Trade and Productivity Dynamics during Sudden Stops

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Very Preliminary

The views expressed in this paper are those of the author(s) and do not necessarily reflect the official views of the Bank of Japan.

Introduction

- Sudden stops in developing countries:
  - Reversal of net export and current account
  - Sharp drops in output, consumption, investment, and asset prices
  - Modeled in DSGE framework by Mendoza (2010) and subsequent literature
- Recent studies on sudden stops show:
  - Persistently lower output suggests slowdown of productivity growth
  - Exchange rate depreciation has differential impacts on imports and exports
- This paper:
  - Incorporate growth and trade dynamics into DSGE model
  - Study welfare implications of growth and trade dynamics

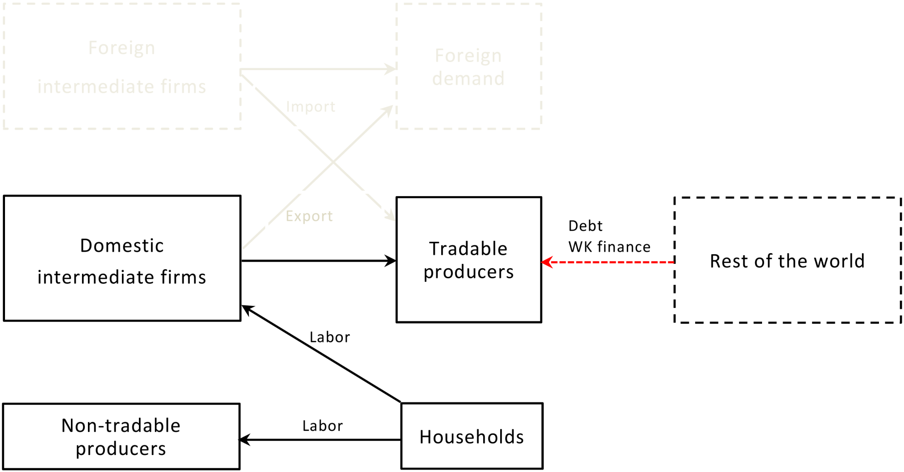
This Paper

- Model features:
  - Endogenous sudden stops by collateral constraint (Mendoza (2010))
  - Endogenous firm dynamics and productivity growth (Ates and Saffie (2014), Matsumoto (2017))
  - Endogenous exporting decisions (Alessandria and Choi (2018))
  - Calibrated to product-level firm-size distribution in Chile
- Result preview:
  - Sudden stops slow down productivity growth, causing persistently lower output
  - Real depreciation causes expansion of extensive margin of exports
  - 38% of welfare loss by sudden stops comes from lower productivity
  - Expansion of extensive margin of exports mitigates welfare loss by 36%

Model

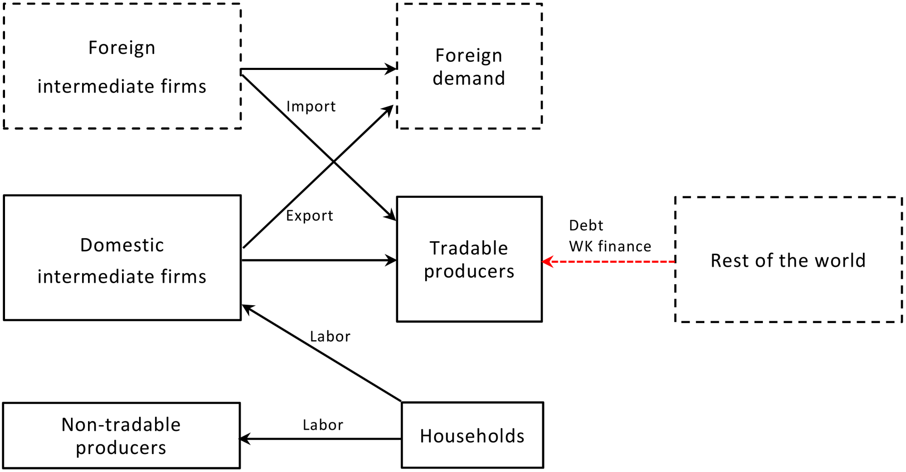
Model Overview

- Small open economy with tradable and non-tradable sector
- Occasionally binding borrowing constraint triggers sudden stops



Model Overview

- Intermediate goods can be imported and exported
- Firm dynamics determine productivity growth and trade margins



Final Tradable Sector

- Production function:

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

- Borrow from abroad on behalf of households
- Own and rent productive asset ($L_t = 1$) to intermediate firms

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

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

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

FOC

Final Tradable Sector: FOCs

- Demand for each type of intermediate good i:

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

  - When constraint binds, $\mu_t > 0$, and demand falls

- FOC w.r.t. asset L_t:

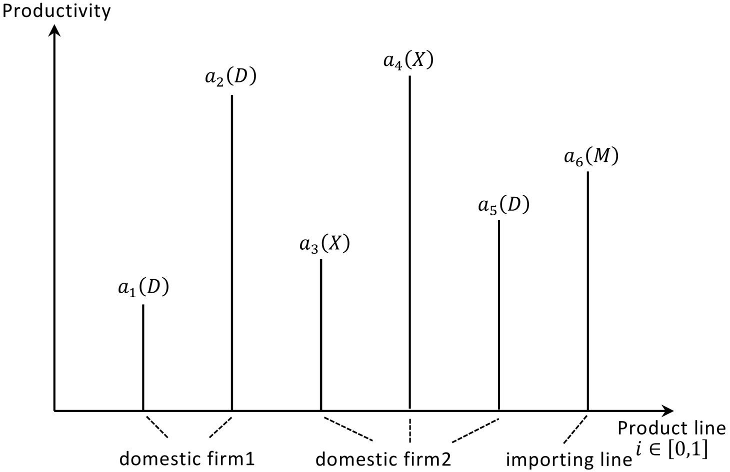
$$Q_t = \frac{\beta E_t \left[\lambda_{t+1} \left(Q_{t+1} + R_{t+1}^L \right) + \kappa \mu_{t+1} Q_{t+1} \right]}{\lambda_t}$$

  - When constraint binds, $\lambda_t \uparrow$, and asset price Q_t drops

    $\rightarrow$ Tightens borrowing constraint, and triggers amplification effect

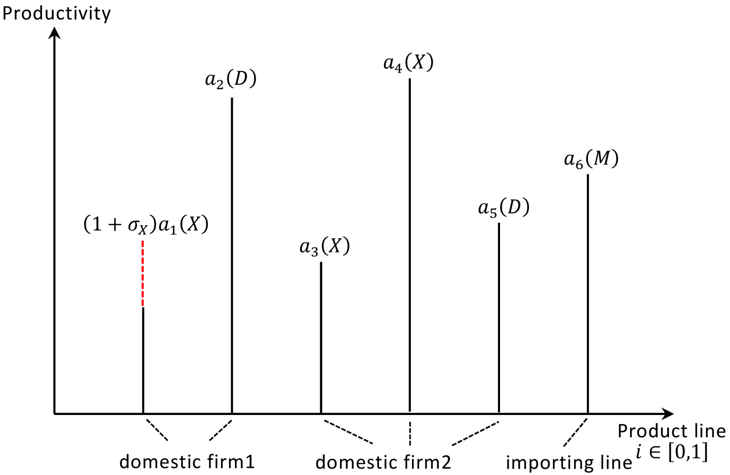
Intermediate Sector: Overview

- Each firm is a collection of product lines
- Production function: $y_t(i) = a_t(i)\,(\ell_t(i))^{\alpha}\,(h_t(i))^{1-\alpha}$



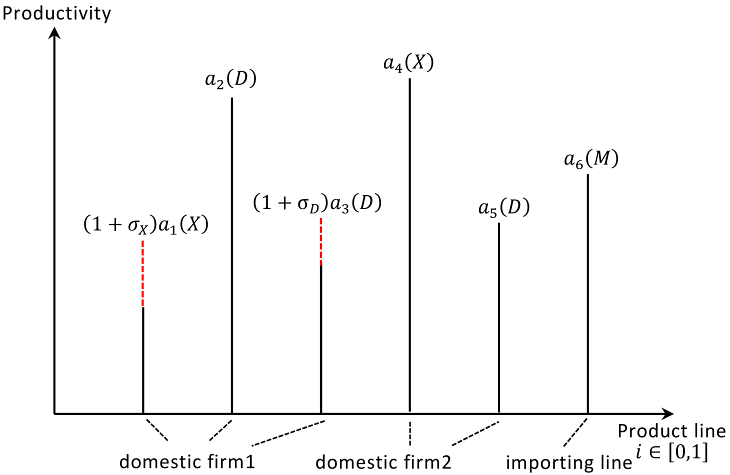
Exporting Innovation

- Domestic firms invest in their own lines to start exporting
- Exporting lines sell products both in domestic and foreign market



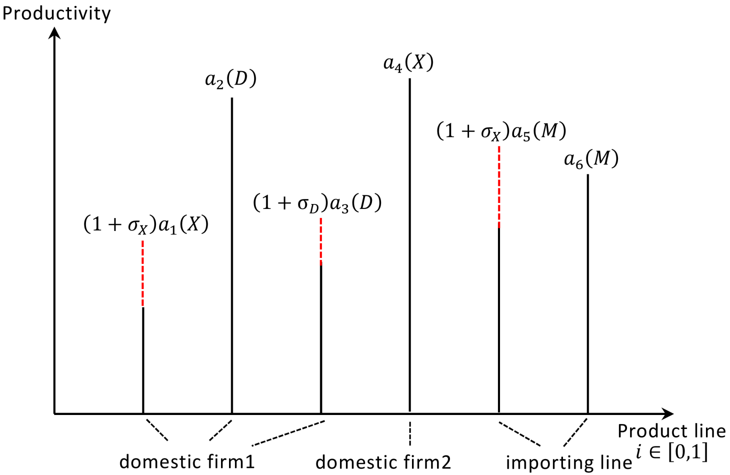
Domestic Innovation

- Domestic innovation replaces other firms for product lines
- Size of domestic firms endogenously expands and shrinks



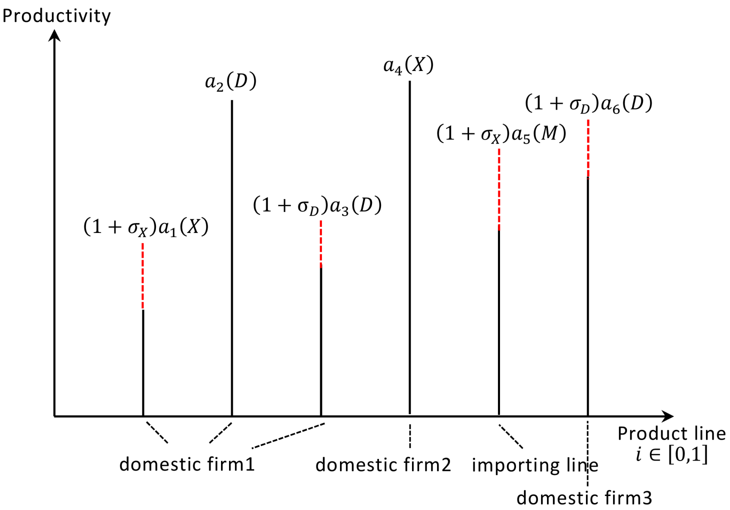
Foreign Innovation

- Some types of intermediate goods are imported
- Foreign innovation happens exogenously



Domestic Entry

- Domestic entry replaces incumbent firms for a product line
- A new firm starts with a single domestic line



Intermediate Sector: Profit

- Profit in the domestic market: math

$$\pi_t^s(i) = \left(1 - \frac{MC_t(i)}{\widetilde{MC}_t(i)}\right) Y_t^T \frac{1}{1+\phi\mu_t/\lambda_t} = \left(\frac{\sigma_s}{1+\sigma_s}\right) Y_t^T \frac{1}{1+\phi\mu_t/\lambda_t}$$

  - $\widetilde{MC}_t$: marginal cost for domestic rival firms
  - $1+\sigma_s$: productivity lead by productivity leader over follower, $s = D, X$

- Profit in the foreign market:

$$\pi_t^*(i) = \left(1 - \frac{MC_t(i)}{\widetilde{MC}_t(i)}\right) Y_t^* = \left(1 - \frac{(1+\xi)\left(R_t^L\right)^\alpha (W_t)^{1-\alpha}}{(1+\sigma_X)\left(R_t^{L*}\right)^\alpha (W_t^*)^{1-\alpha}}\right) Y_t^*$$

  - $\widetilde{MC}_t$: marginal cost for foreign rival firms
  - Cheaper factor prices $R_t^L, W_t \rightarrow$ Higher profit

Intermediate Sector: Investment in Innovation

- Firms invest final tradable goods for innovation: value aggregate
  - Domestic: $i^{D\prime}(Z_t^D)E_t\left[\Lambda_{t,t+1}V_{t+1}^D\right] = 1$
  - Exporting: $(1-d_t)i^{X\prime}(Z_t^X)\left(E_t\left[\Lambda_{t,t+1}V_{t+1}^X\right] - E_t\left[\Lambda_{t,t+1}V_{t+1}^D\right]\right) = 1$
- Non-tradable goods are produced using labor
- Households consume C_t^T, C_t^N, supply labor, receive profits from firms, and invest to start new firms detail eqm

Quantitative Analysis

Calibration: Firm-Level Data in Chile

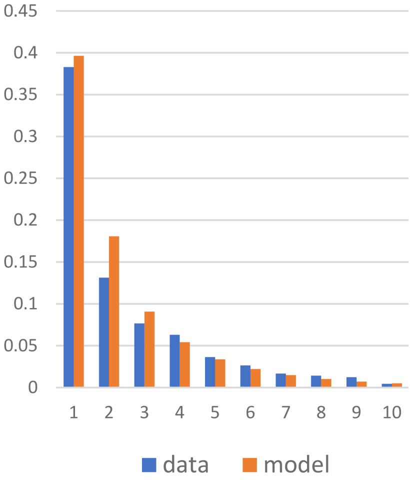
- One period is one year
- Standard parameters are set to standard values parameters
- Target product-level firm data in Chilean economy

Variable		Value	Target	Model
η^E	domestic entry coeff.	1.98	Share of single-good non-exporters 38.3%	39.6%
η^D	domestic innov. coeff.	4.05	Non-exporters' average products 2.07	2.01
η^X	exporting innov. coeff.	1.42	Share of single-good exporters 14.9%	15.1%
σ^D	domestic innov. size	0.06	Average growth rate 2.5%	2.5%
σ^X	exporting innov. size	0.38	Relative profits non-exporters/exporters 26.2%	26.1%
Y^*	foreign demand	0.79	Export revenue share for exporters 35.9%	34.3%

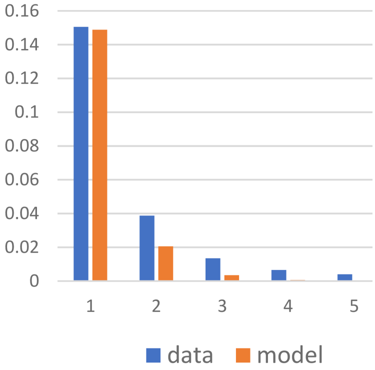
- Shocks: TFP of final tradable production ε_t^A and interest rate ε_t^R
  - Taken from Mendoza (2010)
  - 2-state joint Markov process with negative correlation

Product-Level Firm-Size Distribution

Non-exporters' product distribution



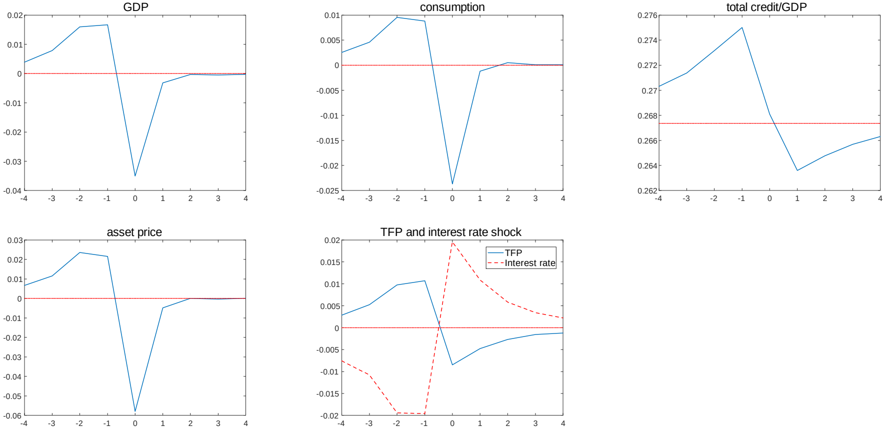
Exporters' product distribution



Simulation and Sudden Stops

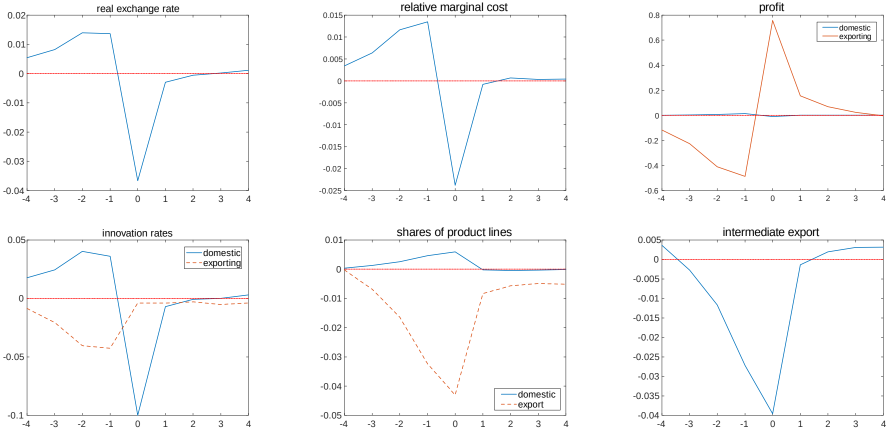
- Simulate 10,000 periods with stochastic shocks, drop first 1,000 periods
- Sudden stops:
  - Current account-to-GDP is more than two standard deviations above its mean
  - Unconditional probability is 7.7%, in line with other papers

Dynamics of Aggregate Variables



- Large capital inflows and economic boom precede sudden stops
- Reversal of goods shocks to bad shocks trigger sudden stops

Dynamics of Firm and Trade

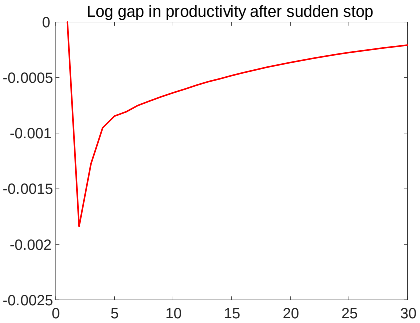


- Lower marginal cost boosts exporting innovation during SS
- Expansion of extensive margin of exports, in line with empirical fact

Productivity and Welfare Loss

- Set initial state at the average of period $t-1$ in previous simulations
- Compare two economies:
  - Economy 1: feed a good shock at period 1
  - Economy 2: feed a bad shock at period 1, which triggers a sudden stop
- Random simulation for the following periods
- Compare the average productivity paths and expected welfare

Productivity and Welfare Loss



Economy	welfare loss
baseline	-0.068%

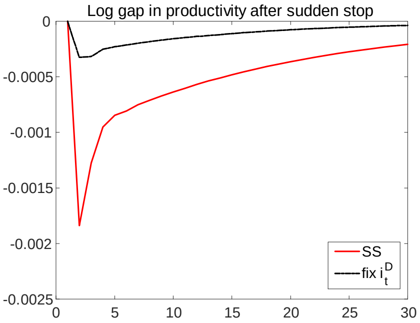
- Productivity level falls below trend by 0.19% on impact, and slow recovery

Productivity and Welfare Loss

Economy	welfare loss
baseline	-0.068%
g_t from no SS	-0.042%

- Take productivity growth g_t from no-SS economy and feed into SS economy
- Lower productivity accounts for 38% of welfare loss by sudden stop

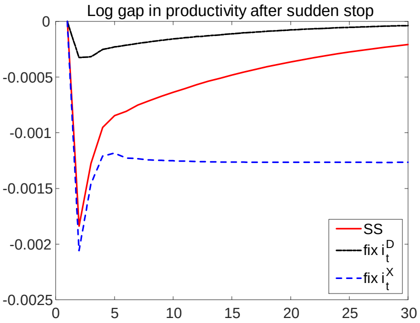
Productivity and Welfare Loss: Domestic Innovation



Economy	welfare loss
baseline	−0.068%
g_t from no SS	−0.042%
i_t^D from no SS	−0.046%

- Take domestic innovation i_t^D from no-SS economy and feed into SS economy
- Lower domestic innovation accounts for most of productivity and welfare loss

Productivity and Welfare Loss: Exporting Innovation



Economy	welfare loss
baseline	-0.068%
g_t from no SS	-0.042%
i_t^D from no SS	-0.046%
i_t^X from no SS	-0.107%

- Exporting innovation helps productivity recovery and reduces welfare loss

Conclusion

- Small-open-economy model with following features:
  - Endogenous sudden stops by collateral constraint
  - Endogenous firm dynamics and growth
  - Endogenous extensive margins of trade
  - Product-level distribution matches the data
- Sudden stop dynamics:
  - Sudden stops cause persistently lower productivity and output
  - Extensive margin of exports expands through real depreciation
  - 38% of welfare loss by sudden stops comes from lower productivity
  - Expansion of export extensive margin reduces welfare loss by 36%

Appendix

Final Tradable Sector

back

- Maximization problem:

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

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

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

- FOCs:

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

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

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

Intermediate Firms' Profit

back

- Marginal cost for production:

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

- Intermediate firms' profit:

$$\pi_t^s(i) = p_t(i)y_t(i) - R_t^L \ell_t(i) - W_t h_t(i)$$

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

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

Domestic Product Line

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 a domestic product line

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

- FOC w.r.t. Z_t^D:

$$\eta^D \frac{1}{\rho^D}\left(\frac{Z_t^D}{A_t}\right)^{1/\rho-1} \frac{1}{A_t} E_t\left[\Lambda_{t,t+1} V_{t+1}(1,0)\right] = 1$$

- FOC w.r.t. Z_t^X:

$$(1-d_t)\eta^X \frac{1}{\rho^X}\left(\frac{Z_t^X}{A_t}\right)^{1/\rho-1} \frac{1}{A_t}\left(E_t\left[\Lambda_{t,t+1} V_{t+1}(0,1)\right] - E_t\left[\Lambda_{t,t+1} V_{t+1}(1,0)\right]\right) = 1$$

Exporting Product Line

back

- Value of an exporting product line

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

- FOC w.r.t. Z_t^D:

$$\eta^D \frac{1}{\rho^D}\left(\frac{Z_t^D}{A_t}\right)^{1/\rho-1} \frac{1}{A_t} E_t\left[\Lambda_{t,t+1} V_{t+1}(1,0)\right] = 1$$

- FOC for domestic entry by households:

$$\eta^E \frac{1}{\rho^E}\left(\frac{Z_t^E}{A_t}\right)^{1/\rho-1} \frac{1}{A_t} E_t\left[\Lambda_{t,t+1} V_{t+1}(1,0)\right] = 1$$

Extensive Margins of Trade

back

- Share of domestic lines:

$$\theta_t^D = \theta_{t-1}^D \underbrace{+\left(1-\theta_{t-1}^D\right)\left(e_t + \left(\theta_{t-1}^D + \theta_{t-1}^X\right) i_t^D\right)}_{\substack{\text{entry and domestic innov.}\\ \text{on exporting and foreign lines}}} \underbrace{-\theta_{t-1}^D\left(i_t^X + i^F\right)}_{\substack{\text{exporting and foreign innov.}\\ \text{on domestic lines}}}$$

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

$$\theta_t^X = \theta_{t-1}^X \underbrace{+\theta_{t-1}^D i_t^X}_{\text{exporting innov.}} \underbrace{-\theta_{t-1}^X\left(e_t + \left(\theta_{t-1}^D + \theta_{t-1}^X\right) i_t^D + i^F\right)}_{\substack{\text{entry, domestic and foreign innov.}\\ \text{on exporting lines}}}$$

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

other

Aggregation of Intermediate Sector

back

- Growth in average productivity:

$$\frac{A_{t+1}}{A_t} = \underbrace{(1+\sigma^D)^{e_t+(\theta^D_{t-1}+\theta^X_{t-1})i^D_t}(1+\sigma^X)^{\theta^D_{t-1}i^{HX}_t}}_{\text{domestic}}\underbrace{(1+\sigma^X)^{i^F}}_{\text{foreign}}$$

- Replacement rate:

$$d_t = (\theta^D_{t-1}+\theta^X_{t-1})i^D_t + e_t + i^F$$

- Asset and labor allocations:

$$1 = \theta^D_{t-1}\ell^D_t + \theta^X_{t-1}\left(\ell^X_t + \ell^*_t\right)$$

$$H_t = \theta^D_{t-1}h^D_t + \theta^X_{t-1}\left(h^X_t + h^*_t\right) + H^N_t$$

Households

back

- Maximization problem:

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

$$C_t = \left[(\gamma)^{1/\varepsilon} (C_t^T)^{\frac{\varepsilon-1}{\varepsilon}} + (1-\gamma)^{1/\varepsilon} (C_t^N)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}$$

subject to

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

- FOCs:

$$\frac{C_t^T}{C_t^N} = \frac{\gamma}{1-\gamma} (P_t^N)^{\varepsilon}$$

$$A_t (H_t)^{\omega-1} = W_t \left(\gamma \frac{C_t}{C_t^T} \right)^{1/\varepsilon}$$

and λ_t is given by:

$$\lambda_t = \frac{1}{C_t - A_t (H_t)^{\omega}/\omega} \left(\gamma \frac{C_t}{C_t^T} \right)^{1/\varepsilon}$$

Trade Balance and Current Account

$$TB_t = \underbrace{Y_t^T - C_t^T - Z_t^E - \theta_{t-1}^D \left(Z_t^D + Z_t^X \right) - \theta_{t-1}^X Z_t^D}_{\text{final tradable output - absorption}}$$

$$+ \underbrace{\theta_{t-1}^X Y_t^*}_{\text{export of intermediate goods}} - \underbrace{\left(1 - \theta_{t-1}^D - \theta_{t-1}^X \right) \frac{Y_t^T}{1 + \phi \mu_t / \lambda_t}}_{\text{import of intermediate goods}}$$

$$CA_t = TB_t + \left(\exp(\varepsilon_{t-1}^R) R - 1 \right) B_{t-1} = B_t - B_{t-1}$$

Calibration: Externally-Determined Parameters

back

Variable		Value	Source
β	discount factor	0.96	standard
R	foreign bond interest rate	1.06	standard
γ	T share in consumption	0.31	Bianchi (2011)
ε	CES between T and NT	0.6	middle value in literature
ω	Frisch elasticity $1/(\omega-1)$	1.455	Mendoza (1991)
α	asset share in tradable	0.3	standard
$1-\alpha^N$	labor share in non-tradable	0.75	Schmitt-Grohe & Uribe (2016)
ξ	iceberg cost	0.21	Anderson & van Wincoop (2004)
ϕ	fraction of input s.t. WK	0.4	middle value in literature
κ	coeff. on borrowing constraint	0.15	Mendoza (2010)
ρ	concavity of innov. investment	2	Akcigit & Kerr (2015)
i^F	foreign innovation rate	0.01	small contribution of foreign

Equilibrium of the Model Economy

back

- Equilibrium of the model economy is defined as follows:
  - Initial states $A_{-1}, A^*_{-1}, R_{-1} B_{-1}, \theta^D_{-1}, \theta^X_{-1}$
  - Stochastic shocks $\{\varepsilon^A_t, \varepsilon^R_t\}_{t=0}^{\infty}$
  - Tradable producers optimally choose $\{\{y_t(i)\}_{i \in [0,1]}, B_t, L_t\}_{t=0}^{\infty}$
  - Intermediate firms optimally choose $\{p_t(i), \ell^D_t, h^D_t, \ell^X_t, h^X_t, Z^D_t, Z^X_t\}_{t=0}^{\infty}$
  - Non-tradable producers optimally choose $\{H^N_t\}_{t=0}^{\infty}$
  - Households optimally choose $\{C^T_t, C^N_t, H_t, Z^E_t\}_{t=0}^{\infty}$
  - Markets for asset, labor, tradable and non-tradable goods clear
  - $\{A_t, A^*_t, \theta^D_t, \theta^X_t\}_{t=0}^{\infty}$ evolve according to their laws of motion