm{d}b\right)}{\mathrm{d}\alpha} > 0. \tag{A.33}$$

Equations (A.32) and (A.33) demonstrate why inherently risk-neutral firms can appear to be risk-averse to exchange rate risk when bond prices are endogenous. First, equation (A.32) implies that marginal increment of foreign currency debt lowers the local currency bond price *less steeply* than the local currency debt. Intuitively, when the exchange rate shock is large (considerable local currency depreciation), the marginal change in b matters less to $\tilde{\phi}$, making the term $\mathrm{Cov}\left(f(\tilde{\phi})\frac{\mathrm{d}\tilde{\phi}}{\mathrm{d}b}, X\right)$ negative in equation (A.31). Moreover, equation (A.33) shows that when α increases, it further decreases the the rate at which the increment of b^* lowers the local currency bond price relative to b, and thus we expect the equilibrium foreign currency debt ratio to increase for a marginal increase in α. In sum, the differential rate at which the bond price decreases with respect to foreign and local currency debts increases with α. Therefore, the equilibrium share of foreign currency debt will increase with α. The comparative statics analysis for λ is similar (in the opposite direction) to that of α and hence omitted to save space.

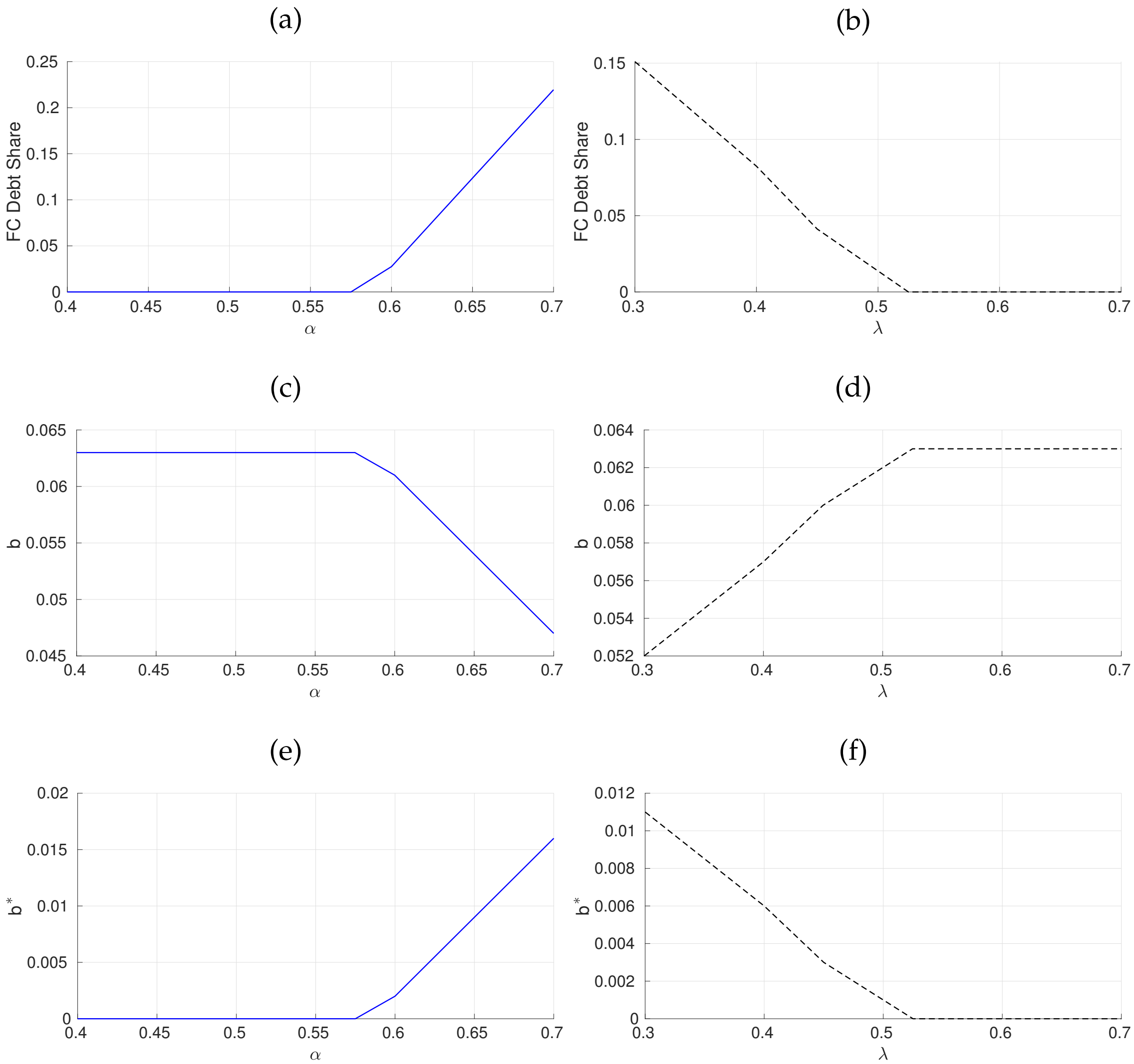
The second term in equation (A.29) represents the differential in debt payments for foreign and local currency debts. When the firm expects a depreciation of local currency (corresponding to a higher σ in our context), it lowers the equilibrium foreign currency debt ratio.

Finally, the third term in equation (A.29) denotes the differential in the change in the default productivity cutoff caused by a marginal increase in b^* and b. Analogous to the first term, all components are the same except for the term $\left(\frac{d\tilde{\phi}}{db^*} - \frac{d\tilde{\phi}}{db}\right)$, the sign of which we attempt to determine. After a linear approximation of X around 0, it can be shown that $\left(\frac{d\tilde{\phi}}{db^*} - \frac{d\tilde{\phi}}{db}\right) \approx \frac{\beta+\eta(1-\beta)}{\eta-1}\left(\frac{b+b^*}{\tilde{\Pi}}\right)^{\frac{1-\beta(\eta-1)}{\eta-1}} \frac{1}{K^{1-\beta}} \frac{\sigma}{\tilde{\Pi}} X$. As a result, the third term in equation (A.29) is less consequential than the first term as the standard deviation of the logarithm of the exchange rate σ is usually a small number.[34]

To visualize our discussion on the endogenous default model, we perform numerical exercises to confirm the monotonic relationship between α, λ and foreign currency debt shares under a set of reasonable parameter values presented under Figure A.1. The equilibrium foreign currency debt share is given by q^*b^*/K and we numerically illustrate the change in foreign currency debt share with respect to α and λ in panels (a) and (b) of Figure A.1, respectively. We observe that the foreign currency debt share is zero when α is low (or λ is high) and increases as α increases (or as λ decreases). The trade-off between two types of debts is also clear from the remaining panels in Figure A.1. These figures suggest that an endogenous default model in which bond prices are endogenously determined also delivers similar comparative statics as our baseline model.

[34] As Salomao and Varela (2020) demonstrate in a similar context, the third term is very unlikely to lead to "gambling effects", where firms become risk-loving.

Figure A.1: Numerical Solution to the Endogenous Default Model



Notes: The figures illustrate the changes in the equilibrium foreign currency debt share (and the level of each debt) with respect to changes in two key parameters α (export share) and λ (import share). The details of the model are elaborated in Appendix A.4. The parameter values are $\sigma = 0.15$, $r = 0.05$, $r^* = 0.039$, $\phi_H = 1.05$, $\phi_L = 1.05$, $p_\phi = 0.5$, $\beta = 0.7$, $\eta = 3$, $\tilde{\Pi} = 0.5$ and $K_0 = 0.01$.

A.5 Approximation of the Objective Function

In this section, we show the detailed procedure to obtain the second order approximation to the firm's objective function in the first period. Recall that the profit of the firm can be expressed as

$$\Pi(b, b^*, \xi) = \tilde{\Pi} \left(\phi K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}} \left\{[\alpha + (1-\alpha)\xi^{\eta}]\, \xi^{\lambda\beta(1-\eta)}\right\}^{\frac{1}{\beta+\eta(1-\beta)}} - (b + \xi b^*) \tag{A.34}$$

Next, we approximate the previous equation around $X = 0$ to the second order under the assumption that ξ is a function of X defined as $\xi = \exp(\sigma X)$ and that X follows a standard normal distribution. Define $f \equiv \left\{[(1-\alpha) + \alpha\xi^{\eta}]\, \xi^{\lambda\beta(1-\eta)}\right\}^{\frac{1}{\beta+\eta(1-\beta)}}$, taking the first order and second order derivative with respect to X, we have[35]

$$\frac{df}{dX} = \frac{\sigma}{\beta+\eta(1-\beta)} \{\cdot\}^{\frac{1}{\beta+\eta(1-\beta)}-1} \xi^{\lambda\beta(1-\eta)} \left[\xi^{\eta}\alpha\eta + [(1-\alpha) + \alpha\xi^{\eta}]\, \lambda\beta(1-\eta)\right]$$

and

$$\begin{aligned}\frac{d^2 f}{dX^2} =& \frac{\sigma^2}{\beta+\eta(1-\beta)} \left[\frac{1}{\beta+\eta(1-\beta)} - 1\right] \{\cdot\}^{\frac{1}{\beta+\eta(1-\beta)}-2} \xi^{2\lambda\beta(1-\eta)} \left[\xi^{\eta}\alpha\eta + [(1-\alpha) + \alpha\xi^{\eta}]\, \lambda\beta(1-\eta)\right]^2 \\ &+ \frac{\sigma^2}{\beta+\eta(1-\beta)} \{\cdot\}^{\frac{1}{\beta+\eta(1-\beta)}-1} \xi^{\lambda\beta(1-\eta)} \left\{\alpha\eta^2\xi^{\eta} + 2\alpha\beta\lambda\eta(1-\eta)\xi^{\eta} + \lambda^2\beta^2(1-\eta)^2 [(1-\alpha) + \alpha\xi^{\eta}]\right\}\end{aligned}$$

where $\{\cdot\} \equiv \left\{[(1-\alpha) + \alpha\xi^{\eta}]\, \xi^{\lambda\beta(1-\eta)}\right\}$.

The second order Taylor approximation of the objective function around $X = 0$ can be expressed as

$$\Pi \approx \tilde{\Pi} \left(\phi K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}} \left\{1 + \left.\frac{df}{dX}\right|_{X=0} \cdot X + \frac{1}{2} \left.\frac{d^2 f}{dX^2}\right|_{X=0} \cdot X^2\right\} - \left[b + \left(1 + \sigma X + \frac{\sigma^2}{2} X^2\right) b^*\right] \tag{A.35}$$

Note that we obtain

[35] We have repeatedly used the property that $\frac{d\xi}{dX} = \sigma \exp\{\sigma X\} = \sigma\xi$

$$\left.\frac{df}{dX}\right|_{X=0} = \frac{\sigma}{\beta+\eta(1-\beta)}\left[\alpha\eta+\lambda\beta(1-\eta)\right]$$

and

$$\begin{aligned}\left.\frac{df^2}{dX^2}\right|_{X=0} =& \frac{\sigma^2}{\beta+\eta(1-\beta)}\left(\frac{1}{\beta+\eta(1-\beta)}-1\right)\left(\alpha\eta+\lambda\beta(1-\eta)\right)^2 \\ &+\frac{\sigma^2}{\beta+\eta(1-\beta)}\left(\alpha\eta^2+2\alpha\beta\lambda(1-\eta)\eta+\lambda^2\beta^2(1-\eta)^2\right) \\ &=\frac{\sigma^2}{\beta+\eta(1-\beta)}\left\{\frac{\left(\alpha\eta+\lambda\beta(1-\eta)\right)^2}{\beta+\eta(1-\beta)}+\alpha\eta^2(1-\alpha)\right\}.\end{aligned} \tag{A.36}$$

Thus, the second order approximation of the profit can be expressed as

$$\begin{aligned}\Pi \approx& \tilde{\Pi}\left(\phi K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}}\left\{1+\frac{\sigma}{\beta+\eta(1-\beta)}\left[\alpha\eta+\lambda\beta(1-\eta)\right]X\right. \\ &\left.+\frac{1}{2}\frac{\sigma^2}{\beta+\eta(1-\beta)}\left\{\frac{\left(\alpha\eta+\lambda\beta(1-\eta)\right)^2}{\beta+\eta(1-\beta)}+\alpha\eta^2(1-\alpha)\right\}X^2\right\}-\left[b+\left(1+\sigma X+\frac{\sigma^2}{2}X^2\right)b^*\right]\end{aligned} \tag{A.37}$$

With previous expressions, we can express the mean and the variance of the objective function as, respectively:

$$\begin{aligned}\mathbb{E}_\xi(\Pi) =& \tilde{\Pi}\left(\phi K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}}\left\{1+\frac{1}{2}\frac{\sigma^2}{\beta+\eta(1-\beta)}\left\{\frac{\left(\alpha\eta+\lambda\beta(1-\eta)\right)^2}{\beta+\eta(1-\beta)}+\alpha\eta^2(1-\alpha)\right\}\right\} \\ &-\left(b+\left(1+\frac{1}{2}\sigma^2\right)b^*\right)\end{aligned} \tag{A.38}$$

$$\mathrm{Var}_\xi(\Pi) = \left(\tilde{\Pi}\left(\phi K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}}\frac{\alpha\eta+\lambda\beta(1-\eta)}{\beta+\eta(1-\beta)}-b^*\right)^2\sigma^2 \tag{A.39}$$

A.6 Proofs of Propositions

A.6.1 Proof of Proposition 1

The first part of Proposition 2 follows from the FOC with respect to b^*, which can be expresses as

$$\frac{1+\frac{1}{2}\sigma^2-\frac{1+r}{1+r^*}}{\gamma\sigma^2}=\tilde{\Pi}\phi^{-\frac{1-\eta}{\beta+\eta(1-\beta)}}\frac{\alpha\eta+\lambda\beta(1-\eta)}{\beta+\eta(1-\beta)}K^{1-\frac{1}{\beta+\eta(1-\beta)}}-b^*. \tag{A.40}$$

The second part of the proposition follows from the expression of the variance in profit in equilibrium in equation A.39.

A.6.2 Proof of Proposition 2

With Proposition 1, the firm's profit maximization problem regarding K can be simplified. As we have shown that the variance term in the objective function becomes a constant $\Sigma^2\sigma^2$ at the optimal level of b^*, the profit maximization problem in (5) is equivalent to maximizing expected profit by choosing the optimal level of K as follows

$$\begin{aligned}\max_K \mathbb{E}_\xi(\Pi) =&\tilde{\Pi}\left(\phi K^{1-\beta}\right)^{\frac{\eta-1}{\beta+\eta(1-\beta)}}\left\{1+\frac{1}{2}\frac{\sigma^2}{\beta+\eta(1-\beta)}\left[\frac{(\alpha\eta+\lambda\beta(1-\eta))^2}{\beta+\eta(1-\beta)}+\alpha(1-\alpha)\eta^2\right]\right\}\\ &-K(1+r)-\Sigma\gamma\sigma^2b^*\end{aligned} \tag{A.41}$$

where we have used the definition of Σ to replace the expected debt repayment in the second period.[36] The following lemma summarizes the optimal level of capital derived from the expected profit maximization problem specified in equation (A.41).

Lemma 1. *Under the UIP condition, the optimal level of capital maximizes the expected profit in*

[36]Note that $b+b^*\left(1+\frac{\sigma^2}{2}\right)=(1+r)K+\Sigma\gamma\sigma^2b^*$.

equation (A.41)*. The solution to the optimal level of capital is given by*

$$K^{\frac{1}{\beta+\eta(1-\beta)}} = \frac{1}{1+r}\tilde{\Pi}\phi^{\frac{\eta-1}{\beta+\eta(1-\beta)}}\Psi\frac{(1-\beta)(\eta-1)}{\beta+\eta(1-\beta)}$$

where

$$\Psi \equiv \left\{1+\frac{1}{2}\frac{\sigma^2}{\beta+\eta(1-\beta)}\left[\frac{(\alpha\eta+\lambda\beta(1-\eta))^2}{\beta+\eta(1-\beta)}+\alpha(1-\alpha)\eta^2\right]\right\}.$$

In Appendix A.7, we show that the the second order terms (those with σ^2) are relatively small compared with the first order terms.[37] Thus, we derive the following proposition with the first order approximation of the foreign currency debt share in equilibrium.[38]

Under the UIP condition, we obtain

$$\frac{b^*}{K} = \frac{\alpha\eta+\lambda\beta(1-\eta)}{(1-\beta)(\eta-1)}(1+r)\Psi^{-1}. \tag{A.42}$$

With the first order approximation, equation (A.42) becomes

$$\frac{b^*}{K} = \frac{\alpha\eta+\lambda\beta(1-\eta)}{(1-\beta)(\eta-1)}(1+r), \tag{A.43}$$

which is equivalent to equation (9). Apparently, equation (A.43) is an increasing function with respect to α and decreasing with respect to λ. Thus, we have shown that the optimal foreign currency debt ratio is an increasing function with respect to the export share α with both first and second order approximations.

[37] In Appendix B, we show that the magnitude of estimated σ^2 using the historical exchange rate data is around 0.01.

[38] In Appendix A.6, we show that the main results remain the same if we consider the second order terms.

A.7 UIP Deviation and the First Order Approximation in Proposition 2

If there are UIP deviations, the solution to the optimal FC debt share is

$$\frac{b^*}{K} = \frac{\alpha\eta + \lambda\beta(1-\eta)}{(1-\beta)(\eta-1)} \frac{1+r}{\Psi - \Sigma\gamma\sigma^2 \frac{\alpha\eta+\lambda\beta(1-\eta)}{\beta+\eta(1-\beta)}} - \frac{\Sigma}{K}, \tag{A.44}$$

where K is given by

$$K^{\frac{1}{\beta+\eta(1-\beta)}} = \frac{(1-\beta)(\eta-1)}{\beta+\eta(1-\beta)} \tilde{\Pi} \phi^{\frac{\eta-1}{\beta+\eta(1-\beta)}} \left(\frac{1+r}{\Psi - \Sigma\gamma\sigma^2 \frac{\alpha\eta+\lambda\beta(1-\eta)}{\beta+\eta(1-\beta)}} \right)^{-1} \tag{A.45}$$

We show in that since σ^2 is very small around 0.01, the second order terms become negligible compared with first order terms. Specifically, in the reasonable range of α ($\alpha \in (0, 0.5)$) and λ ($\lambda \in (0, 0.5)$), the ratio of the first order terms ($\frac{\alpha\eta+\lambda\beta(1-\eta)}{(1-\beta)(\eta-1)}$) to the second term (($\Psi - \Sigma\gamma\sigma^2 \frac{\alpha\eta+\lambda\beta(1-\eta)}{\beta+\eta(1-\beta)}$)) has a mean of 99.04 and a median of 66.07.

Thus, we omit the second order terms to express

$$\frac{b^*}{K} = (1+r) \frac{\alpha\eta + \lambda\beta(1-\eta)}{(1-\beta)(\eta-1)} - \frac{\Sigma}{K}, \tag{A.46}$$

For the UIP deviation term Σ, notice that the dominant currency used in South Korea's foreign currency borrowing is U.S. dollar (see Figure C.3). It has been well documented that there are UIP deviations and U.S. dollar borrowing usually enjoys lower interest rate (see e.g., Gilmore and Hayashi (2011) and Hassan (2013)), so $\Sigma < 0$. The direction of change in $\frac{\Sigma}{K}$ is ambiguous when α increases. But as long as Σ is relatively small, the monotonic relationship of $\frac{b^*}{K}$ with respect to α will preserve. In our empirical exercise, we account for the term $\frac{\Sigma}{K}$ by treating the term as a firm-specific unobservable, which is cancelled out in our long-difference regressions.

B Estimation of σ^2

We estimate the variance of exchange rate (in log terms) using post-1980 exchange rate data as follows. We specify that the logarithm of KRW exchange rate (against USD) X_t is a random walk process

$$X_t = X_{t-1} + \epsilon_t. \tag{B.1}$$

We then obtain residuals

$$\epsilon_t = X_t - X_{t-1}.$$

The sample variance of ϵ_t gives an estimate of $\hat{\sigma}^2 = 0.010$.

We also have tried an AR (1) process process $X_t = \rho X_{t-1} + \epsilon_t$ and compute residuals $\epsilon_t = X_t - \hat{\rho} X_{t-1}$ where $\hat{\rho}$ is estimated. The sample variance of ϵ_t is 0.009, which is close to 0.010.

C Additional Tables and Figures

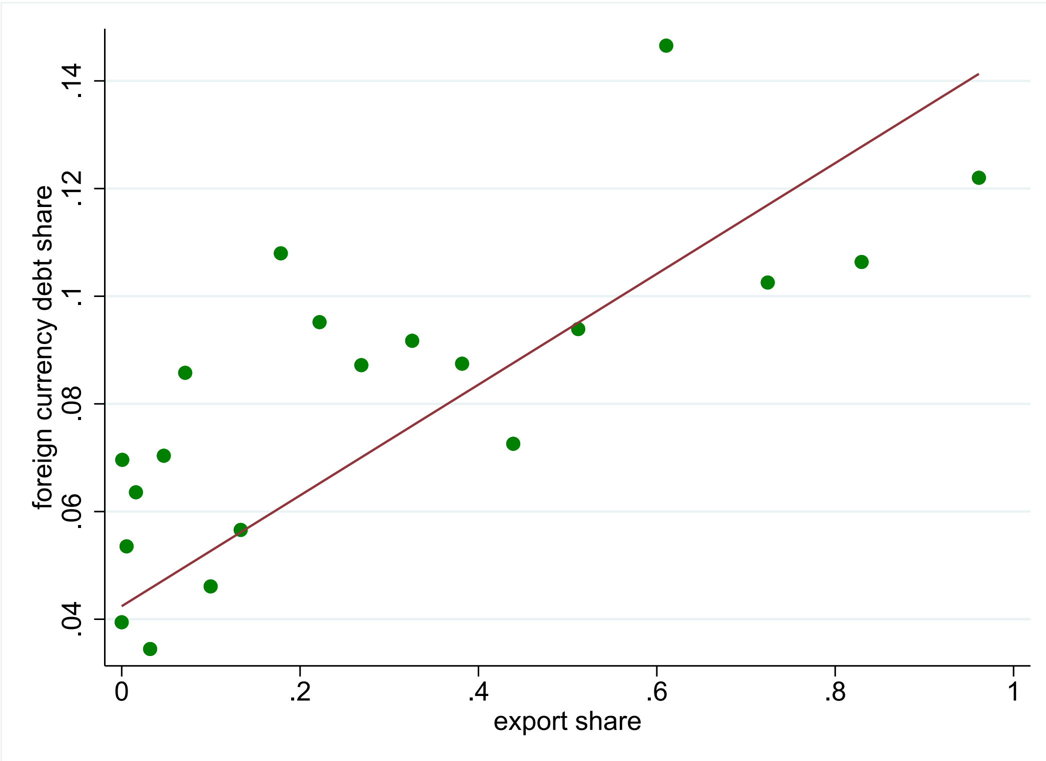
Table C.1: FC Debt and Export Share: Cross Sectional Patterns

Dependent Variable: FC debt share								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			full sample				subsample: exporters	
export dummy	0.045***	0.042***						
	(0.007)	(0.007)						
export share			0.103***	0.095***	0.066***	0.067***	0.073***	0.071***
			(0.011)	(0.012)	(0.013)	(0.018)	(0.019)	(0.022)
Industry FE	N	Y	N	Y	Y	N	Y	Y
Location FE	N	N	N	N	Y	N	N	Y
Founded Year FE	N	N	N	N	Y	N	N	Y
Chaebol dummy	N	N	N	N	Y	N	N	Y
Public firm dummy	N	N	N	N	Y	N	N	Y
Main bank dummy	N	N	N	N	Y	N	N	Y
Observations	4902	4902	4902	4902	4831	1155	1155	1087
R^2	0.022	0.102	0.024	0.103	0.185	0.018	0.195	0.336

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table displays the relationship between foreign currency (FC) debt share and export status (export dummy and export share) in 1999. In columns (1)-(4) and (6)-(7), we cluster standard errors at the industry level and in columns (5) and (8), standard errors are two-way clustered at the industry level and the location level.

Figure C.1: Scatter Plot of the Cross-Sectional Patterns



Notes: This figure displays the cross-sectional relationship between export and foreign currency debt shares using a bin-scatter plot.

Table C.2: FC Debt and Export Share (Year 2007)

Dependent Variable: FC debt share	(1)	(2)	(3)	(4)	(5)	(6)
		full sample			subsample: exporters	
export dummy	0.030***	0.029***				
	(0.005)	(0.005)				
export share			0.072***	0.069***	0.057***	0.056***
			(0.009)	(0.008)	(0.011)	(0.011)
Observations	7754	7754	7754	7754	1637	1637
R^2	0.010	0.062	0.013	0.064	0.014	0.151

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table displays the relationship between foreign currency (FC) debt share and export status (export dummy and export share) in year 2007.

Table C.3: Firm Level FC Debt and Export Share: Panel Regression

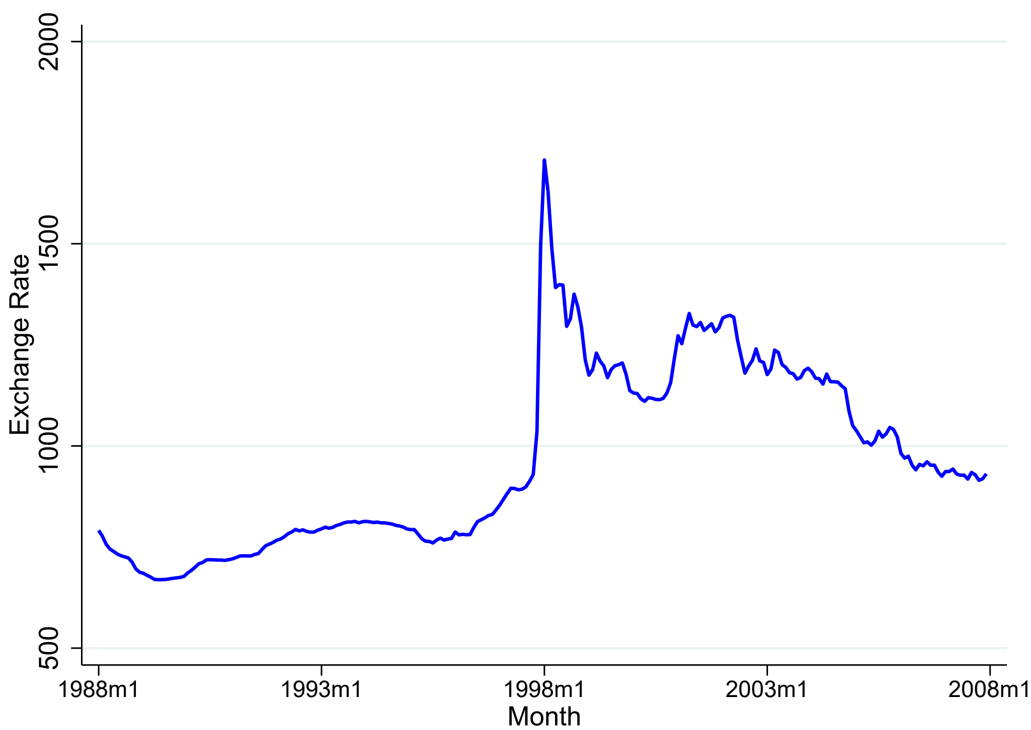
Dependent Variable: FC debt share				
	(1)	(2)	(3)	(4)
export share	0.075***	0.017**	0.076***	0.018**
	(0.007)	(0.008)	(0.007)	(0.008)
Year FE	Y	Y		
Industry FE	Y			
Firm FE		Y		Y
Industry× Year FE			Y	Y
Observations	60461	60461	60461	59998
R^2	0.063	0.564	0.072	0.571

Standard errors clustered at ISIC rev.3 industry level in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table displays the relationship between foreign currency (FC) debt share and export share in a panel regression from 1999 to 2007.

Figure C.2: Korean Won-US Dollar Exchange Rate



Notes: This figure displays Korean Won-US Dollar exchange rate. Data source: FRED.

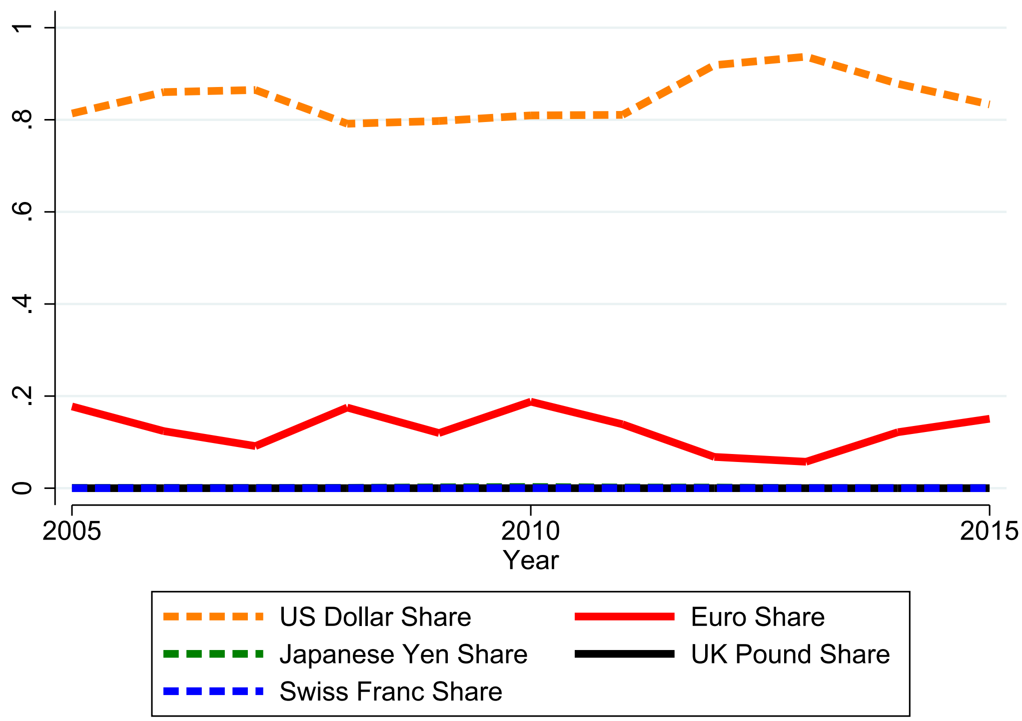
Table C.4: Additional Controls

	(1)	(2)	(3)
Dependent Variable:	FC debt share	change in FC debt share	
	Cross Section: OLS	Long Difference: OLS	Long Difference: IV
export share	0.049***		
	(0.012)		
leverage ratio	0.008		
	(0.006)		
fc asset share	-0.000		
	(0.001)		
size	0.011***		
	(0.001)		
change in export share		0.040***	0.116**
		(0.011)	(0.053)
change in leverage ratio		0.035***	0.034***
		(0.009)	(0.010)
change in fc asset share		0.000	-0.000
		(0.003)	(0.003)
change in size		0.005***	0.004***
		(0.001)	(0.001)
Industry FE	Y	Y	Y
Location FE	Y	Y	Y
Founded Year FE	Y	Y	Y
Chaebol dummy	Y	Y	Y
Public firm dummy	Y	Y	Y
Main bank dummy	Y	Y	Y
Observations	4,831	4,637	4,494
R^2	0.202	0.112	0.000

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the relationship between foreign currency debt share and export share by adding more control variables. Variable "labor prod" denotes labor productivity, calculated by $\frac{\text{sales}}{employment}$. Variable "leverage ratio" is calculated by $\frac{\text{debt}}{asset}$. Variable "fc asset share" is calculated by $\frac{\text{foreign currency asset}}{asset}$. Variable "size" is $\log(employment)$. Standard errors are two-way clustered at the industry level and the location level.

Figure C.3: Dealscan Korean Foreign Currency Debt's Currency Composition



Notes: This figure provides a breakdown of Korean firms' foreign currency debt by currencies using Dealscan database.

D Discussions on the Instrumental Variable Approach

Denote $s_i = \frac{export\_sales_{i0}}{export\_sales_{i0}+domestic\_sales_{i0}}$ as the initial export share of firm i. The change in export share of firm i is

$$\begin{aligned}
\Delta ex_share_i &= \frac{export_sales_{i0} * (1+g_{ei})}{export_sales_{i0} * (1+g_{ei}) + domestic_sales_{i0} * (1+g_{di})} \\
&\quad - \frac{export_sales_{i0}}{export_sales_{i0} + domestic_sales_{i0}} \\
&= \frac{1}{1+(\frac{1}{s_i}-1)\frac{1+g_{di}}{1+g_{ei}}} - s_i \\
&\approx (1-s_i)s_i\left[1-\frac{1+g_{di}}{1+g_{ei}}\right] \approx (1-s_i)s_i(g_{ei}-g_{di}),
\end{aligned} \tag{D.1}$$

where the last two steps uses the first order approximation.

Our proposed instrumental variable is

$$\begin{aligned}
\Delta ex_share_i &= \frac{export_sales_{i0} * (1+g_j^{IV})}{export_sales_{i0} * (1+g_j^{IV}) + domestic_sales_{i0} * (1+z_d^{IV})} \\
&\quad - \frac{export_sales_{i0}}{export_sales_{i0} + domestic_sales_{i0}} \\
&\approx (1-s_i)s_i(g_j^{IV}-z_d^{IV}),
\end{aligned} \tag{D.2}$$

Note that the growth rate difference between exports and domestic sales $g_{ei}-g_{di}$ can be instrumented by the difference between demand shocks from foreign and home $g_j^{IV}-z_d^{IV}$. Following similar discussions in Goldsmith-Pinkham et al. (2020), exogeneity of $(1-s_i)s_i$ is necessary for the estimator to be consistent when the number of firms is large.

Guided by Goldsmith-Pinkham et al. (2020), we perform additional tests that examine several firm-level variables' relationship with the initial export shares. In particular, we check whether firms' initial size, leverage ratio and foreign currency asset share are correlates of their initial export share. The test is performed in column (1) of Table D.1. It shows that firm size is positively associated with initial export share. In column (2), we add the initial size as an additional control and find that the point estimate before change in export share is close to what we have in column (2) of Table 3. Including more initial variables as controls in column (3) show robustness of our results. As a result, we conclude that our identification strategy is less likely to be threatened by the violation of the exogeneity assumption of the initial export shares.

Table D.1: Checking Identifying Assumptions of the Instrument

	(1)	(2)	(3)
		IV Regression	
Dependent variable:	initial export share	change in FC debt share	
change in export share		0.097*	0.113**
		(0.057)	(0.055)
change in leverage ratio		0.037***	0.071***
		(0.010)	(0.018)
change in FC asset share		-0.000	0.023
		(0.003)	(0.024)
change in size		0.009**	0.009**
		(0.005)	(0.005)
initial size	0.030***	-0.003	-0.001
	(0.003)	(0.003)	(0.003)
initial leverage ratio	-0.004		0.063***
	(0.008)		(0.020)
initial FC asset share	-0.000		0.024
	(0.002)		(0.023)
Industry FE	Y	Y	Y
Location FE	Y	Y	Y
Founded Year FE	Y	Y	Y
Chaebol dummy	Y	Y	Y
Public firm dummy	Y	Y	Y
Main bank dummy	Y	Y	Y
N	4638	4494	4494
R^2	0.322	0.006	0.008

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows tests the exogeneity of the instrument. The variable "initial size" is log(employment) in 1999. Variables "initial leverage ratio" and "initial FC asset share" are in the same year. Standard errors are two-way clustered at the industry level and the location level. Some detailed discussions are also provided in the texts in Appendix Section D.