Liability Dollarization and Exchange Rate Pass-Through to Domestic Prices

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Abstract

We explore the negative balance sheet effect of foreign currency borrowing on the exchange rate pass-through to domestic prices. Exploiting a large, unexpected depreciation episode in Korea in 1997, we show that firms with higher foreign currency debt experience balance sheet deterioration and face lower growth rates of net worth, sales, and price–cost markups. We then empirically document that sectors populated by firms with higher foreign currency debt exposure prior to the depreciation exhibit larger price increases. Building a heterogeneous-firm model with financial constraints, we quantify the role of foreign currency debt in explaining the exchange rate pass-through to prices and find that 10% to 48% of sectoral price changes during the depreciation episode can be explained by the balance sheet effect of foreign currency debt alone. We emphasize the role of strategic complementarity in amplifying sectoral price increases.

JEL classification: D22, E31, E44, F31, F34

Keywords: Exchange rate pass-through, Financial constraints, Strategic complementarity, Balance sheet effects, Price setting, Asian Financial Crisis

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1 Introduction

A sharp appreciation of the U.S. dollar is not a rare phenomenon. Such an appreciation of the U.S. dollar has often concerned policymakers around the globe, given the dollar's dominant role in international trade and finance. Because many countries, especially emerging markets, depend heavily on imported intermediate inputs in their production of goods and services, the sharp appreciation of the U.S. dollar raises the cost of these inputs, which in turn feeds through to higher domestic prices and the overall cost of living.

Moreover, many emerging economies are alarmed by the rapid strengthening of the U.S. dollar because their corporate sectors have high levels of dollar-denominated debt. When emerging-market currencies depreciate against the dollar, the negative balance sheet effects of the dollar debt can significantly affect firms' activities – reducing their net worth, sales, and investment – and may, in turn, generate sizable macroeconomic consequences. While the adverse balance sheet effects of foreign currency liabilities and their contractionary impact on aggregate economic activity are well documented in the literature (Krugman (1999), Céspedes et al. (2004), Aguiar (2005), Kim et al. (2015), Bruno and Shin (2023) and Kalemli-Ozcan et al. (2016)), their very effect on prices, specifically domestic inflation, remains largely neglected.

Given the prevalence of liability dollarization in emerging markets, this paper seeks to answer two key questions. First, after a domestic currency depreciation, how do firms' price-setting decisions vary with the extent of their foreign currency indebtedness? Second, how much of the sectoral domestic producer inflation can be explained by the often-neglected balance sheet effects of foreign currency debt? In answering these two questions, we would like to advance our understanding of how the exchange rate depreciation shock passes through to domestic prices, not just through a well-documented imported input channel (Goldberg and Campa (2010) and Amiti et al. (2019)), but also via the deterioration of firms' balance sheets due to their exposure to foreign currency debt.

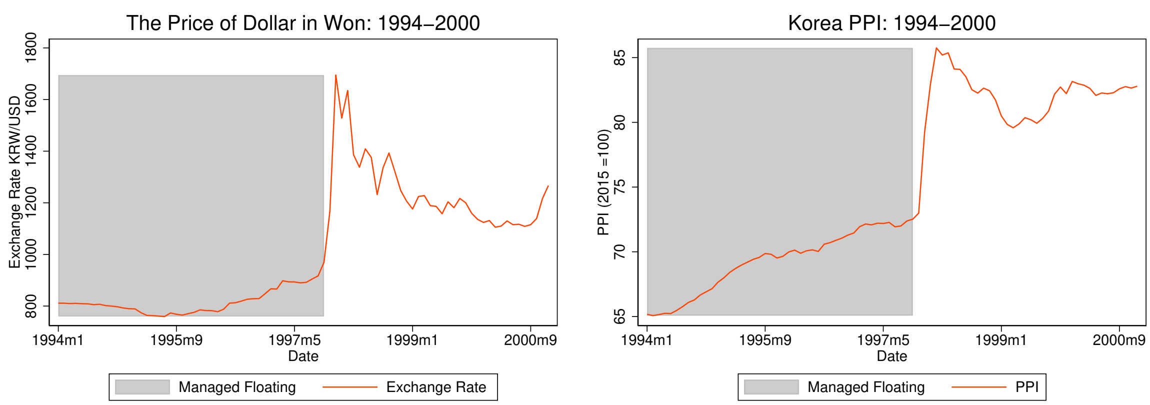
To answer these questions, we exploit a large, unexpected depreciation in Korea at the end of 1997 and different foreign currency debt exposure across firms and thereby sectors. We examine how higher foreign currency debt exposure affects firms' net worth, sales, and markup dynamics, and, in turn, sectoral domestic price dynamics, following the large depreciation of the Korean won against the U.S. dollar. At the end of 1997, the Korean won price of the U.S. dollar increased sharply from around 800 to 1,695 as Korea adopted a free-floating exchange rate regime, and the average producer price index (PPI) rose by about 20 percent as depicted in Figure 1.[1] The currency

[1] The policy reforms deregulating financial markets and opening capital accounts fueled a rapid rise in external borrowing from abroad. In particular, eased regulations on short-term foreign currency borrowing increased the dollar share of corporate loans. Moreover, the deregulation of the financial sector lowered the entry barriers to the financial sector, increasing the number of merchant banks from six to thirty from 1993 to 1996. These merchant banks borrowed in dollars to finance dollar credits to domestic firms.

crisis in Korea caught market participants by surprise. Shown in Park (2001), the 30-day offshore forward rate, a proxy for the expected future spot exchange rate, tracked the spot exchange rate closely and remained stable until very late in 1997. The close co-movement of forward and spot rates underscores the largely unanticipated nature of the sharp depreciation.[2]

On top of that, financial hedging against foreign exchange risk was barely existing at the time, as the exchange for trading financial derivatives was only established in 1999 in Korea, after the Asian Financial Crisis.[3] Consequently, most of these loans were extended to firms without any foreign exchange hedging. Firms' accumulation of *unhedged foreign currency liabilities*, together with an unexpected and large depreciation, provides a quasi-natural experiment environment that allows us to identify the negative balance sheet effects on firms' price setting.

Figure 1: Korean Won Against U.S. Dollar and PPI: 1994 – 2000



Notes: The gray shaded area represents the period when Korea was adopting the managed floating exchange rate regime. Under this system, the interbank spot exchange rate was allowed to move within an upper and a lower limit around each day's basic exchange rate. In December 1997, the daily fluctuation limits for the interbank exchange rate were abolished and, thus, Korea's exchange rate system was shifted to a free-floating system.

Identifying the negative balance sheet effect of foreign currency debt, we employ a unique dataset that merges the Korean firm-level balance sheet data with industry producer price indices.[4] The Korean firm-level balance sheet data are conducive to our identification of the balance sheet effects of foreign currency liabilities in that (1) the dataset contains information about the maturity and the currency composition of firms' debt; (2) it contains not only large listed firms but also small and medium-sized non-listed firms; and (3) it contains a large set of other firm-level variables, such as firm-level exports and foreign currency liquid assets, which allow us to mitigate concerns about potential endogeneity bias.

[2]The BIS chair, Alfons Verplaetse, visited the Bank of Korea in September 1997 and said: "Korea has strong fundamentals, unlike Latin American countries and Thailand; therefore, the probability of Korea facing a currency crisis is abysmal."

[3]More than 97% of FX transactions in Korea were trading spot exchange rate contracts before the large depreciation.

[4]We focus on the manufacturing sector because of the sectoral price data availability.

With the rich information on firm-level variables in our novel dataset, we first investigate whether and to what extent firms with higher foreign currency debt exposure experience deterioration of their balance sheets during the 1996 – 1998 period. When conducting the empirical analysis, we distinguish between short-term and long-term foreign currency debt and examine potential asymmetries across debt maturities. This distinction follows empirical evidence showing that short-term debt leads to stronger adjustments in firm-level sales and investment, as well as theoretical work that highlights its higher rollover risk during periods of financial stress.

Our empirical results corroborate the negative balance sheet effects of foreign currency debt – particularly short-term foreign currency debt – documented in the existing literature: firms with a higher foreign currency share of short-term debt exhibit lower growth of their net worth. The deterioration of their balance sheets constrains their production and reduces their domestic sales growth. The negative balance sheet effects on net worth and domestic sales growth are more pronounced for smaller firms.

We then examine how firms' estimated price-cost markups change after a large depreciation when they are more indebted in foreign currency. Firms with a higher foreign currency share of short-term debt experience lower markup growth. The deterioration of their balance sheet due to foreign currency debt exposure constrains firms' production and lowers their market share and markups. The negative balance sheet effect of short-term foreign currency debt on markup growth is larger in magnitude for smaller firms.

We then estimate local projections following Jordà (2005) to capture the dynamic responses of firm-level outcomes surrounding the large depreciation. We find that the negative balance sheet effects of foreign currency liability on these firm-level variables are not present before the large depreciation, further confirming that the empirical results are not driven by spurious relationships or pre-trends in firm-level variables across short-term foreign currency debt exposure. Moreover, the negative balance sheet effects on firm-level outcomes intensify over time, becoming substantially larger in 1998 relative to 1997. In sum, firms with short-term debt more heavily tilted toward foreign currency experience a sharp decline in their net worth and sales, along with a plunge in their market shares and, consequently, their price-cost markups.

On top of these results, we also examine how short-term foreign currency debt exposure affects firms' capital and liquid asset holdings. We find that firms with greater foreign currency short-term debt exposure exhibit lower growth in both capital and liquid assets, and these effects are more pronounced for smaller firms. These empirical patterns align with the core mechanism of our model, in which a heightened debt burden constrains production and affects firms' price setting.

We then analyze the sectoral price changes after a large depreciation. We first construct the sectoral foreign currency debt exposure across manufacturing industries using firm-level balance sheet data. The industry-level short-term foreign currency debt exposure is defined as the weighted average of firms' foreign currency share of short-term debt with their sales as weights. We find that industries with higher short-term foreign currency debt exposure show a larger increase in their sectoral producer prices from 1996 to 1998 than those with lower short-term foreign currency debt exposure. Specifically, one percentage point increase in industry-level foreign debt exposure leads to a 0.57 percentage point increase in sectoral price change. These heterogeneous price responses across industries are robust even after controlling for other channels of the pass-through, such as the degree of product differentiation, imported input share, price stickiness, and the weighted average of firm-level characteristics and two-digit sector fixed effects. The sectoral price response is consistent with firm-level evidence: when firms with foreign currency debt face higher debt burdens following the depreciation, they lower production and sales, increasing the price of goods sold.

We also investigate the dynamic effect of short-term foreign currency debt exposure on sectoral producer prices employing monthly producer price indices. The positive and persistent effects of short-term FC debt exposure on sectoral producer price dynamics upon a large drop in the value of Korean won are saliently shown. We also clearly observe that the effect of foreign currency liabilities on producer prices is absent prior to the devaluation, further confirming that our empirical results are not driven by pre-depreciation trends in prices across sectors.

Based on the empirical findings, we build a heterogeneous firm model with working capital and financial constraints to study an industry equilibrium and quantify the role of balance sheet channel in shaping the price dynamics across industries. We build a model where heterogeneous firms owned by entrepreneurs produce differentiated goods with domestic inputs, foreign inputs, and capital accumulated in the previous period. Firms borrow in domestic and foreign final goods and the currency choice is exogenous given by a parameter λ, a share of the foreign currency debt. The variations across industries in our model are twofold: (i) the *industry-specific* distribution of firms' foreign currency debt shares and (ii) the *industry-specific* imported input share that is common across all firms within an industry. Both are disciplined by their empirical counterparts. Each firm faces a financial constraint on how much debt it can issue, where the maximum amount that it can borrow is a fraction of its physical capital. In addition, each firm faces a working capital constraint requiring it to hold liquid assets to cover a fraction of domestic inputs and imported intermediate inputs before production and sales take place.

In our model, currency depreciation inflates the domestic value of foreign-denominated debt, thereby raising firms' debt burdens. Consequently, firms reduce their liquid asset holdings, tightening working capital constraints in the next period and increasing their effective marginal costs. Furthermore, firms that face tighter financial constraints reduce their investment, which lowers their productivity of variable inputs in the next period and leads to higher production costs. Both margins imply that firms with substantial foreign currency borrowing charge higher prices, and these effects are more pronounced when firms are more financially constrained.

With the calibrated model, we find that the balance sheet effect of foreign currency debt explains a substantial share of the sectoral price changes after the depreciation shock. First, we find that around 21% of the observed mean effect of the foreign currency debt share on sectoral price changes can be explained. Our estimated model can explain around 22% of the variation in price changes across industries. Second, using model-simulated data, we show that the estimated effects of foreign currency debt exposure on the growth rates of net worth, domestic sales, and markups are similar in magnitude to those we have found empirically, and the heterogeneous effects across firm size are likewise comparable. The firm-level responses of capital stock and liquid asset holdings are also consistent with the empirical patterns, capturing our key model mechanism. We also show that firms increase their prices as their foreign currency debt exposure rises, and the effect is stronger for smaller firms.

Lastly, we quantify the balance sheet channel in sectoral price dynamics following a domestic currency depreciation shock. We find that around 10% to 48% of sectoral price changes after the depreciation can be explained by the balance sheet effect of foreign currency debt alone, conditional on borrowing in foreign currency. Moreover, 42% to 87% of the balance sheet effect of foreign currency debt can be attributed to strategic complementarity in firms' price setting, i.e., general equilibrium effects arising from firms' strategic responses to other firms' price increases due to their foreign currency debt exposure. The quantitative importance of the balance sheet channel of foreign currency debt in explaining heterogeneous sectoral price dynamics has an important implication for the optimal monetary policy, especially for emerging economies with dollarized liabilities.

The rest of the paper is organized as follows. Section 2 discusses the related literature and elaborates how our work complements existing research. Section 3 introduces our dataset and reports key summary statistics of firm-level and aggregate industry-level data. This section also presents the motivating facts and the results of our empirical analyses on firm-level outcomes and sectoral price dynamics after the depreciation, depending on exposure to foreign currency debt. Section 4 presents our heterogeneous firm model. Section 5 calibrates our model to analyze the qualitative and quantitative role of the balance sheet channel in shaping price dynamics across industries, and Section 6 illustrates the model mechanism using policy functions. Section 7 compares the patterns of the model-simulated data with their empirical counterparts. Section 8 quantifies the role of the balance sheet effects of foreign currency debt in driving sectoral price dynamics. Concluding remarks follow in Section 9.

2 Literature Review

This paper bridges two important strands of literature in international macroeconomics: the exchange rate pass-through to prices and the contractionary effects of liability dollarization.

In the literature, the degree of exchange rate pass-through to prices is extensively studied (see an extensive survey of this topic in Burstein and Gopinath (2014)). Some of the factors that previous papers have focused on are: nominal and real rigidity, currency of invoicing, pricing to market, market structure, and imported input share. A large theoretical and empirical literature has explored the role of invoicing currency and its implications for the exchange rate pass-through to prices (see, for example, Devereux and Engel (2002); Engel (2006); Goldberg and Tille (2008); Gopinath et al. (2010); Goldberg and Tille (2016); Mukhin (2022); Corsetti et al. (2022); and Drenik and Perez (2021)). Goldberg and Campa (2010) and Amiti et al. (2019) emphasize the role of imported inputs in shaping the degree of exchange rate pass-through to domestic prices. Investigating the balance sheet effect of foreign currency debt upon a large depreciation of domestic currency, this paper identifies an underexplored channel of how the exchange rate shock passes through to prices.

On a related note, there is a vast literature on the relationship between the nominal exchange rate and the real exchange rate: Engel (1993), Engel (1999), Crucini and Telmer (2020), Gopinath et al. (2011), and Burstein et al. (2005). Specifically, Burstein et al. (2005) find that movements in the real exchange rate of tradable goods constructed with border prices are smaller than the overall decline in the CPI-based real exchange rates after a large depreciation and argue that the slow adjustment in non-traded goods prices is the reason behind a large fall in the real exchange rate during the crisis. As the extent to which the real exchange rate is affected by the nominal exchange rate crucially depends on the degree of exchange rate pass-through to prices, our study provides an additional factor – the balance sheet channel of foreign currency debt– that explains real exchange rate fluctuations.

The other strand of literature that we are bringing into the exchange rate pass-through literature is the macroeconomic consequence of liability dollarization. There is a large empirical and theoretical literature investigating the contractionary effects of liability dollarization in emerging economies when their currencies depreciate. Many past studies have both empirically and theoretically uncovered the contractionary effect of liability dollarization when the domestic currency crashes, including Krugman (1999), Céspedes et al. (2004), Gilchrist and Sim (2007), Kim et al. (2015), Kalemli-Ozcan et al. (2016), and Bruno and Shin (2023). Specifically, Kim et al. (2015) show that Korean firms holding higher foreign currency debt suffered more during the Asian Financial Crisis, and Gilchrist and Sim (2007) investigate the role of financial factors and foreign currency denominated debt in accounting for the drop in investment during the Asian Financial

Crisis in Korea.[5] Moreover, Kohn et al. (2020) and Bruno and Shin (2023) study the role of firms' foreign currency debt holdings and their exports.[6] The literature, however, has overlooked how liability dollarization may affect firms' *pricing decisions* as firms' balance sheets deteriorate upon a large depreciation of the domestic currency. Investigating the interaction between foreign currency debt exposure and price dynamics, this paper provides another important aggregate implication – price dynamics after a large depreciation.[7]

There are several papers that investigate the determination of the currency denomination of corporate borrowing in emerging economies. Salomao and Varela (2022) study the role of firms' foreign currency borrowing on economic growth with endogenous currency debt compositions. They find that firms with a high marginal product of capital borrow more in foreign currency. Using Peruvian data, Gutierrez et al. (2023) find that firms in emerging economies are willing to borrow dollar denominated loans because doing so is cheaper even after controlling for expectations of exchange rate movement. Bruno and Shin (2017), Huang et al. 2024, Hardy and Saffie (2024) and Lee and Wu (forthcoming) argue that firms seem to engage in carry trades when borrowing in foreign currency. Kedia and Mozumdar (2003), Yang and Kwon (2023), and Colacito et al. (2022) show empirically that the currency choice in debt issuance is driven by natural hedging motives from business operations. We take the distribution of foreign currency debt holdings prior to the depreciation as exogenous in our model, but we address potential endogeneity bias by controlling for various firm-level characteristics documented in the literature in our empirical analyses.

3 Empirical Analysis

The Korean currency crisis of 1997 caught market participants by surprise, given the reassurances about the country's strong fundamentals by political leaders and policymakers in Korea and around the globe. Moreover, financial hedging against foreign exchange risk was nearly nonexistent at the time, as the exchange to trade financial derivatives was established only in 1999. The *unexpected* depreciation, combined with firms' accumulation of *unhedged* short-term foreign currency liabilities, provides a good quasi-natural experiment to identify the negative balance sheet effect on

[5]Some focus on how bank credit supply shock affects firms' investment: Amiti and Weinstein (2018) and Alfaro et al. (2021).

[6]Casas et al. (2023) explore how the exchange rate affects exports and imports through the financial channel using the Colombian customs data. Casacuberta and Licandro (2023) study how exporters adjust their exports and domestic sales facing a real exchange rate depreciation.

[7]There are recent papers after the Global Financial Crisis, studying the role of financial frictions in firms' pricing in the closed economy setting: Christiano et al. (2015), Del Negro et al. (2015), Gilchrist et al. (2017) and Kim (2021). In an open economy setting, a recent paper by Ma and Schmidt-Eisenlohr (2025), contemporaneous with our work, explores a similar channel in determining the exchange rate pass-through to export prices

firms' activities.[8]

Exploiting a sharp and largely unexpected depreciation episode at the end of 1997, we first show that firms indeed experience balance sheet deterioration when more indebted in foreign currency short-term debt. We then empirically investigate how an industry populated by firms with higher foreign currency short-term debt exposure changes its price compared to other industries upon a large depreciation.

3.1 Data and Summary Statistics

Our analysis employs Korean firm-level data from the NICE (formerly the Korea Information Service Inc., KIS). Our dataset includes firms with assets exceeding 7 billion won (around 5.3 million dollars at the current exchange rate), as they are required to report their balance sheet information to the Financial Supervisory Commission.[9] The data are then compiled by the KIS.[10] As shown in Kim et al. (2015), the dataset coverage of firms is extensive, and firm-level data exhibit the patterns consistent with aggregate macroeconomic dynamics.[11]

As previously mentioned, the KISVALUE dataset has a number of advantages over other datasets: first, it covers a large number of not only large listed but also small, medium-sized non-listed firms, in total around 3,000 manufacturing firms (vs. 760 publicly listed firms in *all* sectors); secondly, it contains the foreign currency split for short-term and long-term debt.[12] One thing we would like to emphasize is that foreign currency debt does not include trade credit, such as foreign currency accounts payable for imported inputs. The relationship documented later in this section therefore does not capture a spurious correlation between imported input share and price changes. Lastly, rich firm-level balance sheet information, including exports and foreign currency liquid assets, allows us to address potential endogeneity issues.

We employ short-term and long-term foreign currency debt exposure prior to the large depreciation as the main regressors, the ratio of short-term foreign currency debt to total short-term debt and the ratio of long-term foreign currency debt to total long-term debt, in order to capture the degree of firms' balance sheet deterioration following the exchange rate shock. As we show in Sections 3.3 and 3.4, our results are robust to an alternative measure of foreign currency indebtedness.

In our KISVALUE dataset, each firm's industry is identified with a five-digit KSIC code (Korea Standard Industrial Classification). Since our main variable of interest is the producer price index

[8] Lyonnet et al. (2022) explore the role of financial hedging in shaping the invoicing currency choice of exporters.

[9] Some firms voluntarily report their balance sheet information even when the assets are less than 7 billion won as of 1996, and the threshold has gone up to 10 billion won.

[10] All the balance sheet information after 2000 are publicly available at http://dart.fss.or.kr/.

[11] Lee and Wu (forthcoming) closely examine the coverage of each firm-level variables and the similarity between firm-level and aggregate dynamics from 2001 – 2017 in Section 2 of their paper.

[12] Bonds are not included in the data.

(PPI) at the sector-level – a four-digit industry code that the Bank of Korea uses to classify each sector – we first map each KSIC code to the closest PPI industry classification.[13] Then, we aggregate all the firm-level variables at the sector level, where each sector is an industry defined by the Bank of Korea for its PPI classification. A *sector* in our empirical analysis corresponds to a four-digit industry defined by the Bank of Korea for its PPI.

We measure a sector's short-term foreign currency debt exposure as the weighted average of the firm-level foreign currency share of short-term debt, where the weight is firm size.[14] Hence, a sector with higher foreign currency debt exposure refers to a sector comprising more firms with a higher foreign currency share of short-term debt. Other industry-level variables aggregated from the firm-level data are defined similarly.

Table 1 presents the summary statistics of firm-level foreign currency debt exposure. It is noticeable that 52.1% of firms hold foreign currency debt and 42.2% of firms hold short-term foreign currency debt in 1996, indicating that foreign currency borrowing is not limited to a few large firms. Short-term debt is the amount of debt due within twelve months. Moreover, conditional on holding a positive amount of foreign currency debt, the mean of the foreign currency share of short-term debt is 15.6% in 1996. In 1996, considering both the extensive and intensive margins of foreign currency borrowing, a large fraction of firms borrow in foreign currency, and a substantial fraction of the total debt is denominated in foreign currency among firms that issue foreign currency debt.

In Table 2, we report the summary statistics of firm-level variables that we employ in the empirical analysis and their correlations with the foreign currency share of short-term debt. Firm size is positively correlated with the foreign currency short-term debt ratio, confirming that larger firms do borrow more in foreign currency debt. While the export share and the foreign currency share of liquid assets are also positively related to the foreign currency share of short-term debt, their correlations are much weaker. Nonetheless, we control for all these firm-level variables in the firm-level regressions and the weighted average of them in the sector-level regressions.

3.2 Motivating Facts: Imported Input vs. Dollar Debt Channel

Before presenting our empirical specifications, we first demonstrate that the imported input channel, even under the strong assumption of a complete exchange rate pass-through of marginal cost shocks, cannot account for the magnitude of domestic producer price changes observed during large depreciation episodes.[15]

[13] There is no matching code between KSIC codes and PPI industry classification; therefore, we manually map these two. We map each KSIC code to one PPI industry classification, i.e., one PPI industry classification is mapped to one or a few KSIC codes. More details can be found in the Appendix.

[14] We use the log of real sales to limit the effects of the outliers.

[15] We also assume a production function with constant returns to scale.

Table 1: Firm-level Summary Statistics: FC Debt Exposure

	1994	1995	1996	1997	1998
Extensive Margin					
Number of firms	2623	3517	4143	5025	5850
Fraction of firms with FC debt (%)	52.5	45.5	43.7	42.4	36.1
Fraction of firms with short-term FC debt (%)	43.3	36.8	35.4	33.1	28.6
Intensive Margin					
FC share of short-term debt (%)	15.8	16.7	18.1	22.2	24.6
	(21.7)	(23.6)	(24.5)	(25.9)	(29.2)
FC share of long-term debt (%)	38.3	37.8	41.0	50.0	48.2
	(29.0)	(29.4)	(29.7)	(30.7)	(31.5)
Short-term FC debt to total debt (%)	8.9	9.6	10.0	11.9	12.4
	(13.7)	(15.4)	(15.2)	(15.5)	(16.7)
Long-term FC debt to total debt (%)	14.9	15.2	17.0	23.9	22.7
	(16.2)	(16.8)	(17.9)	(22.3)	(22.2)
Short-term FC debt to total asset (%)	2.7	3.0	3.5	4.6	4.2
	(4.3)	(5.3)	(6.2)	(7.1)	(6.2)
Long-term FC debt to total asset (%)	4.8	5.0	6.0	9.8	8.7
	(5.9)	(5.8)	(7.2)	(10.9)	(10.3)

Notes: Short-term debt is defined as debt with a remaining maturity of less than one year; long-term debt includes all other debt. Mean values are reported, and standard deviations are shown in parentheses.

Table 2: Foreign Currency Debt and Other Firm-level Characteristics

	Mean (1)	*Stdev* (2)	*Corr with Short-term FC Debt Ratio* (3)
Export Share (%)	7.19	19.68	0.11
Size	23.83	1.56	0.29
Leverage (%)	36.42	26.66	-0.11
Short-term Debt Ratio (%)	58.43	30.13	-0.09
FC Cash Ratio (%)	0.14	1.40	0.13

Notes: The table shows the summary statistics for firm-level variables in 1996. Columns (1) and (2) show the average and standard deviation of each variable, respectively, and Column (3) shows the correlations with short-term FC debt. Firm-level variables that we examine are: export share (export to sales ratio), size (log of real sales), leverage ratio (total debt to total assets ratio), short-term debt ratio (short-term debt to total debt ratio), and foreign currency cash ratio (foreign currency cash to total current assets ratio).

In Table 3, we report, for each country, the average increase in marginal cost following the devaluation, calculated by multiplying the change in import price indices by the pre-crisis share of imported intermediate inputs. Under a complete pass-through, the average domestic producer price would rise by the same proportion as the marginal cost increase.[16] Yet, in the data, we observe a much larger increase in domestic producer prices, an order of magnitude larger for some countries.

Moreover, Figure 2 shows that, following the large depreciation at the end of 1997 in Korea, most narrowly defined manufacturing sectors experience domestic producer price increases that

[16] In fact, the exchange rate pass-through of marginal cost shocks is incomplete in the data.

Table 3: PPI Changes vs. Hypothetical PPI Implied Via Imported Input Channel

	Year (i)	ΔImport Price Index (ii)	Imported Input Share (iii)	ΔMC (iv)	ΔPPI (v)
Brazil	1999	64.08	6.0	3.84	33.00
Mexico	1994	165.39	13.2	21.87	47.11
Korea	1997	40.37	11.0	4.4407	16.46
Thailand	1997	20.09	22.0	4.43	17.86
Argentina	2002	169.87	6.1	10.39	122.22

Notes: All the price changes are price changes from one year prior to a large devaluation to one year after. We multiply imported input price index changes, summarized in Column (ii), by the pre-devaluation imported intermediate input share in the total inputs used (both domestic and imported intermediate inputs and value added from labor and capital), summarized in Column (iii), assuming a production function with a constant return to scale. Due to data availability, we use the imported input share of 1995 for Mexico, one year after the devaluation. For Korea, we use the imported input share of 1995, two years prior to the devaluation. The remaining countries' imported input shares are from one year prior to the crisis. Import price indices are from Burstein et al. (2005), and PPI changes are from the IMF International Financial Statistics (IFS). The imported input share is computed from the input–output table from the OECD Statistics and Bank of Korea. The country sample is identical to that of Burstein et al. (2005).

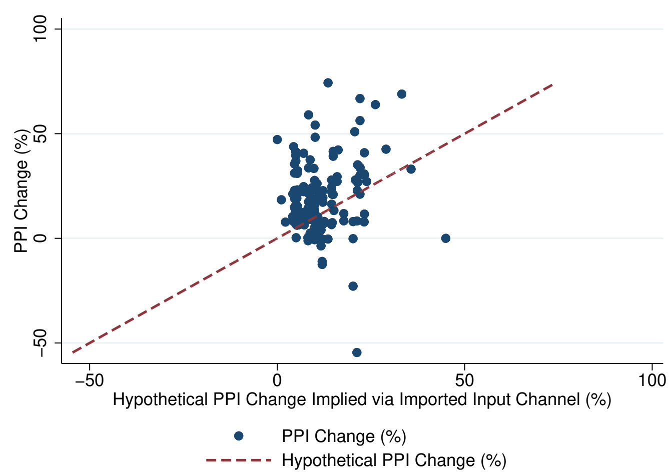
far exceed those predicted by higher marginal costs from their imported inputs, even under the assumption of a complete pass-through of marginal cost shocks.[17] Notably, more than 70% of sectors show PPI increases in 1996 – 98 greater than the hypothetical PPI changes implied by the imported input channel, even with a *100% pass-through* of higher marginal costs from imported inputs.

More strikingly, the residual PPI changes, defined as actual PPI changes minus the hypothetical changes implied by the imported input channel, are strongly and positively correlated with the pre-depreciation foreign currency (FC) share of short-term debt, as illustrated in Figure 3. In this figure, sectors are grouped into seven bins: the first includes sectors with zero short-term foreign currency debt, and the remaining six represent equally sized intervals of foreign currency debt shares. For example, the second bin covers sectors with a foreign currency share greater than 0 and less than or equal to 0.1. We compute the mean residual PPI change within each bin and find that sectors with higher short-term foreign currency debt shares exhibit, on average, larger residual PPI changes, i.e., price increases unexplained by the imported input channel. This finding strongly hints at the relevance of our balance sheet channel in explaining domestic price dynamics.

These cross-country and cross-sectoral back-of-the-envelope calculations strongly suggest that there is an additional mechanism at work beyond the imported input channel that the literature has mostly focused on. We show in subsequent sections that the balance sheet effects of foreign currency debt account for the much more pronounced increases in domestic producer prices following a sharp depreciation of the domestic currency.

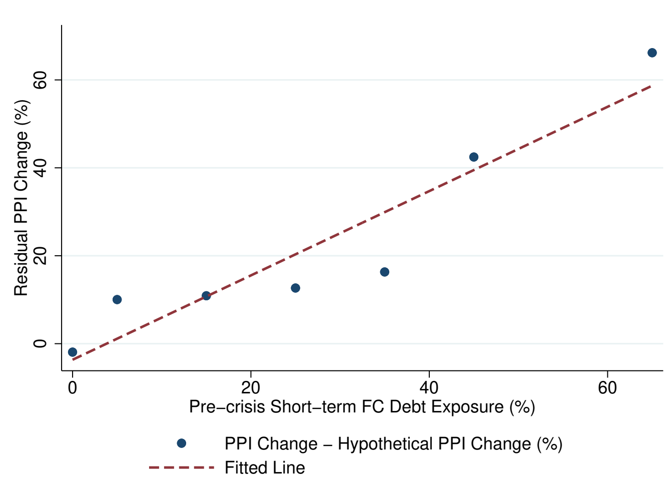
[17]Each sector has varying levels of marginal cost increases from imported inputs as (i) each imported input price increases by a different magnitude, and (ii) each sector uses a different amount of *each* imported input in production.

Figure 2: PPI Changes vs. Hypothetical PPI Changes



Notes: A dot represents a narrowly defined manufacturing sector in our analysis. The y-axis shows sectoral PPI changes in 1996-98. The x-axis shows the hypothetical PPI changes implied by the imported input channel, which we compute as the product of each imported input's price increase from 1996-98 and its share in the production. Dots above the 45-degree line represent sectors with higher realized PPI changes in 1996-1998 than those implied by the increase in marginal costs from imported inputs, under the assumption of a complete pass-through of marginal cost shocks.

Figure 3: Residual PPI Changes and Short-term FC Debt Exposure



Notes: The residual PPI changes are the actual PPI changes in 1996-1998 minus the hypothetical PPI changes implied from the imported input price changes, assuming a complete exchange rate pass-through of marginal cost shocks. We define seven equally-sized bins of short-term FC debt to short-term total debt ratio in 1996. For instance, the first bin includes sectors with a zero FC share of short-term debt, and the second bin contains sectors with a FC share of short-term debt between 0 and 0.1. The rest of the bins are defined similarly. We compute the mean of residual PPI changes over sectors in each bin.

3.3 Negative Balance Sheet Effects of FC Debt: Firm-level Regression

Using information on firm-level variables from our novel dataset, we investigate whether and to what extent firms with higher foreign currency debt exposure actually experience deterioration of their balance sheets following the depreciation. We examine the growth rates of net worth and sales, following Kim et al. (2015), to quantify the degree of balance sheet deterioration. In addition, we analyze how the negative balance sheet effect of foreign currency debt would affect firm-level price-cost markups following the depreciation.

Below is the firm-level empirical specification that we adopt for the firm-level analyses.

$$\begin{aligned}\Delta y_{j,96-98} = {} & \beta_0 + \beta_1 \text{ST FC}_{j,1996} + \beta_2 \text{LT FC}_{j,1996} + \beta_3 \text{Size}_{j,1996} \\ & + \beta_4 \text{ST FC}_{j,1996} \cdot \text{Size}_{j,1996} + \beta_5 \text{LT FC}_{j,1996} \cdot \text{Size}_{j,1996} + \beta_6 \text{X}_{j,1996} + \epsilon_j\end{aligned} \tag{1}$$

As explained above, the dependent variables y_j that we examine are firm-level real net worth, real domestic sales, and markups.[18] The dependent variable is the growth rate of y_j from 1996 to 1998, capturing the change over one year before and one year after the large depreciation.[19] Price-cost markups are computed following De Loecker and Warzynski (2012). We estimate the *changes* in markup as the changes in the ratio of total sales to the cost of sales, assuming that output elasticity is the same across firms within each two-digit manufacturing industry.[20]

ST FC and LT FC denote the firm-level foreign currency share of short-term debt and the foreign currency share of long-term debt, respectively. We investigate their marginal effects separately to capture potential asymmetries in the impact of foreign currency exposure across debt maturity structures. This distinction is motivated by empirical evidence showing that short-term indebtedness leads to stronger adjustments in firm-level sales and investment – particularly when debt is denominated in foreign currency (Aguiar, 2005; and Kim et al., 2015), and more broadly for overall short-term leverage (Kalemli-Özcan et al., 2022). These empirical findings are consistent with theoretical work emphasizing that short-term debt carries greater rollover risk, especially during periods of financial stress and economic downturns (Chang and Velasco, 1999; He and Xiong, 2012; and Diamond and He, 2014). Nonetheless, long-term foreign currency debt may also affect firm performance following a sharp decline in the value of the domestic currency, as firms should service higher interest and principal payments.

Moreover, we interact FC debt variables with the firm size, measured by log of real sales, to see if the balance sheet effect would be smaller for large firms who are less financially constrained compared to small ones, following Kim et al. (2015). Other firm-level characteristics X_j – the export to sales ratio, the leverage ratio (total debt to total assets), the short-term debt to total debt ratio, and the foreign currency cash to total current assets ratio, and the interactions of short-term FC debt exposure with the log of total short-term debt and long-term FC debt exposure with the log

[18] All nominal series are deflated by the CPI to compute real series.

[19] Net worth can be negative, and therefore, changes in real net worth from 1996 to 1998 are computed and normalized by real domestic sales.

[20] We estimate the regressions with two-digit industry fixed effects.

of total long-term debt – are controlled to address potential endogeneity issues.[21] Importantly, we control for both the export to sales ratio and the foreign currency share of liquid assets, as both can be determinants of the currency composition of debt, capturing natural hedges. We also include *two-digit industry fixed effects* to absorb differences across two-digit industries and control for other industry-level shocks, such as demand shocks. Our main coefficients of interest are β_1 and β_4 in each regression.

Table 4: Firm Performance and FC Debt

	Net Worth Growth	Domestic Sales Growth	Markup Growth
	(1)	(2)	(3)
ST FC	-5.6555***	-9.4335**	-0.8923***
	(1.5268)	(4.1259)	(0.3062)
LT FC	-0.0652	-0.7135	0.1563
	(0.7161)	(2.2891)	(0.1499)
Size	-0.0420***	-0.2495***	-0.0094***
	(0.0101)	(0.0279)	(0.0023)
ST FC x Size	0.2269***	0.3710**	0.0353***
	(0.0628)	(0.1651)	(0.0124)
LT FC x Size	-0.0256	-0.2074	-0.0066
	(0.0408)	(0.1350)	(0.0071)
Leverage Ratio	0.1600***	0.1511	0.0153
	(0.0524)	(0.1150)	(0.0125)
Export to Sale Ratio	0.7703***	1.4090***	0.0413***
	(0.0823)	(0.2007)	(0.0089)
ST Debt Ratio	0.0133	0.0465	-0.0055
	(0.0318)	(0.0948)	(0.0085)
FC Cash Ratio	-1.5078*	-3.1991***	0.2177**
	(0.7740)	(1.1927)	(0.1042)
ST FC x ln(ST Debt)	-0.2462**	-0.0332	-0.0115
	(0.0998)	(0.1805)	(0.0169)
LT FC x ln(LT Debt)	0.0362	0.2823***	0.0006
	(0.0290)	(0.0858)	(0.0051)
Adjusted R^2	0.1571	0.1881	0.0463
N	3135	3135	3134

Notes: The dependent variables are the growth rates of net worth, domestic sales, and estimated markups from 1996 to 1998. All the nominal series are deflated with the CPI. The main regressors are the firm-level short-term foreign currency debt ratio (ST FC) and the interaction between firm size and ST FC in 1996. Firm size is measured as the log of real sales. Robust standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table 4 summarizes the firm-level regression results. As we can see in Columns (1) and (2), firms with higher short-term foreign currency debt exposure suffer a larger decline in net worth and

[21] The inclusion of the last two control variables are motivated by our structural model, where the effect of the foreign currency debt share depends on the size of debt shown in Section 6. For ease of comparison with the model counterparts, we standardize the log of short-term debt as we do with the model simulated data in Section 7. The key empirical results reported in this section do not depend on this normalization, and results without normalization as well as results excluding the last two control variables are available upon request.

sales, indicating a deterioration of their balance sheets following the depreciation. The negative effect is more pronounced when firm size is smaller, since smaller firms are more financially constrained. Specifically, a one percentage point rise in the short-term foreign currency ratio leads to a 0.19 percentage point reduction in net worth for an average-sized firm. When firm size decreases by one standard deviation, the negative effect gets larger in magnitude by 0.32 percentage points. For real domestic sales, one percentage point increase in the short-term foreign currency ratio is associated with a 0.49 percentage point decrease in domestic sales of an average-sized firm. This negative impact becomes more pronounced, rising by 0.52 percentage points, when firm size decreases by one standard deviation.[22] This finding is consistent with the result of Kim et al. (2015).

Column (3) shows how each firm's markup growth changes when it is more indebted in short-term foreign currency debt. The regression result indicates that deterioration of the balance sheet reduces firms' market share and their markups. Specifically, a one percentage point increase in short-term foreign currency debt exposure is associated with a 0.04 percentage point decrease in the price-cost markup for an average-sized firm. If firm size decreases by one standard deviation, the impact of short-term foreign currency debt exposure on markup growth becomes more negative by 0.05 percentage points. Figure 4 shows a complete picture of how the marginal effects of short-term foreign currency debt exposure on the growth of firm-level variables vary with firm size.[23]

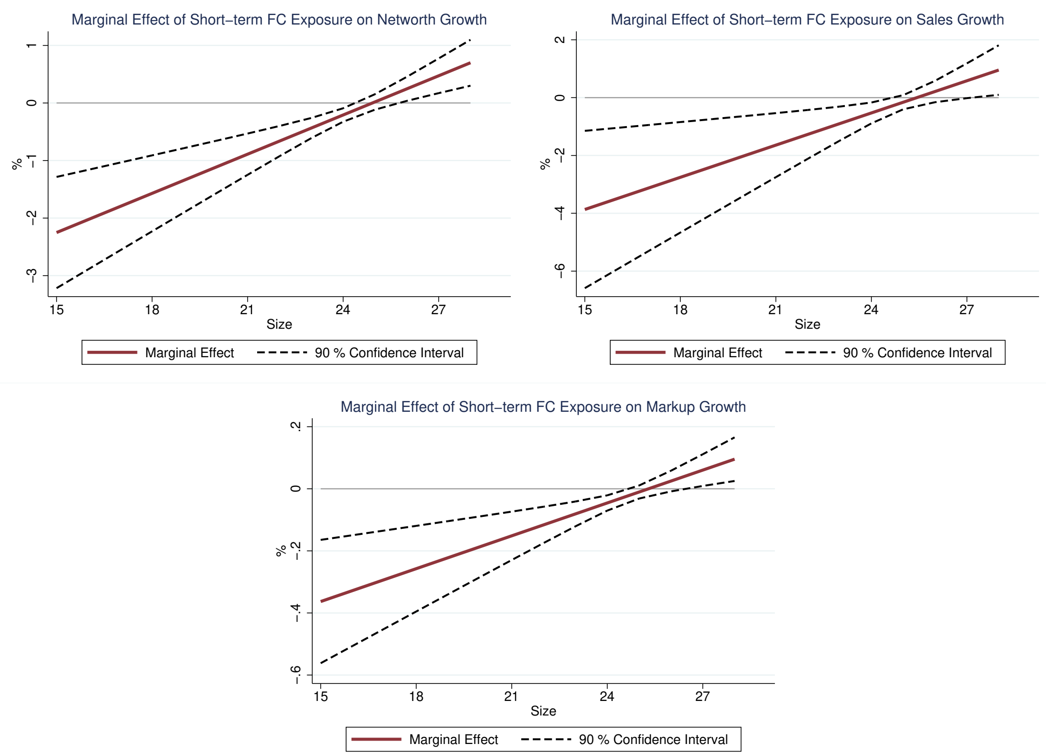
We have conducted a number of robustness checks. First, we show that the results do not change qualitatively with two alternative definitions of foreign currency debt exposure: one defined using the short-term and long-term foreign currency debt to *total debt* ratio, shown in Table A4 in the Appendix, and the other using the ratio of short-term and long-term foreign currency debt to *total assets*, summarized in Table A5 in the Appendix. Regardless of how we define the foreign currency debt exposure, we see that firms with high short-term foreign currency debt exposure experience a larger decline in their net worth, sales and markups. Second, we show that the results are intact even when including five-digit industry fixed effects. The estimates on ST $\text{FC}_{j,1996}$ and the interaction term of ST $\text{FC}_{j,1996}$ and $\text{Size}_{j,1996}$, shown in Table A6 in the Appendix, are very similar quantitatively to what we see in Table 4.

Moreover, we examine the dynamic effects of foreign currency debt exposure on net worth growth, sales growth and markup growths before and after the large depreciation. We estimate Equation (2), following Jordà (2005):

[22]The mean and the standard deviation of firm size are 24.1 and 1.4, respectively.

[23]The marginal effect of short-term foreign currency debt exposure is evaluated conditional on short-term debt being at its mean value.

Figure 4: Marginal Effects of Short-term FC Exposure on Firm-level Variables



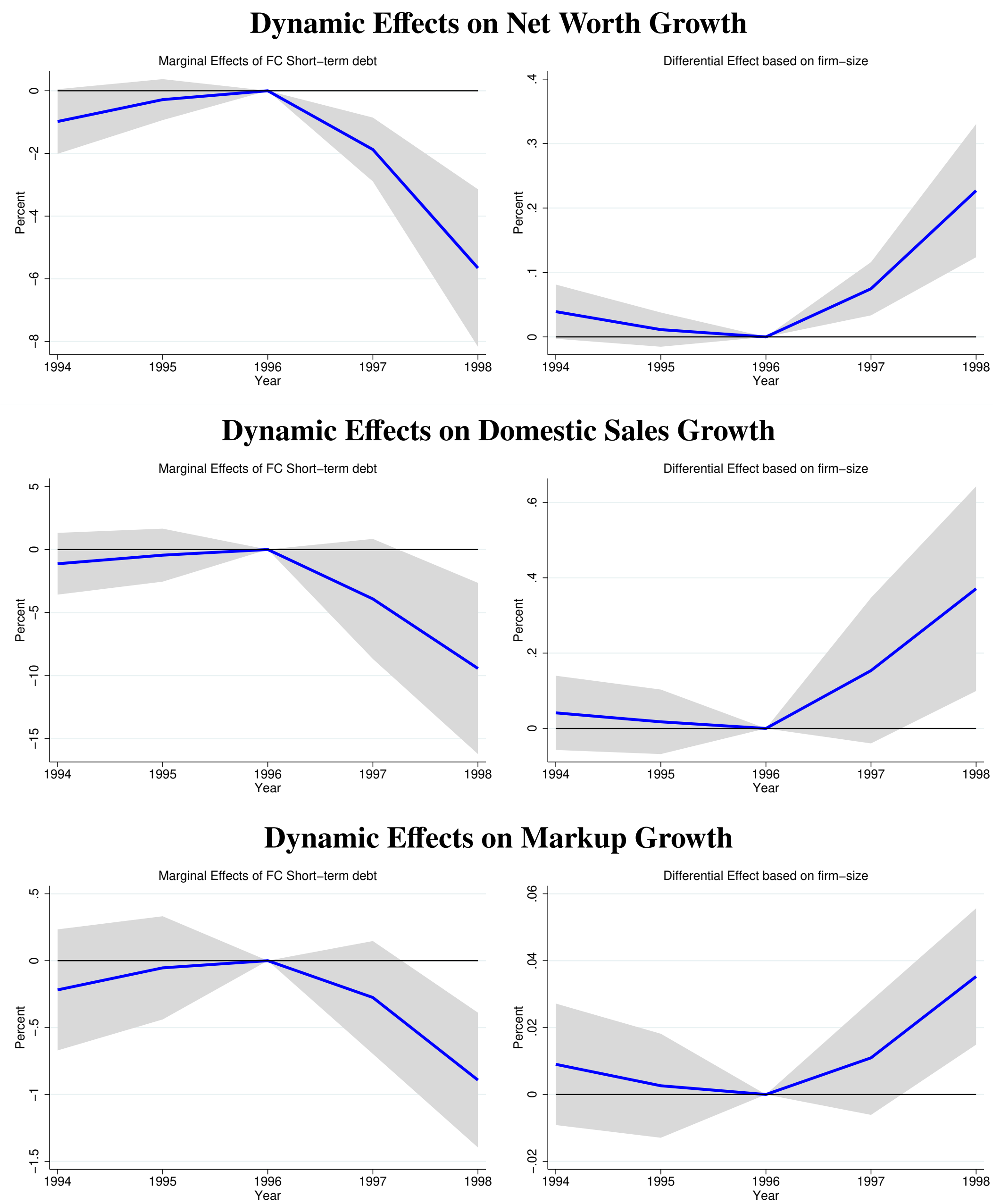
Notes: The solid red lines depict the marginal effects of short-term foreign currency debt exposure on firm-level variables across firm size. The navy dashed lines show the 90 percent confidence intervals of the marginal effects. The graphs are based on the results in Table 4.

$$\frac{y_{j,1996+h} - y_{j,1996}}{y_{j,1996}} = \beta_{0,h} + \beta_{1,h}\text{ST FC}_{j,1996} + \beta_{2,h}\text{LT FC}_{j,1996} + \beta_{3,h}\text{Size}_{j,1996} \tag{2}$$

$$+ \beta_{4,h}\text{ST FC}_{j,1996} \cdot \text{Size}_{j,1996} + \beta_{5,h}\text{LT FC}_{j,1996} \cdot \text{Size}_{j,1996} + \beta_{6,h}\text{X}_{j,1996} + \epsilon_j, \tag{3}$$

where $h = \{-2, -1, 1, 2\}$. The dependent variable is the growth rate of firm-level variable y_j over h years relative to its value in 1996. We aim to explore if and how firms' net worth, sales and markups, relative to their values in 1996, have shown different dynamics depending on their short-term foreign currency debt exposure in 1996. Our key coefficients of interest are $\beta_{1,h}$ and $\beta_{4,h}$.

Figure 5: Dynamic Effects of Short-term FC Exposure on Firm Performance



Notes: The solid blue lines depict the dynamic estimates on short-term FC exposure (left panel) and the interaction term between short-term FC debt exposure and firm size (right panel). The grey areas show the 90 percent confidence intervals, computed with robust standard errors.

Figure 5 illustrates the dynamic effects of foreign currency debt on firm net worth, sales and markups around the 1996. The left panels show that prior to 1996, short-term foreign currency debt exposure had no systematic relationship with any of the three outcome variables; the marginal effects of short-term foreign currency debt exposure are not significantly different from zero for $h < 0$, confirming parallel pre-trends. Following the depreciation, the effects turn sharply negative in 1997, particularly for firms' net worth, and continue to grow in magnitude through 1998. This pattern confirms that the negative balance sheet effect intensifies over time.

The right panels reveal that smaller firms are significantly more vulnerable to foreign currency debt exposure after the depreciation. The differential size effect remains close to zero before 1996 and becomes positive for net worth in 1997 and for sales and markups in 1998. This pattern indicates that smaller firms with short-term foreign currency debt experience larger declines in net worth compared to larger firms with similar exposure, which subsequently translates into greater drops in sales and markups.

Table 5: Other Firm-level Outcomes and FC Debt

	Capital Growth	Liquid Assets Growth
	(1)	(2)
ST FC	-5.4521***	-8.6206**
	(1.7197)	(4.0127)
LT FC	-0.0302	0.7378
	(0.7647)	(1.8844)
Size	-0.0160	-0.1141***
	(0.0114)	(0.0196)
ST FC x Size	0.2184***	0.3398**
	(0.0706)	(0.1627)
LT FC x Size	0.0034	-0.1302
	(0.0312)	(0.1075)
Leverage Ratio	-0.0499	-0.0004
	(0.0535)	(0.1076)
Export to Sale Ratio	0.0544	0.3175***
	(0.0441)	(0.0946)
ST Debt Ratio	0.0259	-0.2085**
	(0.0477)	(0.0816)
FC Cash Ratio	0.6892	-2.5175***
	(0.5911)	(0.7137)
ST FC x ln(ST Debt)	-0.0941	-0.1604
	(0.1006)	(0.1961)
LT FC x ln(LT Debt)	-0.0029	0.1233**
	(0.0243)	(0.0623)
Adjusted R^2	0.0216	0.0632
N	3136	3129

Notes: The dependent variables are the growth rate of (1) capital (total assets minus liquid assets minus inventories) and (2) liquid assets (the sum of cash and cash equivalents, short-term financial instruments and accounts receivable) from 1996 to 1998. All the nominal series are deflated with the CPI. The main regressors are the firm-level short-term foreign currency debt ratio (ST FC) and the interaction between firm size and ST FC in 1996. Firm size is measured as the log of real sales. Robust standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

On top of these results, we also examine the effect of short-term foreign currency debt exposure on other firm-level variables: capital (defined as total assets minus liquid assets minus inventories) and liquid assets (the sum of cash and cash equivalents, short-term financial instruments and accounts receivable), summarized in Table 5.[24] We find that firms indebted in short-term foreign currency experience lower growth rates of capital and liquid asset holdings, and the magnitude of the negative balance sheet effects on them increases as firm size decreases. The empirical results are aligned with our model mechanisms, elaborated in detail in Section 6. We also run analogous regressions with our model simulated data and show that these estimates, the non-targeted moments, are qualitatively and quantitatively aligned with what we have found empirically in Tables 4 and 5.

In sum, after the large depreciation, firms with higher foreign currency debt exposure experience a larger decline in their net worth and output, and consequently a greater drop in their market shares and price-cost markups.

3.4 FC Debt Exposure and Price Dynamics: Industry-level Regression

Analyzing the negative balance sheet effect of FC debt on domestic prices, we estimate Equation (4):

$$\Delta p_{I,1996-98} = \beta_0 + \beta_1 \text{ST FC}_{I,1996} + \beta_2 \text{LT FC}_{I,1996} + \beta_3 \text{X}_{I,1996} + \epsilon_I. \tag{4}$$

The dependent variable is the growth rate of sector I's domestic producer price from 1996 to 1998. The main regressors are sector-level short-term foreign currency debt exposure (ST FC) and long-term foreign currency debt exposure (LT FC) in 1996. We measure a sector's short-term foreign currency debt exposure as the weighted average of the firm-level foreign currency share of short-term debt, where the weight is firm size. Following the firm-level regression (1) in Section 3.3, we investigate the marginal effects of short-term and long-term foreign currency debt exposure separately. To alleviate potential endogeneity concerns, we use the pre-depreciation (1996) value of regressors.[25]

To mitigate the concerns about endogeneity, we control for X_I, the weighted average of firm-level characteristics and other key industry-level pass-through determinants. For sectoral characteristics, we include the level of the product differentiation, the imported intermediate input share prior to the depreciation, and price stickiness. We classify each industry selling homogeneous or differentiated goods, based on the method of Rauch (1999). When the Rauch dummy variable is equal to one, the sector is characterized as selling differentiated products. The imported input share for each sector is the ratio of imported intermediate inputs to total amount of inputs, which include all intermediate inputs and value added from labor and capital. We use the 1995 Input-Output table due to the data availability. The degree of price stickiness for each industry is measured as the

[24]Capital and liquid assets are deflated by the CPI.

[25]Ten industries with highest foreign currency share of short-term debt are reported in Table A2 in the Appendix. Summary statistics of industry-level controls are included in Table A3 in the Appendix.

median frequency of price adjustment, documented by Nakamura and Steinsson (2008); a higher value indicates less sticky prices. We also include the weighted average values of firm-level characteristics: firm size (log of real sales), the export to sales ratio, the leverage ratio (total debt to total assets), the short-term debt to total debt ratio, and the foreign currency cash to total current assets ratio. We use firm size as the weight when computing the weighted averages of firm-level variables. We also include two-digit PPI sector fixed effects to control for some sector-level shocks during this period and unobservable sectoral characteristics.

Table 6: Industry Price Dynamics and FC Debt

	(1)	(2)	(3)	(4)	(5)
ST FC	0.6950***	0.7109***	0.6722***	0.6565***	0.5685***
	(0.1607)	(0.1856)	(0.1783)	(0.2162)	(0.2038)
LT FC		-0.0295	-0.1302	-0.1899	-0.1846
		(0.1173)	(0.1245)	(0.1351)	(0.1365)
Size				0.0063	0.0024
				(0.0183)	(0.0181)
Export to Sale Ratio				-0.0243	-0.0469
				(0.1583)	(0.1543)
Leverage Ratio				0.3611**	0.3351**
				(0.1452)	(0.1589)
ST Debt Ratio				0.0778	0.1255
				(0.1172)	(0.1253)
FC Cash Ratio				0.3556	-0.2252
				(3.0707)	(3.1429)
Rauch Dummy					0.0075
					(0.0447)
Imported Input Share					0.2830*
					(0.1656)
Degree of Price Stickiness					0.0317*
					(0.0168)
Broad Sector FE	No	No	Yes	Yes	Yes
Adjusted R^2	0.1400	0.1348	0.4245	0.4439	0.4513
N	156	156	156	156	156

Notes: This table shows the results from regression 4. The dependent variable is the growth rate of sectoral domestic producer prices from 1996 to 1998. The main regressors are the sector-level short-term foreign currency debt exposure (ST FC) and the long-term foreign currency debt exposure (LT FC) in 1996. Robust standard errors are reported in parentheses.* p<0.1, ** p<0.05, *** p<0.01.

Table 6 summarizes the regression estimates of Equation (4). Column (1) summarizes the estimates using only the foreign currency share of short-term debt. When a sector has higher short-term foreign currency debt exposure, it shows a larger price increase following the large depreciation. Specifically, a one-percentage point increase in short-term foreign currency debt exposure is associated with a 0.70 percentage point increase in prices. After controlling for other sector-level characteristics, the estimate declines to 0.57, yet remains statistically significant, indicating that short-term foreign currency debt exposure still has an important effect on price changes even after accounting for other pass-through determinants documented in the literature.

As expected, sectors with a higher imported intermediate input share exhibit larger increases in domestic producer prices. In addition, sectors with a lower average degree of price stickiness are associated with greater increases in domestic prices. By contrast, the level of product differentiation does not have a significant effect on price dynamics after controlling for broad industry fixed effects and the weighted average of firm-level characteristics.

Overall, the industry-level price responses across short-term foreign currency debt exposure are consistent with our firm-level evidence: when firms with higher foreign currency debt face increased debt burdens after the depreciation, their production becomes constrained, leading to lower sales and, consequently, higher prices for goods sold.

For robustness checks, we conduct four additional exercises. First, we control for changes in the number of firms in each industry, which may have some implications for industrial price dynamics following the depreciation. The results are shown in Table A8 in the Appendix. The main results are robust to controlling for changes in the level of competition that may occur when firms exit during the economic turmoil. Second, we control for the ratio of imported *output* to total output in each sector. We use the 1995 input-output table to compute the share of imported output in total output. The results are summarized in Table A9 in the Appendix. The positive estimate on the short-term foreign currency debt exposure hardly changes after controlling for the imported output share. Third, we use a subsample of firms with zero exports and re-estimate regression (4) with newly constructed industry-level regressors. Table A10 in the Appendix summarizes the results, showing that the estimated effect of foreign currency debt exposure on sectoral prices remains positive and quantitatively large.

Fourth, we also have explored if the results may change with alternative definitions of foreign currency debt exposure: one defined using the short-term and long-term foreign currency debt to *total debt* ratio and another defined using short-term and long-term foreign currency debt to *total assets* ratio. The results do not change shown in Table A11 and Table A12 in the Appendix.

Fifth, we use an alternative measure of sectoral foreign currency debt exposure instead of taking a weighted average of firm-level exposure. We define the sectoral foreign currency short-term and long-term debt exposure as:

$$\text{FC ST of Sector } S = \frac{\sum_{f\in S(f)} \text{FC ST Debt}_f}{\sum_{f\in S(f)} \text{Total ST Debt}_f}, \text{ and FC LT of Sector } S = \frac{\sum_{f\in S(f)} \text{FC LT Debt}_f}{\sum_{f\in S(f)} \text{Total LT Debt}_f}.$$

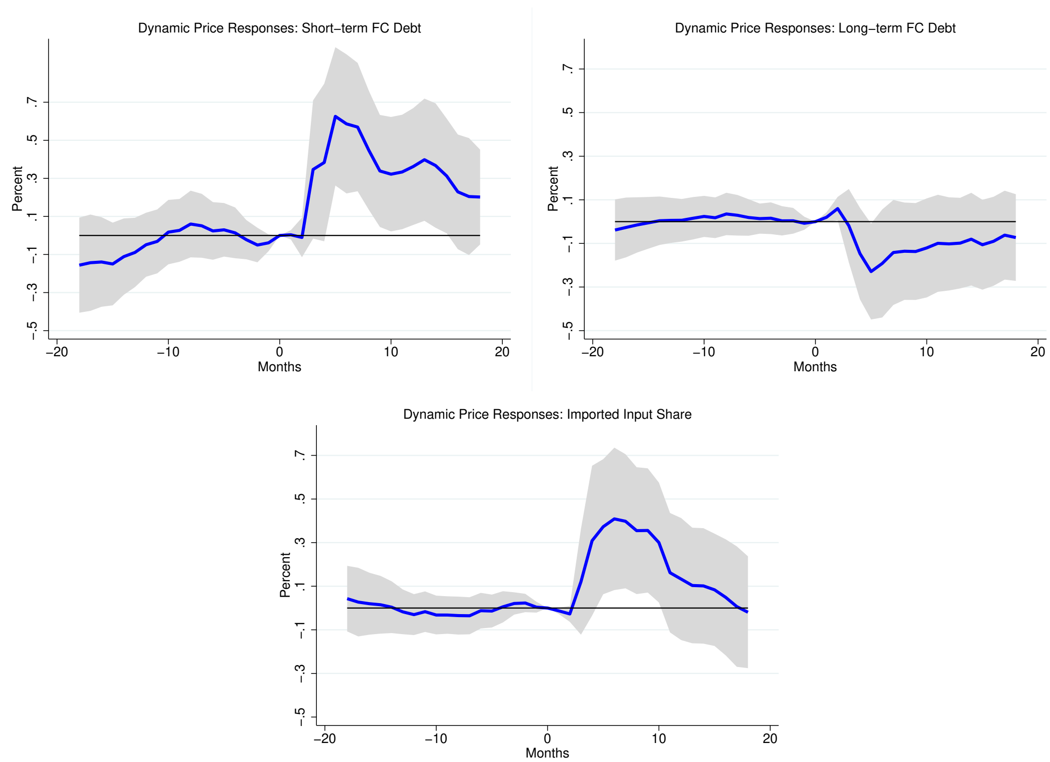
The estimate on short-term foreign currency debt exposure is robust to this alternative aggregation, shown in Table A13 in the Appendix. Lastly, we use a subsample of industries that have at least four firms and re-estimate regression (4). Shown in Table A14 in the Appendix, the results do not change much quantitatively, where the effect of short-term foreign currency debt exposure is estimated at 0.5 and significant at 5% level.[26]

Furthermore, we explore the dynamic and higher frequency responses of monthly sectoral PPI, 18 months before and after the large depreciation. We estimate Equation (5), following Jordà (2005):

$$\frac{p_{I,1997\text{m}9+h} - p_{I,1997\text{m}9}}{p_{I,1997\text{m}9}} = \beta_h + \beta_{1,h}\text{ST FC}_{I,96} + \beta_{2,h}\text{LT FC}_{I,96} + \beta_{3,h}\text{X}_{I,96} + \epsilon_{I,h}, \tag{5}$$

where $h = \{-18, ..., -1, 0, 1, ..., 18\}$. Our key coefficients of interest are $\beta_{1,h}$.

Figure 6: Monthly PPI Before and After the Depreciation of Korean Won



Notes: The figure plots the dynamic effects β_h of short-term FC debt exposure, long-term FC debt exposure and the imported input share on monthly sectoral PPIs, estimated in regression 5. The area represents the 90% confidence intervals with robust standard errors.

Figure 6 shows the dynamic effects of short-term foreign currency debt exposure, long-term foreign currency debt exposure and the imported input share. We see that industries show persistently higher levels of monthly PPIs for around a year when they are more indebted in short-term foreign

[26]We also have experimented with higher cutoffs for a number of firms in each industry. The results do not change when using a subsample of industries with more than five firms and those with more than ten firms. The results are available upon request.

currency; however, we see no differential responses of monthly PPIs for those sectors borrowing more in long-term foreign currency debt. Importantly, we see that coefficients are not significantly different from zero at 10 % significance level before December 1997 when Korea finally decided to float the exchange rate. We also observe positive dynamic effects of the imported input share on sectoral monthly PPIs, lasting for around ten months. The results are robust to using quarterly PPIs, shown in Figure A1 in the Appendix.

Lastly, we also examine the exchange rate pass-through to sectoral prices in more recent periods from 2000–2019. We estimate the panel regression of Equation (6):

$$\begin{aligned}\Delta p_{I,t} &= \beta_I + \beta_t + \beta_1 \text{ ST FC}_{I,t-1} + \beta_2 \text{LT FC}_{I,t-1} \\ &\quad + \beta_3 \Delta e_t \times \text{ST FC}_{I,t-1} + \beta_4 \Delta e_t \times \text{LT FC}_{I,t-1} + \beta_5 \text{X}_{I,t-1} + \epsilon_{I,t}.\end{aligned} \tag{6}$$

The dependent variable is the annual growth rate of sector I's domestic producer price. The exchange rate is defined as the Korean won price of the U.S. dollar, and therefore, an increase in the exchange rate is the depreciation of Korean won against the U.S. dollar. We are interested in how the exchange rate shock passes through to domestic producer prices through the balance sheet channel. The coefficient estimates of our interest are β_3 and β_4. We include both year fixed effects and PPI sector I fixed effects. We find that the estimates are qualitatively and quantitatively aligned with what we observe during the large depreciation in 1997, where β_3 is estimated to be at 0.42 and 0.56 without and with the interaction term of $\Delta e_t \times \text{X}_{i,t-1}$, respectively. The results are reported in Table A16 in the Appendix. In a nutshell, the panel regression results reaffirm that the balance sheet effect of foreign currency debt plays an important role in determining the degree of exchange rate pass-through to domestic prices.[27]

In sum, from the empirical analyses, we find that during the large depreciation episode, firms with higher foreign currency debt exposure indeed experience balance sheet deterioration and a larger drop in their price-cost markups. Moreover, at the industry-level, we document that industries populated by firms with higher foreign currency debt exposure increase their domestic producer prices more. Based on these results, we develop a structural model, in which high foreign currency debt exposure, together with a large depreciation, increases firms' effective marginal costs. We aim to quantify how important the balance sheet effect of foreign currency debt is in channeling the exchange rate shock to domestic producer prices.

[27]We re-estimate the panel regression with two subsample periods: periods of KRW appreciation against USD and periods of KRW depreciation against USD. Our estimation results shown in Table A17 in the Appendix corroborate that it is the depreciation of the domestic currency that balloons firms' foreign currency debt burden, constrains their production, and raises their prices.

4 Model

In this section, we build a heterogeneous firm model to rationalize our empirical findings and quantify the balance sheet effects of foreign currency debt exposure on industry price dynamics following the depreciation. Even though our industry- and firm-level empirical analyses provide clear evidence for the negative balance sheet effect, this evidence mainly relies on the cross-sectional variation in the data and focuses on the relative changes across industries and firms. Hence, the model provides a clear understanding of the underlying channel based on the empirical analysis and helps us to quantify the importance of balance sheet deterioration in explaining the aggregate industry-level price dynamics upon a large depreciation.

Our model is based on Kohn et al., 2020. We build an industry equilibrium model, where heterogeneous firms, owned by entrepreneurs, produce differentiated goods and issue one-period non-defaultable debt, of which a fraction (firm-specific) is denominated in foreign final goods. Each firm has a varying level of foreign currency debt ratio, exogenously given in our model.[28] The variations across industries in our model are (i) the *industry-specific* firm-level distribution of foreign currency debt ratios and (ii) the *industry-specific* imported input share common across all firms in the same industry. Both of these are disciplined by their empirical counterparts. Each firm faces two types of financial frictions. First, firms face financial constraints on how much debt they can issue, determined by a fraction of capital. Second, when firms produce output, they face a working capital constraint that requires non-interest-bearing liquid assets for the domestic input and imported intermediate input payment, as seen in Uribe and Yue (2006). We also introduce exogenous firm entry and exit into the model following Khan and Thomas (2013) and Ottonello and Winberry (2020). This feature prevents firms from excessively accumulating capital, ensuring that financial constraints remain relevant.[29] We will assume that the economy is in the stationary equilibrium before an unexpected real exchange rate depreciation. Our key focus is on the transition dynamics of the industry prices.

4.1 Market Structure

We assume that each industry I faces an exogenous CES demand, where the demand for industry I's composite goods is given by:[30]

$$Y_I = P_I^{-\nu}\bar{Y}.$$

[28] In the model, the foreign currency debt ratio is equivalent to the foreign currency short-term debt ratio, since all debt is assumed to be short-term; therefore, we use the two terms interchangeably from this point onward.

[29] The modeling assumption also helps us to generate a more realistic distribution of firm-level sales.

[30] We assume that $\bar{Y} = 1$ without loss of generality.

Each industry is populated by a continuum of entrepreneurs indexed by j with a measure of 1. The technology of transforming intermediate goods into industry I's composite goods is characterized by the Kimball (1995) aggregator:

$$\int \Upsilon\left(\frac{y_j}{Y_I}\right)dj = 1.$$

The Kimball demand structure gives the demand for an intermediate good produced by an entrepreneur j:[31]

$$y_j = \psi\left(D_I\frac{p_j}{P_I}\right)Y_I \quad \text{, where} \quad \psi(.) = \Upsilon'^{-1}(.),\ D_I \equiv \int \Upsilon'\left(\frac{y_j}{Y_I}\right)\frac{y_j}{Y_I}dj.$$

4.2 Firms' Technology

Each firm j in industry I produces a differentiated intermediate good, $y_{j,I}$ and sells it at price $p_{j,I}$ in a monopolistically competitive market.[32] We assume that each firm faces a Kimball demand structure, which is characterized by two parameters, σ and ϵ.[33] Firms produce differentiated goods with the production technology $y_t = z_t k_t^{\alpha} x_t^{\kappa} n_t^{1-\alpha-\kappa}$, hiring domestic input n_t, imported intermediate input x_t and physical capital k_t.[34] z_t is an idiosyncratic productivity that follows AR(1) process, $ln(z_t) = (1-\rho_z)\mu_z + \rho_z \ln(z_{t-1}) + \epsilon_t$, where ϵ_t is normally distributed with a mean of zero and a standard deviation of σ_ϵ. We discretize the idiosyncratic shock process following Tauchen (1986). In our model, we assume that firms import intermediate inputs but do not export their products. We focus on domestic sales and domestic price dynamics.[35]

Each entrepreneur owns a firm and receives an instantaneous utility from her final goods consumption, c_t. We assume a CRRA utility function with relative risk aversion, γ. An entrepreneur is endowed with one unit of labor and supplies that labor inelastically. Each entrepreneur accumulates physical capital, which is subject to a convex adjustment cost $\Phi(k_t, k_{t+1})$, by investing i_t amount of final goods as capital. Physical capital in the model has two modes: production and collateral.

In the beginning of the period, entrepreneurs learn this period's productivity z_t and the exchange rate ξ_t. The exchange rate ξ_t is exogenous and defined as the price of foreign final goods in units of domestic final goods. With probability π_d, each firm receives an i.i.d. exit shock and must exit the economy after producing as in Ottonello and Winberry (2020). Firms hire domestic input n_t and import intermediate goods x_t, a fraction of which they need to pay for with their working capital

[31] Detailed information on the functional form of Kimball demand can be found in the Appendix.

[32] From here on, we will simplify the notation by dropping industry and firm indices I and j, and we will use them only when needed for clarification.

[33] We normalize the aggregate price and aggregate output to one. Similarly, the aggregate wage and the domestic intermediate input price, denoted by w, are also normalized to one.

[34] Domestic input is a composite of domestic intermediate input and labor.

[35] We have a detailed discussion on this modeling assumption in Section 4.4.

a_t, which is chosen in the previous period. With those inputs, they produce and sell differentiated goods y_t at price p_t. Exiting firms liquidate their remaining assets, consume all available resources, and exit the economy. An equal mass of new firms π_d enter the economy. New entrants are endowed with k_0 units of capital and start with no debt and working capital, aligned with the assumptions in Ottonello and Winberry (2020). In the beginning of the next period, they draw an idiosyncratic productivity from its ergodic productivity distribution implied by the AR(1) process of z_t.

All the continuing firms choose how much new debt d_{t+1} they want to issue, and decide the next period's level of capital k_{t+1} and working capital a_{t+1}. Each firm chooses to borrow d_{t+1} (in units of domestic final goods) at the price $\frac{1}{1+r}$, where $(1-\lambda)\frac{d_{t+1}}{1+r}$ is denominated in domestic final goods. Then, each entrepreneur holds $\lambda\frac{d_{t+1}}{1+r}\frac{1}{\xi_t}$ amount of the foreign debt in units of foreign final goods in period t. In the beginning of the following period, each entrepreneur pays back $(1-\lambda)d_{t+1}$ for domestic debt and $\lambda d_{t+1}\frac{\xi_{t+1}}{\xi_t}$ for foreign debt in units of domestic final goods. We abstract away from the portfolio choices, and the share of foreign debt is exogenous and pre-determined at the **firm level**. Since the agents in the economy expect that the exchange rate will be constant before and after an one-time unexpected exchange rate depreciation, the currency composition of debt cannot be determined in the model, justifying our assumption on the exogeneity of the foreign currency debt share.

Entrepreneurs face a borrowing constraint whereby they can only borrow up to a fraction θ_k of the capital. Thus, the amount that each entrepreneur can borrow is given by:

$$\frac{d_{t+1}}{1+r} \leq \theta_k k_{t+1}.$$

It is important to note that the exchange rate does not *directly* affect the constraint. That is, the borrowing constraint is not getting mechanically tighter upon the depreciation of domestic currency. We would like to explore firms' pricing decisions when facing higher debt burden due to their foreign currency debt exposure, while abstracting away from the financial constraint itself getting directly affected by the exchange rate and the foreign currency debt exposure. Nonetheless, allowing for such extensions would make our mechanism even stronger.

In addition, each entrepreneur faces a working capital constraint. Specifically, in order to finance a $\frac{1}{\theta_a}$ fraction of their domestic input payment $w_t n_t$ and imported intermediate input $\xi_t^\omega x_t$, firms need to hold a non-interest-bearing asset a_t that is chosen in the previous period. Note that ω captures the degree of exchange rate pass-trough to import prices, and ω equal to one implies a complete exchange rate pass-through to import prices. Hence, the amount of domestic inputs and imported intermediate inputs that each entrepreneur can pay is limited by the amount of the non-interest bearing liquid asset a_t:

$$w_t n_t + \xi_t^\omega x_t \leq \theta_a a_t.$$

Each industry has a different firm-level distribution of foreign currency debt exposure λ and a different imported input share κ. The average foreign currency debt ratio for industry I is determined by the distribution of λ_m across firms in industry I. We approximate the distribution by assuming a finite number of values that λ can take, $\{\lambda_m : m = 1, 2, \dots, n\}$, with the industry-specific probability mass function of $\{\pi^I_m : m = 1, 2, \dots, n\}$. We calibrate λ_m and π^I_m to match the data counterparts, which will be explained in more detail in the calibration section. In the model, the average foreign currency debt ratio of an industry I will be defined as: $\bar{\lambda}_I = \sum_m \lambda_m \pi^I_m$. Since firm-level imported input data are not available, we assume that all firms in an industry share a common value of industry-level imported input share κ_I.

4.3 Recursive Formulation and Equilibrium

The aggregate state X is defined as

$$X_I = \{P_I, Y_I, \psi_I, \xi, \xi_{-1}, w\},$$

where P_I is the industry-level price, Y_I is the industry output, ψ_I is the distribution of firms, ξ is the exchange rate, and w is the price of domestic input. The Kimball demand function faced by firms in industry I, the production function, capital adjustment cost function are summarized below:

$$(i)\ y = \left(1 - \epsilon \ln(\frac{p}{P_I})\right)^{\sigma/\epsilon} P_I^{-\nu}, \quad (ii)\ y = z k^{\alpha} x^{\kappa} n^{1-\alpha-\kappa}, \quad (iii)\ \Phi(k, k') = \frac{\phi}{2}\Big(\frac{k' - (1-\delta)k}{k}\Big)^2 k.$$

Then, a continuing entrepreneur's problem is summarized as follows:

$$v_c(k, d, a, z, \lambda, \kappa; X) = \max_{c \geq 0, d', k', a', n, x, p} \frac{c^{1-\gamma}}{1-\gamma} + \beta E_{z'|z}[v(k', d', a', z', \lambda, \kappa; X')]$$

$$s.t. \quad (a)\ c + k' + \Phi(k, k') + a' + d\big((1-\lambda) + \lambda \frac{\xi}{\xi_{-1}}\big) = py - wn - \xi^{\omega} x + (1-\delta)k + \frac{d'}{1+r} + w$$

$$(b)\ \frac{1}{1+r} d' \leq \theta_k k', \quad (c)\ wn + \xi^{\omega} x \leq \theta_a a,$$

The next period's value function $v(.)$ is a probability weighted average of the value function of continuing firms $v^c(.)$ and that of exiting firms $v^x(.)$.

$$v(k, d, a, z, \lambda, \kappa; X') = (1 - \pi_d) v_c(k, d, a, z, \lambda, \kappa; X) + \pi_d v_x(k, d, a, z, \lambda, \kappa; X).$$

An exiting entrepreneur's problem is summarized as follows:

$$v_x(k,d,a,z,\lambda,\kappa;X) = \max_{c\geq 0,d',k',a',n,x,p} \frac{c^{1-\gamma}}{1-\gamma}$$

$$s.t. \quad (a)\ c = py - wn - \xi^{\omega}x + (1-\delta)k + a - \Phi(k,0) - d\big((1-\lambda) + \lambda\frac{\xi}{\xi_{-1}}\big) + w$$

$$(b)\ wn + \xi^{\omega}x \leq \theta_a a,$$

Lastly, a new entrant's problem is summarized as follows:

$$\max_{d',k',a'} E_{z'}[v(k',d',a',z',\lambda,\kappa;X')]$$

$$s.t. \quad (a)\ k' + a' + \Phi(k_{ini},k') = k_{ini} + \frac{d'}{1+r}, \quad (b)\ \frac{d'}{1+r} \leq \theta_k k'$$

We define a recursive stationary industry equilibrium as (i) industry I's price P_I and output Y_I, (ii) a set of policy functions $\{d'_c, k'_c, a'_c, c_c, n_c, x_c, y_c, p_c\}$ and value functions $v_c(k,d,a,z,\lambda,\kappa)$ for continuing firms, (iii) a set of policy functions $\{c_x, n_x, x_x, y_x, p_x\}$ and value functions $v_x(k,d,a,z,\lambda,\kappa)$ for exiting firms, (iv) a set of policy functions $\{d'_e, k'_e, a'_e\}$ for new entrants, and (iii) a measure ψ_I on (k,d,a,z,λ,κ) satisfying:

1. Policy and value functions solve the firm's problem.

2. Industry output market clears.

$$\ln P_I = (1-\pi_d)\int \ln(p_c(k,d,a,z,\lambda,\kappa))d\psi_I(k,d,a,z,\lambda,\kappa)$$
$$+ \pi_d \int \ln(p_x(k,d,a,z,\lambda,\kappa))d\psi_I(k,d,a,z,\lambda,\kappa)$$

$$Y_I = \Bigg((1-\pi_d)\int y_c(k,d,a,z,\lambda,\kappa)^{\sigma/\epsilon}d\psi_I(k,d,a,z,\lambda,\kappa)$$
$$+ \pi_d \int y_x(k,d,a,z,\lambda,\kappa)^{\sigma/\epsilon}d\psi_I(k,d,a,z,\lambda,\kappa)\Bigg)^{\sigma/\epsilon}$$

3. Measure ψ_I is stationary and consistent with decision rules and exogenous processes.

We assume that the economy is in a stationary industry equilibrium prior to the unexpected depreciation of the real exchange rate. We study the transition dynamics of different industries upon an unexpected depreciation of the real exchange rate, where industries are characterized by varying levels of foreign debt exposure and different imported input shares.

4.4 Discussion of Model Assumptions

4.4.1 No Export Decision

Our model assumes that firms sell only to domestic markets and do not choose how to allocate their sales between domestic and foreign destinations. A potential concern is that exporting firms may borrow more in foreign currency and use foreign revenues as a natural hedge, which could weaken the balance sheet effects of foreign currency debt we document. However, the empirical evidence indicates that natural hedging motive is a *not* a key determinant of the currency composition of debt, and consequently, exporters indebted in foreign currency debt also experienced a large decline in their domestic sales. Moreover, a reallocation of sales toward export markets may reduce domestic sales, which could reinforce, rather than weaken, the balance sheet effects of foreign currency debt on domestic sales and prices.

Using confidential Korean Customs data merged with firm-level balance-sheet information, Kim et al. (2024) show that export-intensive firms do not borrow more in foreign currency. The correlation between the export to sales ratio and the foreign currency share of debt is close to zero, which is consistent with our own firm-level estimate of roughly 0.1. Kim et al. (2024) further shows that net exports are *negatively* correlated with the foreign currency share of debt. Hence, firms with higher imports relative to exports tend to borrow more in foreign currency — the opposite of what the natural hedging motive would predict.

Consequently, exporters do experience negative balance sheet effects from foreign currency debt following a large depreciation. To assess whether exporters are affected to the same extent as domestic firms, we examine how their domestic sales respond to foreign currency short-term debt exposure, relative to domestic firms. We include an interaction term between a firm's foreign currency debt ratio and its export status (or export to total sales ratio) in our baseline regression model. Shown in Table A18 in the Appendix, exporters indeed experience a large decline in their domestic sales, even larger than that of domestic firms. This empirical pattern could reflect the potential reallocation of sales towards export markets following a devaluation, as exports become more profitable relative to domestic sales, particularly when liquidity needs rise due to higher foreign currency debt burden. While this export reallocation channel is not modeled explicitly, it would likely reinforce rather than weaken our mechanism: if *financially constrained* firms divert output away from domestic markets to generate foreign currency revenues, domestic sales would decline further, putting upward pressure on domestic prices. Incorporating such endogenous reallocation decisions would be a very interesting extension but significantly complicates the model and its numerical computation without altering the core mechanism of our interest.

4.4.2 Two Financial Frictions in the Model

Our model features two types of financial constraints. With only the working capital constraint, firms can offset the increase in debt burden by borrowing more to repay their foreign currency debt. As a result, the increase in debt burden following a depreciation would have a more limited impact on their investment and working capital decisions. With the collateral constraint only, the investment response should be *unrealistically* high to generate a quantitatively meaningful price response after the depreciation of domestic currency.[36] Therefore, we include both types of financial constraints in the model.

5 Calibration

Table 7 summarizes the parameter values that we use for the quantitative exercise. The first half of the parameters are either from the literature or directly computed from the data we have, and the second half of the parameters are estimated via the simulated methods of moments.

There are two important variations across industries, the average imported input share κ_I and the distribution of foreign currency debt ratios across firms π^I_m. We use data from the 1995 Korean Input–Output Table to calculate each industry's imported input share in total costs (intermediate inputs plus value added) κ_I. Most importantly, we set λ_m and π^I_m to match the cross-sectional distribution of foreign currency debt ratios across firms in each industry. We first set $\{\lambda_m : m = 1, 2, \ldots, 21\}$ = $\{0\%, 2.5\%, 7.5\%, 12.5\%, ...97.5\%\}$, which are the median values of 21 bins: $\{\lambda = 0\%, 0\% < \lambda \leq 5\%, 5\% < \lambda \leq 10\%, \ldots, 95\% < \lambda \leq 100\%.\}$ Then, for each industry we compute the probability mass function $\{\pi^I_m : m = 1, 2, \ldots, 21\}$ using the firm-level short-term foreign currency debt to total debt ratios in each industry I. We calibrate π^I_m using the weighted probability mass function, where the weight is firm size. $\bar{\lambda}_I = \sum_m \lambda_m \pi^I_m$ represents the average industry-level foreign currency debt exposure. It is consistent with how we have computed the average foreign currency debt ratio for each industry in the industry-level empirical analysis. To check for any substantial rounding errors, we compare $\bar{\lambda}_I$ and the data counterpart, the actual weighted mean of each firm's ratio of short-term foreign currency debt to total short-term debt, using firm size as the weight. We find that their correlation is close to one.

The degree of exchange rate pass-through to import prices ω is calibrated to 0.353, obtained by taking the ratio of the growth rate of Korea's average import price to the growth rate of the

[36] For instance, in a steady state with a representative firm, investment equals to depreciation: $I = \delta K$. A 100% drop in investment (during 1996 – 98 period, the aggregate investment dropped by 58%) would only imply a 10% drop in capital stock (with $\delta = 0.1$), and effectively the same as lowering the next period's effective productivity by 2.4% with the capital share equal to 0.24. Then, even when the complete pass-through to prices, the increase in prices would be 2.4%.

KRW/USD exchange rate during 1996–98. The Cobb–Douglas production parameter α is calibrated to match the aggregate capital share in the total inputs used (domestic and imported intermediate inputs used plus value added from labor and capital), using the 1995 input-output table. Due to data availability, we use monthly observations of three-year government bond yields and realized inflation rates in 1996, we compute the real interest rate r by subtracting the mean of the realized year-over-year inflation rates from the mean of the annualized three-year government bond yields, which yields a real interest rate of approximately 8%.

Following Ackerberg et al. (2006), we estimate the firm-level productivity process using our data outside the model. We estimate ρ_z and σ_z as 0.9 and 0.1, respectively.[37] We discretize the productivity process following Tauchen (1986). The exit probability p is calibrated to match an exit rate of 4.7% for all industries in Korea in 1996. The capital adjustment cost ϕ is set to 0.9569, following Gilchrist and Sim (2007), who employ the same Korean firm-level balance sheet dataset as this study. The risk aversion parameter γ, the depreciation of capital δ, and the elasticity of substitution ν are set to standard values used in the literature.

For the parameters estimated within the model, i.e., the discount factor β, the fraction of capital used as collateral θ_k, the tightness of working capital constraint θ_a, the elasticity of substitution within the sector σ, the super-elasticity of demand ϵ, and the initial capital of the entrant firm k_0, we estimate them with the simulated methods of moments, minimizing the distance between the model and data moments.[38] We target the six model moments in the stationary equilibrium summarized in Table 8: the average liquid assets to capital ratio, the average debt to capital ratio, the average capital to sales ratio, the average log of markup, and the standard deviation of log of markup, and the ratio of average capital of firms aged 0 and 1 to the average capital. All moments are computed using firm-level data from 1991 to 1996, except for the average domestic markup in Korea from 1991 to 1996, which is taken from Choi et al. (2024).[39]

Although the six parameters are jointly determined to match six moments, we can still provide a heuristic description of how each parameter is mostly inferred from an empirical moment. The time discount factor β determines the extent to which firms value future production and therefore influences the average capital to sales ratio. The tightness of the financial constraints θ_k affects the amount of debt that firms can issue given their capital, so the average debt to capital ratio disciplines this parameter. The tightness of working capital θ_a governs the amount of liquid assets that firms must hold to finance next period's working capital relative to the scale of production; thus, the

[37]We estimate the AR(1) process using z_t estimates from 1980 to 1996. For more details on the productivity estimation, please refer to the Appendix.

[38]When estimating the parameters, we set the imported input share κ to match the aggregate imported input share at 0.11.

[39]In Figure B5 of Choi et al. (2024), the average domestic markup is 1.26 in 1991-1996. The log of markup that we target, therefore, is ln(1.26) = 0.23.

average liquid assets to capital ratio informs θ_a. k_0 naturally is linked to the ratio of average capital of firms aged 0 and 1 to average capital. The elasticity of substitution within sector σ and the super-elasticity of demand ϵ disciplines the average markup and markup variability. Moreover, our identification strategy is further supported by Table A20 in the Appendix, which reports the elasticities of the targeted moments with respect to each of the six parameters.

For the exchange rate shock, we compute the Korean won price of dollar percentage growth rate from 1996 to 1997. Following the actual dynamics of the exchange rate after the depreciation, we simulate the economy upon the unexpected shock where ξ increases from 1 to 2.0 in the first period and ξ remains at 2.0 afterwards. We effectively assume an one-time unexpected shock to the exchange rate *returns* but assume zero expected returns afterwards.[40] Hence, there will be no deviation from the UIP condition. Upon this so-called MIT shock, we compute the transition dynamics, focusing on the industry-level prices.

Table 7: List of Parameter Values

Predetermined & Calibrated Outside Model		
Parameter	**Value**	**Description**
λ_m	$\in$ $[0, 0.975]$	Distribution of FC Debt Share for
π_m^I	$\in$ $[0, 1]$	Each Sector
κ_I	$\in$ $[0, 1]$	Sector-level Imported Input Share
ω	0.353	Degree of FX Pass-through to Import Prices
r	0.08	Real Interest Rate
α	0.24	Capital Share
ρ_z	0.9	AR Coefficient of z
σ_z	0.1	Stdev of z
p	0.047	Exit Probability
ϕ	0.9569	Physical Capital Adjustment Cost
γ	2.0	Relative Risk Aversion
δ	0.1	Depreciation Rate of Physical Capital
ν	2.0	Elasticity of Substitution Across Sectors
Estimated Parameters – Simulated Methods of Moments		
Parameter	**Value**	**Description**
β	0.892	Time Discount Factor
θ_k	0.679	Fraction of Capital as a Collateral
θ_a	0.928	Tightness of Working Capital Constraint
σ	5.1	Elasticity of Substitution Within A Sector
ϵ	9.8	Super Elasticity of Demand
k_0	0.0235	Initial Capital for Entrant Firm

[40]The depreciation in the first period is unexpected and they know that in the future $\xi/\xi_{-1} = 1$.

Table 8: Targeted Moments from Data and Model

Targeted Moments	Data	Model
Average Liquid Assets to Capital, $\frac{a}{k}$	0.77	0.77
Average Debt to Capital, $\frac{d}{k}$	0.71	0.71
Average Capital to Sales, $\frac{k}{y}$	0.80	0.80
Average Log of Markup	0.23	0.23
Standard Deviation of Log of Markup	0.19	0.19
Ratio of Average Capital of Firms 0 and 1 to Average Capital	0.09	0.09

6 Inspecting Mechanism: Policy Function Analysis

We first examine firm-level policy functions to explore the underlying mechanism of firms' pricing decisions. We abstract from the imported input channel in this section to focus on illustrating the balance sheet effects of foreign currency debt exposure. Specifically, we assume that a firm's debt burden increases while the price of imported input remains constant following a large depreciation, i.e., $\omega = 0$. All other parameters are set to our calibrated values summarized in Table 7. We start with a firm's optimal pricing decision from the model,

$$p_{j,t} = \mu_{j,t} mc_{j,t}(1 + \eta_{2,j,t}),$$

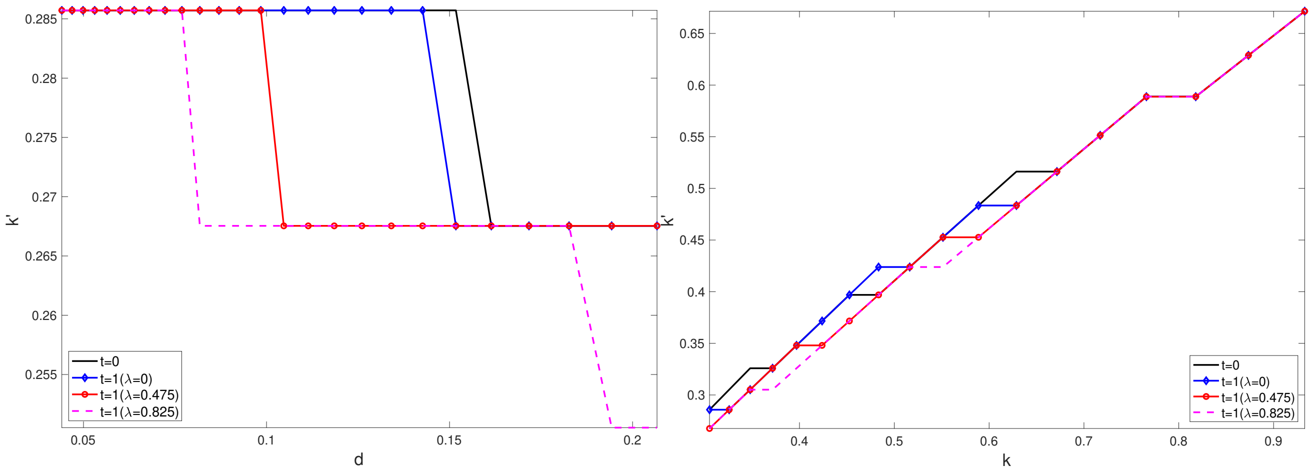
where $\mu_{j,t}$ is a firm's optimal markup, $mc_{j,t}$ is the marginal cost of production, and $\eta_{2,j,t}$ is the value of the Lagrangian multiplier on the working capital constraint.

Following a large depreciation, firms face higher debt burdens, which affect their pricing decisions through two channels: (i) investment adjustment and (ii) liquid asset adjustment. First, firms lower their investment and become less productive in the next period, increasing the marginal cost of production $mc_{j,t}$. Second, firms lower their liquid asset savings and face a tighter working capital constraint in the next period, resulting in a higher value of the Lagrangian multiplier $\eta_{2,j,t}$, which puts upward pressure on prices.

Our analysis examines these two margins, investment decisions and working capital constraints, both in the steady state and along the transition path. Specifically, we plot policy functions against the debt level d and the capital stock k, as firms with higher debt burdens or lower capital stocks are more likely to experience severe balance sheet deterioration and tighter financial constraints. We also consider policy functions for different levels of foreign currency debt exposure λ to capture the balance sheet effects of foreign currency debt exposure following a large depreciation. To illustrate the mechanism, we focus on an industry with a non-degenerate cross-sectional distribution of foreign currency debt ratios across firms and productivity z at the median level.[41]

[41] We set k and d at their mode values in the stationary distribution and a at its lowest 10th percentile value such that financial constraints are meaningfully operating for policy function illustration.

Figure 7: k' against (i) d (Left) and (ii) k (Right).



Notes: The solid black lines are the policy functions in the stationary equilibrium. The blue diamond lines, red circle lines, and dashed magenta lines are policy functions for firms with 0, 0.475, and 0.825 of foreign currency debt ratio, respectively.

Figure 7 shows the policy functions of k' against k and d.[42] For any positive level of foreign currency debt, firms need to pay a higher amount in units of domestic currency following a depreciation. This increased debt burden reduces investment. Moreover, when a firm's reliance on foreign currency debt is large prior to the depreciation, the increase in debt burden is more pronounced, further lowering investment and, consequently, capital in the next period. In addition, when debt is sufficiently low or capital is sufficiently high, the balance sheet effect of foreign currency debt does not lead to a much of a significant adjustment in investment.

To understand the working capital channel, we begin the analysis with the firm's Euler equations regarding debt choice d' and working capital a', as follows:

$$\beta E_{z'|z}[(c')^{-\gamma}(1+r)\big((1-\lambda)+\lambda\frac{\xi'}{\xi}\big)]+\eta_1=\beta E_{z'|z}[(c')^{-\gamma}+\theta_a\eta_2'] \tag{7}$$

, where η_1 and η_2 are the Lagrangian multipliers on the collateral constraint, $\frac{1}{1+r}d' \leq \theta_k k'$, and the working capital constraint, $wn+\xi^{\omega}x \leq \theta_a a$, respectively. Equation (7) shows that even when the collateral constraint is not binding ($\eta_1 = 0$), any positive value of the expected net interest rate r implies that the working-capital constraint always binds, i.e., $E_{z'|z}[\eta_2'] > 0$.[43] More importantly, when the collateral constraint becomes tighter, i.e., $\eta_1 > 0$ increases, it has a direct effect on the Lagrangian multiplier, $E_{z'|z}[\eta_2']$, on working capital constraint. Because the firm's optimal pricing decision is

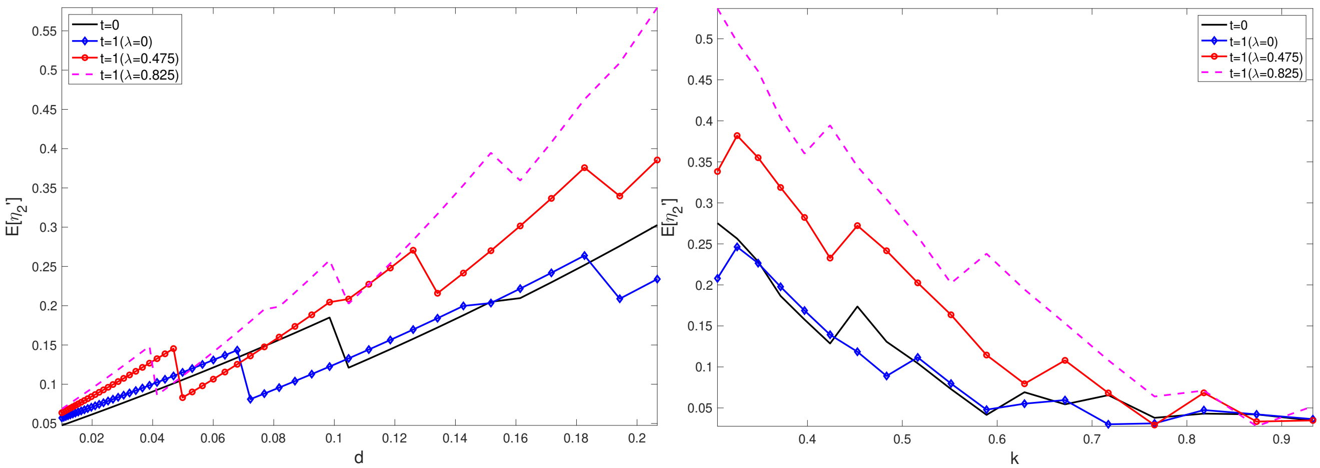
$$p' = \mu' \times mc' \times (1+\eta_2'),$$

[42] Note that the policy function is the same for all λ in the stationary equilibrium.

[43] Agents expect that the exchange rate to be held constant all the time: $\frac{\xi'}{\xi}=1$.

tighter collateral constraint (higher η_1) this period implies higher next-period shadow costs η_2', leading to higher next-period prices.

Figure 8: $E_{z'|z}[\eta_2']$ against (i) d (Left) and (ii) k (Right).



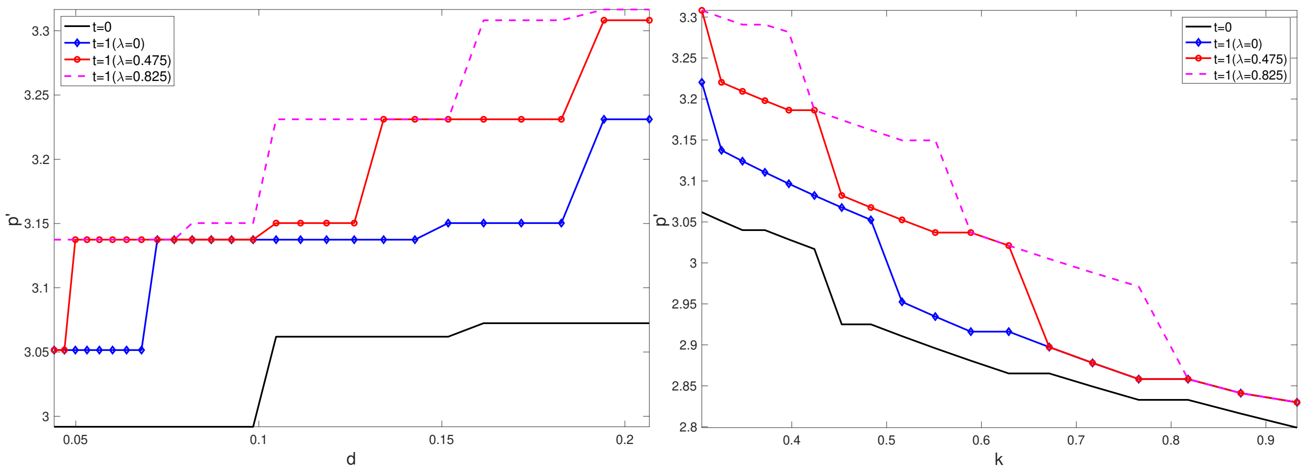
Notes: The solid black lines are the policy functions in the stationary equilibrium. The blue diamond lines, red circle lines, and dashed magenta lines are the policy functions for firms with 0, 0.475, and 0.825 of foreign currency debt ratio, respectively.

Figure 8 plots the Lagrangian multiplier: $E_{z'|z}[\eta_2']$. For any positive level of foreign currency debt, the increased debt burden tightens the working capital constraint on average following a depreciation. When a firm's reliance on foreign currency debt is larger prior to the depreciation, the working capital constraint becomes even tighter, thereby increasing the effective cost of production. In addition, when debt is sufficiently low or capital is sufficiently high, the balance sheet effect of foreign currency debt does not lead to a significant adjustment in working capital, and therefore has only a limited impact on the tightness of the constraint. Figure A2 in the Appendix shows the policy functions of liquid assets against d and k, corroborating that firms choose to hold less liquid assets when indebtedness is high, especially when the debt is denominated in foreign currency.

Then, we explore how this period's debt d and capital stock k affects the price p' and the markup μ' in the next period, the ultimate objects of our interest.

Figure 9 illustrates how firms change their prices following a large depreciation. When the debt burden becomes larger following the depreciation, firms tend to charge higher prices in the subsequent period. Furthermore, firms that have higher foreign currency debt exposure (i.e., higher λ) increase their prices even more after a large depreciation. This result echoes the findings in Figures 7 and 8, namely that a higher debt burden in the current period translates into a lower level of capital stock and liquid asset savings. If a firm invests less in this period, it becomes less productive in the next period, raising its cost of production. Furthermore, lower liquid assets tighten the working capital constraint, raising effective cost of production. Both channels put upward pressure on prices. Finally, when debt is sufficiently low or capital is sufficiently high, the balance sheet effect

Figure 9: p' against (i) d (Left) and (ii) k (Right).



Notes: The left panel shows the pricing decision in the next period as a function of this period's debt level, and the right panel shows the pricing decision as a function of the initial capital stock. The solid black lines are the price policy functions in the stationary equilibrium. Blue diamond lines, red circle lines, and dashed magenta lines are policy functions for firms with 0, 0.475, and 0.825 of foreign currency debt ratio, respectively.

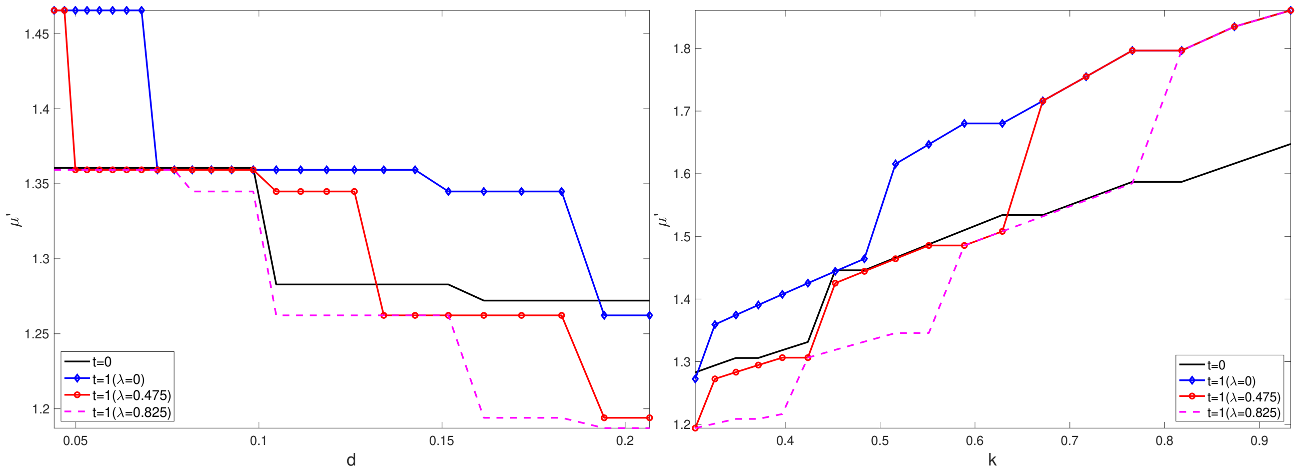
of foreign currency debt has only a limited impact on prices.

In addition to the negative balance sheet effect, we find that strategic complementarity plays an important role in determining firm-level pricing decisions. Even if firms with zero foreign currency debt are not directly affected by the depreciation (the blue diamond lines in both panels), they still choose to set prices above the steady-state level (the solid black lines in both panels). This result arises from strategic complementarity embedded in the Kimball preference, whereby firms raise their prices in response to higher prices set by competitors. Thus, in our model, firms increase their prices both due to their own balance sheet deterioration and as a strategic reaction to competitors' pricing decisions.

Lastly, we investigate how firm-level markups change following a large depreciation in Figure 10. When the debt burden becomes larger following the depreciation, firms tend to charge lower markups in the subsequent period. Furthermore, firms that have higher foreign currency debt exposure (i.e., higher λ) show larger declines in their markups after a large depreciation. Firms indebted in foreign currency reduce both investment and liquid asset holdings, which constrains their production capacity and makes them less competitive within the industry. As a result, they charge lower markups than firms with less foreign currency debt exposure.

On top of that, firms with zero foreign currency debt, ceteris paribus, increase their markups following the depreciation. That is, policy functions of markups for firms with zero foreign currency debt exposure have shifted up (from the solid black lines to the blue diamond lines) as they are unaffected directly by the depreciation of the domestic currency and become more competitive in their sector. Moreover, some firms with positive foreign currency debt set their markups higher than

Figure 10: μ' against (i) d (Left) and (ii) k (Right).



Notes: The left panel shows the markup decision in the next period as a function of this period's debt level, and the right panel shows the markup decision as a function of the initial capital stock. The solid black lines in both graphs show the markup policy functions under steady state. The blue diamond lines, red circle lines, and dashed magenta lines are the policy functions for firms with 0, 0.475, and 0.825 of foreign currency debt ratio, respectively.

what they would have chosen before the depreciation, while others charge lower; that is, the red and the magenta lines cross the black lines. Specifically, firms with lower debt or higher capital charge higher markups in the next period than what they would have charged in the stationary equilibrium. These firms are not affected by a large depreciation, relatively better off than their competitors; therefore, they increase their market shares and markups and charge higher prices.[44]

7 Quantitative Analysis

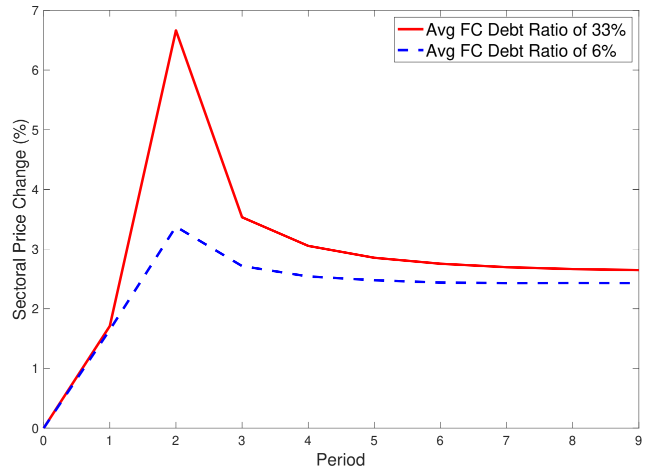
7.1 Model Simulations of Industry Price Dynamics

This section summarizes the results from the model simulations of 156 sectors with the parameter values calibrated. We first investigate the transition path of sectoral prices following a large unexpected depreciation in period 1. Figure 11 depicts the transition path of prices for two sectors with the same imported input share of 13%, but different average shares of foreign currency debt to total debt, $\bar{\lambda}_I$: 33% and 12%. After a large depreciation of the domestic currency, those sectors experience price increases of around 6.7% and 3.4%, respectively, over the course of two years. Thus, sectors with greater exposure to foreign currency debt raise their prices more following an unexpected exchange rate depreciation.

Sectoral transition paths arise from both the negative balance sheet effects and the strategic

[44] Additionally, we empirically confirm that firms with zero foreign currency short-term debt increase their markups, as shown in Table A7 in the Appendix.

Figure 11: Impulse Response Functions of Sectoral Prices



Notes: The red solid line and blue dashed line show the price responses of sectors with foreign currency debt shares of 33% and 12%, respectively. Both sectors have the same imported input share of 13%. An unexpected large depreciation happens in period 1.

complementarity between firms within the same sector, as illustrated by the policy functions in the previous section. Firms with high foreign currency debt exposure face a larger debt burden following an unexpected depreciation; hence, they reduce investment and liquid assets more, which leads to more pronounced price increases. The effect is stronger when firms are more financially constrained due to lower initial capital or higher initial debt before the depreciation. On top of that, the Kimball demand structure allows firms to strategically interact with each other, which amplifies the price responses of firms to the balance sheet deterioration. In our model, smaller firms experience larger increases in marginal costs due to tighter financial constraints. With this negative correlation of firm size and the increase in marginal costs, the within sector strategic complementarity in pricing leads to a higher increase in the industry price (Amiti et al. (2018)).

Table 9: Marginal Effect of Short-term FC Debt Ratio on Sectoral Price Changes

	Data	Model
ST FC	0.5685	0.1192
	(0.2038)	
Imported Input Share	0.2830	0.2389
	(0.1656)	
R^2	0.4316	0.9231
N	156	156

Notes: The left column shows the regression result from our empirical analysis. The right column shows the result from the model simulated data.

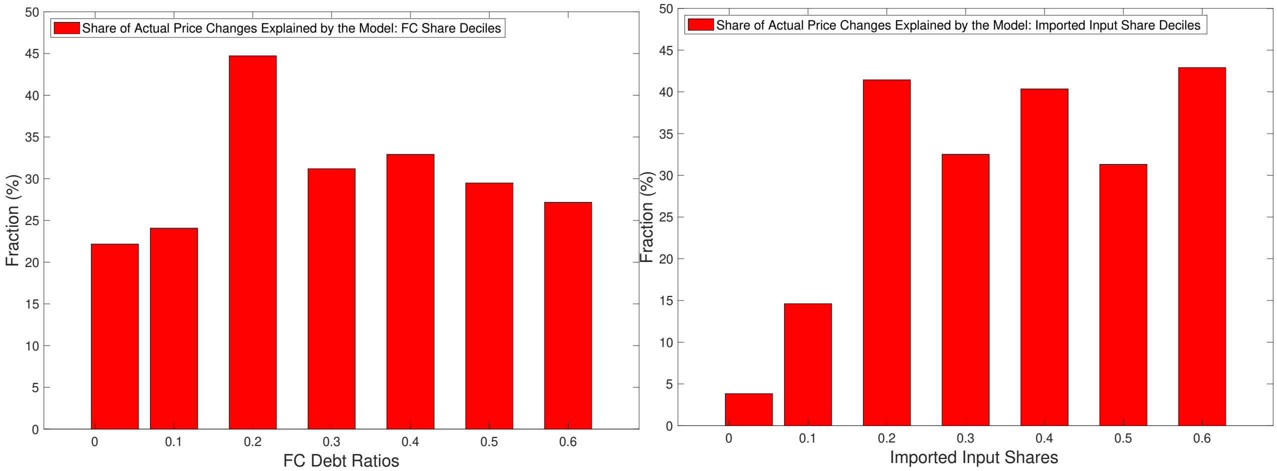
We regress PPI changes on both $\bar{\lambda}_I$ and tthe imported input share κ_I. As shown in Table 9, the coefficient estimate on the sectoral foreign currency debt ratio is 0.1192, and the data counterpart is 0.5685. The model explains around 21% of the mean effect of short-term foreign currency debt exposure on sectoral price changes across industries. The model also reproduces the untargeted empirical estimate of the sectoral price changes based on the imported input share.

Given that the model underestimates the impact of foreign currency debt exposure on sectoral price changes, the quantitative significance of foreign currency debt on sectoral price changes in Section 8 can be thought of as a lower bound. The quantitative fit could improve if the cost of working capital or the tightness of financial constraints were modeled as a function of firms' net worth, as in Céspedes et al. (2004), or as a function of foreign currency debt and the exchange rate, as in Kohn et al. (2020) and Drenik and Perez (2021). In such settings, a depreciation of the domestic currency – particularly for firms indebted in foreign currency debt – would raise the cost of working capital or tighten the financial constraints. This feature would further amplify the balance sheet effect of foreign currency debt. In this paper, we currently focus on more of a direct consequence of heightened debt burden following the depreciation whilst holding the tightness of financial constraints fixed.

We also compute the standard deviation of the growth rate of domestic producer prices from 1996 to 1998 across industries and its model counterpart and find 17.1% and 3.7%, respectively. Our simple model – with two variations across industries regarding foreign currency exposure and imported input share – can explain 22% of the observed variation in price changes during the large depreciation episode. We emphasize that none of these moments were targeted in our calibration; therefore, their quantitative magnitudes demonstrate how well our model captures both sectoral price dynamics after the depreciation and the cross-sectional variation in price changes across industries with differing exposure to foreign currency debt and imported input shares.

Lastly, we assess how much of the observed sectoral price movements from 1996 to 1998 can be accounted for by the model across different levels of (i) foreign currency debt exposure and (ii) imported input shares in Figure 12. We first group 156 sectors into bins based on their average foreign currency debt ratios: $[0\%, 5\%), [5\%, 15\%), \ldots, [45\%, 55\%), [55\%, 70\%)$. Then, we compute, for each bin, the share of the average price change in the data that is explained by the model. Across these bins, the model explains between 22% and 45% of the realized price movements. We then group sectors into bins of imported input shares, and find that the model accounts for approximately 4% to 43% of observed sectoral price movements. On average, the model explains 26% of the variation in sectoral price changes. As noted earlier, the framework captures only the balance sheet effects arising from increases in debt burden, and the borrowing constraint itself does not directly depend on foreign currency debt or the exchange rate. Therefore, the quantitative magnitude implied by the model should be interpreted as a conservative estimate of the mechanism's role.

Figure 12: Share of Sectoral Price Changes in the Data Explained by the Model
Across FC Debt Ratios and Imported Input Shares



Notes: The figure plots the share of sectoral price changes in the data that are explained by the baseline model. We first group the 156 sectors into bins based on (i) foreign currency debt ratios (left panel) and (ii) imported input shares (right panel): $[0\%, 5\%), [5\%, 15\%), \ldots, [45\%, 55\%), [55\%, 70\%)$. Within each bin, we compute the average price change in the data and in the model and plot the share explained by the model (i.e., the ratio of model-generated to data-based averages).

7.2 Model Simulations of Firm Dynamics

Using our structural model, we simulate firm-level data for 156 industries ($15,600,000$ firms), pool all the simulated data, and run the regression to quantitatively compare with the data patterns. With the simulated data, we also investigate the role of foreign currency debt in shaping the price dynamics upon the depreciation shock.[45]

We run the following regression specifications, analogous to our empirical regression in Equation (1):

$$\Delta y_j = \beta_{I(j)} + \beta_1 \text{ST FC}_j + \beta_3 \text{Size}_j + \beta_4 \text{ST FC}_j \cdot \text{Size}_j + \beta_6 \text{X}_j + \epsilon_j \tag{8}$$

ST FC denotes the short-term foreign currency debt ratio of firm j in industry I, which corresponds to λ in our model. We interact the short-term foreign currency debt ratio with firm-size, measured as the log of total sales. Firm size is standardized. X_j contains the interaction between the short-term FC debt ratio and the log of total short-term debt, in line with the controls used when estimating Equation (1).[46] Sector fixed effects are also included.

Our goal is to examine how well the model reproduces the observed data patterns, with a particular focus on the role of financial constraints in amplifying the negative balance sheet effect

[45]We restrict the sample to firms that survive for at least one year.
[46]We standardize the log of short-term foreign currency debt, in line with our empirical analysis.

of foreign currency debt on firm-level outcomes after a large depreciation of domestic currency. β_1 and β_4 are the coefficients of our interest. To make the model-estimated coefficients directly comparable to the empirical estimates, we rescale the estimated coefficients, β_1 and β_4, using the *empirical* mean and standard deviation of firm size. We report $\beta_1^{reported} = \beta_1 - \beta_4 \frac{Mean(Size)}{Std(Size)}$ and $\beta_4^{reported} = \frac{\beta_4}{Std(Size)}$ in Table 10.[47]

Table 10 shows that our model successfully replicates the empirical results. Across all firm-level outcomes - domestic sales, net worth and markups - the estimated marginal effects are similar in order of magnitude, and heterogeneous effects are likewise comparable. In particular, all model based estimates fall within, or only slightly outside, the 95 percent confidence interval implied by the data. Nonetheless, it is worth noting that the model tends to underpredict the response of net worth and sales growth, which may help explain why it also underestimates the effect of foreign currency debt exposure on sectoral prices.

In the data, firms that are one standard deviation smaller than the average exhibit more negative marginal effects of foreign currency debt, by 0.32, 0.52, and 0.05 percentage points for net worth, domestic sales and markups, respectively. In the model, the corresponding magnitudes are 0.23, 0.41 and 0.08 percentage points, respectively.

Table 10: Firm Performance and FC Debt: Model vs. Data

	ΔNet Worth		ΔSales		ΔMark up	
	Data	Model	Data	Model	Data	Model
ST FC	-5.6555***	-4.0684	-9.4335**	-7.1310	-0.8923***	-1.4066
	(1.5268)		(4.1259)		(0.3062)	
Size $\times$ST FC	0.2269***	0.1667	0.3710**	0.2896	0.0353***	0.0546
	(0.0628)		(0.1651)		(0.0124)	
R^2	0.1571	0.3786	0.1881	0.3497	0.0463	0.0411

Notes: For each outcome variable, the left column shows the regression result from our empirical analysis. The right column shows the result from the model simulated data. We estimate $\Delta y_j = \beta_{I(j)} + \beta_1 \text{ST FC}_j + \beta_3 \text{Size}_j + \beta_4 \text{ST FC}_j \cdot \text{Size}_j + \beta_6 \text{X}_j + \epsilon_j$ using standardized firm size in the model. We then rescale the estimated coefficients β_1 and β_4, using the empirical mean and standard deviation of firm size. That is, we report $\beta_1^{scaled}$and β_4^{scaled}: $\beta_1^{scaled} = \beta_1 - \beta_4 \frac{Mean(Size)}{Std(Size)}$ and $\beta_4^{scaled} = \frac{\beta_4}{Std(Size)}$.

Table 11 reports the regression estimates for capital stock and cash holdings that are central to our model mechanism. Similar to the results shown in Table 10, the estimated marginal effects from the model simulated data are similar in order of magnitude to what we have found empirically, and heterogeneous effects are likewise comparable. In particular, all model-based estimates lie within, or slightly outside, the 95% confidence interval of empirical estimates. In the data, when firm size

[47] In the empirical section, we do not normalize firm size, as our primary interest is in how strongly smaller firms are affected by short-term foreign currency debt exposure. The coefficient on ST FC captures the marginal effect for very small firms. Nonetheless, this is analogous to comparing the coefficients when firm size is normalized in both the empirical and model regressions. The empirical mean and standard deviation of firm size are 24.1 and 1.4, respectively.

decreases by one standard deviation, the marginal effects of foreign currency debt become more negative, by 0.31 percentage points for capital stock and 0.48 percentage points for liquid asset holdings. In the model, the corresponding effects are 0.55 and 0.15 percentage points, respectively.

Our model overpredicts the effect of capital adjustment but underpredicts the effect of working capital relative to what we observe empirically. These findings may suggest that the relatively muted response of industry-level prices could be related to the weak adjustment of firms' working capital. An alternative model assumption in which the cost of working capital increases more for firms with greater foreign currency debt exposure following the exchange rate depreciation as in Drenik and Perez (2021), could allow our model to better capture the response of working capital. In this paper, we currently focus more of a direct consequence of heightened debt burden following the depreciation whilst holding the tightness of financial constraints fixed.

Table 11: Other Firm-level Outcomes and FC Debt: Model vs. Data

	ΔCapital		ΔLiquid Assets	
	Data	Model	Data	Model
ST FC	-5.4521***	-9.5496	-8.6206**	-2.5586
	(1.7197)		(4.0127)	
Size $\times$ST FC	0.2184***	0.3942	0.3398**	0.1037
	(0.0706)		(0.1627)	
R^2	0.0216	0.3407	0.0632	0.3457

Notes: For each outcome variable, the left column shows the regression result from our empirical analysis. The right column shows the result from the model simulated data. We estimate $\Delta y_j = \beta_{I(j)} + \beta_1 \text{ST FC}_j + \beta_3 \text{Size}_j + \beta_4 \text{ST FC}_j \cdot \text{Size}_j + \beta_6 \text{X}_j + \epsilon_j$ using standardized firm size in the model. We then rescale the estimated coefficients β_1 and β_4, using the empirical mean and standard deviation of firm size. That is, we report $\beta_1^{scaled}$and β_4^{scaled}: $\beta_1^{scaled} = \beta_1 - \beta_4 \frac{Mean(Size)}{Std(Size)}$ and $\beta_4^{scaled} = \frac{\beta_4}{Std(Size)}$.

Lastly, using the firm-level model simulated data, we confirm that the negative balance sheet effect puts an upward pressure on firm-level prices, shown in Table 12 Firms with higher foreign currency debt exposure increase their prices more, and, on top of that, smaller and more financially constrained firms increase their prices more compared to unconstrained firms with the same level of foreign currency debt exposure. Even with the same amount of short-term foreign currency debt exposure, larger firms are less financially constrained than smaller firms, and therefore their production is less restricted following an exchange rate depreciation. Consequently, the price increase is considerably more muted for these large unconstrained firms.

Table 12: Marginal Effect of Firm-level Short-term FC Debt Ratio on Firm-level Price Changes

	ΔPrice
ST FC	0.6936
Size $\times$ST FC	-0.0273
R^2	0.4165

Notes: The dependent variable is the firm-level price changes computed with the model simulated data. We estimate $\Delta y_j = \beta_{I(j)} + \beta_1 \text{ST FC}_j + \beta_3 \text{Size}_j + \beta_4 \text{ST FC}_j \cdot \text{Size}_j + \beta_6 \text{X}_j + \epsilon_j$ using standardized firm size in the model. We then rescale the estimated coefficients β_1 and β_4, using the empirical mean and standard deviation of firm size. That is, we report $\beta_1^{scaled}$and β_4^{scaled}: $\beta_1^{scaled} = \beta_1 - \beta_4 \frac{Mean(Size)}{Std(Size)}$ and $\beta_4^{scaled} = \frac{\beta_4}{Std(Size)}$.

8 Counterfactuals: Quantifying Balance Sheet Effects

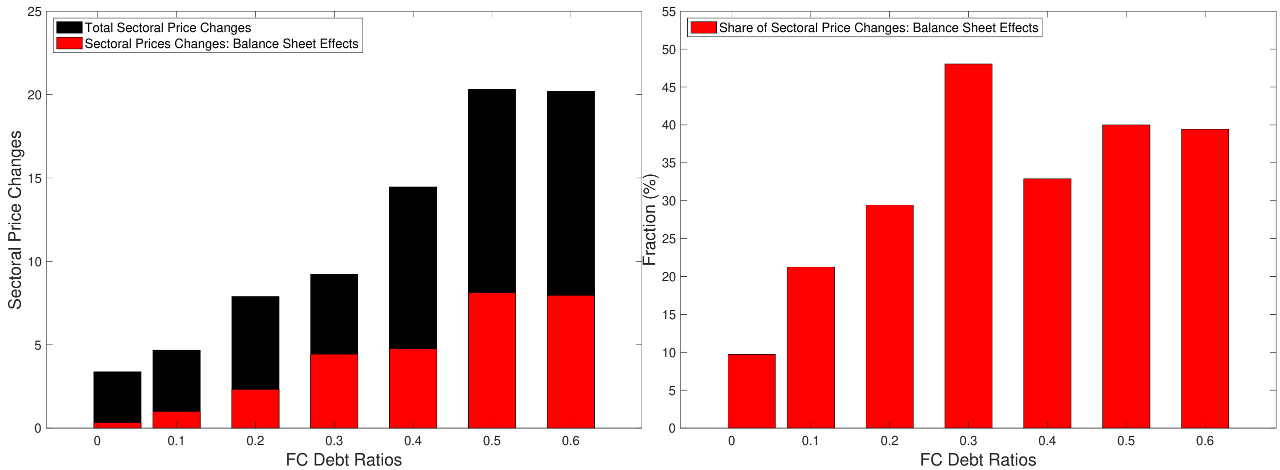
While the firm-level regression with simulated data shows that firms within the same sector experience *significantly larger* price increases due to their foreign currency borrowing, it is hard to infer how much of each sectoral price change can be attributed to the balance sheet channel once firms' strategic interactions within the industry are taken into account. Each sector faces a different firm-level distribution of foreign currency debt ratios and imported input shares, and both channels put upward pressure on sectoral prices, further amplified by firms' strategic complementarity in their pricing decisions. To quantify the role of the balance sheet channel of foreign currency debt in explaining sectoral price dynamics, we run a counterfactual exercise, assuming that the imported input price stays constant upon a depreciation shock. That is, we set ω =0.

We compute the average sectoral price changes across foreign currency debt ratios in the baseline model and in the counterfactual economy, shutting down the effect of exchange rate shock on imported input prices. We group sectors with foreign currency debt ratios in $(0\%, 5\%)$, $[5\%, 15\%)$, $\ldots, [45\%, 55\%), [55\%, 70\%)$. Figure 13 shows that the balance sheet effect of foreign currency debt alone explains around 10% to 48 % of sectoral price changes observed in the baseline model. For an average industry with positive foreign currency short-term debt, 32% of sectoral price changes can be attributed to the balance sheet effect of foreign currency debt.

Alternatively, we turn off the balance sheet effect of foreign currency debt by assuming $\lambda = 0$ following the exchange rate depreciation, and then compute the average price changes explained by the imported input channel. We then quantify how much of the average sectoral price changes in the baseline economy that *cannot* be accounted for by higher marginal costs due to imported inputs. We subtract the average sectoral price changes from the counterfactual exercise setting $\lambda = 0$ from the average price changes in the baseline economy to back out the balance sheet effects of foreign currency debt. As seen in Figure A3 in the Appendix, the results are very similar to what we have seen in Figure 13.

Furthermore, we quantify the share of the balance sheet effect that reflects the general equilib-

Figure 13: Counterfactual Exercise I: Quantitative Size of the Balance Sheet Effect at the Sector-level



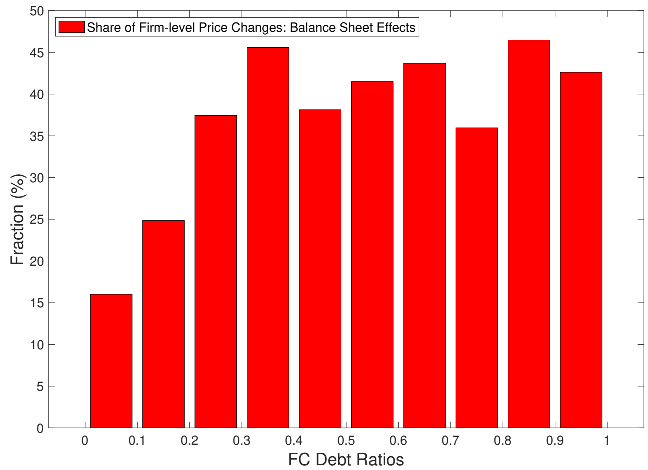
Notes: The figure plots the two sets of sectoral price changes: one computed in the baseline model and the other computed in the counterfactual model with $\omega = 0$, shutting down the effect of exchange rate shock on imported input prices. We group sectors with foreign currency debt ratios in $(0\%, 5\%), [5\%, 15\%), \ldots, [45\%, 55\%), [55\%, 70\%)$. We first compute (i) the average sectoral price changes in the baseline model and (ii) that in the counterfactual exercise across sectoral foreign currency debt ratios. The figure on the left shows (i) in black bars and (ii) in red bars across sectoral foreign currency debt ratios. The figure on the right shows the ratio of (ii) to (i) across sectoral foreign currency debt ratios.

rium forces arising from strategic complementarity in price setting. We decompose the balance sheet effect of foreign currency debt on firm-level price changes into two components: *direct* effects from firms' own foreign currency debt exposure on their pricing decisions and the *general equilibrium* effects arising from firms strategically responding to *other firms' price changes* due to *other firms'* foreign currency debt exposure.

To compute the direct effect of foreign currency debt, we feed in the path of exchange rate ξ, but hold the *sectoral price fixed* at the steady state level, while muting the imported input channel (i.e., setting $\omega = 0$). This approach follows how Ottonello and Winberry (2020) quantify the general equilibrium effect in their model. It captures the effect of a firm's own foreign currency debt exposure on its own pricing decision. We then calculate the *general equilibrium* component of the balance sheet effect of foreign currency debt on firm-level price changes. To ensure comparability of firm-level price changes across different model economies, we normalize firm-level price changes relative to the average response of firms with zero foreign currency debt in the counterfactual economy that features only the balance sheet channel with the sectoral price fixed.

We compute, across foreign currency debt ratio deciles, the average firm-level price changes in three model economies: the baseline economy; the counterfactual economy with only the balance sheet channel active; and the counterfactual economy with only the balance sheet channel active and sectoral prices held fixed. Shown in Figure 14, 16% to 46% of firm-level price changes can

Figure 14: Counterfactual Exercise I: Quantifying Balance Sheet Effects of FC Debt at the Firm-level

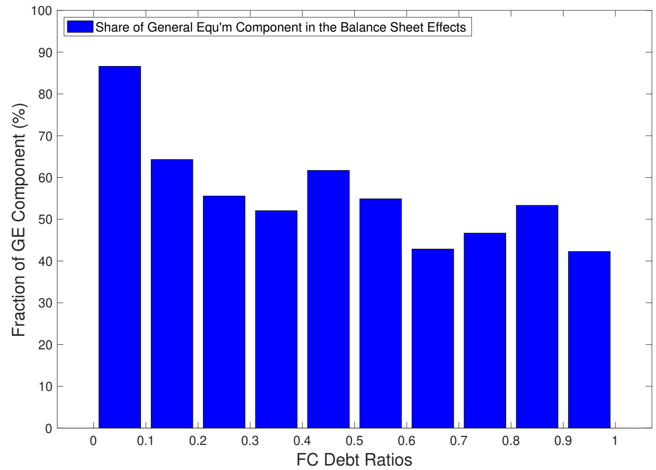


Notes: The figure is plotted with the model-simulated firm-level price data. To ensure comparability of firm-level price changes across different model economies, we normalize firm-level price changes relative to the average response of firms with zero foreign currency debt in the counterfactual economy that features only the balance sheet channel, with the sectoral prices held fixed. We first compute (i) the average firm-level price changes in the baseline economy and (ii) those in the counterfactual economy with only the balance sheet channel active, across firm-level foreign currency debt ratio deciles. The figure shows the ratio of (ii) to (i) for each foreign currency debt ratio decile.

be attributed to the balance sheet channel of foreign currency debt. These magnitudes are aligned with what we have shown with sectoral level price changes in the baseline model and in the counterfactual economy, depicted in Figure 13. To compute the *general equilibrium* component of the balance sheet effect, for each foreign currency debt ratio decile, we subtract the average direct effect of a firm's own foreign currency debt exposure from the average firm-level price changes in the counterfactual economy with only the balance sheet channel active. The relative contributions of the direct vs. indirect components are shown in Figure 15, where 42% to 87% of the balance sheet effect of foreign currency debt is accounted for by strategic complementarity in firms' price setting.

In sum, we construct a heterogeneous firm model that links foreign currency debt and the exchange rate pass-through to domestic prices after a large depreciation. The model is able to account for the industry-level empirical patterns larger price increases in industries with higher average foreign currency debt ratios. Moreover, from firm-level simulations, we confirm that the model captures key features of observed firm behavior after a large depreciation. The counterfactual exercise affirms the quantitatively sizable role of the balance sheet channel in explaining sectoral price dynamics and highlights the significance of strategic complementarity in firms' price setting.

Figure 15: Counterfactual Exercise II: Share of General Equilibrium Effects in the Balance Sheet Effects of FC Debt



Notes: The figure is plotted with the model-simulated firm-level price data. To ensure comparability of firm-level price changes across different model economies, we normalize firm-level price changes relative to the average response of firms with zero foreign currency debt in the counterfactual economy that features only the balance sheet channel, with sectoral prices held fixed. The figure shows the share of the balance sheet effect accounted for by the general equilibrium forces arising from strategic complementarity in price setting. We first compute (i) the average firm-level price changes in the counterfactual economy with only the balance sheet channel active and (ii) those in the counterfactual economy with only the balance sheet channel active while sectoral prices are held fixed, across firm-level foreign currency debt ratio deciles. The figure shows the ratio of (i) - (ii) to (i) for each foreign currency debt ratio decile.

9 Conclusion

With a unique firm-level and aggregated industry-level dataset, our empirical findings suggest that the balance sheet channel of foreign currency debt – whose role is understudied in the exchange rate pass-through literature – plays an important role in explaining how the exchange rate affects domestic prices, especially for emerging economies with dollarized liabilities. During a large depreciation in Korea, we first find that firms indeed suffer from lower sales and net worth growth when they are indebted in foreign currency before the large depreciation. The negative balance sheet effect is stronger as firm size is smaller since smaller firms are more financially constrained. Moreover, our firm-level analysis shows that their markups have *declined* more when indebted in foreign currency, especially for smaller firms.

We then find that industries populated by firms with higher foreign currency debt exposure raise their prices more following a large depreciation. The industry-level price responses are consistent with the findings from our firm-level analyses. When firms with high foreign currency debt exposure face a larger debt burden after depreciation, their production becomes constrained, which causes them to reduce sales and increase the prices of goods sold. Strategic complementarity in firms' price-setting behavior further amplifies sectoral producer inflation.

Based on these empirical findings, we build a quantitative heterogeneous firm model to study an industry equilibrium and its transition path upon an unexpected exchange rate depreciation. We analyze the qualitative and quantitative implications of the financial frictions in explaining the average changes in the sectoral prices and its dispersion. With the industry-specific firm-level distribution of foreign currency debt and the industry-specific imported input share, the model can explain around 21% of the mean effect of the foreign currency debt ratio on sectoral price changes and 22% of the variation in price changes across industries.

Moreover, we decompose the two distinct channels of exchange rate pass-through to domestic prices – balance sheet channel and imported input channel and show that both are significant contributors to the sectoral price dynamics following the depreciation of domestic currency. We find that on average, 32% of sectoral price changes and 37% of firm-level price changes can be attributed to the balance sheet channel of foreign currency debt. We also emphasize the role of strategic complementarity in price-setting in explaining sectoral price dynamics after a large depreciation of the domestic currency. Approximately 42% to 87% of these balance sheet effects of foreign currency debt can be attributed to firms responding to the price changes of other firms.

Our empirical analysis and our quantitative analysis through a heterogeneous firm model reveal that it is important, albeit overlooked, to incorporate the balance sheet effect when analyzing how the exchange rate affects domestic prices, especially for emerging economies with dollarized liabilities. Our findings have important policy implications on shaping the optimal monetary policy and currency choice in external borrowings. We believe that it is an important normative question to ask, but we will leave it for future research.

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Appendix

Data Sources

The below table summarizes the data sources of variables that we use in the empirical section.

Table A1: Data Sources

Data	Data Source	Note
Firm-level variables	KISVALUE	
Producer Price Index	Bank of Korea (1991 – 2000)	Base year of 2015
Consumer Price Index	Bank of Korea (1991 – 2000)	Base year of 2015
Imported Price Index	Bank of Korea	Base year of 2015
Rauch Classification	Rauch (1999)	4-digit SITC Rev. 2 commodities
Imported Input Share	Bank of Korea	Input-Output table
Price Stickiness	Nakamura and Steinsson (2008)	Median Frequency, Table 12

Data Cleaning

In the firm-level data (both in industry-level and firm-level regressions), we exclude observations with the following properties:

- Missing value of sales, total assets, total liability, and net worth
- Negative or zero value of sales, total assets, total liability
- Not included in manufacturing sector ($KSIC \in [10, 34]$)
- For short-term foreign currency debt exposure and long-term foreign currency debt exposure: (i) values greater than 1, and then (ii) the top 0.5 percent of the remaining distribution
- Foreign currency cash to total current assets ratio larger than 1
- Leverage (total debt to total asset ratio) greater than 10

In each of the firm-level regression analyses, we exclude firms whose dependent variables (e.g., sales growth, net worth growth, etc.) are above the top and or below the bottom 1 percent of the distribution. We do not drop industries in a similar manner, as the number of industries we employ in the analysis is more limited. Nonetheless, all the results are robust to dropping the industries whose price changes are above the top 1 percent and or below the bottom 1 percent of the distribution. These results are included in Table A15 in the Appendix.

Data Merging

Our analysis focuses on the manufacturing sector. A *sector* in our empirical analysis corresponds to the most narrowly defined group that the Bank of Korea uses to compute each PPI, which we will call a PPI industry classification. In other words, *a sector is a PPI industry classification*. All the matching work is done to merge data at the PPI industry-level.

Firm-Level Data Matching

In the KISVALUE dataset, each firm's industry is identified with a five-digit KSIC (Korea Standard Industrial Classification) code. There is no matching code available between KSIC codes and PPI industries. We manually map those two datasets. We map each KSIC code to the closest PPI industry classification. As a result, one PPI industry classification is now matched to none, one, or a few KSIC codes. Hence, those firms that have different KSIC codes mapped to the same PPI industry classification are now treated as if they are in the same sector. For each sector, S, we compute X_S, the weighted average of a firm-level variable of interest, x_i, as:

$$X_S = \sum_{i \in S} x_i \frac{y_i}{Y_S} \text{ and } Y_S = \sum_{i \in S} y_i$$

, where S is a sector (PPI industry classification) and y_i is firm i's size[48] and Y_S is the sum of y_is in sector S.

Rauch Classification

For each of the commodities at the 4–digit SITC Rev.2 level, Rauch (1999) defines whether it is a differentiated product or not. Following Affendy et al. (2010), we map each 4–digit SITC code to an ISIC Rev.3 code. This mapping means that one ISIC Rev.3 code is mapped to none, one, or a few 4–digit SITC codes. Then, following the United Nations' conversion table, we map each ISIC Rev.3 code to *one or more* ISIC Rev.4 codes. This implies not only that one ISIC Rev.3 code is mapped to one or a few ISIC Rev.4 codes but also that one ISIC Rev.4 code is now mapped to one or a few ISIC Rev.3 codes.[49] Next, we map each ISIC Rev.4 code to a KSIC Rev.10 code, following Kim (2008). In this mapping, exactly one ISIC Rev.4 code is matched with one KSIC Rev.10 code. From the above section, we describe that one PPI industry classification is mapped with none, one, or a number of KSIC Rev.10 codes. Hence, now we have one PPI industry classification is mapped to none or one or a few 4–digit SITC Rev.2 codes.

[48]We use the log of real sales when computing firms' sales share to limit the effects of the outliers.
[49]This is an N:N matching.

For each commodity at the 4–digit SITC code Rev.2 level, we define a dummy variable that is equal to 1 if it is a differentiated product. Then, for each sector (PPI industry classification), we take the weighted average of those binary values, where the weights are the commodities' trade shares in 1996.[50] We define each sector's product as *differentiated* when this weighted average is above 0.5 and *homogeneous* otherwise.

Input-Output Table and Import Price Index

We use the 1995 Input-Ouput (IO) table from the Bank of Korea. We map each PPI industry classification to one or two closely related items in the IO table. [51] For each item j in the IO table, we compute the share of imported intermediate inputs in the total inputs (all intermediate inputs and value-added from labor and capital) used for the production of IO item j:

$$\textit{Imported Input Share}_j = \frac{\textit{Imported Input}_j}{\textit{Total Inputs}_j}$$

Then, for each PPI sector S, we compute the weighted average of those imported input shares across each item j, where the weight of item j is the total inputs used in the production of item j, divided by the total inputs used in the production of all items in sector S. This is essentially the same as the imported inputs used for the items in Sector S, divided by the total inputs used for the items in Sector S.

$$\begin{aligned}\textit{Imported Input Share}_S &= \sum_{j\in S} \textit{Imported Input Share}_j \times \frac{\textit{Total Input}_j}{\textit{Total Inputs}_S} \\ &= \frac{\sum_{j\in S}\textit{Imported Input}_j}{\textit{Total Inputs}_S} \\ \textit{,where Total Input}_S &= \sum_{j\in S} \textit{Total Inputs}_j\end{aligned}$$

Price Stickiness

We use the median frequency of price changes in Table 12 of Nakamura and Steinsson (2008) to measure price stickiness. We map each PPI industry classification to a broad group over which the price stickiness is measured in Table 12 of Nakamura and Steinsson (2008).[52]

[50] This is following Rauch's method. Each commodity's trade share is its imports and exports divided by the sum of total imports and exports of all the commodities in that sector. We implicitly assume that each commodity's importance in a sector is proportional to its trading volume.

[51] Since the IO table contains fewer and broader categories, we map PPI industries to IO items —not the other way around— and some PPI industries are therefore matched to the same IO item(s).

[52] In this mapping, the number of groups in Table 12 of Nakamura and Steinsson (2008) is much smaller, so many of PPI industries are matched to the same broad groups, over which the price stickiness is defined.

Additional Tables

Table A2: Ten Sectors with Highest FC Share of Short-term Debt

Sector	FC share of Short-term Debt (%)
Naphtha	67
Sugars & starches	49
Nonferrous metal primary products	40
Gold & silver bullion	35
Other manufacturing products	33
Reinforced & reproduced wood	33
Bags & handbags	28
Other electronic components	24
Wooden products	23
Crude steel	23

Note: The table shows the top 10 industries with the highest FC share of short-term debt in 1996.

Table A3: Summary Statistics of Industry-level Control Variables

	Mean (1)	*Stdev* *(2)*	[Min,Max] (3)	Corr with Short-term FC Debt Ratio (4)
Short-term FC Debt Ratio	10%	10%	[0%, 67%]	1
Long-term FC Debt Ratio	20%	13%	[0%, 53%]	0.4037
Import Share (%)	18%	12%	[0%, 60%]	0.4932
Rauch dummy	0.82	0.38	[0, 1]	-0.3310
Price Stickiness	7.70	6.67	[4.07, 35.98]	0.1984

Notes: The table shows the summary statistics of industry-level control variables in 1996. Columns (1) and (2) show the average and standard deviation of each variable, respectively.

Table A4: Firm Performance and FC Debt
Alternative Definition of Foreign Currency Debt Exposure, FC Debt to *Total Debt*

	Net Worth Growth	Domestic Sales Growth	Markup Growth
	(1)	(2)	(3)
ST $FC_{TotalDebt}$	-8.7812**	-20.9089***	-1.6795***
	(3.6515)	(7.5414)	(0.6237)
LT $FC_{TotalDebt}$	-0.5494	-1.1446	0.2135
	(1.3023)	(3.5995)	(0.2880)
Size	-0.0404***	-0.2313***	-0.0094***
	(0.0095)	(0.0284)	(0.0022)
ST $FC_{TotalDebt}$ x Size	0.3528**	0.8518***	0.0674***
	(0.1535)	(0.3130)	(0.0260)
LT $FC_{TotalDebt}$ x Size	0.0139	-0.7320**	-0.0143
	(0.1469)	(0.3672)	(0.0171)
Leverage Ratio	0.1714***	0.1332	0.0164
	(0.0536)	(0.1174)	(0.0126)
Export to Sale Ratio	0.7730***	1.4394***	0.0416***
	(0.0820)	(0.2007)	(0.0089)
ST Debt Ratio	0.0290	0.1198	-0.0019
	(0.0315)	(0.0937)	(0.0083)
FC Cash Ratio	-1.4048*	-2.8961**	0.2473**
	(0.7832)	(1.2276)	(0.1040)
ST $FC_{TotalDebt}$ x ln(ST Debt)	-0.3738	-0.6315	-0.0537
	(0.2751)	(0.5150)	(0.0443)
LT $FC_{TotalDebt}$ x ln(LT Debt)	0.0175	0.8681***	0.0063
	(0.1173)	(0.3076)	(0.0150)
Adjusted R^2	0.1555	0.1912	0.0462
N	3135	3135	3134

Notes: The dependent variables are the growth rates of net worth, domestic sales, and estimated markups from 1996 to 1998. All the nominal series are deflated with the CPI. We use an alternative definition of the foreign currency exposure. Short-term foreign currency debt exposure is defined as the ratio of short-term foreign currency debt to *total debt*, and long-term foreign currency debt exposure as the ratio of long-term foreign currency debt to total debt. Robust standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A5: Firm Performance and FC Debt
Alternative Definition of Foreign Currency Debt Exposure, FC Debt to *Total Assets*

	Net Worth Growth	Domestic Sales Growth	Markup Growth
	(1)	(2)	(3)
ST FC_{TOAS}	-36.6359***	-54.7598**	-4.0045**
	(10.8123)	(23.7650)	(2.0360)
LT FC_{TOAS}	2.1096	4.7515	0.2957
	(4.3242)	(11.1394)	(0.6660)
Size	-0.0344***	-0.1973***	-0.0093***
	(0.0093)	(0.0276)	(0.0020)
ST FC_{TOAS} x Size	1.5222***	2.2801**	0.1621*
	(0.4582)	(1.0053)	(0.0860)
LT FC_{TOAS} x Size	-0.1287	-2.3309***	-0.0207
	(0.5211)	(0.8308)	(0.0420)
Leverage Ratio	0.1729***	0.1382	0.0184
	(0.0495)	(0.1167)	(0.0121)
Export to Sale Ratio	0.7778***	1.4689***	0.0411***
	(0.0821)	(0.2006)	(0.0089)
ST Debt Ratio	0.0217	0.0380	-0.0022
	(0.0305)	(0.0911)	(0.0080)
FC Cash Ratio	-1.3439*	-2.3057*	0.2443**
	(0.7697)	(1.3807)	(0.1077)
ST FC_{TOAS} x ln(ST Debt)	-2.1795***	-2.4756	-0.1471
	(0.7698)	(1.7166)	(0.1453)
LT FC_{TOAS} x ln(LT Debt)	0.0621	2.2860***	0.0098
	(0.3990)	(0.7616)	(0.0379)
Adjusted R^2	0.1574	0.1937	0.0459
N	3135	3135	3134

Notes: The dependent variables are the growth rates of net worth, domestic sales, and estimated markups from 1996 to 1998. All the nominal series are deflated with the CPI. We use an alternative definition of the foreign currency exposure. Short-term foreign currency debt exposure is defined as the ratio of short-term foreign currency debt to *total assets,* and long-term foreign currency debt exposure as the ratio of long-term foreign currency debt to *total assets*. Robust standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A6: Firm Performance and FC Debt
Controlling for Five-Digit Industry FE

	Net Worth Growth	Domestic Sales Growth	Markup Growth
	(1)	(2)	(3)
ST FC	-5.7279***	-9.6019**	-1.0589***
	(1.6856)	(3.9780)	(0.3450)
LT FC	0.0960	0.1872	0.2404
	(0.7077)	(2.0475)	(0.1558)
Size	-0.0502***	-0.2791***	-0.0103***
	(0.0111)	(0.0305)	(0.0025)
ST FC x Size	0.2305***	0.3823**	0.0424***
	(0.0687)	(0.1591)	(0.0139)
LT FC x Size	-0.0400	-0.2320*	-0.0129
	(0.0430)	(0.1212)	(0.0079)
Leverage Ratio	0.1456***	0.1057	0.0132
	(0.0561)	(0.1205)	(0.0133)
Export to Sale Ratio	0.7394***	1.3904***	0.0269***
	(0.0851)	(0.2020)	(0.0094)
ST Debt Ratio	0.0287	0.0464	-0.0022
	(0.0363)	(0.1016)	(0.0091)
FC Cash Ratio	-1.8734*	-3.9079***	0.1548
	(0.9567)	(1.3612)	(0.1071)
ST FC x ln(ST Debt)	-0.2706**	-0.0643	-0.0146
	(0.1071)	(0.1845)	(0.0181)
LT FC x ln(LT Debt)	0.0445	0.2674***	0.0037
	(0.0323)	(0.0852)	(0.0056)
Adjusted R^2	0.1633	0.2257	0.0762
N	3092	3089	3088

Notes: The dependent variables are the growth rates of net worth, domestic sales, and estimated markups from 1996 to 1998. All the nominal series are deflated with the CPI. We include five-digit industry fixed effects. Robust standard errors are reported in the parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A7: Markup Growth Rate for Firms with Zero FC Short-term Debt

	Markup Growth
	(1)
$D_{\text{ST FC=0}}$	0.0119***
	(0.0046)
LT FC	0.0047
	(0.0101)
D_{size}	-0.0315**
	(0.0144)
LT FC x D_{size}	0.0360
	(0.0252)
Leverage Ratio	0.0290**
	(0.0120)
Export to Sale Ratio	0.0367***
	(0.0087)
ST Debt Ratio	-0.0138*
	(0.0080)
FC Cash Ratio	0.2120**
	(0.1057)
ST FC x ln(ST Debt)	-0.0292
	(0.0289)
LT FC x ln(LT Debt)	-0.0003
	(0.0024)
Adjusted R^2	0.0387
N	3135

Notes: The dependent variable is the growth rate of estimated markups from 1996 to 1998. $D_{\text{ST FC=0}}$ is the dummy variable that is equal to one when firms' short-term FC debt in 1996 is zero and zero otherwise. D_{size} is the dummy variable that is equal to one when firm size is large than its 95th percentile. Robust standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A8: Industry Price Dynamics and FC Debt
Accounting for Change in Number of Firms

	(1)	(2)
ST FC	0.6437***	0.5531***
	(0.2173)	(0.2060)
LT FC	-0.1920	-0.1830
	(0.1346)	(0.1363)
Size	0.0066	0.0023
	(0.0184)	(0.0183)
Export to Sale Ratio	-0.0169	-0.0413
	(0.1562)	(0.1526)
Leverage Ratio	0.3365**	0.3076*
	(0.1494)	(0.1645)
Domestic ST Ratio	0.0929	0.1443
	(0.1176)	(0.1253)
FC Cash Ratio	0.4050	-0.1171
	(3.1391)	(3.2099)
Log Change of # of Firms	1.0001**	1.0207*
	(0.4832)	(0.5382)
Rauch Dummy		-0.0020
		(0.0465)
Imported Input Share		0.2728
		(0.1675)
Degree of Price Stickiness		0.0327*
		(0.0167)
Broad Industry FE	Yes	Yes
Adjusted R^2	0.4440	0.4515
N	156	156

Notes: The dependent variable is the growth rate of sectoral prices from 1996 to 1998. The main regressors are the sector-level short-term foreign currency debt exposure (ST FC) and the long-term foreign currency debt exposure (LT FC) in 1996. We include the change in the number of firms in each sector as an additional control variable. The number of firms in each industry is collected from the Korean Statistical Information Service (KOSIS). Robust standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A9: Industry Price Dynamics and FC Debt
Controlling for Imported Output Share

	(1)	(2)
ST FC	0.6255***	0.5717***
	(0.2083)	(0.2022)
LT FC	-0.1601	-0.1638
	(0.1364)	(0.1381)
Size	0.0031	0.0012
	(0.0163)	(0.0168)
Export to Sale Ratio	-0.0076	-0.0284
	(0.1569)	(0.1567)
Leverage Ratio	0.3158**	0.3072**
	(0.1384)	(0.1482)
Domestic ST Ratio	0.0996	0.1287
	(0.1137)	(0.1204)
FC Cash Ratio	-0.8390	-1.0209
	(3.2153)	(3.2589)
Imported Output Share	0.2096**	0.1657
	(0.0901)	(0.1038)
Rauch Dummy		0.0106
		(0.0441)
Imported Input Share		0.2041
		(0.1769)
Degree of Price Stickiness		0.0250*
		(0.0150)
Adjusted R^2	0.4641	0.4608
N	156	156

Notes: The dependent variable is the growth rate of sectoral prices from 1996 to 1998. The main regressors are the sector-level short-term foreign currency debt exposure (ST FC) and the long-term foreign currency debt exposure (LT FC) in 1996. We include the sectoral imported *output* share as an additional control variable. Robust standard errors are reported in parentheses.* p<0.1, ** p<0.05, *** p<0.01.

Table A10: Industry Price Dynamics and FC Debt
Domestic Firms Only

	(1)	(2)	(3)
ST FC	0.5862***	0.5808***	0.5602***
	(0.1386)	(0.1672)	(0.1587)
LT FC	-0.1370*	-0.1319*	-0.1336*
	(0.0794)	(0.0784)	(0.0778)
Size		0.0057	0.0025
		(0.0188)	(0.0192)
Leverage Ratio		0.3138**	0.2886*
		(0.1383)	(0.1518)
Domestic ST Ratio		0.0247	0.0601
		(0.1077)	(0.1145)
FC Cash Ratio		-1.7904	-2.0874
		(4.5006)	(4.2077)
Rauch Dummy			0.0164
			(0.0477)
Imported Input Share			0.2298
			(0.1888)
Degree of Price Stickiness			0.0268*
			(0.0159)
Broad Industry FE	Yes	Yes	Yes
Adjusted R^2	0.4157	0.4373	0.4365
N	155	155	155

Notes: This table shows the regression estimates from Equation (4) using a subsample of firms whose exports are zero. The dependent variable is the growth rate of sectoral prices from 1996 to 1998. The main regressors are the sector-level short-term foreign currency debt exposure (ST FC) and the long-term foreign currency debt exposure (LT FC) in 1996. Robust standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A11: Industry Price Dynamics and FC Debt
Alternative Definition of Foreign Currency Debt Exposure, FC Debt to *Total Debt*

	(3)	(4)	(5)
ST $FC_{TotalDebt}$	0.7497***	0.7598***	0.6780***
	(0.1597)	(0.2293)	(0.2099)
LT $FC_{TotalDebt}$	-0.0943	-0.4331	-0.4063
	(0.2991)	(0.3141)	(0.3288)
Size		0.0147	0.0120
		(0.0180)	(0.0196)
Export to Sale Ratio		0.0545	0.0414
		(0.1710)	(0.1614)
Leverage Ratio		0.3587**	0.3296*
		(0.1548)	(0.1744)
ST Debt Ratio		-0.1527	-0.1449
		(0.1463)	(0.1466)
FC Cash Ratio		-2.6870	-3.3565
		(2.4338)	(2.5768)
Rauch Dummy			0.0176
			(0.0486)
Imported Input Share			0.2549
			(0.1927)
Degree of Price Stickiness			0.0194
			(0.0231)
Broad Industry FE	Yes	Yes	Yes
Adjusted R^2	0.4131	0.4452	0.4457
N	156	156	156

Notes: This table shows the regression estimates from Equation (4) using an alternative definition of foreign currency exposure. Short-term foreign currency debt exposure is defined as the ratio of short-term foreign currency debt to *total debt*, and long-term foreign currency debt exposure as the ratio of long-term foreign currency debt to total debt. The dependent variable is the growth rate of sectoral prices from 1996 to 1998. The main regressors are the sector-level short-term foreign currency debt exposure (ST FC) and the long-term foreign currency debt exposure (LT FC) in 1996. Robust standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A12: Industry Price Dynamics and FC Debt
Alternative Definition of Foreign Currency Debt Exposure, FC Debt to *Total Assets*

	(1)	(2)	(3)
ST FC_{TOAS}	1.8686***	1.6171***	1.4084***
	(0.4671)	(0.5555)	(0.5122)
LT FC_{TOAS}	-0.1756	-0.6506	-0.4908
	(0.6286)	(0.7393)	(0.7550)
Size		0.0120	0.0046
		(0.0165)	(0.0171)
Export to Sale Ratio		-0.0087	-0.0443
		(0.1641)	(0.1595)
Leverage Ratio		0.3219**	0.2903*
		(0.1523)	(0.1679)
Domestic ST Ratio		-0.0028	0.0631
		(0.1258)	(0.1296)
FC Cash Ratio		0.9561	0.3937
		(3.0322)	(3.0606)
Rauch Dummy			-0.0041
			(0.0445)
Imported Input Share			0.2903*
			(0.1605)
Degree of Price Stickiness			0.0295
			(0.0180)
Adjusted R^2	0.4316	0.4372	0.4458
N	156	156	156

Notes: This table shows the regression estimates from Equation (4) using an alternative definition of foreign currency exposure. Short-term foreign currency debt exposure is defined as the ratio of short-term foreign currency debt to *total assets,* and long-term foreign currency debt exposure as the ratio of long-term foreign currency debt to *total assets*. The dependent variable is the growth rate of sectoral prices from 1996 to 1998. The main regressors are the sector-level short-term foreign currency debt exposure (ST FC) and the long-term foreign currency debt exposure (LT FC) in 1996. Robust standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A13: Industry Price Dynamics and FC Debt
Alternative Aggregation

	(1)	(2)	(3)
Aggregate ST FC	0.3382**	0.3590**	0.3131*
	(0.1636)	(0.1739)	(0.1646)
Aggregate LT FC	0.0414	-0.0114	-0.0188
	(0.0943)	(0.0921)	(0.0884)
Size		0.0135	0.0058
		(0.0150)	(0.0160)
Export to Sale Ratio		-0.0718	-0.0971
		(0.1642)	(0.1584)
Leverage Ratio		0.3675**	0.3330**
		(0.1444)	(0.1654)
Domestic ST Ratio		0.0851	0.1410
		(0.1154)	(0.1255)
FC Cash Ratio		-1.3302	-1.8078
		(3.2513)	(3.2500)
Rauch Dummy			-0.0009
			(0.0440)
Imported Input Share			0.3404**
			(0.1686)
Degree of Price Stickiness			0.0353*
			(0.0183)
Adjusted R^2	0.3847	0.4094	0.4268
N	156	156	156

Notes: This table shows the regression estimates from Equation (4) using an alternative aggregation of firm-level foreign currency exposure. We take the sum of short-term foreign currency debt and long-term foreign currency debt and normalize each by the corresponding sum of short-term and long-term debt. The dependent variable is the growth rate of sectoral prices from 1996 to 1998. The main regressors are the sector-level short-term foreign currency debt exposure (ST FC) and the long-term foreign currency debt exposure (LT FC) in 1996. Robust standard errors are reported in parentheses.* p<0.1, ** p<0.05, *** p<0.01.

Table A14: Industry Price Dynamics and FC Debt
Subsample of Industries

	(1)	(2)	(3)
ST FC	0.4862**	0.5779**	0.4956**
	(0.2008)	(0.2529)	(0.2477)
LT FC	-0.2039	-0.2048	-0.1616
	(0.1530)	(0.1667)	(0.1695)
Size		-0.0145	-0.0219
		(0.0194)	(0.0185)
Export to Sale Ratio		0.0467	0.0414
		(0.1588)	(0.1508)
Leverage Ratio		0.3469**	0.2499
		(0.1461)	(0.1590)
ST Debt Ratio		-0.0444	-0.0406
		(0.2072)	(0.2028)
FC Cash Ratio		1.9991	1.7374
		(4.1867)	(4.0960)
Rauch Dummy			0.0076
			(0.0423)
Imported Input Share			0.3678**
			(0.1819)
Degree of Price Stickiness			0.0300
			(0.0187)
Broad Industry FE	Yes	Yes	Yes
Adjusted R^2	0.4160	0.4360	0.4479
N	136	136	136

Notes: This table shows the regression estimates from Equation (4) using a subsample of sectors that have at least four firms. The dependent variable is the growth rate of sectoral prices from 1996 to 1998. The main regressors are the sector-level short-term foreign currency debt exposure (ST FC) and the long-term foreign currency debt exposure (LT FC) in 1996. Robust standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A15: Industry Price Dynamics and FC Debt
After Dropping Outliers

	(1)	(2)	(3)
ST FC	0.6338***	0.6722***	0.5376**
	(0.2239)	(0.2441)	(0.2278)
LT FC	-0.1564	-0.2245*	-0.2221
	(0.1219)	(0.1349)	(0.1368)
Size		0.0141	0.0088
		(0.0182)	(0.0181)
Export to Sale Ratio		-0.0574	-0.0695
		(0.1643)	(0.1591)
Leverage Ratio		0.3335**	0.2862*
		(0.1401)	(0.1572)
Domestic ST Ratio		0.1179	0.1703
		(0.1135)	(0.1209)
FC Cash Ratio		-1.7927	-2.4333
		(2.4173)	(2.4438)
Rauch Dummy			0.0070
			(0.0441)
Imported Input Share			0.3095*
			(0.1698)
Degree of Price Stickiness			0.0352**
			(0.0170)
Broad Industry FE	Yes	Yes	Yes
Adjusted R^2	0.3519	0.3750	0.3899
N	154	154	154

Notes: This table shows the regression estimates from Equation (4) after dropping outliers. We exclude industries whose price changes are in the top 1% and bottom 1% of the distribution. The dependent variable is the growth rate of sectoral prices from 1996 to 1998. The main regressors are the sector-level short-term foreign currency debt exposure (ST FC) and long-term foreign currency debt exposure (LT FC) in 1996. Robust standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table A16: Panel Regression

	(1)	(2)
ST FC	0.0074	0.0123
	(0.0265)	(0.0278)
LT FC	-0.0191	-0.0190
	(0.0160)	(0.0166)
ST FC $\times$dFX	0.4211**	0.5599***
	(0.1681)	(0.1906)
LT FC $\times$dFX	0.1967	0.1906
	(0.2442)	(0.2605)
Imported Input Share	-0.0149	-0.0220
	(0.0165)	(0.0177)
Size	-0.0086**	-0.0099**
	(0.0042)	(0.0046)
Export to Sale Ratio	0.0031	-0.0004
	(0.0201)	(0.0198)
Leverage Ratio	-0.0157	-0.0089
	(0.0214)	(0.0231)
Domestic ST Ratio	0.0087	0.0139
	(0.0166)	(0.0176)
FC Cash Ratio	-0.0417	-0.0564
	(0.0526)	(0.0496)
Imported Input Share $\times$dFX		0.0830
		(0.1740)
Rauch Dummy $\times$dFX		0.1491*
		(0.0780)
Degree of Price Stickiness $\times$dFX		0.0042
		(0.0035)
Size $\times$dFX		-0.0073
		(0.0225)
Export to Sale Ratio $\times$dFX		-0.2665
		(0.1627)
Leverage Ratio$\times$dFX		-0.1364
		(0.2115)
Domestic ST Ratio$\times$dFX		0.0271
		(0.1908)
FC Cash Ratio$\times$dFX		0.2278
		(0.7283)
Sector FE	Yes	Yes
Time FE	Yes	Yes
Adjusted R^2	0.2363	0.2451
N	3498	3300

Notes: This table shows the panel regression estimates from Equation (6). The dependent variable is the annual growth rate of sectoral producer prices. The main regressors are the interactions between the change in the exchange rate (dFX) and sectoral short-term foreign currency debt exposure (ST FC) as well as long-term foreign currency debt exposure (LT FC). To alleviate a potential endogeneity issue, we use the one-year lagged value of the regressors. Clustered standard errors are reported in parentheses, with clustering at the PPI sector level. * p<0.1, ** p<0.05, *** p<0.01.

Table A17: Panel Regression, Appreciation vs. Depreciation

FX: KRW price of USD	Periods with dFX < 0	Periods with dFX > 0
	(1)	(2)
ST FC	-0.0447	-0.0094
	(0.0337)	(0.0309)
LT FC	-0.0215	0.0111
	(0.0247)	(0.0231)
ST FC $\times$dFX	-0.1408	0.8456***
	(0.5084)	(0.2353)
LT FC $\times$dFX	0.3100	0.0219
	(0.3205)	(0.4324)
Imported Input Share	-0.0561*	-0.0441
	(0.0326)	(0.0351)
Size	-0.0175***	-0.0112
	(0.0048)	(0.0073)
Export to Sale Ratio	-0.0174	0.0709**
	(0.0400)	(0.0283)
Leverage Ratio	-0.0311	-0.0191
	(0.0449)	(0.0407)
Domestic ST Ratio	-0.0075	0.0153
	(0.0347)	(0.0256)
FC Cash Ratio	-0.0015	-0.0107
	(0.1063)	(0.0560)
Imported Input Share $\times$dFX	-0.4039**	0.3562
	(0.2030)	(0.3383)
Rauch Dummy $\times$dFX	0.1126	0.2224*
	(0.1416)	(0.1274)
Degree of Price Stickiness $\times$dFX	0.0103*	0.0057
	(0.0055)	(0.0068)
Size $\times$dFX	-0.1173**	0.0424
	(0.0518)	(0.0434)
Export to Sale Ratio $\times$dFX	0.1396	-0.7640**
	(0.4565)	(0.3368)
Leverage Ratio$\times$dFX	-0.6741	0.0346
	(0.4978)	(0.3632)
Domestic ST Ratio$\times$dFX	-0.2580	0.0601
	(0.3329)	(0.3300)
FC Cash Ratio$\times$dFX	2.0941	0.0603
	(1.2987)	(1.0167)
Sector FE	Yes	Yes
Year FE	Yes	Yes
Adjusted R^2	0.2184	0.2719
N	1636	1662

Notes: This table shows the panel regression estimates from Equation (6) after dividing the sample into two sub-periods. The estimation results for KRW appreciation against the USD and KRW depreciation against the USD are reported in Columns (1) and (2), respectively. The dependent variable is the annual growth rate of sectoral producer prices. The main regressors are the interactions between the change in the exchange rate (dFX) and sectoral short-term foreign currency debt exposure (ST FC) as well as long-term foreign currency debt exposure (LT FC). To alleviate a potential endogeneity issue, we use the one-year lagged value of the regressors. Clustered standard errors are reported in parentheses, with clustering at the PPI sector level. * p<0.1, ** p<0.05, *** p<0.01.

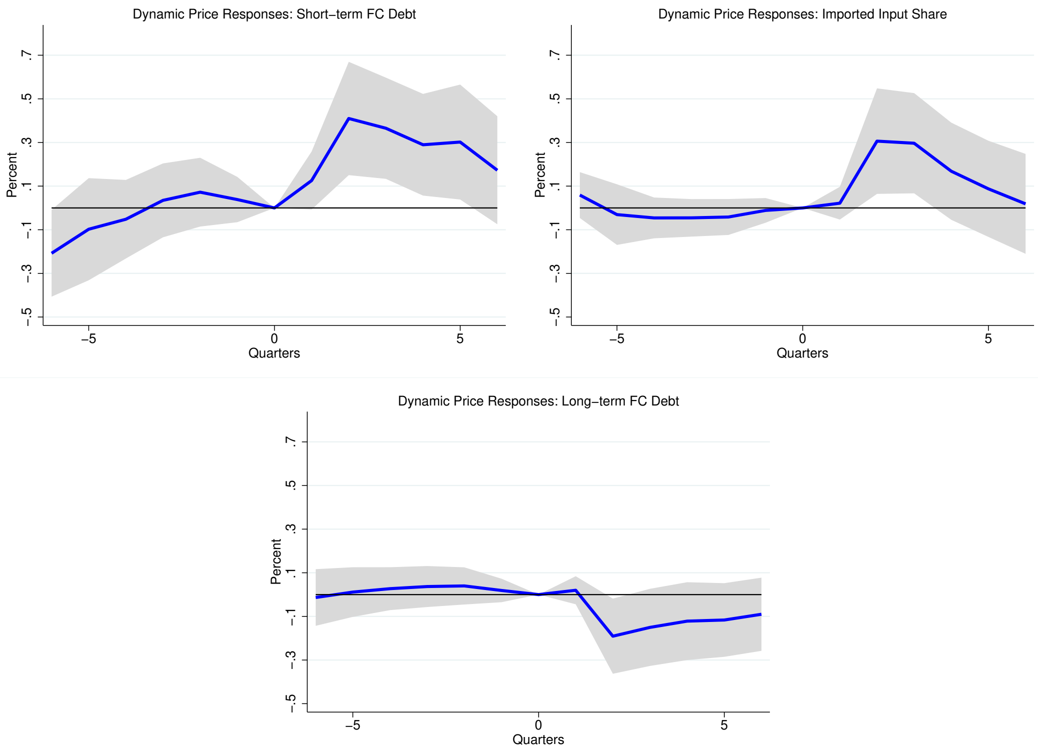
Table A18: Firm Performance and FC Debt
Exporters vs. Non-Exporters

	Domestic Sales Growth	
	(1)	(2)
ST FC	-8.6069**	-8.4576**
	(4.0502)	(3.9162)
ST FC x D_{Exporter}	-1.1125***	
	(0.2891)	
ST FC x Export to Sale Ratio		-2.3474***
		(0.6683)
LT FC	-0.5309	-0.7755
	(2.2887)	(2.2862)
Size	-0.2497***	-0.2553***
	(0.0279)	(0.0281)
ST FC x Size	0.3494**	0.3420**
	(0.1624)	(0.1569)
LT FC x Size	-0.2103	-0.2090
	(0.1348)	(0.1345)
Leverage Ratio	0.1407	0.1331
	(0.1145)	(0.1144)
Export to Sale Ratio	1.5685***	1.6476***
	(0.2198)	(0.2322)
ST Debt Ratio	0.0344	0.0365
	(0.0952)	(0.0949)
FC Cash Ratio	-2.9101***	-2.3009**
	(1.1225)	(1.1525)
ST FC x ln(ST Debt)	0.0555	0.0455
	(0.1765)	(0.1617)
LT FC x ln(LT Debt)	0.2767***	0.2866***
	(0.0855)	(0.0853)
Adjusted R^2	0.1929	0.1945
N	3135	3135

Notes: The dependent variable is the growth rate of domestic sales from 1996 to 1998. All the nominal series are deflated with the CPI. $D_{\text{Exporter}}$is equal to one when a firm is an exporter in 1996 and zero otherwise. Robust standard errors are reported in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

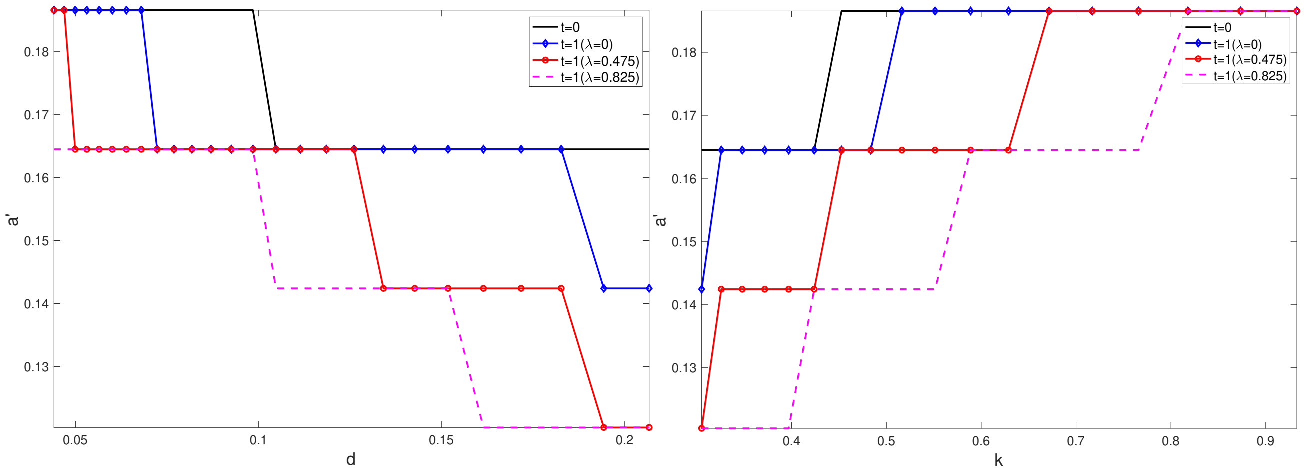
Additional Figures

Figure A1: Quarterly PPI Before and After the Depreciation of Korean Won



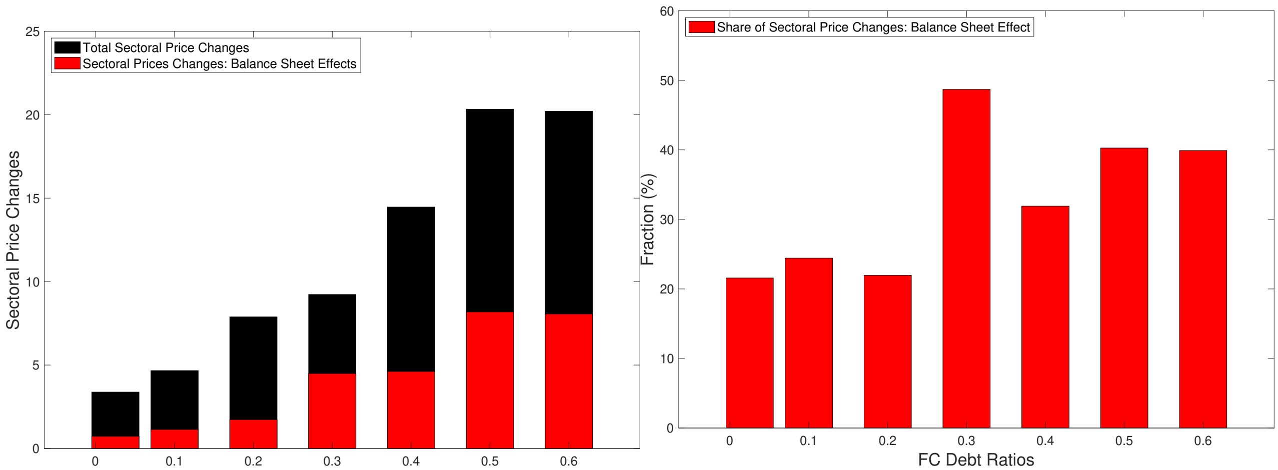
Notes: The figure plots the dynamic effects β_h of short-term FC debt exposure, long-term FC debt exposure and the imported input share on quarterly sectoral PPIs: $\frac{p_{I,1997Q3+h}-p_{I,1997Q3}}{p_{I,1997Q3}} = \beta_h + \beta_{1,h}\text{ST FC}_{I,96} + \beta_{2,h}\text{LT FC}_{I,96} + \beta_{3,h}\text{X}_{I,96} + \epsilon_{I,h}$. The area represents the 90% confidence intervals with robust standard errors.

Figure A2: a' against (i) d (Left) and (ii) k (Right).



Notes: The solid black lines are the policy functions in the stationary equilibrium. The blue diamond lines, red circle lines, and dashed magenta lines are the policy functions for firms with 0, 0.475, and 0.825 of foreign currency debt ratio, respectively.

Figure A3: Counterfactual Exercise
Quantitative Size of the Balance Sheet Effect at the Sector-level, Alternative Approach



Notes: The figure plots the two sets of sectoral price changes: one computed in the baseline model and the other computed in the counterfactual model with λ=0, shutting down the balance sheet effect of foreign currency debt following the exchange rate depreciation. We group sectors with foreign currency debt ratios in $(0\%, 5\%), [5\%, 15\%), \ldots, [45\%, 55\%), [55\%, 70\%)$. We first compute (i) the average sectoral price changes in the baseline model and (ii) that in the counterfactual exercise across sectoral foreign currency debt ratios. To back out (iii) the average sectoral price changes due to the balance sheet effect of foreign currency debt across sectoral foreign currency debt ratios, we subtract (ii) from (i). The figure on the left shows (i) in black bars and (iii) in red bars across sectoral foreign currency debt ratios. The figure on the right shows the ratio of (iii)/(i) across sectoral foreign currency debt ratios.

Productivity Shock Estimation

Estimation

Following Ackerberg et al. (2006), we assume the below production function in logs (variables with hat):

$$\hat{y}_{it} = \beta_k \hat{k_{it}} + \beta_\ell \hat{\ell}_{it} + \beta_m \hat{m}_{it} + \hat{z}_{it} + u_{it} \tag{9}$$

, where $\hat{y}_{it}$ is total output, $\hat{k}_{it}$ is capital stock, $\hat{l}_{it}$ is labor input, $\hat{m}_{it}$ is intermediate input, and $\hat{z}_{it}$ is a productivity shock that evolves according to a first order Markov process. Additionally, we assume that labor is "less variable" (chosen slightly before) than intermediate input $\hat{m}_{it}$

$$\hat{m}_{it} = f_t(\hat{z}_{it}, \hat{k}_{it}, \hat{\ell}_{it}).$$

Then, we invert this function for $\hat{z}_{it}$ and substitute it into the value added production:

$$\hat{y}_{it} = \beta_k \hat{k}_{it} + \beta_\ell \hat{\ell}_{it} + \beta_m \hat{m}_{it} + f_t^{-1}(\hat{m}_{it}, \hat{k}_{it}, \hat{\ell}_{it}) + u_{it} \tag{10}$$

We can obtain an estimate of $\hat{\Phi}_{it}$, which represents the value added net of the unpredictable/untransmitted shock u_{it}:

$$\hat{\Phi}_{it} = \beta_k \hat{k}_{it} + \beta_\ell \hat{\ell}_{it} + \beta_m \hat{m}_{it} + f_t^{-1}(\hat{m}_{it}, \hat{k}_{it}, \hat{\ell}_{it}).$$

We approximate $f_t^{-1}(\hat{m}_{it}, \hat{k}_{it}, \hat{\ell}_{it})$ with a second-order polynomial function of $\hat{m}_{it}, \hat{k}_{it}, \hat{\ell}_{it}$. Given the first-order Markov assumption on $\hat{z}_{it}$, we have

$$\hat{z}_{it} = \mathbb{E}[\hat{z}_{it}|I_{i,t-1}] = \mathbb{E}[\hat{z}_{it}|\hat{z}_{i,t-1}] + \zeta_{it}$$

, where ζ_{it} is mean independent of all information known at time $t-1$. We then approximate $\mathbb{E}[\hat{z}_{it}|\hat{z}_{i,t-1}]$ with $\hat{z}_{i,t-1}$, its squared, and its cubed.

We then use the three moment conditions for the identification of β_k, β_l,and β_m:

$$\mathbb{E}[\zeta_{it}|\hat{k}_{it}] = 0$$

$$\mathbb{E}[\zeta_{it}|\hat{\ell}_{i,t-1}] = 0$$

$$\mathbb{E}[\zeta_{it}|\hat{m}_{i,t-1}] = 0.$$

Then, we back out the productivity shocks as:

$$\hat{z}_{it} = \hat{\Phi}_{it} - \hat{\beta}_k \hat{k}_{it} - \hat{\beta}_\ell \hat{\ell}_{it} - \hat{\beta}_m \hat{m}_{it}.$$

In our model, the output production function (in logs) is defined as

$$\hat{y}_{it} = \alpha\hat{k}_{it} + \kappa\hat{x}_{it} + (1-\alpha-\kappa)\hat{n}_{it} + \hat{z}_{it} \tag{11}$$

where $\hat{k}_{it}$is capital stock, $\hat{x}_{it}$is imported intermediate input, $\hat{n}_{it}$is domestic input, and $\hat{z}_{it}$ is a productivity shock. When estimating productivity, however, firm-level data only allow us to separate labor input $\hat{l}_{it}$ and total intermediate input $\hat{m}_{it}$. As long as we assume (i) domestic input $\hat{n}_{it}$ as a composite of labor $\hat{l}_{it}$ and domestic intermediate input $\hat{d}_{it}$, i.e., $\hat{n}_{i,t} = \chi_1\hat{\ell}_{it} + (1-\chi_1)\hat{d}_{it}$, and (ii) total intermediate input $\hat{m}_{it}$ as a composite of imported intermediate $\hat{x}_{it}$ and domestic intermediate $\hat{d}_{it}$, i.e., $\hat{m}_{i,t} = \chi_2\hat{x}_{it} + (1-\chi_2)\hat{d}_{it}$, production function 11 can be expressed as a value added production function as in 9. Hence, the two production functions are equivalent for the purpose of estimating the productivity shocks.

Data

Table A19 summarizes a detailed description of the data used to estimate the productivity shocks to firms.

Table A19: Variables Used for Estimation: 1991-1996

		Data Used	Variable Descriptions
Total outputy_{it}	y_{it}= $ln((SALE_{it}) * 100/CPI_t)$	$SALE_{it}$	Sales
		CPI_t	Consumer Price Index
Capital k_{it}	k_{it}= $ln(K_{it}/CPI_t)$ $K_{i,t} = TOAS_{i,t} - LIQUID_{i,t} - INTR_{i,t}$ $LIQUID_{i,t} = CASH_{i,t} + STFI_{i,t} + AR_{i,t}$	$K_{i,t}$	Capital Stock
		$LIQUID_{i,t}$	Liquid Asset
		$INTR_{i,t}$	Inventory
		$CASH_{i,t}$	Cash and Cash Equivalents
		$STFI_{i,t}$	Short-term Financial Instruments
		$AR_{i,t}$	Account Receivables
		CPI_t	Consumer Price Index
Labor ℓ_{it}	ℓ_{it}= $ln(LCOST * 100/CPI_t)$	$LCOST$	Labor Cost
		CPI_t	Consumer Price Index
Raw Material Costs m_{it}	m_{it}= $ln(RCOST_{it} * 100/CPI_t)$	$RCOST_{it}$	Raw Material Costs
		CPI_t	Consumer Price Index

Model details

Functional form of Kimball demand

Following Gopinath and Itskhoki (2010), we assume the following functional forms:

$$\psi(x_j) = \left(1 - \epsilon \ln(\frac{\sigma x_j}{\sigma - 1})\right)^{\sigma/\epsilon} \text{where } x_j = D_I \frac{p_j}{P_I}.$$

Then, the demand for an intermediate good produced by an entrepreneur j:

$$y_j = \left(1 - \epsilon \ln(\frac{\sigma x_j}{\sigma - 1})\right)^{\sigma/\epsilon} Y_I \text{ where } x_j = D_I \frac{p_j}{P_I}.$$

$$p_j = \frac{\sigma - 1}{\sigma} \exp\left(\frac{1}{\epsilon}\left(1 - (\frac{y_j}{Y_I})^{\epsilon/\sigma}\right)\right)\frac{P_I}{D_I}.$$

$$P_I = \int p_j \left(1 - \epsilon ln(\frac{\sigma x_j}{\sigma - 1})\right)^{\sigma/\epsilon} dj$$

Using the Kimball aggregator, we would like to capture the strategic complementarity between firms' pricing decisions and see how the model predictions are aligned with what we have seen from the data. Moreover, we can talk about variable markups due to the Kimball aggregator, which would not be possible using the nested CES demand structure. Following Gopinath and Itskhoki (2010), we do the first-order approximation of the industry price level.[53]

$$\ln P_I = \int \ln p_j dj.$$

[53] Gopinath and Itskhoki (2010) show that the first order deviation from D_I from its steady state value $\bar{D} = \frac{\sigma - 1}{\sigma}$ is zero.

Parameter Sensitivity Check

Table A20: Model Moment Sensitivity to A 1% Increase in Each Parameter Value

	Average $\frac{d}{k}$	Average $\frac{k}{y}$	Average $\frac{a}{k}$	Average ln(Markup)	Std ln(Markup)	Average k_0 to Average k
θ_k	***0.63***	0.09	-0.19	0.00	0.03	-0.09
θ_a	0.00	-0.05	***-0.55***	0.05	*0.31*	-0.06
β	***-2.21***	***1.60***	-0.09	0.01	0.06	***-2.43***
ϵ	0.00	0.09	-0.02	0.14	***0.85***	0.02
σ	0.01	0.02	-0.06	***-1.15***	***-1.31***	-0.07
k_0	0.05	*0.30*	*-0.31*	0.00	-0.09	**0.85**

Notes: The table reports how a 1% increase in each parameter value changes the six model moments, holding other parameter values fixed. Std stands for standard deviation. The numerical simulation uses a 4% increase to generate a sufficiently meaningful absolute change in all the parameter values.

Table A20 reports information that helps assess the sources of identification in our calibration exercise. Specifically, it shows the local elasticity of the targeted moments with respect to the parameters chosen in our calibration, computed at the estimated parameter values. The resulting patterns are intuitive. First, a higher degree of the collateral constraint, θ_k, increases the amount of debt firms can borrow for a given level of the capital stock $\frac{d}{k}$. Second, an increase in the working capital constraint parameter θ_a allows firms to hire variable inputs with less liquid assets on hand, so the level of liquid assets relative to the scale of production $\frac{a}{k}$ declines. A higher discount factor β makes firms value future consumption more, which strengthens their incentive to invest; this is reflected in a higher capital to output ratio $\frac{k}{y}$ and higher net assets, so that $\frac{d}{k}$ decreases. An increase in k_0 naturally raises the ratio of the average capital of new firms to overall average capital. Finally, a higher super-elasticity ϵ implies greater variability in markups as illustrated by Amiti et al. (2018), whereas a higher elasticity of substitution σ is associated with lower average markups and less variable markups.