Productivity and Trade Dynamics in Sudden Stops

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Introduction

- Sudden stops in emerging economies:
  - Sudden reversal of current account.
  - Sharp drops in output, consumption, investment, and asset prices.
  - Modeled as SOE-RBC model with occasionally binding borrowing constraint.
- Empirical studies on sudden stops show:
  - Persistently low output suggests slowdown of productivity growth.
  - Depreciation has differential impacts on non-exporters and exporters.
- Questions:
  - How do sudden stops affect firm-level innovation and trade dynamics?
  - What are the implications of these dynamics for aggregate economy?

This Paper

- Model:
  - Embed innovation and trade dynamics into a model of sudden stops.
    - Firms invest in innovation to introduce new products and start exporting.
  - Sudden stops have differential impacts on non-exporters and exporters.
- Quantitative analysis:
  - Match the model with Chilean product-level data.
  - Test model predictions about firm-level innovation and trade dynamics.
  - Examine implications for aggregate economy.

Main Results

- Calibrated model replicates innovation and trade dynamics in the data:
  - Exporters' profits drop less than non-exporters' profits during sudden stops.
  - Exporting innovation declines less than domestic innovation.
- Implications for aggregate dynamics:
  - Declined domestic innovation accounts for most of growth slowdown.
  - Boosted export entry promotes recovery and mitigates growth slowdown.

Related Literature

- Sudden stops with occasionally binding borrowing constraint:

  Mendoza (2010), Bianchi (2011), Benigno et al. (2013), Benigno et al. (2016), Bianchi and Mendoza (2018), Jeanne and Korinek (2020), Ma (2020), Matsumoto (2022)

- Endogenous growth with heterogeneous firms:

  Klette and Kortum (2004), Acemoglu et al. (2018), Akcigit and Kerr (2018), Ates and Saffie (2020)

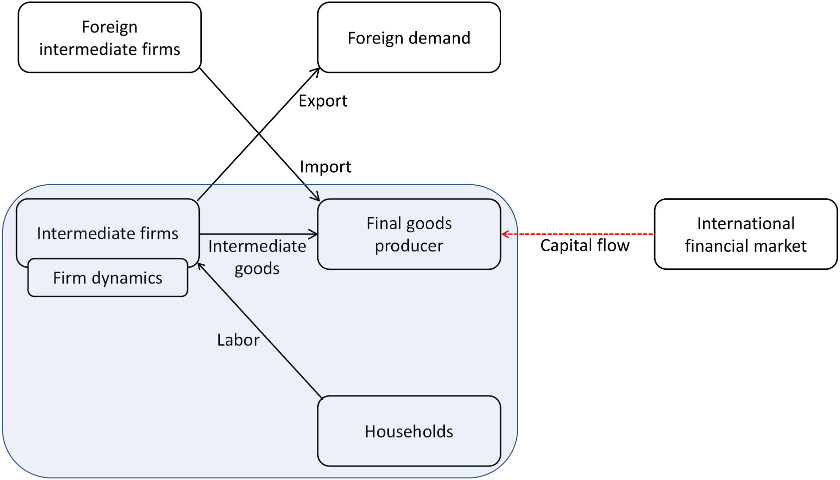
- Trade and growth:

  Sampson (2016), Alfaro et al. (2018), Buera and Oberfield (2020), Akcigit et al. (2021), Perla et al. (2021)

Model

Model Overview

- Small open economy with Schumpeterian growth.
- Occasionally binding borrowing constraint triggers sudden stops.



Final Goods Producer

- Production function:

$$Y_t = \exp\left(\varepsilon_t^A\right) \exp\left[\int_0^1 \ln y_t(i) di\right]$$

- Borrow from abroad, subject to occasionally binding collateral constraint.

$$-B_t + \phi\left[\int_0^1 p_t(i) y_t(i) di\right] \leq \kappa Q_t L$$

- Demand for each type of intermediate good i: FOC

$$y_t(i) = \frac{Y_t}{p_t(i)} \frac{1}{1 + \phi \mu_t / \lambda_t}$$

μ_t: Lagrange multiplier on the borrowing constraint.

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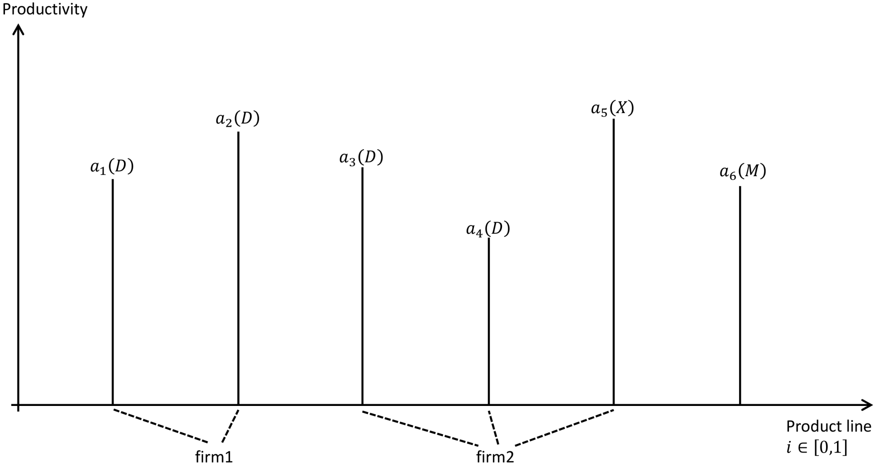
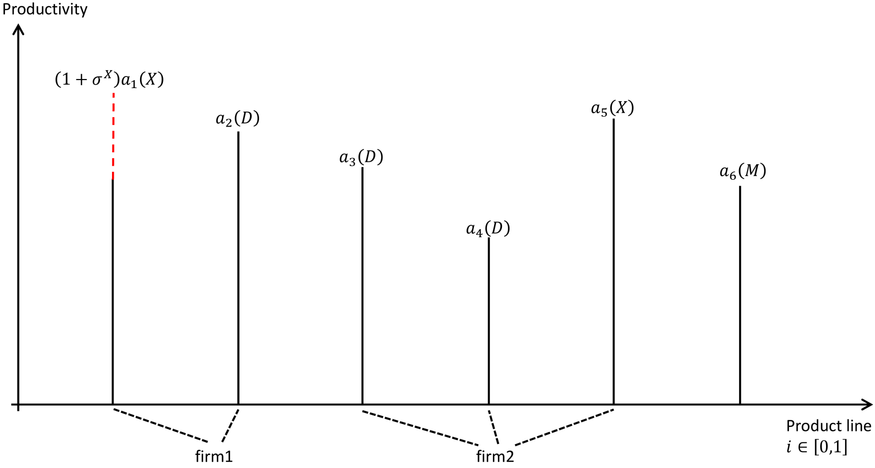
Intermediate Sector: Schumpeterian Growth

- Each product is produced by the firm with the highest productivity.
- Each firm is a collection of domestic (D) and exporting (X) lines.



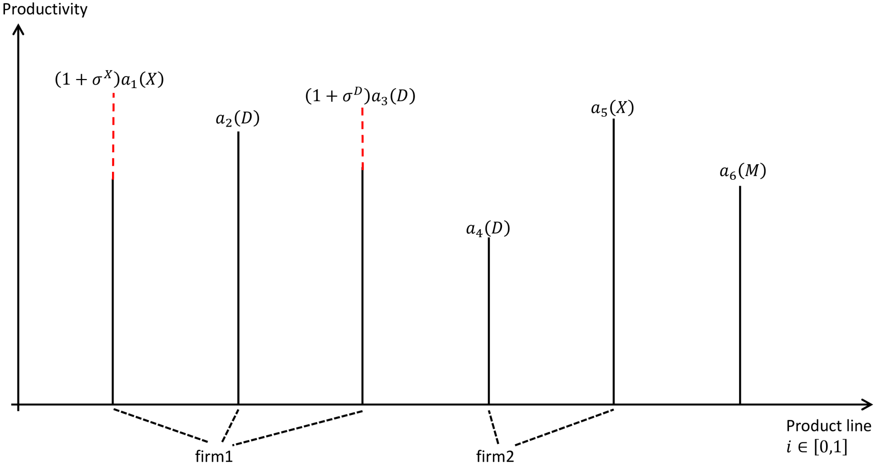
Intermediate Sector: Export Entry

- Firms invest in their own domestic lines to start exporting.
- Products are sold domestically before being exported.



Intermediate Sector: Domestic Product Entry

- Firms invest in other firms' products to replace other firms.
- Firms' product portfolios endogenously expand and shrink over time.



Intermediate Sector: Production and Profit

- Production uses capital and labor: $y_t(i) = a_t(i) \left(\ell_t(i)\right)^{\alpha} \left(h_t(i)\right)^{1-\alpha}$
- Profit in the domestic market $(s = D, X)$:

$$\pi_t^s = \left(\frac{\sigma^s}{1+\sigma^s}\right) \frac{Y_t}{1 + \phi \mu_t / \lambda_t}$$

- Profits from export sales:

$$\pi_t^* = \underbrace{\left(1 - \frac{(1+\xi)\left(R_t^L\right)^{\alpha} \left(W_t\right)^{1-\alpha}}{(1+\sigma^X)\left(R_t^{L*}\right)^{\alpha}\left(W_t^*\right)^{1-\alpha}}\right)}_{\text{1 - relative marginal cost}} \underbrace{Y_t^*}_{\text{Foreign demand}}$$

- Two differences during sudden stops:
  - Sudden stop negatively affects domestic demand but not foreign demand.
  - Lower factor prices increase export profits.

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Intermediate Sector: Innovation

- Consider a firm with n^D domestic lines and n^X exporting lines.
- Assumptions for innovation opportunity:
  - This firm has $n^D + n^X$ domestic innovation opportunities.
  - This firm has n^D exporting innovation opportunities.
- Total investment by this firm: $(n^D + n^X)Z_t^D + n^D Z_t^X$.
- Total profit of this firm: $n^D \pi_t^D + n^X(\pi_t^X + \pi_t^*)$
- Value function of a firm is linear in the number of product lines:

value

$$V_t(n^D, n^X) = n^D V_t^D + n^X V_t^X$$

Intermediate Sector: Investment in Innovation

- Invest final goods Z_t^D to make domestic innovation:

$$\underbrace{i^{D\prime}(Z_t^D)}_{\substack{\text{marginal increase in} \\ \text{success probability}}} \quad \underbrace{E_t\left[\Lambda_{t,t+1} V_{t+1}^D\right]}_{\substack{\text{expected value of} \\ \text{domestic product line}}} = 1$$

- Invest final goods Z_t^X to make exporting innovation:

$$\underbrace{(1-d_t) i^{X\prime}(Z_t^X)}_{\substack{\text{marginal increase in} \\ \text{success probability}}} \underbrace{E_t\left[\Lambda_{t,t+1}\left(V_{t+1}^X - V_{t+1}^D\right)\right]}_{\text{gap in expected value}} = 1$$

- Key mechanism:
  - During sudden stops, domestic profit declines whereas export profit increases.
  - Differentiated impacts on profits affect two types of innovation differently.

eqm

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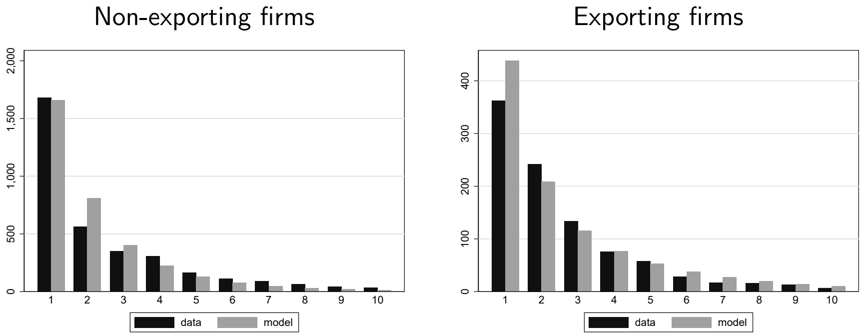
Quantitative Analysis

Data and Calibration

- Chilean plant-and-product level data (ENIA).
  - Covers all manufacturing plants that employ at least ten workers.
  - Contains product-level data that distinguishes domestic and export markets.
  - We use data in $1996 - 1999$, which includes sudden stop in 1998.
- Calibrate the model to aggregate and micro-level data: parameters
  1. Share of single-product non-exporters.
  2. Share of exporters in single-product firms.
  3. Average number of products by non-exporters.
  4. Average number of exported products by exporters.

Product Distribution across Firms

- Compute the stationary product distribution for 5,000 firms in the model.
- Only single-product firm and the average are targeted by model parameters.



Product Portfolio and Product Transition

- How are the number of products and product transitions related?

$$Y_f = \beta_1 \cdot X_f + \phi_s + \epsilon_f$$

	Domestic entry	Export entry	Domestic exit	Export exit
Panel A: Data				
Number of Products	0.042*** (0.006)			
Number of Domestic Products		0.017*** (0.004)	0.181*** (0.006)	
Number of Exported Products				0.047*** (0.011)
Observations	3996	3996	3996	870
Panel B: Model				
Number of Products	0.175*** (0.007)			
Number of Domestic Products		0.022*** (0.003)	0.266*** (0.006)	
Number of Exported Products				0.027** (0.013)
Observations	4478	4478	4478	1120

Exporting Firms' Premia

- How much is the exporting firms' premia over non-exporting firms?

$$\log Y_f = \beta_1 \cdot \text{Exporter}_f + \phi_s + \epsilon_f$$

	Revenue	Employment	Productivity
Data			
Exporter	1.07***	1.12***	0.61***
	(0.03)	(0.03)	(0.03)
Observations	5185	5185	4923
Model			
Exporter	1.02***	0.92***	2.19***
	(0.03)	(0.03)	(0.142)
Observations	4937	4937	4937

Product Innovation during Sudden Stop

- Compute average crisis dynamics from 10,000-period simulation, then simulate 5,000 firms using the crisis dynamics of innovation rates. aggregate
- How does sudden stop affect domestic and export innovation?

$$Y_{ft} = \beta_1 \times \mathbf{1}[\text{Sudden Stop}_t] + \phi_f + \epsilon_{ft}$$

- Export innovation rate drops much less than domestic innovation rate.

	Data		Model	
	Domestic entry	Export entry	Domestic entry	Export entry
$\mathbf{1}[\text{Sudden Stop}_t]$	−0.083***	−0.018***	−0.091***	−0.003
	(0.006)	(0.003)	(0.008)	(0.004)
Observations	15523	15523	12533	12533

Exporters' Performance during Sudden Stop

- How does sudden stop affect non-exporters' and exporters' performance?

$$\log Y_{ft} = \beta_1 \times \mathbf{1}[\text{Sudden Stop}_t] \times \mathbf{1}[\text{Exporter}_{ft}] + \phi_f + \delta_t + \epsilon_{ft}$$

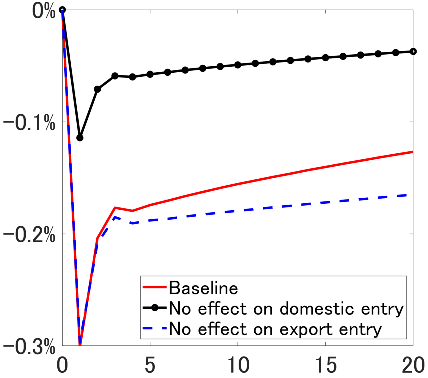
- Sudden stops have negative impacts on firm performance.
- Exporting firms survive better than non-exporting firms.

	Data			Model		
	Revenue	Profits	Productivity	Revenue	Profits	Productivity
SS×Exporter	0.040***	0.063***	0.093***	0.115***	0.120***	0.091***
	(0.006)	(0.010)	(0.016)	(0.016)	(0.013)	(0.009)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	21213	20797	19547	18711	18711	18711

Productivity and Welfare Loss by Sudden Stop

- Productivity loss is mostly due to low domestic innovation.
- Export innovation is boosted after crisis and promotes recovery.

Productivity loss



Welfare loss in consumption

Baseline	4.62%
No loss in productivity	3.24%
No effect on domestic entry	3.49%
No effect on export entry	5.04%

Conclusion

- Embed heterogeneous firm dynamics into non-linear sudden-stop model.
- Calibrate the model to Chilean manufacturing product-level data:
  - Replicates product distribution across firms.
  - Innovation and trade dynamics are consistent with the data.
- Growth and trade dynamics have important implications for welfare cost.
- Capital controls discourage investment, bringing limited welfare gains.

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Appendix

Final Goods Sector back

- Maximization problem:

$$\max_{\{\{y_t(i)\}_{i=0}^{1}, B_t, K_t\}} E_0 \sum_{t=0}^{\infty} \left[\beta^t \lambda_t \Pi_t^T \right]$$

$$\Pi_t = \underbrace{Y_t - \int_0^1 p_t(i) y_t(i) di}_{\text{output - cost}} \underbrace{- B_t + R_{t-1} B_{t-1}}_{\text{net foreign asset}} \underbrace{- Q_t K_t + (Q_t + R_t^k) K_{t-1}}_{\text{capital holding and return}}$$

$$-B_t + \phi \left[\int_0^1 p_t(i) y_t(i) di \right] \leq \kappa Q_t K_{t-1}$$

- FOCs:

$$y_t(i) = \frac{Y_t}{p_t(i)} \frac{1}{1 + \phi \mu_t / \lambda_t}$$

$$\lambda_t - \mu_t = \beta R_t E_t \left[\lambda_{t+1} \right]$$

$$Q_t = \frac{\beta E_t \left[\lambda_{t+1} \left(Q_{t+1} + R_{t+1}^k \right) + \kappa \mu_{t+1} Q_{t+1} \right]}{\lambda_t}$$

Intermediate Firms' Profit

back

- Marginal cost for production:

$$MC_t(i) = \frac{1}{a_t(i)} \alpha^{-\alpha} (1-\alpha)^{-(1-\alpha)} \left(R_t^k\right)^{\alpha} (W_t)^{1-\alpha}$$

- Intermediate firms' profit:

$$\pi_t^s(i) = p_t(i) y_t(i) - R_t^k k_t(i) - W_t \ell_t(i)$$

- Using optimal price $p_t(i) = \widetilde{MC}_t(i)$ and demand function $y_t(i) = Y_t / p_t(i)$,

$$\begin{aligned} \pi_t^s(i) &= p_t(i) y_t(i) - MC_t(i) y_t(i) = Y_t - MC_t(i) \frac{Y_t}{p_t(i)} \\ &= \left(1 - \frac{MC_t(i)}{\widetilde{MC}_t(i)}\right) Y_t \end{aligned}$$

Value of Product Lines

back

- Value of a firm satisfies:

$$V_t\left(n^D, n^X\right) = n^D V_t(1,0) + n^X V_t(0,1)$$

- Value of each product line:

$$\begin{aligned}
V_t(1,0) &= \max_{Z_t^D, Z_t^X} \pi_t^D - Z_t^D - Z_t^X \\
&+ \left[i^D(Z_t^D) + (1-d_t)\left(1 - i^X(Z_t^X)\right)\right] E_t\left[\Lambda_{t,t+1} V_{t+1}(1,0)\right] \\
&+ \left[(1-d_t) i^X(Z_t^X)\right] E_t\left[\Lambda_{t,t+1} V_{t+1}(0,1)\right] \\
V_t(0,1) &= \max_{Z_t^D} \pi_t^X + \pi_t^* - Z_t^D \\
&+ \left(i^D(Z_t^D) + i^{FX}\right) E_t\left[\Lambda_{t,t+1} V_{t+1}(1,0)\right] \\
&+ (1 - i^{FX}) E_t\left[\Lambda_{t,t+1} V_{t+1}(0,1)\right]
\end{aligned}$$

Households back

- Maximization problem:

$$\max_{\{C_t, H_t, Z_t^E, Z_t^{EX}\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t \ln\left(C_t - A_t \frac{(H_t)^{\omega}}{\omega} \right)$$

subject to

$$\begin{aligned} C_t + Z_t^E + Z_t^{EX} &= W_t H_t + \Pi_t \\ &\quad + \theta_{t-1}^D \left(\pi_t^D - Z_t^D - Z_t^X \right) + \theta_{t-1}^X \left(\pi_t^X + \pi_t^* - Z_t^D \right) \end{aligned}$$

- FOCs:

$$A_t (H_t)^{\omega - 1} = W_t$$

$$\lambda_t = \frac{1}{C_t - A_t (H_t)^{\omega} / \omega}$$

Transition of Product Lines

back

- Share of domestic lines:

$$\theta_t^D = \theta_{t-1}^D + (e_t^D + (\theta_{t-1}^D + \theta_{t-1}^X) i_t^D) \frac{1 - \theta_{t-1}^D - \theta_{t-1}^X}{1 - \theta_{t-1}^X} + \theta_{t-1}^X i^{FX}$$

$$- \theta_{t-1}^D (1 - d_t) i_t^X - \theta_{t-1}^D i^{FD} - e_t^X \frac{\theta_{t-1}^D}{1 - \theta_{t-1}^X} .$$

- Share of exporting lines (extensive margin of export):

$$\theta_t^X = \theta_{t-1}^X + \theta_{t-1}^D (1 - d_t) i_t^X + e_t^X - \theta_{t-1}^X i^{FX}$$

- Share of importing lines (extensive margin of import): $1 - \theta_t^D - \theta_t^X$

Aggregation of Intermediate Sector

back

- Growth in aggregate productivity:

$$\frac{A_{t+1}}{A_t} = 1 + g_t = (1+\sigma^D)^{e_t^D + (\theta_{t-1}^D + \theta_{t-1}^X) i_t^D} (1+\sigma^X)^{e_t^X + \theta_{t-1}^D (1-d_t) i_t^X} (1+\sigma^X)^{i^{FD}}$$

- Replacement rate:

$$d_t = \left(e_t^D + e_t^X + (\theta_{t-1}^D + \theta_{t-1}^X) i_t^D \right) \frac{1}{1-\theta_{t-1}^X} + i^{FD}$$

- Asset and labor allocations:

$$L = \theta_{t-1}^D \ell_t^D + \theta_{t-1}^X \left(\ell_t^X + \ell_t^* \right)$$

$$H_t = \theta_{t-1}^D h_t^D + \theta_{t-1}^X \left(h_t^X + h_t^* \right)$$

Parameter Values

back

Variable		Value	Source
β	Discount factor	0.96	Standard
R	Foreign bond interest rate	1.05	Standard
ω	Frisch elasticity $1/(\omega-1)$	1.455	Mendoza (1991)
α	Asset share in production	0.08	Capital to Output ratio (Chile)
ξ	Iceberg trade cost	0.21	Anderson and van Wincoop (2004)
ϕ	Fraction of input subject to WK	0.2	Total credit to GDP ratio (Chile)
κ	Coefficient on borrowing constraint	0.2	Mendoza (2010)
L	Amount of productive asset	0.6	Frequency of Sudden Stops
ρ	Concavity of innovation investment	1.5	Median value from literature

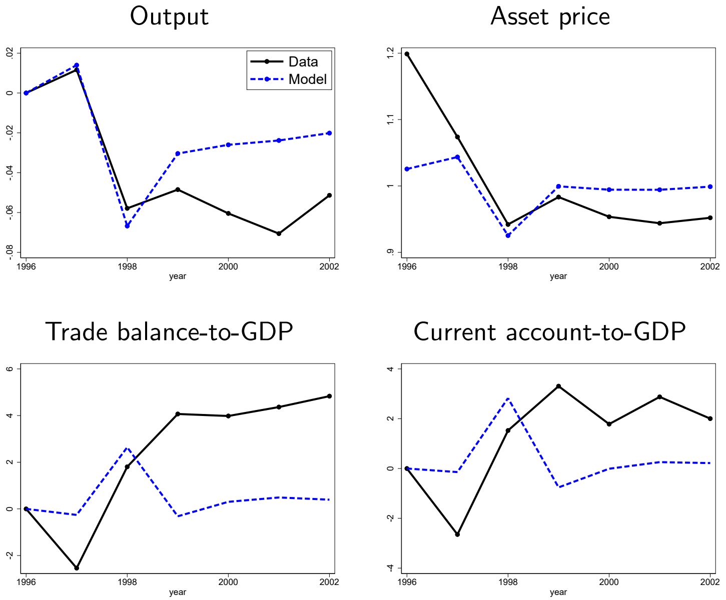
Internally Calibrated Parameters

back

Variable		Value	Target	Model	Data
σ^D	Domestic innovation step size	0.06	Aggregate growth rate	2.5%	2.5%
σ^X	Export innovation step size	0.30	Relative profit of non-exporters to exporters	27.8%	26.2%
η^{ED}	Non-exporter entry coefficient	1.46	Share of single-product non-exporters	37.1%	38.3%
η^{EX}	Exporter entry coefficient	0.31	Share of exporters in single-product firms	20.8%	21%
η^D	Domestic innovation coefficient	2.97	Avg. # of products by non-exporters	2.24	2.56
η^X	Export innovation coefficient	0.52	Avg. # of exported products by exporters	1.05	1.7
y^*	Foreign demand	0.74	Export revenue share for exporters	30.5%	35.9%
i^{FX}	Foreign innovation rate on X lines	0.23	Domestic innovation rate by domestic firms		
i^{FD}	Foreign innovation rate on D lines	0.01	Export innovation rate by domestic firms		

Aggregate Dynamics

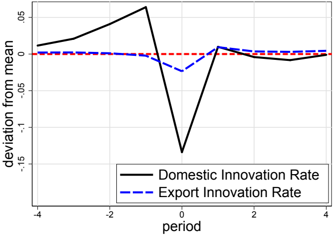
back



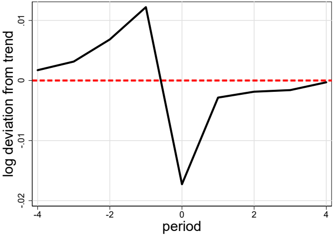
Aggregate Dynamics

back

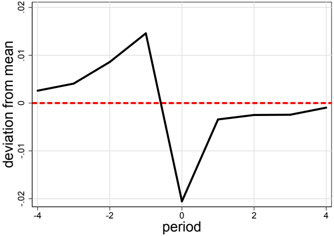
Innovation rate



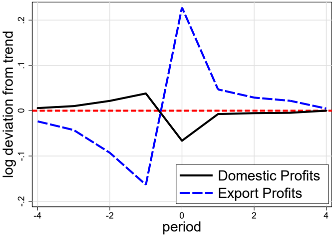
Wage



Relative marginal cost



Profit of each product



Macroprudential Capital Controls

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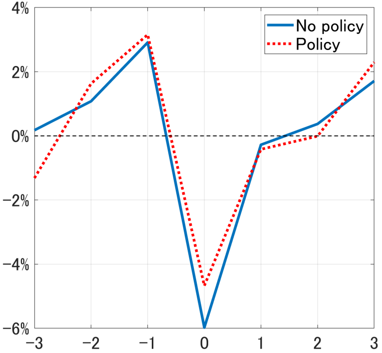
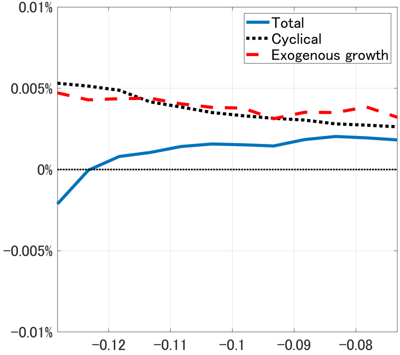
- Welfare effect is very small positive or can be even negative.
- Capital control discourages investment and growth in normal times.

Consumption crisis dynamics



Welfare gain/loss by policy



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