# Liability Dollarization and Exchange Rate Pass-Through

Junhyong Kim (Korea Development Institute) Annie Soyean Lee (Johns Hopkins University) • The dollar hit a two decade high in Sep 2022, appreciated by 16% since the beginning of 2022.

- 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 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.

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. PPI changes implied via the imported input channel

Imported Input Share  $\times \Delta$ 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



• 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)

 $\Rightarrow\,$  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)
- $\Rightarrow\,$  Balance sheet effects of foreign currency debt on prices

#### **Literature Review**

#### **Exchange Rate Pass-Through to Prices**

Exchange rate pass-through to domestic prices

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

 $\Rightarrow\,$  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)
- $\Rightarrow\,$  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)

 $\Rightarrow$  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

## 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

(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) 39% 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) Preliminary: We decompose the price changes via the imported input channel and those via the balance sheet effect.

## **Empirical Analysis**

Firm-level balance sheet data: KISVALUE Dataset

- currency composition & maturity of their debt: foreign currency vs. domestic currency, short-term vs. long-term
- 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

Firm-level balance sheet data: KISVALUE Dataset

- currency composition & maturity of their debt: foreign currency vs. domestic currency, short-term vs. long-term
- 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).

Firm-level balance sheet data: KISVALUE Dataset

- currency composition & maturity of their debt: foreign currency vs. domestic currency, short-term vs. long-term
- 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 S

	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 (%)		47.7	42.7	41.9	39.8	35.4
Mean FC share of short-term debt (%)		7.0	6.3	6.7	7.6	7.0
Mean FC share of long-term debt (%)		20.2	18.1	19.0	22.2	18.8
Mean FC share of short-term debt (%) given positive holding		14.6	14.7	16.0	19.0	19.8
Mean FC share of long-term debt (%) given positive holding		37.9	36.8	40.4	48.6	47.0

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

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

•  $\Delta p_{i,96-98}$ : the growth rates of PPI for industry *i* in 1996-98.

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

- $\Delta p_{i,96-98}$ : the growth rates of PPI for industry *i* in 1996-98.
- ST FC<sub>i</sub>: weighted average of firms' short-term FC debt to total short-term debt ratio in industry i.
- LT FC<sub>i</sub>: weighted average of firms' long-term FC debt to total long-term debt ratio in industry i.

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

- $\Delta p_{i,96-98}$ : the growth rates of PPI for industry *i* in 1996-98.
- ST FC<sub>i</sub>: weighted average of firms' short-term FC debt to total short-term debt ratio in industry i.
- LT FC<sub>i</sub>: weighted average of firms' long-term FC debt to total long-term debt ratio in industry i.
- X<sub>i</sub> 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.

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

Pre-crisis
 Pre-Post trends
 Firm Exit
 OnlyDomesticFirms

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

- $\Delta y_j$ : the growth rates of firm *j*'s y variables in 1996-98.
- y includes (1) sales, (2) net worth and (3) estimated mark-ups.

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

- $\Delta y_j$ : 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<sub>j</sub>: 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<sub>j</sub>: log of real assets of firm j

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

- $\Delta y_j$ : 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<sub>j</sub>: 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<sub>j</sub>: log of real assets of firm j
- X includes: leverage ratio, domestic short-term debt ratio, export/sales ratio, FC cash ratio, and industry FE.

### **Empirics: Firm-Level Analysis**

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

 $\Delta y_{j,96-98} = \beta_0 + \beta_1 \text{ ST FC}_{j,96} + \beta_2 \text{LT FC}_{j,96} + \beta_3 \text{Size}_{j,96}$ 

 $+ \frac{\beta_4}{\beta_4} \text{ ST FC}_{j,96} \cdot \text{Size}_{j,96} + \beta_5 \text{ LT FC}_{j,96} \cdot \text{Size}_{j,96} + \beta_6 \text{X}_{j,96} + \epsilon_i$ 

	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 × Size	0.2354***	0.2467*	0.0155**
	(0.0707)	(0.1432)	(0.0073)
LT FC $\times$ Size	0.0183	-0.0335	-0.0048
	(0.0484)	(0.1265)	(0.0048)
Adjusted $R^2$	0.1490	0.1284	0.0365
Ν	2815	2815	2814

 $X_{j,96}$ : size (measured by log of real sales), 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

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

• An industry equilibrium model with heterogeneous firms.

- 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 ( $\lambda$ )
  - (ii) the industry-specific imported input share ( $\kappa$ )

- 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 ( $\lambda$ )
  - (ii) the industry-specific imported input share ( $\kappa$ )
- Kimball aggregator to examine variable mark-ups / strategic complementarity.

- 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  $(\lambda)$
  - (ii) the industry-specific imported input share ( $\kappa$ )
- Kimball aggregator to examine variable mark-ups / strategic complementarity.
- Firms face two types of financial frictions.

- 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 ( $\lambda$ )
  - (ii) the industry-specific imported input share ( $\kappa$ )
- Kimball aggregator to examine variable mark-ups / strategic complementarity.
- 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

## **Preferences: Kimball-CES Structure**

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

$$Y_l = \frac{P_l}{\bar{P}}^{-\nu} \bar{Y}$$

### **Preferences: Kimball-CES Structure**

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

$$Y_l = \frac{P_l}{\bar{P}}^{-\nu} \bar{Y}$$

• Each industry I is populated by a continuum of entrepreneurs indexed by j(I).

### **Preferences: Kimball-CES Structure**

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

$$Y_l = \frac{P_l}{\bar{P}}^{-\nu} \bar{Y}$$

- Each industry I is populated by a continuum of entrepreneurs indexed by j(I).
- Intermediate goods, *y<sub>j</sub>*, are produced by entrepreneurs *j*, aggregated into industry *l*'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:

$$y_j = \left(1 - \epsilon \ln\left(\frac{p_j}{P_l}\right)\right)^{\sigma/\epsilon} Y_l, \quad p_j = \exp\left(\frac{1}{\epsilon} \left(1 - \left(\frac{y_j}{Y_l}\right)^{\epsilon/\sigma}\right)\right) P_l$$
### **Technology: Entrepreneurs-Production**

- In the beginning of each period, entrepreneur j learns this period's productivity  $z_{jt}$
- $z_{jt}$  is an idiosyncratic productivity that follows AR(1) process:

$$ln(z') = (1 - 
ho_z)\mu_z + 
ho_z \ln(z) + \omega_z$$
, where  $\omega \sim N(0, \sigma_\epsilon)$ 

- In the beginning of each period, entrepreneur j learns this period's productivity  $z_{jt}$
- $z_{jt}$  is an idiosyncratic productivity that follows AR(1) process:

$$ln(z') = (1 - 
ho_z)\mu_z + 
ho_z \ln(z) + \omega_z$$
, where  $\omega \sim N(0, \sigma_\epsilon)$ 

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

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

- In the beginning of each period, entrepreneur j learns this period's productivity  $z_{jt}$
- $z_{jt}$  is an idiosyncratic productivity that follows AR(1) process:

$$ln(z') = (1 - 
ho_z)\mu_z + 
ho_z \ln(z) + \omega_z$$
, where  $\omega \sim N(0, \sigma_\epsilon)$ 

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

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

ξ is the real exchange rate, the price of foreign final goods in units of domestic final goods
expect ξ<sub>t</sub> = 1 for all t

• Invests in physical capital used in production and as a collateral:

$$k_{t+1} = (1-\delta)k_t + i_t$$

• Investment also subject to convex adjustment costs:

 $\Phi(k_t,k_{t+1})$ 

• Invests in physical capital used in production and as a collateral:

$$k_{t+1} = (1-\delta)k_t + i_t$$

• Investment also subject to convex adjustment costs:

$$\Phi(k_t, k_{t+1})$$

• Saves in liquid assets to pay a certain faction  $\left(\frac{1}{\theta_{a}}\right)$  of production costs before profits are realized:

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

where a is non-interest-bearing asset chosen from previous period.

• Chooses to issue debt d' (in units of domestic final goods) and allocates exogenously:

• Chooses to issue debt d' (in units of domestic final goods) and allocates exogenously:

–  $(1-\lambda)d'$  to debt denominated in domestic final goods

- Chooses to issue debt d' (in units of domestic final goods) and allocates exogenously:
  - $(1-\lambda)d'$  to debt denominated in domestic final goods
  - $-\lambda d'$  to debt denominated in foreign final goods (in units of domestic goods)

 $\iff \lambda d' \frac{1}{\xi}$  to debt denominated in foreign final goods (in units of foreign goods)

- Chooses to issue debt d' (in units of domestic final goods) and allocates exogenously:
  - $(1-\lambda)d'$  to debt denominated in domestic final goods

 $-\lambda d'$  to debt denominated in foreign final goods (in units of domestic goods)

 $\iff \lambda d' \frac{1}{\varepsilon}$  to debt denominated in foreign final goods (in units of foreign goods)

 Note that the UIP holds so the prices of debt denominated in domestic and foreign final goods are the same as they expect the exchange rate to stay constant: price is <sup>1</sup>/<sub>1+r</sub>

$$1+r_D=(1+r_F)\mathbb{E}\frac{\xi'}{\xi}=(1+r_F)\equiv(1+r)$$

# Financial mkt: Entrepreneurs-Debt

• So, given the amount of debt  $\frac{d'}{1+r}$ , they owe

$$\displaystyle rac{d'}{1+r}(1-\lambda)$$
 units of domestic final goods  $\displaystyle rac{d'}{1+r}\lambdarac{1}{\xi}$  units of foreign final goods

#### Financial mkt: Entrepreneurs-Debt

• So, given the amount of debt  $\frac{d'}{1+r}$ , they owe

$$\displaystyle rac{d'}{1+r}(1-\lambda)$$
 units of domestic final goods  $\displaystyle rac{d'}{1+r}\lambdarac{1}{\xi}$  units of foreign final goods

• In the beginning of next period, need to pay back in units of domestic goods

$$d'(1-\lambda) + ig( d'\lambda rac{\xi'}{\xi} ig)$$

#### Financial mkt: Entrepreneurs-Debt

• So, given the amount of debt  $\frac{d'}{1+r}$ , they owe

$$\frac{d'}{1+r}(1-\lambda) \text{ units of domestic final goods}$$
$$\frac{d'}{1+r}\lambda\frac{1}{\xi} \text{ units of foreign final goods}$$

• In the beginning of next period, need to pay back in units of domestic goods

$$d'(1-\lambda) + ig( d'\lambda rac{\xi'}{\xi} ig)$$

• Face financial constraints:

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

## Model: Recursive Firm Problem

• The stationary equilibrium doesn't depend on  $\lambda$  but it depends on  $\kappa$ .

$$v(k, d, a, z; \lambda, \kappa, \xi) = \max_{c \ge 0, d', k', a', n, p} \frac{c^{1-\gamma}}{1-\gamma} + \beta E_{z'}[v(k', d', a', z'; \lambda, \kappa, \xi')]$$
  
s.t.  $c + k' - (1-\delta)k + \Phi(k, k') + a' + d((1-\lambda) + \lambda \underbrace{\xi}_{\xi-1}_{=1}) = \underbrace{py - wn - \xi x}_{\pi(k, z)} + a + \frac{d'}{1+r}$   
 $\frac{1}{1+r}d' \le \theta_k k' \quad \{\eta_1\}, \quad wn + \xi x \le \theta_a a \quad \{\eta_2\},$ 

where

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

- 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  $\infty$ : new stationary equilibrium (SS)

• We investigate the transition dynamics when  $\xi$  goes up from 1 to 2.1 in the first period and stays there afterwards for each of 155 industries

Model Mechanism

• Firm *j*'s optimal pricing decision is

$$p_{j,t} = \mu_{j,t} m c_{j,t}$$
 $\uparrow$  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  $\Rightarrow \uparrow m_{c_{j,t+1}}$ 

• 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  $\Rightarrow \uparrow m_{c_{j,t+1}}$ 

#### (ii) Working-capital channel

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

• Firm *j*'s optimal pricing decision is

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

• Balance sheet deterioration has an effect on price by

## (i) Investment adjustment

$$\mathsf{Balance \ sheet \ deterioration} \quad \Rightarrow \quad \downarrow \ \mathsf{Investment}(k_{j,t+1}) \quad \Rightarrow \quad \downarrow \ \mathsf{productivity} \quad \Rightarrow \quad \uparrow \ \textit{mc}_{j,t+1}$$

#### (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 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  $\lambda$ , investment  $k' \downarrow$



## Policy Function of $\eta_2$ : (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  $\lambda$ 



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



- Firms lower their markups  $\mu \downarrow$  with lower k, higher d and higher  $\lambda$  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  $\lambda$ .



**Quantitative Analysis** 

Predetermined							
Parameter	Value	Description	Data Source				
$\gamma$	2.0	Relative risk aversion	Standard				
δ	0.1	Depreciation rate of physical capital	Standard				
u	2.0	Elasticity of substitution across sectors	Standard				
$\sigma$	5.0	Elasticity of substitution within a sector	Gopinath and Itskhoki (2010)				
$\epsilon$	4.0	Super elasticity of demand	Gopinath and Itskhoki (2010)				
$\phi$	0.9569	Physical capital adjustment cost	Gilchrist and Sim (2007)				
r	0.08	Interest rate	Bank of Korea				
$\rho_z$	0.9106	AR coefficient of z	Estimated				
$\sigma_z$	0.0986	STD of z	Estimated				
$\lambda_m$	∈ [0,0.975]	Distribution of FC debt share	KIS data				
$\pi'_m$	∈ [0, 1]	Distribution of FC debt share	KIS data				
$\kappa_l$	∈ [0, 1]	Industry-level imported input share	Korea Input-Output table in 1995				
Calibrated							
Parameter	Value	Description	Targeted Moments				
$\beta$	0.9101	Time discount factor	Mean of Debt to Sales Ratio (0.66)				
$\theta_k$	0.7114	Fraction of capital as a collateral	Std of Debt to Sales Ratio (0.26)				
$\theta_{a}$	1.3812	Fraction of working capital	Mean of Cash to Sales ratio (0.44)				

# Industry-Level Analysis

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



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

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

 $\Delta p_{I,0-2} = \beta_0 + \beta_1$  ST FC<sub>I,0</sub> +  $\beta_2$  Imported Input Share<sub>I</sub> +  $\epsilon_I$ 

• 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

 $\Delta p_{j} = \beta_{0} + \beta_{1} \text{ST FC}_{j} + \beta_{2} \text{Imported Input Share}_{I} + \beta_{3} \Delta P_{I} + \beta_{4} \mathbf{1}_{\text{Unconstrained},j} + \beta_{5} \text{ST FC}_{j} \times \mathbf{1}_{\text{Unconstrained},j} + \epsilon_{j}$  $\Delta p_{j} = \beta_{0} + \beta_{1} \text{ST FC}_{j} + \beta_{2} \text{Imported Input Share}_{I} + \beta_{3} \Delta P_{I} + \beta_{4} \log(k_{j}) + \beta_{5} \text{ST FC}_{j} \times \log(k_{j}) + \epsilon_{j}$ 

 $\Delta \textit{p}_{j} = \beta_{0} + \beta_{1} \text{ST FC}_{j} + \beta_{2} \text{Imported Input Share}_{i} + \beta_{3} \Delta \textit{P}_{i} + \beta_{4} \textbf{1}_{\text{Unconstrained}, j} + \beta_{5} \text{ST FC}_{j} \times \textbf{1}_{\text{Unconstrained}, j} + \epsilon_{j} \text{ST FC}_{j} + \beta_{2} \text{Imported Input Share}_{i} + \beta_{3} \Delta \textit{P}_{i} + \beta_{4} \textbf{1}_{\text{Unconstrained}, j} + \beta_{5} \text{ST FC}_{j} \times \textbf{1}_{\text{Unconstrained}, j} + \epsilon_{j} \text{ST FC}_{j} + \beta_{4} \text{Imported Input Share}_{i} + \beta_{4} \textbf{1}_{\text{Unconstrained}, j} + \beta_{5} \text{ST FC}_{j} \times \textbf{1}_{\text{Unconstrained}, j} + \epsilon_{j} \text{ST FC}_{j} + \beta_{4} \textbf{1}_{\text{Unconstrained}, j} + \beta_{5} \text{ST FC}_{j} \times \textbf{1}_{\text{Unconstrained}, j} + \epsilon_{j} \text{ST FC}_{j} + \beta_{4} \textbf{1}_{\text{Unconstrained}, j} + \beta_{5} \text{ST FC}_{j} \times \textbf{1}_{\text{Unconstrained}, j} + \epsilon_{j} \text{ST FC}_{j} + \beta_{4} \textbf{1}_{\text{Unconstrained}, j} + \beta_{5} \text{ST FC}_{j} \times \textbf{1}_{\text{Unconstrained}, j} + \epsilon_{j} \text{ST FC}_{j} \times \textbf{1}_{\text{Unconstraine$ 

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

	Price Changes			
ST FC <sub>j</sub>	0.0724	0.0801	0.1483	
Imported Input Share,	0.2300	0.2385	0.2926	
$\Delta P_{I}$	0.6858	0.6784	0.6442	
$1_{Unconstrained,j} imesSTFC_{j}$		-0.0464		
$\mathit{log}(\mathit{k_j})  imes ST \; FC_j$			-0.0053	

Price: log(a+k)

 $\Delta \mu_{j} = \beta_{0} + \beta_{1} \text{ST FC}_{j} + \beta_{2} \text{Imported Input Share}_{I} + \beta_{3} \Delta P_{I} + \beta_{4} \mathbf{1}_{\text{Unconstrained},j} + \beta_{5} \text{ST FC}_{j} \times \mathbf{1}_{\text{Unconstrained},j} + \epsilon_{j}$  $\Delta \mu_{j} = \beta_{0} + \beta_{1} \text{ST FC}_{j} + \beta_{2} \text{Imported Input Share}_{I} + \beta_{3} \Delta P_{I} + \beta_{4} \log(k_{j}) + \beta_{5} \text{ST FC}_{j} \times \log(k_{j}) + \epsilon_{j}$ 

 $\Delta \mu_{j} = \beta_{0} + \beta_{1} \text{ST FC}_{j} + \beta_{2} \text{Imported Input Share}_{l} + \beta_{3} \Delta P_{l} + \beta_{4} \mathbf{1}_{\text{Unconstrained}, j} + \beta_{5} \text{ST FC}_{j} \times \mathbf{1}_{\text{Unconstrained}, j} + \epsilon_{j} + \beta_{j} \sum_{i=1}^{n} \beta_{i} \mathbf{1}_{i} + \beta_{j} \sum_{i=1}^{n} \beta_{i} \sum_{i=1}^{n} \beta_{$ 

 $\Delta \mu_{j} = \beta_{0} + \beta_{1} \mathsf{ST} \mathsf{FC}_{j} + \beta_{2} \mathsf{Imported Input Share}_{I} + \beta_{3} \Delta P_{I} + \beta_{4} \log(k_{j}) + \beta_{5} \mathsf{ST} \mathsf{FC}_{j} \times \log(k_{j}) + \epsilon_{j}$ 

Markup Changes			
ST FC <sub>j</sub>	-0.0609	-0.0677	-0.1214
Imported Input Share,	-0.1913	-0.1994	-0.2415
$\Delta P_l$	0.2656	0.2728	0.2993
$1_{Unconstrained,j}  imes ST \; FC_j$		0.0413	
$\mathit{log}(\mathit{k_j})  imes ST \; FC_j$			0.01

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

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

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





0.6 0.7 0.8 0.9 1

- We find empirically that industries with higher foreign currency debt increased their prices more during the crisis.
- The estimated quantitative model can generate around 39 % of the mean effect of the foreign currency debt ratio on the price changes and 55 % of the variation in price changes across industries.
- With the firm-level model simulated 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! :)

• Realized PPI change vs. Imported input implied PPI change

-	Crisis Year $\Delta$ Import Price Index		Imported Input Share (%)	$\Delta$ MC Due to Import Price Changes	Δ PPI (%)
				Implied PPI Changes via Imported Input*	
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 imported intermediate input

We assume a complete exchange rate pass-through.





Back

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

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

	(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 <sup>2</sup>	0.0023	-0.0037	0.2597	0.2876	0.2894
N	151	151	151	151	151
#### 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

# **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
Ν	155	155	155

► Back

	(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

► Back

• Assume that producer *j* is a cost minimizer:

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

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

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

• Hence, mark-up is:

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

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

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

### **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)	(2)	(3)	(4)	(5)	(6)
	Sales Growth	Net Worth Growth	Markup Growth	Capital Growth	MPL Growth	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 $\times$ 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 $\times$ 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

# Model: Industry-Level Analysis



Back

### Policy Function: (ii) Working-capital channel



▶ back

 $\Delta p_{j} = \beta_{0} + \beta_{1} \text{ST FC}_{j} + \beta_{2} \text{Imported Input Share}_{l} + \beta_{3} \Delta P_{l} + \beta_{4} \log(k_{j}) + \beta_{5} \text{ST FC}_{j} \times \log(k_{j} + a_{j}) + \epsilon_{j}$ 

	Price Changes
ST FC $_j$	0.1521
Imported Input Share <sub>i</sub>	0.2769
$\Delta P_{I}$	0.6557
$log(k_j + a_j)  imes ST \; FC_j$	-0.0041

▶ back

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

	Markup Changes
ST FC <sub>j</sub>	-0.1260
Imported Input Share <sub>j</sub>	-0.2269
$\Delta P_{I}$	0.2885
$log(k_j + a_j)  imes ST \; FC_j$	0.005

back