Investment During the Korean Financial Crisis: The Role of Foreign Denominated Debt.

Simon Gilchrist

Boston University and NBER

Jae Sim

Boston University

Issues:

- Do exchange rate devaluations stimulate investment during financial crises?

- Do financial factors influence investment during financial crises (or more generally)?
- We use unique panel of Korean firm-level data during Korean financial crisis to analyze these questions.

Exchange rates and investment:

- Competiveness channel: increase exports and raise marginal product of capital.
  - Strength depends on amount of exports and imported materials
- Finance channel: Devaluation increases domestic value of foreign-denominated debt.
  - Negative shock to balance sheet.
  - Increases cost of external funds.

This paper:

- Reduced-form regression analysis:
  - Firms differ in degree of foreign debt exposure – devaluation is exogenous to firm's pre-crisis choice of foreign debt.
  - This provides a natural experiment to assess the effect of the devaluation working through the finance channel on investment.
- Structural approach:
  - Specify dynamic model of investment with financial frictions.
  - Estimate model using indirect inference
  - Quantify the effect of finance channel for investment.

Previous literature:

- Dollar-denominated debt and investment (Bleakley and Cowan, Aguiar)
- Financial market imperfections and investment:
  - Reduced-form: e.g. Fazzari, Hubbard and Peterson,
  - Natural Experiments: Blanchard et al., Lamont.
  - Structural: Hennesey and Whited, Cooper and Ejarque
- Both reduced form and structural estimation face same identification problem: how to distinguish balance sheet effects from fundamentals.

Figure 1: Investment, sales and debt during financial crisis.

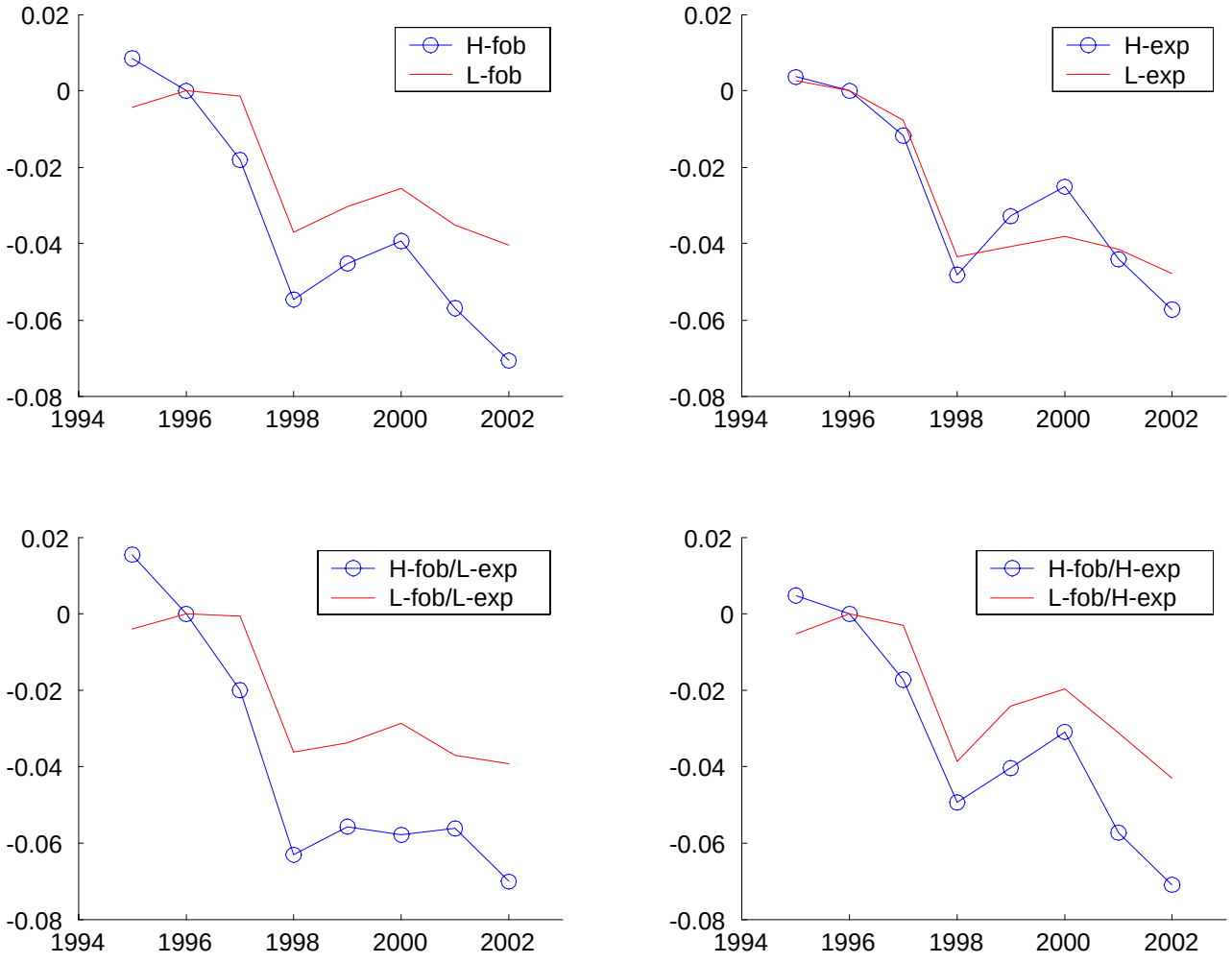

Figure 2: Investment rates.

Investment Model

- Value function:

$$v(k, b_d, b_f, \mathbf{z}) = \max_{k', b'_d, b'_f, d} \{d + E[\Lambda' v(k', b'_d, b'_f, \mathbf{z}')|\mathbf{z}]\}$$

- Dividends:

$$d = \left(\sum_{j=d,f} \pi_j(a, e, z) k^{\alpha_j} - \sigma \right) - i - c(i, k) + b'_d + e b'_f - R_d b_d - e R_f b_f$$

  - Profitability indices $\pi_j(a, e, z)$ depend on e, the real exchange rate, a an aggregate shock and z an iid idiosyncratic shock.
  - σ denotes fixed cost to production.

Financial Market Imperfections:

- No equity issuance:

$$d \geq 0.$$

- Borrowing cost can be decomposed into a risk-free interest rate and an external-finance premium:

$$R_f = (1 + r_f)(1 + \eta)$$

$$R_d = (1 + r_d)(1 + \eta)$$

- Common external-finance premium on domestic and foreign debt combined with uncovered interest parity implies that firm cares about the total debt obligation $b = b_d^{'} + eb_f^{'}$ but is indifferent exante between the currency composition of debt.
- This allows us to simplify model and eliminate one state variable.

Restated value function:

$$v(k, b, \mathbf{z};\omega) = \max_{k',b',d}\{(1+\lambda)\, d + E\left[\Lambda' v(k', b', \mathbf{z}';\omega)|\mathbf{z}\right]\}$$

where

$$\omega \equiv \frac{e_{-1} b_f}{b_d + e b_f}$$

$$d = \left(\sum_{j=d,f} \pi_j(\mathbf{z}) k^{\alpha_j} - \sigma\right) - i - c(i,k) - \Omega\left(e, e_{-1};\omega\right) R_d b + b'$$

and

$$\Omega\left(e, e_{-1};\omega\right) \equiv \left[\omega \frac{e/e_{-1}}{E(e/e_{-1}|\mathbf{z}_{-1})} + (1-\omega)\right]$$

and $\frac{e/e_{-1}}{E(e/e_{-1}|\mathbf{z}_{-1})}$ denotes the surprise to the exchange rate.

Functional form for external finance premium:

- Assume:

$$\eta(x) \equiv \kappa \left[\exp\left(x\right) - 1\right]$$

  where

$$x\left(k, b, \mathbf{z}_{-1}\right) = \frac{b}{\sum_{j=d,f} \pi_j(\mathbf{z}_{-1})k}$$

  and $\sum_j \pi_j(z_{-1})$ measures profitability of installed capital.

- η is strictly convex with curvature $x\eta''(x)/\eta'(x) = x$. Thus the slope of the premium rises more rapidly as leverage increases.

The Efficiency Conditions

- Debt arbitrage condition:

$$1 = E\left[\Lambda'\left(\frac{1+\lambda'}{1+\lambda}\right)\Omega(e', e; \omega)\left(1 + r'_d\right)\left(1 + \eta' + \frac{\partial \eta'}{\partial b'}b'\right)|\mathbf{z}\right]$$

- Investment euler equation:

$$1 + \frac{\partial c}{\partial i}(i, k) = E\left[\Lambda'\left(\frac{1+\lambda'}{1+\lambda}\right)\left(\frac{d}{dk'}d' + (1-\delta)\left(1 + \frac{\partial c}{\partial i'}(i', k')\right)\right)|\mathbf{z}\right]$$

where

$$\frac{d}{dk'}d' = \sum_{j=d,f}\alpha_j \pi_j(\mathbf{z}')k'^{\alpha_j - 1} - \frac{\partial c}{\partial k'}(i', k') - \Omega\left(e', e; \omega\right)\left(1 + r'_d\right)\frac{\partial \eta'}{\partial k'}b'.$$

Table 1: Summary Statistics

	Full Sample		Pre-Crisis	Post-Crisis
	Mean	Std. Dev.	Mean	Mean
$(i/k)_{j,t}$	0.169	0.244	0.230	0.136
$(s/k)_{j,t}$	3.756	3.195	3.939	3.657
$(\pi/k)_{j,t}$	0.764	0.866	0.785	0.753
$(b/a)_{j,t}$	0.371	0.211	0.392	0.363
$\left(s^f/s\right)_{j,t}$	0.284	0.279	0.251	0.307
$\left(b^f/b\right)_{j,t}$	0.140	0.189	0.140	0.140
$corr\left(s^e/s, b^e/b\right)$	0.1669		0.251	0.120

Table 2: Quantiles of Pre-Crisis Firm Means

	0%	25%	50%	75%	100%	mean
$(b/a)_j$	0.000	0.261	0.399	0.504	1.632	0.391
$\left(s^f/s\right)_j$	0.000	0.034	0.158	0.419	0.983	0.255
$\left(b^f/b\right)_j$	0.000	0.024	0.081	0.185	1.000	0.141

Measuring fundamentals and financial variables

- Measure fundamentals using both foreign and domestic sales to capital ratios.

- Measure shock to balance sheet:

$$\hat{\omega}_j = 1/T_j^{pc} \sum \left(b_{j,t}^f / b_{j,t} \right)$$

$$\Omega_{jt} = 1 - \omega_j + \omega_j \left(e_t / e_{t-1} \right)$$

$$AC_{j,t} \equiv \Omega_{j,t} \left(b_{j,t} / a_{j,t} \right)$$

- Ω_{jt} captures contemporaneous effect of exchange rate through balance sheet.

Table 4: Investment Equation

	IV Fixed Effects		First Diff. GMM	
	$(i/k)_{j,t}$	$(i/k)_{j,t}$	$(i/k)_{j,t}$	$(i/k)_{j,t}$
$(s^d/k)_{j,t}$	0.069	0.069	0.054	0.051
	(0.007)	(0.006)	(0.006)	(0.022)
$(s^e/k)_{j,t}$	0.047	0.047	0.035	0.035
	(0.011)	(0.011)	(0.005)	(0.005)
$(\hat{\Omega}b/a)_{j,t}$	-0.208	–	-0.177	–
	(0.037)		(0.041)	
$(b/a)_{j,t}$	–	-0.194	–	-0.160
		(0.038)		(0.049)
$\hat{\omega}_j e_t$	–	-0.503	–	-0.205
		(0.124)		(0.074)
$(i/k)_{j,t-1}$	–	–	0.204	0.201
			(0.018)	(0.022)
Rsq (within)	0.19	0.20	–	–
Sargan	–	–	106.34	105.89
(p-val)	–	–	(0.39)	(0.17)
No. of Obs.	2490	2490	1990	1990
No of Inds.	419	419	412	412

Table 5: Investment: First Differenced GMM by sub-groups

	H-fob/L Exp $(i/k)_{j,t}$	H-fob/H-exp $(i/k)_{j,t}$	L-Fob/L-exp $(i/k)_{j,t}$	L-Fob/H-exp $(i/k)_{j,t}$
$(s^d/k)_{j,t}$	0.060	0.082	0.041	0.058
	(0.004)	(0.004)	(0.002)	(0.002)
$(s^e/k)_{j,t}$	0.028	0.064	0.150	0.041
	(0.001)	(0.002)	(0.014)	(0.003)
$(\hat{\Omega}b/a)_{j,t}$	-0.401	-0.203	-0.197	-0.021
	(0.022)	(0.019)	(0.026)	(0.000)
$(i/k)_{j,t-1}$	0.145	0.148	0.130	0.209
	(0.004)	(0.005)	(0.011)	(0.000)
Sargan	57.13	100.28	88.91	58.97
	(0.99)	(0.56)	(0.84)	(0.99)
m2	-0.63	-0.99	0.51	-0.94
	(0.53)	(0.32)	(0.61)	(0.35)
No of Obs.	349	640	686	315
No of Inds.	70	137	136	69

Profit Function

- Profit function is weighted average of domestic and foreign sales:

$$\pi_{j,t} = \Gamma\left(\chi_d\right) s_{j,t}^{d} + \Gamma\left(\chi_f\right) s_{j,t}^{f}$$

  where $\Gamma\left(\chi_i\right)$ depends on market power and production shares of capital and labor.

- Taking logs:

$$\begin{aligned}
\log s_{j,t}^{d} &= \varsigma_d \log \theta_{d,j} - \xi_d \log e_t + \gamma_d \log k_{j,t} + \varsigma_d \log a_{d,t} + v_{d,j,t} \\
\log s_{j,t}^{f} &= \varsigma_i \log \theta_{i,j} + \left[1 - \xi_f\right] \log e_t + \gamma_f \log k_{j,t} + \varsigma_f \log a_{f,t} + v_{f,j,t}
\end{aligned}$$

- By estimating these equations we identify all relevant coefficients to determine profit opportunities.

Table 6: Profit Function: Export vs Domestic Sales

	$\log e_t$	$\log k_{j,t}$	$\log a_{d,t}$	$\log a_{f,t}$	rho_v	R^2	Obs/Inds
$\log s_{f,t}$	0.360	0.545	–	5.355	0.325	0.41	2544
	(0.086)	(0.038)	–	(1.76)			416
$\log s_{d,t}$	-0.120	0.412	1.479	–	0.223	0.62	2847
	(0.052)	(0.024)	(0.198)	–			441

Structural parameters

- Capital adjustment cost γ
- External finance premium κ where:

$$\eta = \kappa \left[\exp \left(x \right) - 1 \right]$$

- No financial frictions: $\kappa = 0$.

Indirect Inference:

- Data: auxiliary regression estimated with IV fixed effects and time dummies:

$$(i/k)_{j,t} = c_j + \beta^d (s^d/k)_{j,t} + \beta^e (s^e/k)_{j,t} + \beta^f (\hat{\Omega} b/a)_{j,t} + \delta_t + \varepsilon_{j,t}$$

- Model: estimate auxiliary regression using simulated data.
- Match: auxiliary regression parameters from real and simulated data.

Firm-level heterogeneity:

- Allow heterogeneity in export status, foreign-denominated debt ratio and initial leverage.
- Specify types based on empirical distribution of firm-specific characteristics.
- Solve and simulate value function for each "type".

Macroeconomic environment:

- Real exchange rate follows an AR(1) process.
- Domestic interest rate determined by AR(1) shock to country risk premium combined with UIP.
- Aggregate demand shock to domestic sales.

Auxiliary Regression Parameters

	$(s^d/k)_{jt}$	$(s^e/k)_{jt}$	$(\hat{\Omega}b/a)_{jt}$
Data Moments	0.0692	0.0465	−0.2075
Simulated Moments			
Case 1. $\rho_e = 0.85$	0.0689	0.0464	−0.2060
Case 2. $\rho_e = 0.90$	0.0687	0.0468	−0.2006
Case 3. $\rho_e = 0.95$	0.0683	0.0405	−0.1931

Structural Parameter Estimates

	$\hat{\psi}$	$\hat{\kappa}$	$\hat{J}$
Case 1. $\rho_e = 0.85$	**0.9530**	**0.1443**	**0.0042**
	(0.0079)	(0.0042)	(0.9483)
Case 2. $\rho_e = 0.90$	**0.9569**	**0.1355**	**0.0442**
	(0.0762)	(0.0220)	(0.8335)
Case 3. $\rho_e = 0.95$	**1.0670**	**0.1429**	**0.6544**
	(0.0055)	(0.0017)	(0.4185)

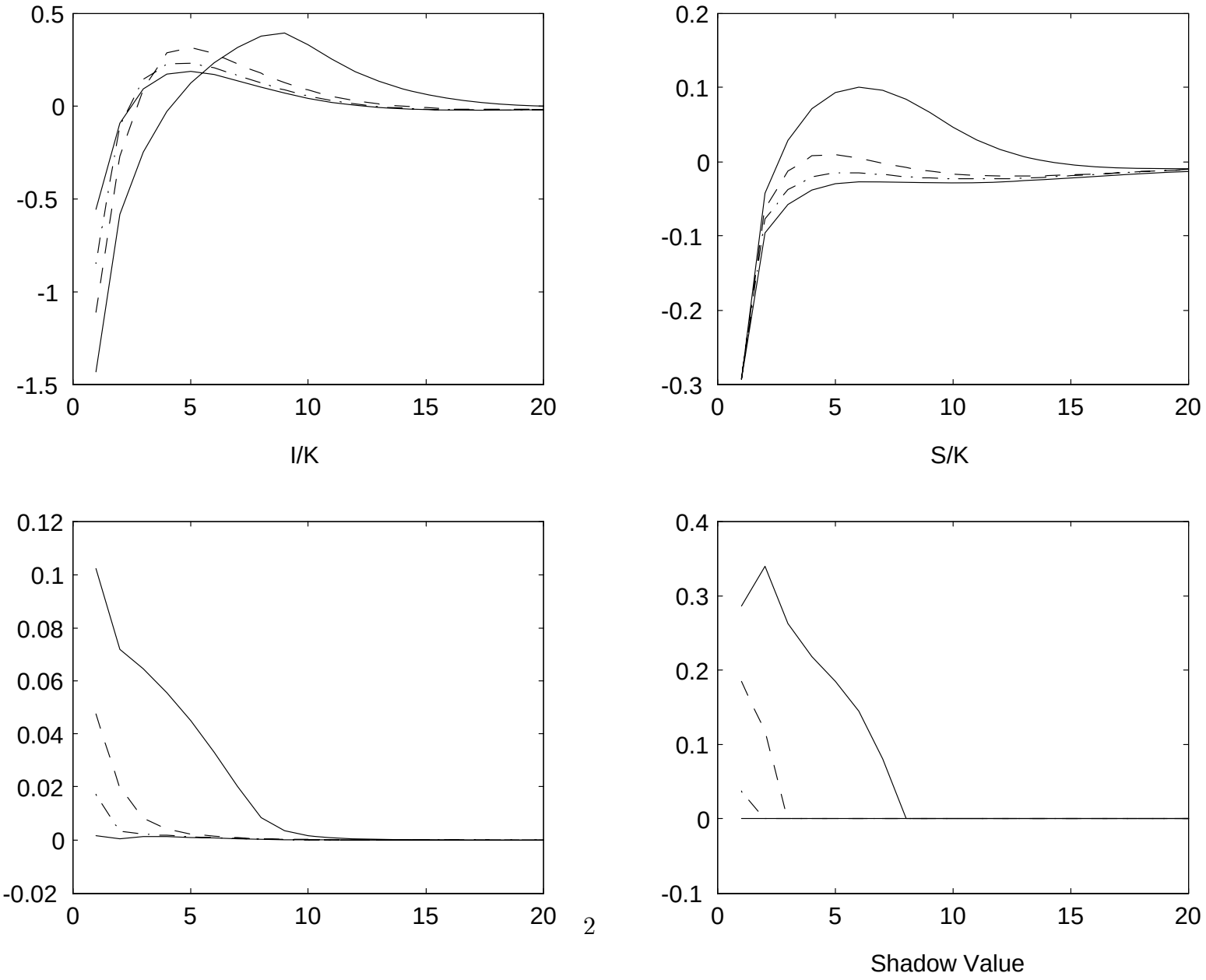

Figure 1: Low Export, High Foreign Debt ($\rho_e = 0.85, r$)

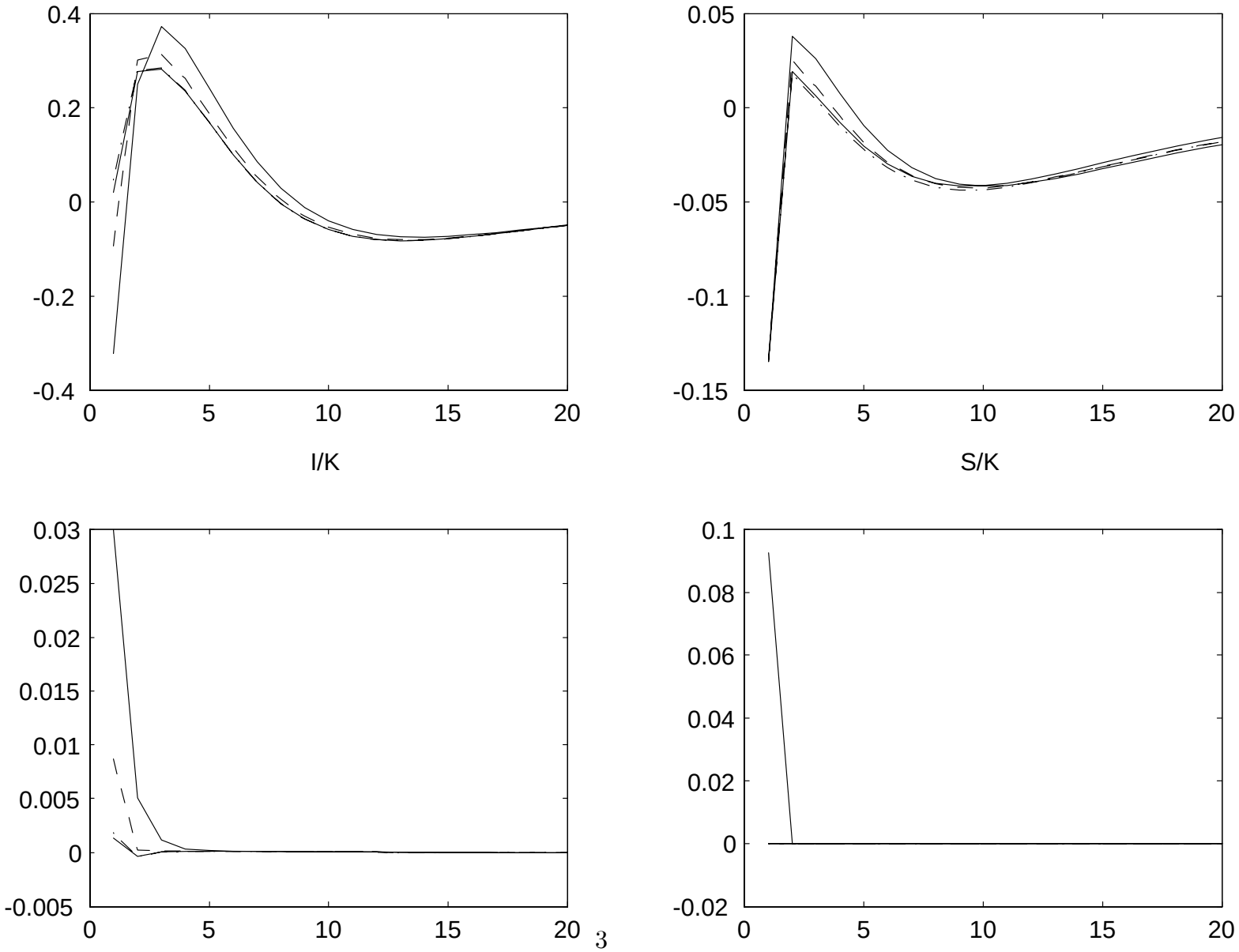

Figure 2: High Export, Low Foreign Debt ($\rho_e = 0.85, r$)

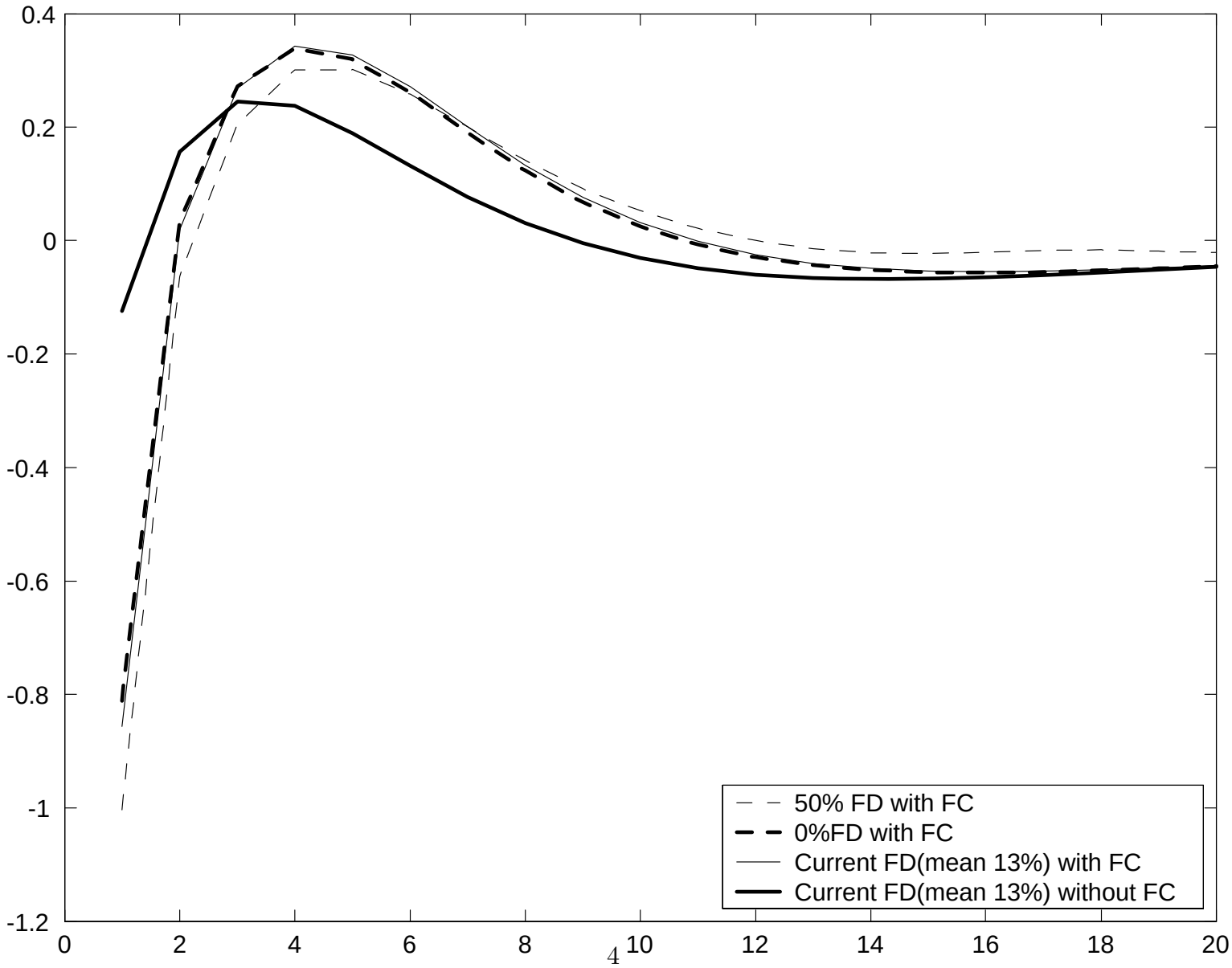

Figure 3: Aggregate Response (1), $r, \rho_e = 0.85$

Summary

- Financial market imperfections important to explain:
  - Firm-level heterogeneity in investment response.
  - Aggregate investment response.
- Role of foreign debt:
  - Firms with high foreign-debt ratio adversely affected through balance sheet mechanism.
  - Aggregate effects of foreign-denominated debt on investment explain 20% of investment decline.
- Broader message: variation in the balance sheet that is distinct from variation in fundamentals is key to identification of models with financial frictions.