Equilibrium Sovereign Default with Endogenous Exchange Rate Depreciation

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Stylized Facts

- Countries default (250 default episodes, 106 countries, since 1824, according to Tomz(2007)).
Stylized Facts

- Countries default.
- After default, country’s currency is depreciating (De Paoli and Hoggarth (2006)).
Stylized Facts: Currency Depreciates

Paraguayan Default

Foreign Currency/Home(normalized)

2002 2003

NEER

REER

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Stylized Facts: Currency Depreciates

Ukrainian Default

Foreign Currency/Home (normalized)

1998 1999

NEER
REER

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## Defaults Examples

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Δ rGDP</th>
<th>Δ log LCU/USD</th>
<th>REER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ukraine</td>
<td>1998</td>
<td>0.05%</td>
<td>59.32%</td>
<td>78.88%</td>
</tr>
<tr>
<td>Argentina</td>
<td>2001</td>
<td>-10.56%</td>
<td>30.20%</td>
<td>84.70%</td>
</tr>
<tr>
<td>Paraguay</td>
<td>2003</td>
<td>0.38%</td>
<td>86.72%</td>
<td>91.17%</td>
</tr>
<tr>
<td>Egypt</td>
<td>1984</td>
<td>2.67%</td>
<td>100%</td>
<td>71.16%</td>
</tr>
<tr>
<td>Russia</td>
<td>1998</td>
<td>-6.41%</td>
<td>27.66%</td>
<td>68.79%</td>
</tr>
</tbody>
</table>
Stylized Facts

- Countries default.
- After default, country’s currency is depreciating (De Paoli and Hoggarth (2006)).
- Is it because of purely monetary effects?

We want to show
- How and why default decision affects real exchange rate.
- How countries become more (or less) prone to default.
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We want to show

- How and why default decision affects real exchange rate.
- How countries become more (or less) prone to default.
Modeling The Default

We want: countries borrow up till threshold, default if borrowed too much.

- Bulow and Rogoff (1989): temporary exclusion from credit markets does not return acceptable borrowing.

All have no explanation for international trade.

- Tomz (2007): 40% of defaults are after positive income shocks.
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### Trade Disruptions

Note: Exchange rate listed as foreign goods per home currency unit. IMF’s IFS database; defaulters since 1975, as identified by Standard & Poor’s (2003) research report by Beers and Chambers.

<table>
<thead>
<tr>
<th>Gross change</th>
<th>NEER</th>
<th>REER</th>
<th>Export Prices</th>
<th>I/Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.8492</td>
<td>0.8900</td>
<td>0.9184</td>
<td>0.8968</td>
</tr>
<tr>
<td>Median</td>
<td>0.9102</td>
<td>0.9220</td>
<td>0.9075</td>
<td>0.9211</td>
</tr>
<tr>
<td>Pr &lt; .2</td>
<td>0.6835</td>
<td>0.7861</td>
<td>0.8291</td>
<td>0.7773</td>
</tr>
<tr>
<td>Pr &lt; .4</td>
<td>0.8729</td>
<td>0.8688</td>
<td>0.8984</td>
<td>0.8978</td>
</tr>
<tr>
<td>Pr &lt; .6</td>
<td>0.9505</td>
<td>0.9429</td>
<td>0.9269</td>
<td>0.9436</td>
</tr>
<tr>
<td>Pr &lt; .8</td>
<td>1.0168</td>
<td>0.9755</td>
<td>1.0068</td>
<td>1.0070</td>
</tr>
</tbody>
</table>

**Table:** One year effect of sovereign default.
Default Disrupts Trade

- Rose (2005): default reduces international trade volume by 8%.
- Arteta and Hale (2008): private firms cannot find international credit.

In the 1861 Mexican default, creditors actually seized the port of Veracruz (see Todd (1991)).
- Hummels (2001): a day of procrastination adds 1% to real costs.
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Income penalty is not enough.

Let’s use terms of trade penalty.
The World

- Country is represented by an infinitely-lived agent.
- Every period, agent has
  - $y$ - endowment for this period.
  - $b$ - borrowed amount that agent needs to repay.
  - status of "being punished" or not.
- Agent chooses whether to default on total borrowed amount or not.
- If agent defaults, he or she
  - cannot borrow
  - gets less import for his or her export
  - stays punished next period with probability $\phi$
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How People Trade?

- Agent has home production.
- Other countries like it.
- Agent trades home production for production of abroad (import).

\[ m = f(x) \]

- If agent defaults, he or she has worse terms of trade.

\[ m = (1 - \pi)f(x) \]
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How Penalty Affects Exchange Rate?

Normal Trade
Penalized

Imports
Disposable Income

Domestic Goods
The Model - Don’t Default

\[ U(y, b) = \max(V(y, b), W(y)) \]

\[ V(y, b) = \max_{c, b', m, x} u(c, m) + \beta EU(y', b') \]

s.t.

\[ c + x = y - b + q(y, b')b' \]

\[ m = f(x) \]

\[ \ln y' = \rho \ln y + \epsilon, \quad \epsilon \sim \mathcal{N}(0, s^2) \]
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The Model - Default

\[ U(y, b) = \max(V(y, b), W(y)) \]

\[ W(y) = \max_{c, x, m} u(c, m) + \beta E \left( \phi W(y') + (1 - \phi) EU(y', 0) \right) \]

s.t.

\[ c + x = y \]

\[ m = (1 - \pi) f(x) \]

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s.t.

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c + x = y \]

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The Model - Borrowing

- There is an infinite supply of lending.
- It has interest rate of $R$.
- Lenders have to account for probability of default.

Default-adjusted coupon on debt is

$$q(y, b') = \frac{P_{y'|y}(V(y', b') > W(y'))}{1 + R}$$
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The Model - Outcome

- If borrowed too much — default.
- If borrowed too much — have to pay higher rate.
- Trade in default is not zero.
- Home currency has to depreciate after default.
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The Model - Outcome

- If borrowed too much — default.
- If borrowed too much — have to pay higher rate.
- Trade in default is not zero.
- Home currency has to depreciate after default.
We got the model.

Let’s calibrate.
### Base Parameters

Arellano (2007) calibrations and regressions:

<table>
<thead>
<tr>
<th>Name</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk aversion</td>
<td>$\sigma$</td>
<td>2</td>
</tr>
<tr>
<td>Risk-free interest</td>
<td>$R$</td>
<td>0.017</td>
</tr>
<tr>
<td>Autocorrelation</td>
<td>$\rho$</td>
<td>0.985</td>
</tr>
<tr>
<td>Variance</td>
<td>$\eta$</td>
<td>0.026</td>
</tr>
<tr>
<td>Discount factor</td>
<td>$\beta$</td>
<td>0.953</td>
</tr>
<tr>
<td>Prob of staying punished</td>
<td>$\phi$</td>
<td>0.718</td>
</tr>
</tbody>
</table>

Utility function is CRRA of CES aggregate.
Our Import-Export Mechanism

Aggregate consumption is

\[ u(c, m) = (\alpha c^\kappa + (1 - \alpha) m^\kappa)^{1/\kappa} \]

Based on INDEC and European Bank data, regressions of Argentina time series:

<table>
<thead>
<tr>
<th>Name</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative preference</td>
<td>(\alpha)</td>
<td>0.586</td>
</tr>
<tr>
<td>Elasticity parameter</td>
<td>(\kappa)</td>
<td>0.845</td>
</tr>
</tbody>
</table>
Our Import-Export Mechanism

Production function is

\[ m = \theta_1 (x - \theta_0)^\theta \]

Based on INDEC and European Bank data, regressions of Argentina time series:

<table>
<thead>
<tr>
<th>Name</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed costs</td>
<td>(\theta_0)</td>
<td>0.047</td>
</tr>
<tr>
<td>Scale</td>
<td>(\theta_1)</td>
<td>0.196</td>
</tr>
<tr>
<td>Curvature</td>
<td>(\theta)</td>
<td>0.208</td>
</tr>
<tr>
<td>Import penalty</td>
<td>(\pi)</td>
<td>0.500</td>
</tr>
</tbody>
</table>
Predictions: Countercyclical Exchange Rate

- Blue line: Good standing
- Green line: Default

**Graph Details:**
- **Y-axis:** Exchange rate, level
- **X-axis:** y
- Points on the Y-axis:
  - 0.95
  - 0.9
  - 0.95
  - 1.0
  - 1.1
  - 1.2
  - 1.3
- Points on the X-axis:
  - 0.5
  - 1.0
  - 1.5
  - 2.0

**Data Points:**

<table>
<thead>
<tr>
<th>y</th>
<th>Exchange Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0.95</td>
</tr>
<tr>
<td>1.0</td>
<td>1.05</td>
</tr>
<tr>
<td>1.5</td>
<td>1.15</td>
</tr>
<tr>
<td>2.0</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Authors:
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Institution:
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Predictions: Countercyclical Capital Account

The graph shows the relationship between the current account, level and y. The line labeled 'Good standing' indicates a positive relationship, while the line labeled 'Default' shows a negative relationship.

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Penalty: Borrowing Threshold

\[ \pi = 0.2 \]
\[ \pi = 0.5 \]
\[ \pi = 0.8 \]
Penalty: Borrowing Threshold

\[ \pi = 0.2 \]
\[ \pi = 0.5 \]
\[ \pi = 0.8 \]

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**Penalty: Exchange Rates**

![Graph showing exchange rate depreciation](graph.png)

- For $\pi = 0.2$, the exchange rate depreciation is approximately 1.05.
- For $\pi = 0.5$, the exchange rate depreciation is approximately 1.15.
- For $\pi = 0.8$, the exchange rate depreciation is approximately 1.25.

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Penalty: Consumption

Before default

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Penalty: Consumption of Imports

$\pi = 0.2$
$\pi = 0.5$
$\pi = 0.8$

Before default

expenditure on imported good, fraction of $y$, after default

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Penalty: Trade Balance

\[ \pi = 0.2 \]
\[ \pi = 0.5 \]
\[ \pi = 0.8 \]

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Penalty: Capital Account

\[ \pi = 0.2 \]
\[ \pi = 0.5 \]
\[ \pi = 0.8 \]

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We capture the depreciation.

What if we got some parameters wrong?
Comparative Statics: Limits

- Benchmark
- $\alpha$ smaller
- $s^2$ bigger
- $\phi$ bigger

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Comparative Statics: Exchange Rates

The graph illustrates the exchange rate depreciation due to default. Different lines represent variations in parameters: Benchmark (blue), $\alpha$ smaller (green), $s^2$ bigger (cyan), and $\phi$ bigger (pink). The x-axis represents the variable $y$, and the y-axis shows the exchange rate depreciation.

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Comparative Statics: Consumption before default

- Consumption of domestic product, fraction of $y$, before default
- Benchmark
- $\alpha$ smaller
- $s^2$ bigger
- $\phi$ bigger

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Comparative Statics: Consumption after default

- Consumption of domestic product, fraction of $y$, after default

- Benchmark
- $\alpha$ smaller
- $s^2$ bigger
- $\phi$ bigger

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Comparative Statics: Trade Balance Change

Trade balance change, fraction of $y$

- Benchmark
- $\alpha$ smaller
- $s^2$ bigger
- $\phi$ bigger

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Comparative Statics: Capital Account Change

- $y$: Capital account change, fraction of $y$

- Benchmark
- $\alpha$ smaller
- $s^2$ bigger
- $\phi$ bigger

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Real reasons for exchange rate fluctuations are significant.

Our model is robust and transparent.

Predictions of statics are coherent with common sense.

Trade should not be forgotten about when modeling defaults, though credit links are also important.

What next?

Mixed models?

Inflation modeling?

Calibrate to moments of data?

Equity premium puzzle consequences?

Exiting punishment state?