Liability Dollarization and Exchange Rate Pass-Through

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Motivation: Strong Dollar & Spillover to Emerging Markets

- The dollar hit a two decade high in Sep 2022, appreciated by 16% since the beginning of 2022.
- The negative spillovers of strong dollar is particularly acute in emerging economies due to
  (i) pass-through to domestic prices via large dependence on the **imported intermediate inputs**.
  (ii) contractinoary effects of high level of **dollar-denominated corporate debt**.
  Krugman (1999), Céspedes, Chang and Velasco (2004) and Kim, Tesar and Zhang (2015)
- The **negative balance sheet effect** of $ debt on **domestic inflation** is neglected in the literature.

Research Question

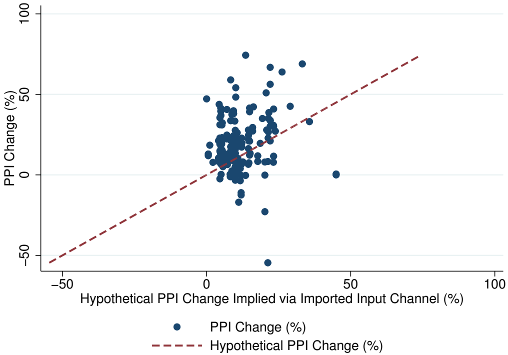
1. How do firms' pricing decisions vary with different levels of FC debt?

2. How significant is this balance sheet effect of FC debt
in explaining the exchange rate pass-through to domestic producer inflation?

Motivation: Domestic PPI Across Manufacturing Sectors in Korea

- From 1996-98, Realized PPI changes vs. $\underbrace{\text{PPI changes implied via the imported input channel}}_{\text{Imported Input Share} \times \Delta \text{Imported Input Price}}$

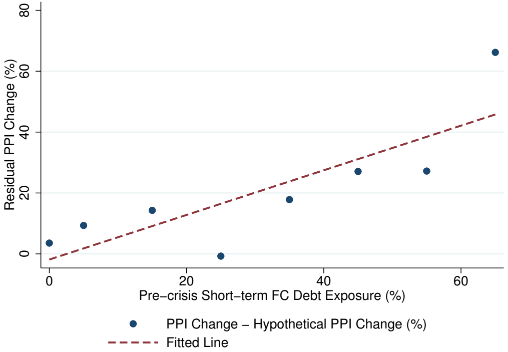
  assuming (i) Cobb-Douglas production function with CRTS, and (ii) a complete pass-through



- The imported input channel is in fall short of generating the level of PPI changes upon a large depreciation. ▸ Cross-country

Motivation: Positive Correlation Between FC Debt Exposure and Residual PPI Changes

- $\underbrace{\text{Unexplained PPI changes}}_{\text{Realized PPI changes - Implied PPI Changes via Imported Input Channel}}$ and Pre-crisis Short-term FC debt exposure



- Relatively neglected balance sheet channel may account for the much pronounced increase in domestic producer prices.

Literature Review

Exchange Rate Pass-Through to Prices

Exchange rate pass-through to domestic prices

Goldberg, Campa (2010), Amiti, Itskhoki, Konings (2019)

⇒ **Exploring the neglected balance sheet channel in the exchange rate pass-through**

Contractionary Effects of Foreign Currency Debt

- Empirical and theoretical investigation of negative balance sheet effects on firm performance

  Krugman (1999), Céspedes, Chang, Velasco (2004), Kim, Tesar, Zhang (2015), Kohn, Leibovici, Szkup (2018)

⇒ **Balance sheet effects of foreign currency debt on prices**

Financial Frictions and Firms' Pricing Decisions

- Closed Economy Setting

  Gilchrist et al. (2017), Christiano et al. (2015), Del Negro et al. (2015), Kim (2021)

⇒ **Open economy setting in the sudden stop episodes with dollar debt and a large depreciation**

Overview

(1) Exploiting **a large devaluation** in Korea in 1997, we identify the **balance sheet channel**

Industries with high FC ST debt exposure

(i) $\uparrow$ their prices more during the crisis

Firms with high FC ST debt exposure

(ii) $\downarrow$ sales growth, $\downarrow$ networth growth and $\downarrow$ **markup growth**

(2) Build a **heterogeneous firm** model with two types of **financial constraints** and **imported inputs**

(i) An industry equilibrium & its transition dynamics upon an **unexpected depreciation**

(3) The estimated model performs well in explaining price dynamics during the crisis:

(i) 40% of the mean effect of the short-term foreign currency debt on the price changes across industries

(ii) 55% of the variation in price changes across industries during the crisis.

(4) A sizable role of the balance sheet channel in explaining sectoral price dynamics

Empirical Analysis

Empirical Strategy & Data

- Our **unique dataset of firm-level B/S data + industry price data** has allowed the identification of the balance sheet channel

Firm-level balance sheet data: KISVALUE Dataset

1. currency composition & maturity of their debt:
   foreign currency vs. domestic currency, short-term vs. long-term ▸ Summary Stats
2. not only large but small and medium-sized firms:
   $\approx$ 3,000 firms in manufacturing sector (as of 1996)
3. a rich set of firm-level variables to control for potential endogenity bias:
   domestic currency debt, assets, sales, exports, and foreign currency cash holdings

Industry-level price data: Bank of Korea

Domestic Produce Price Index (PPI) for 155 industries in manufacturing sector (4-digit).

⋆ We exploit **a large devaluation** in Korea in 1997 & different **FC debt exposure** across industries to identify the balance sheet effect on the exchange rate pass-through to domestic output prices.
▸ Won per $

Industry-level Investigation

$$\Delta p_{i,96-98} = \beta_0 + \beta_1 \text{ ST FC}_{i,96} + \beta_2 \text{LT FC}_{i,96} + \beta_3 \text{X}_{i,96} + \epsilon_i$$

- $\Delta p_{i,96-98}$: the growth rates of PPI for industry i in 1996-98.
- ST FC_i: weighted average of firms' short-term FC debt to total short-term debt ratio in industry i.
- LT FC_i: weighted average of firms' long-term FC debt to total long-term debt ratio in industry i.
- X_i includes:
  - Import channel: imported intermediate input share
  - Other industry-level pass-through determinants: degree of the product differentiation (Rauch classification), degree of price stickiness
  - Weighted average of other firm-level variables: log of real assets, leverage ratio, domestic short-term debt ratio, export/sales ratio, and FC cash/total current assets ratio
  - Broad industry (two-digit) fixed effects

Empirics: Industry-Level Analysis

- Industries with high foreign currency exposure increase their prices more during the crisis.

$$\Delta p_{i,96-98} = \beta_0 + \beta_1 \text{ ST FC}_{i,96} + \beta_2 \text{LT FC}_{i,96} + \beta_3 X_{i,96} + \epsilon_i$$

	(1)	(2)	(3)	(4)	(5)
ST FC	0.5932***	0.6264***	0.5737***	0.5984***	0.5440***
	(0.1577)	(0.1745)	(0.1651)	(0.2185)	(0.2072)
LT FC		-0.0603	-0.1372	-0.1489	-0.1311
		(0.0966)	(0.1023)	(0.1119)	(0.1095)
Rauch Dummy					0.0046
					(0.0495)
Imported Input Share					0.3521**
					(0.1558)
Degree of Price Stickiness					0.0325
					(0.0224)
Broad Industry FE	No	No	Yes	Yes	Yes
Average Firm-level characteristics	No	No	No	Yes	Yes
Adjusted R^2	0.1364	0.1329	0.4191	0.4153	0.4316
N	155	155	155	155	155

Pre-crisis · Pre-Post trends · Pre-Post trends w/o outliers · Firm Exit · OnlyDomesticFirms

Firm-level Investigation: Model Mechanism

$$\Delta y_{j,96-98} = \beta_0 + \beta_1 \text{ ST FC}_{j,96} + \beta_2 \text{LT FC}_{j,96} + \beta_3 \text{Size}_{j,96} + \beta_4 \text{ ST FC}_{j,96} \cdot \text{Size}_{j,96} + \beta_5 \text{ LT FC}_{j,96} \cdot \text{Size}_{j,96} + \beta_6 \text{X}_{j,96} + \epsilon_i$$

- Δy_j: the growth rates of firm j's y variables in 1996-98.
- y includes (1) sales, (2) net worth and (3) **estimated mark-ups**.
- ST FC_j: short-term foreign currency debt to total short-term debt of firm j
- LT FC_j: long-term foreign currency debt to total long-term debt of firm j
- Size_j: log of real assets of firm j
- X includes: leverage ratio, domestic short-term debt ratio, export/sales ratio, FC cash ratio(+ their interactions with firm size), and industry FE.

mark-up estimation

Empirics: Firm-Level Analysis

- Firms with higher foreign currency debt exposure have lower mark-up growth during the crisis.

$$\Delta y_{j,96-98} = \beta_0 + \beta_1 \text{ ST FC}_{j,96} + \beta_2 \text{LT FC}_{j,96} + \beta_3 \text{Size}_{j,96}$$
$$+ \beta_4 \text{ ST FC}_{j,96} \cdot \text{Size}_{j,96} + \beta_5 \text{ LT FC}_{j,96} \cdot \text{Size}_{j,96} + \beta_6 \text{X}_{j,96} + \epsilon_i$$

	Sales Growth	Net Worth Growth	Markup Growth
ST FC	-5.6954***	-6.1853*	-0.4063**
	(1.7782)	(3.4904)	(0.1814)
LT FC	-0.2555	1.1271	0.1199
	(1.2101)	(3.0933)	(0.1188)
Size	-0.1120*	-0.0143	-0.0053
	(0.0601)	(0.2340)	(0.0083)
ST FC x Size	0.2354***	0.2467*	0.0155**
	(0.0707)	(0.1432)	(0.0073)
LT FC x Size	0.0183	-0.0335	-0.0048
	(0.0484)	(0.1265)	(0.0048)
Adjusted R^2	0.1490	0.1284	0.0365
N	2815	2815	2814

$X_{j,96}$: size (measured by log of real assets), export to sales ratio, DC short-term debt ratio, leverage ratio, FC cash to total current assets ratio (their interactions with firm size), and broad industry fixed effects. ▸ Other Dependent Variables

Empirics: Takeaway

During **a large devaluation** in Korea in 1997,

1. Industries with high FC ST debt exposure $\Uparrow$ their prices more
2. Firms with high FC ST debt exposure $\Downarrow$ sales growth, $\Downarrow$ networth growth and $\Downarrow$ markup growth

Model

Model Overview

- An industry equilibrium model with heterogeneous firms.
- The **exogenous** variations across industries in our model:
  (i) the industry-specific **firm-level distribution** of foreign currency debt ratios (λ)
  (ii) the industry-specific imported input share (κ)
- **Kimball aggregator** to examine variable mark-ups / strategic complementarity. Kimball
- Firms face two types of **financial** frictions.
- We assume that the economy is in the stationary equilibrium before **one-time unexpected** real exchange rate depreciation.
- We analyze the **transition dynamics** of industry price for each of 155 industries

Technology: Entrepreneurs-Production

- Produces differentiated goods with domestic inputs n, foreign inputs x and capital k:

$$y = zk^{\alpha}x^{\kappa}n^{1-\alpha-\kappa}$$

- Need to save in liquid assets to pay a certain faction $(\frac{1}{\theta_a})$ of production costs before profits are realized:

$$wn + \xi x \leq \theta_a a$$

- ξ is the real exchange rate, the price of foreign final goods in units of domestic final goods
  - **expect $\xi_t = 1$ for all t**
- Invests in physical capital used in production and as a collateral:

$$k' = (1-\delta)k + i$$

- Investment also subject to convex adjustment costs:

$$\Phi(k, k')$$

Financial mkt: Entrepreneurs-Debt

- Chooses to issue debt $d'/(1+r)$ (in units of domestic final goods) and allocates **exogenously**:
  - $(1-\lambda)\frac{d'}{1+r}$ to debt denominated in domestic final goods
  - $\lambda\frac{d'}{1+r}$ to debt denominated in foreign final goods (in units of domestic goods)

  $\iff \lambda\frac{d'}{1+r}\frac{1}{\xi}$ to debt denominated in foreign final goods (in units of foreign goods)
- In the beginning of next period, need to pay back in units of domestic goods

$$d'(1-\lambda) + \left(d'\lambda\frac{\xi'}{\xi}\right)$$

- Face borrowing constraints:

$$\frac{d'}{1+r} \leq \theta_k k'$$

- The stationary equilibrium **doesn't depend on λ but it depends on κ.**

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

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

$$\frac{1}{1+r}d' \leq \theta_k k' \quad \{\eta_1\}, \quad wn + \xi x \leq \theta_a a \quad \{\eta_2\},$$

where

$$(i)\ y = \left(1 - \epsilon \ln(\frac{p}{P_I})\right)^{\sigma/\epsilon} P_I^{-\nu}$$

$$(ii)\ y = zk^{\alpha}x^{\kappa}n^{1-\alpha-\kappa}, \quad (iii)\ \Phi(k,k') = \frac{\phi}{2}\left(\frac{k'-(1-\delta)k}{k}\right)^2 k$$

Model Mechanism

- Firm j's optimal pricing decision is

$$p_{j,t} = \mu_{j,t} mc_{j,t} \underbrace{(1 + \eta_{2,j,t})}_{\uparrow \text{ tighter working capital constraints}}$$

- Balance sheet deterioration has an effect on price by

(i) Investment adjustment

Balance sheet deterioration $\Rightarrow \downarrow$ Investment$(k_{j,t+1})$ $\Rightarrow \downarrow$ productivity $\Rightarrow \uparrow mc_{j,t+1}$

(ii) Working-capital channel

Balance sheet deterioration $\Rightarrow \downarrow$ Cash$(a_{j,t+1})$ $\Rightarrow \uparrow \eta_{2,j,t+1}$

- **Strategic Complementarity** allows additional channel via the adjustment of $\mu_{j,t+1}$

Policy function analysis

Quantitative Analysis

Calibrated Parameters

Predetermined			
Parameter	**Value**	**Description**	**Data Source**
γ	2.0	Relative risk aversion	Standard
δ	0.1	Depreciation rate of physical capital	Standard
ν	2.0	Elasticity of substitution across sectors	Standard
σ	5.0	Elasticity of substitution within a sector	Gopinath and Itskhoki (2010)
ϵ	4.0	Super elasticity of demand	Gopinath and Itskhoki (2010)
ϕ	0.9569	Physical capital adjustment cost	Gilchrist and Sim (2007)
r	0.08	Interest rate	Bank of Korea
ρ_z	0.9106	AR coefficient of z	Estimated
σ_z	0.0986	STD of z	Estimated
λ_m	$\in [0, 0.975]$	Distribution of FC debt share	KIS data
π_m^I	$\in [0, 1]$	Distribution of FC debt share	KIS data
κ_I	$\in [0, 1]$	Industry-level imported input share	Korea Input-Output table in 1995
Calibrated			
Parameter	**Value**	**Description**	**Targeted Moments**
β	0.9101	Time discount factor	Mean of Debt to Sales Ratio (0.66)
θ_k	0.7114	Fraction of capital as a collateral	Std of Debt to Sales Ratio (0.26)
θ_a	1.3812	Fraction of working capital	Mean of Cash to Sales ratio (0.44)

Transition: MIT Shock

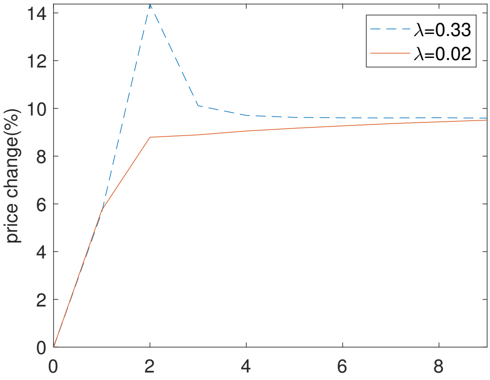
- Each industry with its specific firm-level distribution of λ and the imported input share κ has different stationary equilibrium and different transition dynamics upon **one time unexpected depreciation** of the real exchange rate.
  - period 0 : stationary equilibrium (SS)
  - period 1 : unexpected depreciation of real exchange rate (MIT shock)

    $\Rightarrow k'$ and a' change

    . . .
  - period ∞: new stationary equilibrium (SS)
- We investigate the transition dynamics when ξ goes up from 1 to 2.1 in the first period and stays there afterwards for each of 155 industries

Industry-Level Analysis

- Industry Price Dynamics Upon Unexpected Large Depreciation at Period 1
- Industries with imported input share = 0.13



Model: Industry-Level Analysis

- Marginal Effect of FC Short-term Debt Ratio on Price Changes in Crisis (Data vs. Model)

  ▸ Residual PPI: Model

$$\Delta p_{I,0-2} = \beta_0 + \beta_1 \text{ ST FC}_{I,0} + \beta_2 \text{ Imported Input Share}_I + \epsilon_I$$

	Data	Model
ST FC	0.5440	0.2112
	(0.2072)	
Imported Input Share	0.3521	0.7346
	(0.1558)	
R^2	0.4316	0.9968
N	155	155

- The model can explain more than half of the variation in price changes across industries.

	Data	Model
Std of $\Delta p_{I,0-2}$	0.1830	0.1004

Firm-level Regression: Price Changes

$$\Delta p_j = \beta_0 + \beta_1 \text{ST FC}_j + \beta_2 \text{Imported Input Share}_I + \beta_3 \Delta P_I + \beta_4 1_{\text{Unconstrained},j} + \beta_5 \text{ST FC}_j \times 1_{\text{Unconstrained},j} + \epsilon_j$$

$$\Delta p_j = \beta_0 + \beta_1 \text{ST FC}_j + \beta_2 \text{Imported Input Share}_I + \beta_3 \Delta P_I + \beta_4 \log(k_j) + \beta_5 \text{ST FC}_j \times \log(k_j) + \epsilon_j$$

	Price Changes		
ST FC_j	0.0724	0.0801	0.1483
Imported Input Share_I	0.2300	0.2385	0.2926
ΔP_I	0.6858	0.6784	0.6442
$1_{\text{Unconstrained},j} \times \text{ST FC}_j$		-0.0464	
$log(k_j) \times \text{ST FC}_j$			-0.0053
$log(d_j) \times \text{ST FC}_j$			0.0548

▸ Price: log(a+k)

Firm-level Regression: Markup Changes

$$\Delta\mu_j = \beta_0 + \beta_1 \text{ST FC}_j + \beta_2 \text{Imported Input Share}_I + \beta_3 \Delta P_I + \beta_4 1_{\text{Unconstrained},j} + \beta_5 \text{ST FC}_j \times 1_{\text{Unconstrained},j} + \epsilon_j$$

$$\Delta\mu_j = \beta_0 + \beta_1 \text{ST FC}_j + \beta_2 \text{Imported Input Share}_I + \beta_3 \Delta P_I + \beta_4 \log(k_j) + \beta_5 \text{ST FC}_j \times \log(k_j) + \epsilon_j$$

	Markup Changes		
ST FC_j	-0.0609	-0.0677	-0.1214
Imported Input Share_I	-0.1913	-0.1994	-0.2415
ΔP_I	0.2656	0.2728	0.2993
$1_{\text{Unconstrained},j} \times \text{ST FC}_j$		0.0413	
$log(k_j) \times \text{ST FC}_j$			0.01
$log(d_j) \times \text{ST FC}_j$			-0.05

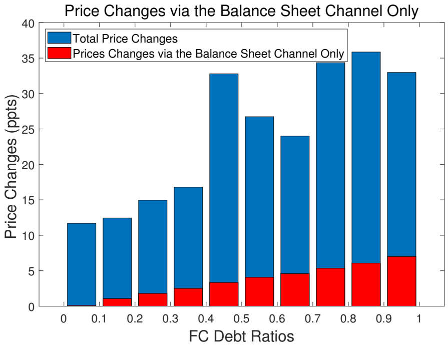
Markup: log(a+k)

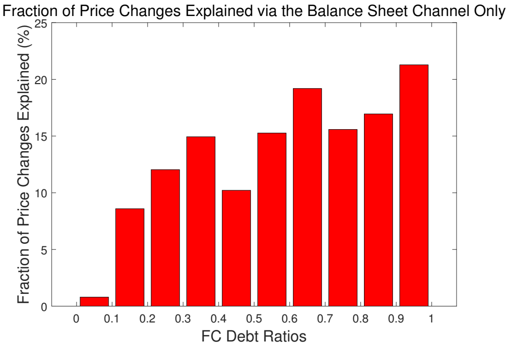
Quantitative Size of the Balance Sheet Channel (Firm-level Direct effect)

$$\Delta p_j = \beta_0 + \beta_1 \text{ST FC}_j + \beta_2 \text{Imported Input Share}_I + \beta_3 \Delta P_I + \epsilon_j$$

$$\Delta \hat{p}_{j,\text{Balance Sheet Channel Only}} = \hat{\beta}_1 \text{ST FC}_j$$

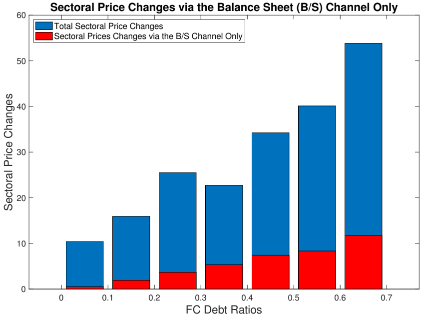
- Across FC debt share deciles, the balance sheet channel explains a substantial share of the simulated **firm-level** price changes.

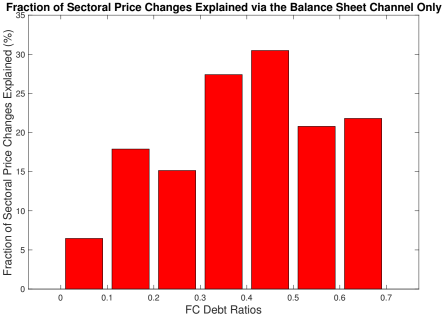




Quantitative Size of the Balance Sheet Channel (Industry-level Direct + Indirect effect)

- Compare the baseline results with counterfactual outcomes where the imported input price stays constant upon a depreciation shocks.
- Across FC debt share deciles, the balance sheet channel explains a substantial share of the simulated **industry-level** price changes.





Conclusion

- We find empirically that **industries with higher foreign currency debt increased their prices more** during the large devaluation period.
- With the model-generated data, we decompose the **two distinct channels of exchange rate pass-through – balance sheet channel and imported input channel** and show that both are significant contributors to the firm-level price dynamics during the crisis.
- Our empirical analysis and our quantitative analysis 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 liability*.

Thank you! :)

Motivation: Cross-Country

- Realized PPI change vs. Imported input implied PPI change

	Crisis Year	Δ Import Price Index	Imported Input Share (%)	Δ MC Due to Import Price Changes Implied PPI Changes via Imported Input*	Δ PPI (%)
Brazil	1999	64.08	6.0	3.84	33.0
Mexico	1994	165.39	13.2	21.87	47.11
Korea	1997	40.37	14.6	6.05	16.46
Thailand	1997	20.09	22.0	4.43	17.89
Argentina	2002	169.87	6.1	10.39	122.22

The country sample is identical to Burstein, Eichenbaum and Rebelo (2005).

The imported input share is $\frac{\text{imported intermediate input}}{\text{total input}}$

We assume a complete exchange rate pass-through.

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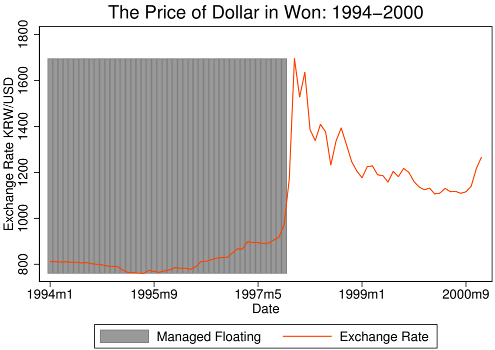
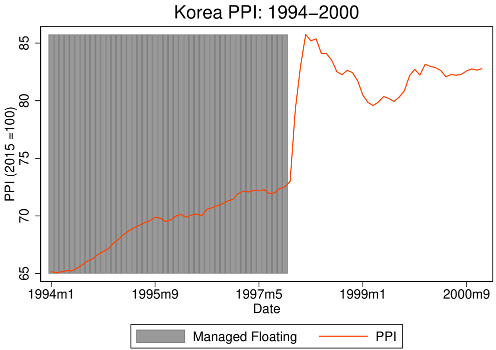
Depreciation of Korean Won After Floating





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Summary Statistics

	1993	1994	1995	1996	1997	1998
Number of firms	1862	2204	2718	3111	3620	3994
Fraction of firms with FC debt (%)	59.7	57.5	52.8	51.9	50.6	44.0
Fraction of firms with FC short-term debt (%)	52.0	47.7	42.7	41.9	39.8	35.4
Mean FC share of short-term debt (%)	8.4	7.0	6.3	6.7	7.6	7.0
Mean FC share of long-term debt (%)	19.8	20.2	18.1	19.0	22.2	18.8
Mean FC share of short-term debt (%) given positive holding	16.2	14.6	14.7	16.0	19.0	19.8
Mean FC share of long-term debt (%) given positive holding	35.4	37.9	36.8	40.4	48.6	47.0

Note: Short-term debt is the amount of debt due within one year.

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Industry Price Dynamics and Short-term FC Debt Ratio (Pre-crisis Period)

$$\Delta p_{i,93-95} = \beta_0 + \beta_1 \text{ ST FC}_{i,93} + \beta_2 \text{LT FC}_{i,93} + \beta_3 \text{X}_{i,93} + \epsilon_i$$

	(1)	(2)	(3)	(4)	(5)
ST FC	0.1029	0.0850	-0.1599	-0.2413	-0.2274
	(0.0859)	(0.0744)	(0.1330)	(0.2341)	(0.2240)
LT FC		0.0280	0.0546	0.0274	0.0436
		(0.0780)	(0.0852)	(0.0836)	(0.0834)
Rauch Dummy					-0.0021
					(0.0552)
Imported Input Share					0.1936
					(0.1267)
Degree of Price Stickiness					-0.0256***
					(0.0045)
Broad Industry FE	No	No	Yes	Yes	Yes
Average Firm-level characteristics	No	No	No	Yes	Yes
Adjusted R^2	0.0023	-0.0037	0.2597	0.2876	0.2894
N	151	151	151	151	151

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Pre- and Post-Crisis Price Dynamics and Short-term FC Debt Ratio in 1996

$$\Delta p_{I,t} = \beta_{0,t} + \beta_{1,t}\text{ST FC}_{I,1996} + \epsilon_I, \quad t = 1993, ..., 1998, ..., 2000$$

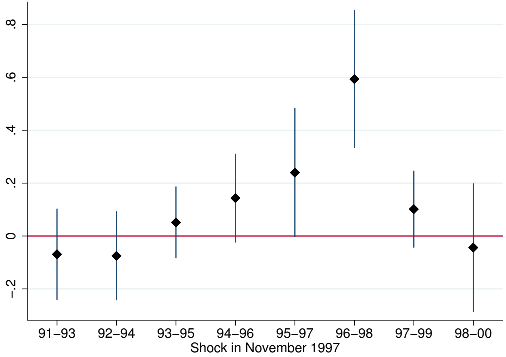

Figure 1: Treatment vs. Control Groups: Pre- and Post-crisis

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Pre- and Post-Crisis Price Dynamics and Short-term FC Debt Ratio in 1996

$$\Delta p_{I,t} = \beta_{0,t} + \beta_{1,t}\text{ST FC}_{I,1996} + \epsilon_I, \quad t = 1993, ..., 1998, ..., 2000$$

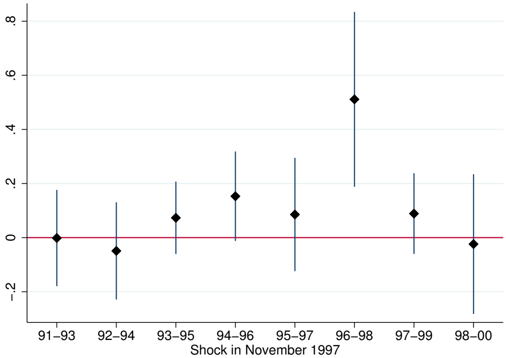

Figure 2: Treatment vs. Control Groups: Pre- and Post-crisis

Controlling the Effect of Firm Exits

	(1)	(2)	(3)
ST FC	0.5440***	0.5952***	0.5443***
	(0.2072)	(0.2183)	(0.2065)
LT FC	-0.1311	-0.1544	-0.1310
	(0.1095)	(0.1106)	(0.1085)
Log Change of # of Firms		1.2896***	1.2394**
		(0.4828)	(0.5049)
Rauch Dummy	0.0046		-0.0074
	(0.0495)		(0.0496)
Imported Input Share	0.3521**		0.3335**
	(0.1558)		(0.1573)
Degree of Price Stickiness	0.0325		0.0331
	(0.0224)		(0.0219)
Broad Industry FE	Yes	Yes	Yes
Average Firm-level characteristics	Yes	Yes	Yes
Adjusted R^2	0.4316	0.4195	0.4349
N	155	155	155

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W/O exporting firms

	(1)	(2)	(3)
ST FC	0.406***	0.389**	0.387**
	(0.140)	(0.193)	(0.186)
LT FC	-0.138*	-0.141*	-0.126
	(0.075)	(0.083)	(0.081)
Rauch Dummy			0.011
			(0.049)
Imported Input Share			0.306*
			(0.180)
Degree of Price Stickiness			0.033
			(0.021)
Broad Industry FE	Yes	Yes	Yes
Average Firm-level characteristics	No	Yes	Yes
N	153	153	153

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Mark-up Measure: De Locker and Warzynski (2011)

- Assume that producer j is a cost minimizer:

$$\min \quad C_{jt} = \sum_{v=1}^{n} \underbrace{p_{jt}^{v} x_{jt}^{v}}_{\text{variable input costs}} + \underbrace{r_{jt} k_{jt}}_{\text{cost of capital}} + \lambda_{jt}(Q_{jt} - \underbrace{F(x_{jt}^{1}, \ldots, x_{jt}^{n}, k_{jt})}_{\text{production function}})$$

- FOC w.r.t a variable input x_{jt}^{v} :

$$\underbrace{\frac{\partial F(.)}{\partial x_{jt}^{i}} \frac{x_{jt}^{v}}{Q_{jt}}}_{\text{output elasticity:}\theta_{jt}^{v}} = \frac{1}{\lambda_{jt}} \frac{p_{jt}^{v} x_{jt}^{v}}{q_{jt}} \quad \text{where} \quad \lambda_{jt} = \frac{\partial C_{jt}}{\partial Q_{jt}}$$

- Hence, mark-up is:

$$\mu_{jt} = \frac{P_{jt}}{\lambda_{jt}} = \theta_{jt}^{v} \times \frac{P_{jt} Q_{jt}}{p_{jt}^{v} x_{jt}^{v}}$$

- Change in mark-up, assuming the output elasticity is constant over time:

$$\Delta log \mu_{jt} = \Delta log \frac{P_{jt} Q_{jt}}{p_{jt}^{v} x_{jt}^{v}}$$

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Empirics: Firm-Level Analysis

- Firms with high foreign currency debt exposure have lower investment growth, lower labor productivity growth and lower employment growth during the crisis.

	(1) Sales Growth	(2) Net Worth Growth	(3) Markup Growth	(4) Capital Growth	(5) MPL Growth	(6) Personnel Expenses Growth
ST FC	-5.6954***	-6.1853*	-0.4063**	-10.9207***	-3.1780*	-5.6181***
	(1.7782)	(3.4904)	(0.1814)	(3.6175)	(1.8791)	(1.5485)
LT FC	-0.2555	1.1271	0.1199	-0.2933	-0.6067	-0.7082
	(1.2101)	(3.0933)	(0.1188)	(1.9657)	(1.0123)	(1.0964)
Size	-0.1120*	-0.0143	-0.0053	-0.1578	-0.0950	-0.1472***
	(0.0601)	(0.2340)	(0.0083)	(0.1453)	(0.0779)	(0.0543)
ST FC x Size	0.2354***	0.2467*	0.0155**	0.4334***	0.1344*	0.2262***
	(0.0707)	(0.1432)	(0.0073)	(0.1457)	(0.0746)	(0.0625)
LT FC x Size	0.0183	-0.0335	-0.0048	0.0130	0.0300	0.0310
	(0.0484)	(0.1265)	(0.0048)	(0.0792)	(0.0406)	(0.0438)
Adjusted R^2	0.1490	0.1284	0.0365	0.0215	0.0692	0.1231
N	2815	2815	2814	2406	2709	1977

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Preferences: Kimball-CES Structure

- Each industry I faces an exogenous CES demand, where the demand for industry I's composite goods is given by:

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

- Each industry I is populated by a continuum of entrepreneurs indexed by $j(I)$.
- **Intermediate goods,** y_j, are produced by entrepreneurs j, aggregated into industry I's composite goods by the Kimball (1995) aggregation.
- Following Gopinath and Itskhoki (2010), we assume functional forms and the demand for an intermediate good produced by an entrepreneur j is:

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

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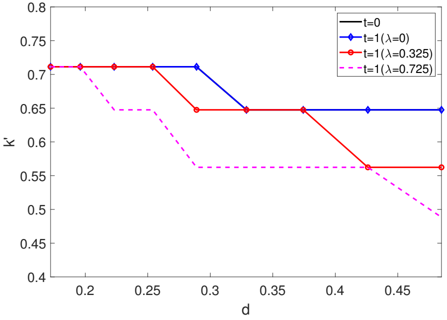
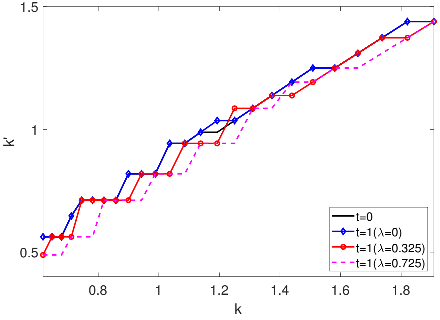
Policy Function of k': (i) Investment adjustment

- With high enough debt d, the borrowing constraint starts binding, lowering investment k'
- With lower k, next-period capital $k' \downarrow$
- With higher FC debt λ, investment $k' \downarrow$





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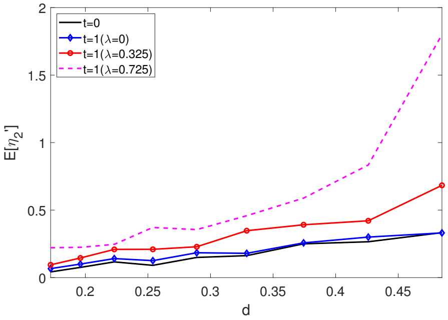
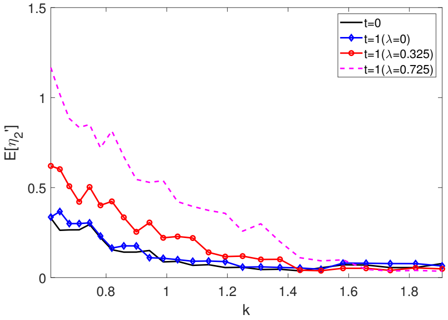
Policy Function of η_2: (ii) Working-capital channel

$$\beta r E_{z'|z}[(c')^{-\gamma}] + \underbrace{\eta_1}_{\text{more binding collateral constraints} \uparrow} = \beta \theta_a E_{z'|z}[\eta_2']$$

- The working capital constraints are more binding $\eta_2 \uparrow$ with lower k, higher d and higher λ





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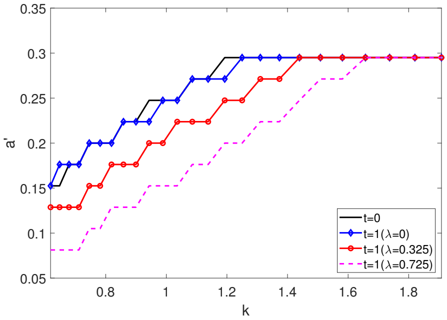
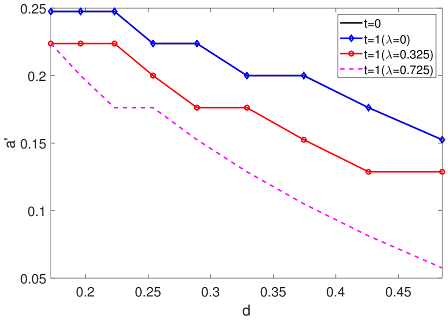
Policy Function of a': (ii) Working-capital channel





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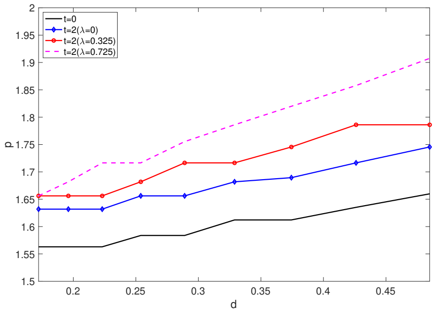
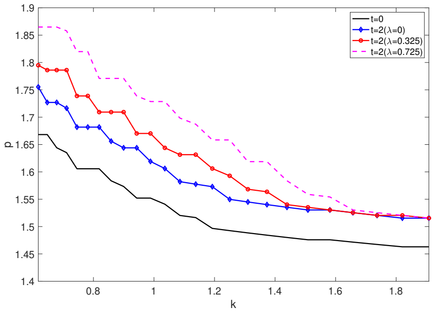
Policy Function of p''

- Firms charge higher $p \uparrow$ with lower k, higher d and higher λ.
- Strategic complementarity pushing up the policy function even with zero FC debt λ.





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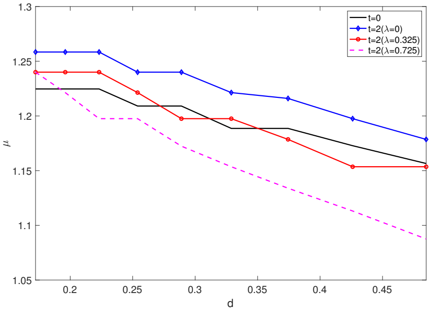
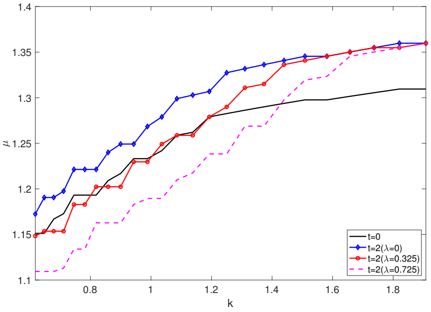
Policy Function of μ''

- Firms lower their markups $\mu \downarrow$ with lower k, higher d and higher λ upon $\uparrow$ effective MC
  - Relatively better off firms with higher k and lower d increase their markups $\mu \uparrow$.

- Strategic complementarity pushing up the policy function even with zero FC debt λ.





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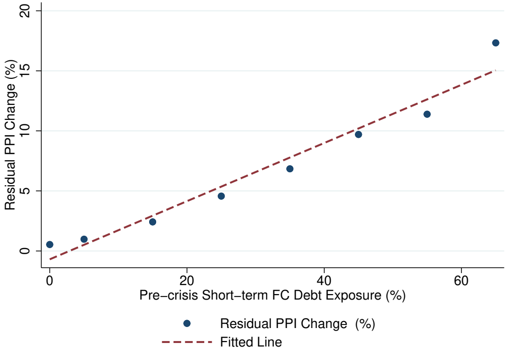
Model: Industry-Level Analysis



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Firm-level Regression: Price Changes

$$\Delta p_j = \beta_0 + \beta_1 \text{ST FC}_j + \beta_2 \text{Imported Input Share}_I + \beta_3 \Delta P_I + \beta_4 \log(k_j + a_j) + \beta_5 \text{ST FC}_j \times \log(k_j + a_j) + \epsilon_j$$

	Price Changes
ST FC_j	0.1521
Imported Input Share_j	0.2769
ΔP_I	0.6557
$log(k_j + a_j) \times$ ST FC_j	-0.0041

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Firm-level Regression: Markup Changes

$$\Delta\mu_j = \beta_0 + \beta_1 \text{ST FC}_j + \beta_2 \text{Imported Input Share}_l + \beta_3 \Delta P_I + \beta_4 \log(k_j + a_j) + \beta_5 \text{ST FC}_j \times \log(k_j + a_j) + \epsilon_j$$

	Markup Changes
ST FC_j	-0.1260
Imported Input Share_j	-0.2269
ΔP_I	0.2885
$log(k_j + a_j) \times \text{ST FC}_j$	0.005

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