Sudden Stops, Sectoral Reallocations, and Real Exchange Rates

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What Happens During a Sudden Stop?  
Mexico 1994-95

Opens to capital flows: late 1980s
- trade deficits
- real exchange rate appreciation

Sudden stop: 1994-95
- trade surplus
- real exchange rate depreciation
- reallocation from nontraded goods to traded goods
- fall in GDP, TFP

End of sudden stop
- trade deficits
- real exchange rate appreciation
- recovery of GDP, TFP
Mexico: trade balance

share of GDP (%)

Candidate Explanations

- labor hoarding
- variable capital utilization

Growth Accounting Discipline

Measured TFP must decline!
Our model

• Small open economy
  ○ multisector: traded, nontraded
  ○ costly to adjust labor across sectors

• Sudden stop
  ○ tradable good price increase, increase production
  ○ capital and labor misallocated

• Model accounts for:
  ○ real exchange rate, relative prices
  ○ trade balance

• Misses:
  ○ TFP, GDP
Model overview

- Growth model: small open economy

- Nontraded good, $y_N$, and domestic traded good, $y_D$
  - production use intermediates, capital, and labor

- Composite traded $y_{Tt} = f(y_{Dt}, m_t)$

- Frictions:
  - costly to move labor across sectors

- Quantitative model
Consumers

\[
\max \sum_{t=1980}^{\infty} \beta^t u_t(c_{Tt}, c_{Nt}, \ell_t)
\]

s.t. \( p_{Tt} c_{Tt} + p_{Nt} c_{Nt} + q_t i_t + b_{t+1} = w_t \ell_t + (1 + r_t) b_t + r_t k_t + T_t, \)

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

initial conditions on \( k_{1988}, b_{1988} \)

where

\[
u_t(c_{Tt}, c_{Nt}, \ell_t) = \frac{1}{\psi} \left( \left( \frac{c_{Tt}}{n_t} \right)^\rho + (1 - \varepsilon) \left( \frac{c_{Nt}}{n_t} \right)^\rho \right) \frac{\eta \psi}{\rho} \left( \frac{\ell_t - \ell_t}{\ell_t} \right)^{(1-\eta)\psi} - 1 \right).
\]
We also experiment with a quasi-linear utility function

\[
u(c_{Tt}, c_{Nt}, \ell_t) = \frac{1}{\psi} \left[ \left( \varepsilon \left( \frac{c_{Tt}}{n_t} \right)^\rho + (1 - \varepsilon) \left( \frac{c_{Nt}}{n_t} \right)^\rho \right)^{\frac{1}{\rho}} - \lambda g^t \left( \frac{\ell_t}{\ell_t} \right)^\eta \right]^\psi - 1 \right].
\]

which, when \( \psi = 0 \), is

\[
u(c_{Tt}, c_{Nt}, \ell_t) = \log \left[ \left( \varepsilon \left( \frac{c_{Tt}}{n_t} \right)^\rho + (1 - \varepsilon) \left( \frac{c_{Nt}}{n_t} \right)^\rho \right)^{\frac{1}{\rho}} - \lambda g^t \left( \frac{\ell_t}{\ell_t} \right)^\eta \right].
\]

No income effects on labor supply.
Production functions

Domestically produced traded good

\[ y_{Dt} = \min \left[ \frac{z_{TDt}}{a_{TD}}, \frac{z_{NDt}}{a_{ND}}, A_D k_{Dt}^{\alpha_D} \left( g^t \ell_{Dt} \right)^{1-\alpha_D} \right] - \Theta_{Dt} \left( \ell_{Dt-1}, \ell_{Dt} \right) \ell_{Dt-1} \]

where \( \Theta_{Dt} \left( \ell_{Dt-1}, \ell_{Dt} \right) = g^t \theta_D \left( \frac{\ell_{Dt} - \ell_{Dt-1}}{\ell_{Dt-1}} \right)^2 \)

Nontraded good

\[ y_{Nt} = \min \left[ \frac{z_{TNt}}{a_{TN}}, \frac{z_{NNt}}{a_{NN}}, A_N k_{Nt}^{\alpha_N} \left( g^t \ell_{Nt} \right)^{1-\alpha_N} \right] - \Theta_{Nt} \left( \ell_{Nt-1}, \ell_{Nt} \right) \ell_{Nt-1} \]

where \( \Theta_{Nt} \left( \ell_{Nt-1}, \ell_{Nt} \right) = g^t \theta_N \left( \frac{\ell_{Nt} - \ell_{Nt-1}}{\ell_{Nt-1}} \right)^2 \)

Base case sets \( \Theta_{Dt} \left( \ell_{Dt-1}, \ell_{Dt} \right) = \Theta_{Nt} \left( \ell_{Nt-1}, \ell_{Nt} \right) = 0 \).
Composite traded good (Armington aggregator)

\[ y_{Tt} = M \left( \mu x_{Dt}^{\zeta} + (1 - \mu) m_t^{\zeta} \right)^{\frac{1}{\zeta}} \]

Foreign demand

\[ x_{Ft} = D_t \left( (1 + \tau_{Ft}) p_{Tt} \right)^{\frac{1}{1-\zeta}} \]

Investment good

\[ i_{Dt} + i_{Nt} = G z_T^\gamma z_T^{1-\gamma} \]

\[ k_{Dt+1} = i_{Dt} + (1 - \delta) k_{Dt} \]

\[ k_{Nt+1} = i_{Nt} + (1 - \delta) k_{Nt} \]

Balance of payments

\[ b_{t+1} - (1 + r_t)b_t = p_{Tt} x_{Ft} - m_t \]

Market clearing.
Exogenous processes

• Country interest rate premia, $\sigma_{t}^{\text{mex}}$

  1. with access to international capital

     \[ r_{t}^{\text{mex}} = r^{\cdot} + \sigma_{t}^{\text{mex}} \]

  2. without access to international capital

     $r_{t}^{\text{mex}}$ is domestically determined

• Adult equivalent populations, $n_{t}$, and working age population, $\ell_{t}$

• Mexican tariff rates, $\tau_{Dt}$, and world tariff rates, $\tau_{Ft}$
Calibration

Rest of world is U.S.
- 60% of foreign direct investment from U.S. (1988-2000)
- \( r^* = 0.04 \Rightarrow \beta \)

Elasticities
- traded versus nontraded consumption: 0.5 (Kravis, et al.)
- intertemporal elasticity: 0.5
- domestic traded versus imports: 2.0

Labor Adjustment \((\theta_D = \theta_N)\)
- labor shift from sudden stop: 6.7%
Calibration continued

Set $\delta = 0.06$ so that $\delta K_{1988} / Y_{1988} = 0.11$

Normalize prices in 1988 to 1

1988 Mexican input-output matrix
- share parameters: $a_{TD}, a_{ND}, a_{TN}, a_{NN}, \alpha_D, \alpha_N, \varepsilon, \mu$
- scale parameters: $A_D, A_N, M, D$

Interest rate in 1988: $r_{1988}^{mex} = 0.1574$

Tax on capital income in 1989 to match 1988 investment:
- $\tau_{K1989} = 0.20$

Exogenous growth:
- $g = 1.02$
### 1988 Input-Output Matrix

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Input</th>
<th>Final Demand</th>
<th>Total Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Traded</td>
<td>Nontraded</td>
<td>Total int. demand</td>
</tr>
<tr>
<td>Traded</td>
<td>33.54</td>
<td>9.28</td>
<td>42.82</td>
</tr>
<tr>
<td>Nontraded</td>
<td>13.13</td>
<td>20.53</td>
<td>33.66</td>
</tr>
<tr>
<td>Total intermediate consumption</td>
<td>46.67</td>
<td>29.81</td>
<td>76.48</td>
</tr>
<tr>
<td>Employee compensation</td>
<td>22.11</td>
<td>38.74</td>
<td>60.85</td>
</tr>
<tr>
<td>Return to capital</td>
<td>10.79</td>
<td>26.51</td>
<td>37.30</td>
</tr>
<tr>
<td>Value added</td>
<td>32.89</td>
<td>65.26</td>
<td>98.15</td>
</tr>
<tr>
<td>Imports</td>
<td>18.54</td>
<td>0.00</td>
<td>18.54</td>
</tr>
<tr>
<td>Tariffs</td>
<td>1.85</td>
<td>0.00</td>
<td>1.85</td>
</tr>
<tr>
<td><strong>Total Gross Output</strong></td>
<td><strong>99.96</strong></td>
<td><strong>95.06</strong></td>
<td><strong>195.02</strong></td>
</tr>
</tbody>
</table>

\[
a_{TN} = \frac{z_{TN1988}}{y_{N1988}} = \frac{\text{intermediate input traded}}{\text{gross output nontraded}} = \frac{9.28}{95.06} = 0.10
\]

\[
\mathcal{w}_{1988} = 1 \Rightarrow \ell_{D1988} = 22.11, \ell_{N1989} = 38.74
\]
## Calibration of model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Statistic</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consumer parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$b_{1988}$</td>
<td>-8.831</td>
<td>Trade balance to GDP in 1988, in percent</td>
<td>1.390</td>
</tr>
<tr>
<td>$k_{1988}$</td>
<td>169.817</td>
<td>Real interest rate in 1988, in percent</td>
<td>15.740</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.987</td>
<td>U.S. real interest rate, in percent</td>
<td>4.000</td>
</tr>
<tr>
<td>$\epsilon$</td>
<td>0.234</td>
<td>Traded good share in consumption in 1988</td>
<td>0.356</td>
</tr>
<tr>
<td>$\rho$</td>
<td>-1.000</td>
<td>Elasticity of substitution: traded to nontraded</td>
<td>0.500</td>
</tr>
<tr>
<td>$\eta$</td>
<td>0.306</td>
<td>Ratio of hours worked to available hours in 1988</td>
<td>0.267</td>
</tr>
<tr>
<td>$\psi$</td>
<td>-1.000</td>
<td>Intertemporal elasticity of substitution</td>
<td>0.500</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.062</td>
<td>Depreciation to GDP in 1988, in percent</td>
<td>10.566</td>
</tr>
<tr>
<td>$\tau_{K1989}$</td>
<td>0.201</td>
<td>Investment in 1988</td>
<td>22.561</td>
</tr>
<tr>
<td><strong>Producer parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$a_{TD}$</td>
<td>0.422</td>
<td>Share of traded inputs in domestic traded in 1988</td>
<td>0.422</td>
</tr>
<tr>
<td>$a_{ND}$</td>
<td>0.165</td>
<td>Share of nontraded inputs in domestic traded in 1988</td>
<td>0.165</td>
</tr>
<tr>
<td>$a_{TN}$</td>
<td>0.098</td>
<td>Share of traded inputs in domestic nontraded in 1988</td>
<td>0.098</td>
</tr>
<tr>
<td>$a_{NN}$</td>
<td>0.216</td>
<td>Share of nontraded inputs in domestic nontraded in 1988</td>
<td>0.216</td>
</tr>
<tr>
<td>$A_D$</td>
<td>2.770</td>
<td>Traded gross output in 1988</td>
<td>79.564</td>
</tr>
<tr>
<td>$A_N$</td>
<td>1.546</td>
<td>Nontraded gross output in 1988</td>
<td>95.065</td>
</tr>
<tr>
<td>$\alpha_D$</td>
<td>0.328</td>
<td>Capital’s share of domestic traded value added in 1988</td>
<td>0.328</td>
</tr>
</tbody>
</table>
### Trade parameters

| $\alpha_N$ | 0.406 | Capital’s share of nontraded value added in 1988 |
| $\gamma$   | 0.450 | Share of traded inputs in investment good production in 1988 |
| $G$        | 1.990 | Investment in 1988 |
| $g$        | 1.020 | Growth rate of U.S. GDP per working age person, percent |

| $M$       | 1.866 | Total traded goods in 1988 |
| $\mu$     | 0.653 | Ratio of imports to domestic traded good in 1988 |
| $\zeta$   | 0.500 | Elasticity of substitution: domestic traded to imports |
| $D_{1988}$| 21.141| Exports in 1988 |

### Time series of parameters

| $\bar{\ell}_t$ | Mexican working age population data and projections |
| $n_t$          | Mexican adult equivalent population data and projections |
| $\sigma_t$     | Mexican interest premia |
| $D_t$          | U.S. working age population data and projections |
| $\tau_t$       | Mexican tariffs on U.S. imposts |
| $\tau_{Fi}$    | U.S. tariffs on Mexican imports |
Model without sudden stop

Trade balance (left scale)

Capital-output ratio (right scale)
Sudden stop!

\[ b_t = b_{t-1}, \quad t = 1995, 1996 \]

- agents do not foresee sudden stop
- agents do foresee length of sudden stop
- domestic interest rate is endogenously determined
- interest payments on foreign debt made at
  \[ r_{1994}^{mex} = r^* + \sigma_{1994}^{mex} \]
Trade balance

Data

Model

percent GDP

Terms of trade

index (1994 = 100)


RER^T data
Model
Tot data
Output and TFP

index (1994 = 100)


GDP/N model
TFP model
TFP data
GDP/N data
Value added by sector

Traded data

Traded model

Nontraded data

Nontraded model

index (1994 = 100)

160
140
120
100
80
60
40
396x92
375x514
212x103
156x103
268x103
325x103
381x103
437x112
493x112
517x124
111x291
191x445
Alternative specifications

• no population growth

• no tariffs

• no interest rate premia

• exogenous TFP drop

• increase in foreign demand in 1995 to moderate deterioration in terms of trade

• labor market frictions

• variable capital utilization

• quasi-linear period utility

• perfect foresight — sudden stop is not a surprise
Variable capital utilization

- law of motion

\[
    k_{Dt+1} = (1 - \delta(u_{Dt})) k_{Dt} + i_{Dt} \\
    k_{Nt+1} = (1 - \delta(u_{Nt})) k_{Nt} + i_{Nt}
\]

where

\[
    \delta(u) = \bar{\delta} + \chi \left( u^o - 1 \right)
\]

- during crisis utilization of nontradable capital falls
- standard growth accounting:

    falling utilization = falling TFP
TFP drop as exogenous

- robustness check: TFP drops **DO NOT** cause sudden stops

\[ y_{D\tau} = \min \left[ z_{TD\tau} / a_{TD}, z_{ND\tau} / a_{ND}, A_D k_{D\tau}^{\alpha_D} \left( (v_{\tau} \gamma)^{\tau} \ell_{D\tau} \right)^{1-\alpha_D} \right] - \Theta_D (\ell_{Dt-1}, \ell_{Dt}) \ell_{Dt-1} \]

\[ y_{N\tau} = \min \left[ z_{TN\tau} / a_{TN}, z_{NN\tau} / a_{NN}, A_N k_{N\tau}^{\alpha_N} \left( (v_{\tau} \gamma)^{\tau} \ell_{N\tau} \right)^{1-\alpha_N} \right] - \Theta_N (\ell_{Nt-1}, \ell_{Nt}) \ell_{Nt-1}. \]

\[ v_t = \begin{cases} 1.0 & t < 1995 \\ 0.89 & t \geq 1995 \end{cases} \]

- All else same
Increase in foreign demand in 1995 to moderate deterioration in terms of trade
Terms of trade

Model

Data

index (1994 = 100)
Real exchange rate

![Graph showing real exchange rate trends with labels for RER data, RER$^N$ model, and RER$^N$ data. The x-axis represents years from 1988 to 2000, and the y-axis represents the log of the real exchange rate.]

- RER data
- RER$^N$ model
- RER$^N$ data
Labor market frictions and variable capital utilization
Output and TFP

GDP/N data

TFP data

TFP model

GDP/N model
Capital utilization by sector

Traded

Nontraded
Exogenous TFP drop and quasi-linear period utility
Why doesn’t the deterioration in the terms of trade cause TFP and real GDP to fall?

Kehoe and Ruhl (2008), “Are Shocks to the Terms of Trade Shocks to Productivity?”
International trade as a production technology

Inputs are exports and outputs are imports.

\[ p_t M_t = X_t \quad \Rightarrow \quad M_t = \frac{1}{p_t} X_t \]

A deterioration in the terms of trade (an increase in \( p_t \)) acts as a productivity shock.
International trade as a production technology

Inputs are exports and outputs are imports.

\[ p_t M_t = X_t \implies M_t = \frac{1}{p_t} X_t \]

A deterioration in the terms of trade (an increase in \( p_t \)) acts as a productivity shock.

Or does it?