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:
  \[ Y_T^T = \exp(\varepsilon^A_t) \exp \left[ \int_0^1 \ln(y_t(i)) \, di \right] \]

- Borrow from abroad on behalf of households

- Own and rent productive asset \((L_t = 1)\) to intermediate firms

\[
\max_{\{\{y_t(i)\}_{i=0}^1, B_t, L_t\}} \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \left[ \beta^t \lambda_t \Pi_T^T \right]
\]

\[
\Pi_T^T = Y_T^T - \int_0^1 p_t(i) y_t(i) \, di - B_t + R_{t-1} B_{t-1} - Q_t L_t + (Q_t + R_t^L) L_{t-1}
\]

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

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

  - 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

![Graph showing productivity and product lines with labels: domestic firm 1, domestic firm 2, importing line, and equations involving a0(D).]
Domestic Innovation

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

![Diagram showing productivity levels for domestic firms and importing lines.](image_url)
Foreign Innovation

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

Productivity

(1 + σ_X) a_1(X)
(1 + σ_D) a_3(D)
(1 + σ_X) a_5(M)
a_6(M)

Product line

i ∈ [0,1]
Domestic Entry

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

Productivity

- $a_2(D)$
- $(1 + \sigma_D)a_3(D)$
- $a_4(X)$
- $(1 + \sigma_D)a_5(M)$
- $(1 + \sigma_D)a_6(D)$

Product line $i \in [0,1]$

- Domestic firm 1
- Domestic firm 2
- Importing line
- Domestic firm 3
Intermediate Sector: Profit

- **Profit in the domestic market:**

\[
\pi^s_t(i) = \left(1 - \frac{MC_t(i)}{\bar{MC}_t(i)}\right) Y_t^T \frac{1}{1 + \phi \mu_t / \lambda_t} = \left(\frac{\sigma_s}{1 + \sigma_s}\right) Y_t^T \frac{1}{1 + \phi \mu_t / \lambda_t}
\]

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

- **Profit in the foreign market:**

\[
\pi^*_t(i) = \left(1 - \frac{MC_t(i)}{\bar{MC}_t(i)}\right) Y_t^* = \left(1 - \frac{(1 + \xi) (R^L_t)^{\alpha} (W_t)^{1-\alpha}}{(1 + \sigma_X) (R^*_t)^{\alpha} (W^*_t)^{1-\alpha}}\right) Y_t^*
\]

  - $\bar{MC}_t$: marginal cost for foreign rival firms
  - Cheaper factor prices $R^L_t, W_t \rightarrow$ Higher profit
Firms invest final tradable goods for innovation:

- Domestic: $i^D_t(Z^D_t)E_t[\Lambda_{t,t+1}V_{t+1}^D] = 1$

- Exporting: $(1 - d_t)i^X_t(Z^X_t)(E_t[\Lambda_{t,t+1}V_{t+1}^X] - E_t[\Lambda_{t,t+1}V_{t+1}^D]) = 1$

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.
Quantitative Analysis
Calibration: Firm-Level Data in Chile

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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Target</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\eta^E$</td>
<td>1.98</td>
<td>Share of single-good non-exporters 38.3%</td>
<td>39.6%</td>
</tr>
<tr>
<td>$\eta^D$</td>
<td>4.05</td>
<td>Non-exporters' average products 2.07</td>
<td>2.01</td>
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<tr>
<td>$\eta^X$</td>
<td>1.42</td>
<td>Share of single-good exporters 14.9%</td>
<td>15.1%</td>
</tr>
<tr>
<td>$\sigma^D$</td>
<td>0.06</td>
<td>Average growth rate 2.5%</td>
<td>2.5%</td>
</tr>
<tr>
<td>$\sigma^X$</td>
<td>0.38</td>
<td>Relative profits non-exporters/exporters 26.2%</td>
<td>26.1%</td>
</tr>
<tr>
<td>$Y^*$</td>
<td>0.79</td>
<td>Export revenue share for exporters 35.9%</td>
<td>34.3%</td>
</tr>
</tbody>
</table>

- Shocks: TFP of final tradable production $\varepsilon^A_t$ and interest rate $\varepsilon^R_t$
  - Taken from Mendoza (2010)
  - 2-state joint Markov process with negative correlation
Product-Level Firm-Size Distribution

Non-exporters’ product distribution

Exporters’ product distribution

Benguria, Matsumoto, Saffie

Trade Dynamics during Sudden Stops

Calibration 12
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
Large capital inflows and economic boom precede sudden stops

Reversal of goods shocks to bad shocks trigger sudden stops
• 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

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

<table>
<thead>
<tr>
<th>Economy</th>
<th>Welfare Loss</th>
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<tr>
<td>baseline</td>
<td>-0.068%</td>
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Productivity and Welfare Loss

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<tr>
<td>baseline</td>
<td>-0.068%</td>
</tr>
<tr>
<td>$g_t$ from no SS</td>
<td>-0.042%</td>
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</table>

- 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

- 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

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</tr>
<tr>
<td>$g_t$ from no SS</td>
<td>$-0.042%$</td>
</tr>
<tr>
<td>$i_t^D$ from no SS</td>
<td>$-0.046%$</td>
</tr>
</tbody>
</table>
Productivity and Welfare Loss: Exporting Innovation

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
Maximization problem:

$$\max_{\{y_t(i)\}_{i=0}^1, B_t, L_t} \quad \mathbb{E}_0 \sum_{t=0}^{\infty} [\beta^t \lambda_t \Pi^T_t]$$

$$\Pi^T_t = Y^T_t - \int_0^1 p_t(i) y_t(i) di - B_t + R_{t-1}B_{t-1} - Q_tL_t + (Q_t + R^L_t)L_{t-1}$$

Output - cost

Net foreign asset

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:

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

$$\lambda_t - \mu_t = \beta R_t \mathbb{E}_t [\lambda_{t+1}]$$

$$Q_t = \frac{\beta \mathbb{E}_t [\lambda_{t+1} (Q_{t+1} + R^L_{t+1}) + \kappa \mu_{t+1} Q_{t+1}]}{\lambda_t}$$
Intermediate Firms’ Profit

- 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 \( p_t(i) = \widehat{MC}_t(i) \) and demand function \( y_t(i) = Y_t^T / p_t(i) \)

  \[ \pi_t^s(i) = p_t(i)y_t(i) - MC_t(i)y_t(i) = Y_t^T - MC_t(i) \frac{Y_t^T}{p_t(i)} \]

  \[ = \left( 1 - \frac{MC_t(i)}{\widehat{MC}_t(i)} \right) Y_t^T \]
Domestic Product Line

- Value of a firm satisfies:

\[ V_t (n^D, n^X) = n^D V_t (1, 0) + n^X V_t (0, 1) \]

- Value of a domestic product line

\[ V_t (1, 0) = \max_{Z^D_t, Z^X_t} \pi_t^D - Z^D_t - Z^X_t \]

\[ + \left[ i^D (Z^D_t) + (1 - d_t) \left( 1 - i^X (Z^X_t) \right) \right] E_t [\Lambda_{t+1} V_{t+1} (1, 0)] \]

\[ + \left[ (1 - d_t) i^X (Z^X_t) \right] E_t [\Lambda_{t+1} V_{t+1} (0, 1)] \]

- FOC w.r.t. \( Z^D_t \):

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

- FOC w.r.t. \( Z^X_t \):

\[ (1 - d_t) \eta^X \frac{1}{\rho^X} \left( \frac{Z^X_t}{A_t} \right)^{1/\rho-1} \frac{1}{A_t} (E_t [\Lambda_{t+1} V_{t+1} (0, 1)] - E_t [\Lambda_{t+1} V_{t+1} (1, 0)]) = 1 \]
Exporting Product Line

- Value of an exporting product line

\[ V_t(0, 1) = \max_{Z_t^D} \pi_t^X + \pi_t^* - Z_t^D \]
\[ + i^D(Z_t^D)E_t[\Lambda_{t,t+1}V_{t+1}(1, 0)] \]
\[ + (1 - d_t)E_t[\Lambda_{t,t+1}V_{t+1}(0, 1)] \]

- FOC w.r.t. \( Z_t^D \):

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

- FOC for domestic entry by households:

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

- **Share of domestic lines:**
  \[\theta^D_t = \theta^D_{t-1} + (1 - \theta^D_{t-1}) \left( e_t + \left( \theta^D_{t-1} + \theta^X_{t-1} \right) i^D_t \right) \]
  - entry and domestic innov.
  - on exporting and foreign lines
  \[ - \theta^D_{t-1} \left( i^X_t + i^F \right) \]
  - exporting and foreign innov.
  - on domestic lines

- **Share of exporting lines (extensive margin of export):**
  \[\theta^X_t = \theta^X_{t-1} + \theta^D_{t-1} i^X_t \]
  - exporting innov.
  \[ - \theta^X_{t-1} \left( e_t + \left( \theta^D_{t-1} + \theta^X_{t-1} \right) i^D_t + i^F \right) \]
  - entry, domestic and foreign innov.
  - on exporting lines

- **Share of importing lines (extensive margin of import):**
  \[1 - \theta^D_t - \theta^X_t\]
Growth in average productivity:

\[
\frac{A_{t+1}}{A_t} = (1 + \sigma^D) e_t + (\theta^{D}_{t-1} + \theta^{X}_{t-1}) i^D_t (1 + \sigma^X) \theta^{D}_{t-1} i^{HX}_{t} (1 + \sigma^X) i^F
\]

Replacement rate:

\[
d_t = (\theta^{D}_{t-1} + \theta^{X}_{t-1}) i^D_t + e_t + i^F
\]

Asset and labor allocations:

\[
1 = \theta^{D}_{t-1} \ell^D_t + \theta^{X}_{t-1} \left( \ell^X_t + \ell^*_t \right)
\]

\[
H_t = \theta^{D}_{t-1} h^D_t + \theta^{X}_{t-1} \left( h^X_t + h^*_t \right) + H^N_t
\]
Maximization problem:

$$\max_{\{C^T_t, C^N_t, H_t, Z^E_t\}_{t=0}^\infty} E_0 \sum_{t=0}^\infty \left[ \ln \left( C_t - A_t \frac{(H_t)^\omega}{\omega} \right) \right]$$

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

subject to

$$C^T_t + P_t C^N_t + Z^E_t = W_t H_t + \Pi^T_t + \Pi^N_t + \theta^D_t \left( \pi^D_t - Z^D_t - Z^X_t \right) + \theta^X_{t-1} \left( \pi^X_t + \pi^*_t - Z^D_t \right)$$

FOCs:

$$\frac{C^T_t}{C^N_t} = \frac{\gamma}{1 - \gamma} (P^N_t)^\varepsilon$$

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

and \( \lambda_t \) is given by:

$$\lambda_t = \frac{1}{C_t - A_t (H_t)^{\omega}/\omega} \left( \gamma \frac{C_t}{C^T_t} \right)^{1/\varepsilon}$$
\[
TB_t = Y_t^T - C_t^T - Z_t^E - \theta_{t-1}^D \left( Z_t^D + Z_t^X \right) - \theta_{t-1}^X Z_t^D
\]

\[
\text{final tradable output - absorption}
\]

\[\quad + \quad \theta_{t-1}^X Y_t^* \quad - \quad \left( 1 - \theta_{t-1}^D - \theta_{t-1}^X \right) \frac{Y_t^T}{1 + \phi \mu_t / \lambda_t}
\]

\[
\text{export of intermediate goods}
\]

\[
\text{import of intermediate goods}
\]

\[
CA_t = TB_t + \left( \exp(\varepsilon_t^R) R - 1 \right) B_{t-1} = B_t - B_{t-1}
\]
<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Source</th>
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<tr>
<td>$\beta$</td>
<td>0.96</td>
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<td>$R$</td>
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<td>$\gamma$</td>
<td>0.31</td>
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<td>$\varepsilon$</td>
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<tr>
<td>$\omega$</td>
<td>1.455</td>
<td>Mendoza (1991)</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.3</td>
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<tr>
<td>$1 - \alpha^N$</td>
<td>0.75</td>
<td>Schmitt-Grohe &amp; Uribe (2016)</td>
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<td>$\zeta$</td>
<td>0.21</td>
<td>Anderson &amp; van Wincoop (2004)</td>
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<td>$\phi$</td>
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<tr>
<td>$\kappa$</td>
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<td>Mendoza (2010)</td>
</tr>
<tr>
<td>$\rho$</td>
<td>2</td>
<td>Akcigit &amp; Kerr (2015)</td>
</tr>
<tr>
<td>$i^F$</td>
<td>0.01</td>
<td>small contribution of foreign</td>
</tr>
</tbody>
</table>
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