A GENERAL EQUILIBRIUM MODEL OF SOVEREIGN DEFAULT AND BUSINESS CYCLES

ENRIQUE G. MENDOZA
AND
VIVIAN Z. YUE
Key Stylized Facts of Sovereign Default

1. **V-shaped output dynamics around default episodes**
   Deep recessions. Most defaults with output 7% below trend

2. **Countercyclical interest rates**
   Average correlations between spreads and GDP: -0.5

3. **Foreign debt/GDP ratios high on average and before default**
   Average: 1/3. After defaults: 2/3
Argentina’s Business Cycles and Sovereign Bond Spread
Cyclical Dynamics Around Default Events

a. GDP

b. Consumption

c. Trade Balance/GDP

d. Imported Intermediate Goods

Median  Mean  One Std. Error Band
Cyclical Dynamics Around Default Events

e. Intermediate Goods

f. Labor

g. Interest Rate

h. Debt/GDP

- Year
- Quarter
- Percentage Point
- Percent

Median
Mean
One Std. Error Band
The Disconnect between Default & Business Cycle Theories

- Business cycle models with working capital constraint take as given country interest rates
  Match Fact No. 2 and generate higher output volatility
  ...but country spreads are unexplained
  ...cannot account for Fact No. 1 and No. 3
  ...entire wages bill needs to be paid in advance
  - Neumeyer & Perri (05), Uribe & Yue (06), Oviedo (05)
The Disconnect between Default & Business Cycle Theories

- Eaton-Gersovitz sovereign default models
  Match Fact No. 2
  ....but output is an endowment with ad-hoc default costs
  ...cannot explain Fact No. 1
  ...cannot account for Fact No. 3 with proportional output cost or Fact No. 1 with asymmetric output cost

- Aguiar & Gopinath (06), Arellano (08), Bi (08), D’Erasmo (08), Bai and Zhang (09), Hatchondo, Martinez & Sapriza (09), Arellano & Ramanarayanan (09), Benjamin & Wright (09), Chatterjee & Eyigungor (09), Yue (10), Cuadra, Sanchez & Sapriza (10), Durdu, Nunes & Sapriza (10)...
Percent Output Cost of Default - Comparison

- Proportional cost (Aguiar and Gopinath 2006, Yue 2010):
  
  \[ y_t^{def} = \lambda y_t. \]

- Asymmetric cost (Arellano 2008):
  
  \[ y_t^{def} = y_t \text{ if } y_t \leq \lambda E[y]; \quad y_t^{def} = \lambda E[y] \text{ if } y_t > \lambda E[y]. \]

Percentage of output cost of default \( h(y_t) = \ln(y_t) - \ln(y_t^{def}) \)
This Paper

- Default model with endogenous output dynamics
  - Continuum of Imported Input Varieties
  - A fraction of imported inputs requires working capital
  - Domestic inputs are imperfect substitutes and require labor reallocation
  - Default triggers exclusion for government and firms
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\[
\text{Interest rate/Default} \rightarrow \text{Output} \quad \uparrow \quad \downarrow \\
\text{Sovereign default risk}
\]
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\[
\text{Interest rate/Default} \rightarrow \text{Output}
\]
\[
\uparrow \quad \downarrow
\]
\[
\text{Sovereign default risk}
\]

Default causes efficiency loss and an output cost increasing in state of TFP
This Paper

- Quantitative analysis calibrated to Argentina shows that the model produces:
  - Countercyclical spreads and key business cycle statistics
  - Dynamics of GDP and bond spreads around default
  - High debt/GDP ratios on average and at default
  - Strong financial amplification of TFP shocks during default events
Basic Model: Production and Working Capital

- Final goods production technology

\[ y = \varepsilon M^{\alpha_m} L^{\alpha_l} k^{\alpha_k} \]

- Armington aggregator of imported and domestic inputs (imperfect substitutes, \( 0 < \mu < 1 \))

\[ M_t = \left[ \lambda \left( m_t^d \right)^\mu + (1 - \lambda) (m_t^*)^\mu \right]^{1/\mu}, \quad m_t^* \equiv \left[ \int_{j\in[0,1]} (m_{jt}^*)^\nu \, dj \right]^{1/\nu} \]
Basic Model: Production and Working Capital

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- A subset \([0, \theta]\) of imported inputs requires working capital \( \kappa \) borrowed abroad.

\[ \frac{\kappa_t}{1 + r_t^*} \geq \int_0^\theta p_j^* m_j^* dj \]

- Domestic intermediate goods do not require working capital but need to be produced hiring domestic labor \( (m = AL_m^\gamma) \).
Producers’ Problems

- Competitive producers take all prices and factor costs as given
- Final goods sector

\[ \pi^f_t = \epsilon_t (M_t)^{\alpha_M} (L^f_t)^{\alpha_L} k^{\alpha_k} - \int_0^1 p^*_j m^*_j dj - r^*_t \int_\theta^0 p^*_j m^*_j dj - p^m_t m^d_t - w_t L^f_t. \]
Producers’ Problems

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\[ \pi_t^f = \varepsilon_t \left( M_t \right)^{\alpha_M} \left( L_t^f \right)^{\alpha_L} k^{\alpha_k} - \int_0^1 p_j^* m_{jt}^* \, dj - r_t^* \int_0^\theta p_j^* m_{jt}^* \, dj \]

\[ - p_t^m m_t^d - w_t L_t^f. \]

- The price of the Dixit-Stiglitz aggregator of imported inputs \( m_t^* \)

\[ P^* (r_t) = \left[ \int_0^1 \left( p_j^* \right)^{\frac{\nu}{\nu-1}} \, dj + \int_0^\theta \left( p_j^* \left( 1 + r_t^* \right) \right)^{\frac{\nu}{\nu-1}} \, dj \right]^{\frac{\nu-1}{\nu}}. \]
Producers’ Problems

- Competitive producers take all prices and factor costs as given
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\[ \pi_f^t = \varepsilon_t (M_t)^{\alpha_M} (L_t)^{\alpha_L} k^{\alpha_k} - \int_0^1 p_j^* m_{jt}^* dj - r_t^* \int_0^\theta p_j^* m_{jt}^* dj \]

\[ - p_t^m m_t^d - w_t L_t^f. \]

- The price of the Dixit-Stiglitz aggregator of imported inputs \( m_t^* \)

\[ P^* (r_t) = \left[ \int_0^\theta (p_j^*) \frac{v}{v-1} dj + \int_0^\theta (p_j^* (1 + r_t^*)) \frac{v}{v-1} dj \right]^{\frac{v-1}{v}}. \]

- Intermediate goods sector

\[ \pi_m = \max_{Lm} [p_m A L_m^\gamma - w L_m] \]
Households’ Problem

- Preference: GHH utility function

\[
\sum_{t=1}^{\infty} \beta^t \frac{(c_t - \frac{L_t}{\omega})^{1-\sigma}}{1 - \sigma} - 1
\]

- Static problem: given gov transfers \(T_t\), wages and profits

\[
\max_{c_t, L_t} \frac{(c_t - \frac{L_t}{\omega})^{1-\sigma}}{1 - \sigma} - 1
\]

\[s.t. \quad c_t = w_t L_t + \pi_{f,t} + \pi_{m,t} + T_t\]
Sovereign Debt Market

- Risk neutral foreign investors face world interest rate $r^*$. 
- Government issues one-period discount bonds with face values $b'$ and price $q(b', \varepsilon)$. Asset markets are incomplete.
- Gov. defaults if value of default exceeds value of repayment.
Sovereign Debt Market

- Risk neutral foreign investors face world interest rate $r^*$. 

- Government issues one-period discount bonds with face values $b'$ and price $q(b', \varepsilon)$. Asset markets are incomplete.

- Gov. defaults if value of default exceeds value of repayment.

- Default causes temporary exclusion from world credit markets (exogenous re-entry with probability $\eta$), affecting both consumption smoothing and access to imported inputs
  
  - *Implicit or explicit trade sanctions during defaults* (Kaletsky (1985), Bulow and Rogoff (1989), Rose (2005), Martinez and Sandleris (2008), Kohlscheen and O’Connell (2008))
Government’s Problem

Given $q(b', \varepsilon)$, the gov. solves a social planner’s problem

$$V(b, \varepsilon) = \max \left\{ v^{nd}(b, \varepsilon), v^d(\varepsilon) \right\}$$
Government’s Problem

Given \( q(b', \varepsilon) \), the gov. solves a social planner’s problem

\[
V(b, \varepsilon) = \max \left\{ V^{nd}(b, \varepsilon), V^d(\varepsilon) \right\}
\]

\[
V^{nd}(b, \varepsilon) = \max_{c, m^d, m^*, L^f, L^m, L, b'} \left[ u(c, L) + \beta EV(b', \varepsilon') \right]
\]

s.t. \( c + q(b', \varepsilon) b' - b \leq \varepsilon f \left( M, L^f, k \right) - m^* P^* (r^*) \)

\( L^f + L^m = L, \ A(L^m) \gamma = m^d, \ M = M \left( m^d, m^* \right) \)
Government’s Problem

Given $q(b', \varepsilon)$, the gov. solves a social planner’s problem

$$V(b, \varepsilon) = \max \left\{ v^{nd}(b, \varepsilon), v^d(\varepsilon) \right\}$$

$$v^d(\varepsilon) = \max_{c, m^d, m^*, L^f, L^m, L} \left[ u(c, L) + \beta(1 - \eta) E v^d(\varepsilon') + \beta \eta E V(0, \varepsilon') \right]$$

subject to

$$c + x = \varepsilon f(M, L^f, k) - m^* P^*$$

$$L^f + L^m = L, \quad A(L^m)^{\gamma} = m^d, \quad M = M\left(m^d, m^*\right)$$
Default Probability and Bond Pricing

Default set

\[ D(b) = \left\{ \varepsilon : \nu^{nd}(b, \varepsilon) \leq \nu^d(\varepsilon) \right\} \]

Default probability (two-dimensional default set)

\[ p(b', \varepsilon) = \int_{D(b')} d\mu(\varepsilon' | \varepsilon) \]
Default Probability and Bond Pricing

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Default probability (two-dimensional default set)

\[ p(b', \varepsilon) = \int_{D(b')} d\mu(\varepsilon' | \varepsilon) \]

Lenders’ no arbitrage conditions:

\[ q(b', \varepsilon) = \begin{cases} \frac{1}{1+r^*} & \text{if } b' \geq 0 \\ \frac{1-p(b', \varepsilon)}{1+r^*} & \text{if } b' < 0 \end{cases} \]
A recursive equilibrium is defined by: (i) decision rules \( b' (b, \varepsilon) \), value function \( V (b, \varepsilon) \) and default set \( D (b) \); and (ii) sovereign bonds price \( q (b', \varepsilon) \) such that:

1. Given \( q (b', \varepsilon) \), the sovereign government’s problem is solved;
2. Given \( D (b) \), the lender’s no arbitrage condition is satisfied.
Production Optimality Conditions

\[ \varepsilon F_{m^*} \left( m^*, m^d, L_f, \bar{k} \right) = P^* \left( r^* \right) \]

\[ \varepsilon F_{L_f} \left( m^*, m^d, L_f, \bar{k} \right) = w \]

\[ \varepsilon F_{m^d} \left( m^*, m^d, L_f, \bar{k} \right) = p^d_m \]

\[ p^d_m \gamma A L_m^{\gamma-1} = w \]

\[ w = \omega L^{\omega-1} \]

\[ L = L_f + L_m \]

\[ m_d = AL_m^\gamma \]
How does Default Cause Efficiency Loss in Production?

Channels

- **direct**: demand for $m^*$ falls with default
- **indirect**: $L_f, M$ fall
- **general equilibrium**: $L$ falls, $L_m, m^d$ rise or fall depending on gross substitutes or complements

Gopinath and Neiman (2010): evidence of drop in imported inputs within-firm in the Argentine debt crisis
How does Default Cause Efficiency Loss in Production?

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At default: firms use only $m^d$ and $m^*_j$, $j \in [\theta,1]$, causing efficiency loss because $m^d$ is imperfect substitute.

- Gopinath and Neiman (2010): evidence of drop in imported inputs within-firm in the Argentine debt crisis


## Effect of Default on Equilibrium Factor Allocations

<table>
<thead>
<tr>
<th></th>
<th>(I)</th>
<th>(II)</th>
<th>(III)</th>
<th>(IV)</th>
<th>(V)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Threshold</td>
<td>Cobb-Douglas</td>
<td>High</td>
<td>Inelastic</td>
</tr>
<tr>
<td>$\eta_{m^d,m^*}$</td>
<td>2.86, 1.96</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\eta_{m^*_j}$</td>
<td>2.44</td>
<td></td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>$M$</td>
<td>-11.36%</td>
<td>-21.90%</td>
<td>-40.72%</td>
<td>-3.08%</td>
<td>-9.61%</td>
</tr>
<tr>
<td>$m^*$</td>
<td>-90.64%</td>
<td>-81.59%</td>
<td>-68.21%</td>
<td>-30.38%</td>
<td>-90.46%</td>
</tr>
<tr>
<td>$m^d$</td>
<td>1.73%</td>
<td>0.01%</td>
<td>-13.65%</td>
<td>0.46%</td>
<td>3.73%</td>
</tr>
<tr>
<td>$L$</td>
<td>-2.77%</td>
<td>-7.11%</td>
<td>-19.12%</td>
<td>-0.73%</td>
<td>0.0%</td>
</tr>
<tr>
<td>$L^f$</td>
<td>-6.29%</td>
<td>-11.40%</td>
<td>-19.22%</td>
<td>-1.67%</td>
<td>-3.65%</td>
</tr>
<tr>
<td>$L^m$</td>
<td>2.48%</td>
<td>0.02%</td>
<td>-18.91%</td>
<td>0.65%</td>
<td>5.37%</td>
</tr>
</tbody>
</table>

(percent changes relative to a state with $r^* = 0.01$)
Output Cost of Default

Output Costs of Default as a Function of TFP Shock

- Output cost of default is increasing and strictly convex in TFP
- Output cost of default is higher and a steeper function of $\varepsilon$ at lower elasticities
- Debt provides more hedging. Model supports more debt.
Output Cost of Default

Output costs of default for a neutral TFP shock at different elasticities of substitution

Elasticity of substitution between foreign and domestic intermediate costs

Output Costs of Default at a Neutral TFP Shock
Labor Market Equilibrium

\[ L^D = L^D_f + L^D_m \]

Diagram showing the equilibrium in the labor market with the supply and demand curves intersecting at point A.
Effect of Default

\[ L^D = L^D + L^D \]

\[ \tilde{L}^D = \tilde{L}^D + L^D \]
Calibration: Parameters set using Data and RBC values

<table>
<thead>
<tr>
<th>Calibrated Parameters</th>
<th>Value</th>
<th>Target statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRRA risk aversion</td>
<td>$\sigma$</td>
<td>2</td>
</tr>
<tr>
<td>Risk-free interest rate</td>
<td>$r^*$</td>
<td>1%</td>
</tr>
<tr>
<td>Capital share</td>
<td>$\alpha_k$</td>
<td>0.17</td>
</tr>
<tr>
<td>Int. goods share</td>
<td>$\alpha_m$</td>
<td>0.43</td>
</tr>
<tr>
<td>Labor share</td>
<td>$\alpha_L$</td>
<td>0.40</td>
</tr>
<tr>
<td>Labor share</td>
<td>$\gamma$</td>
<td>0.7</td>
</tr>
<tr>
<td>Labor elasticity parameter</td>
<td>$\omega$</td>
<td>1.455</td>
</tr>
<tr>
<td>Re-entry probability</td>
<td>$\eta$</td>
<td>0.83</td>
</tr>
<tr>
<td>Armington weight in M</td>
<td>$\lambda$</td>
<td>0.62</td>
</tr>
<tr>
<td>Armington curvature in M</td>
<td>$\mu$</td>
<td>0.65</td>
</tr>
<tr>
<td>CES elasticity parameter</td>
<td>$\nu$</td>
<td>0.59</td>
</tr>
</tbody>
</table>
Calibration: Parameters set by SMM

<table>
<thead>
<tr>
<th>Estimated Parameters</th>
<th>Value</th>
<th>Targets from data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity persistence</td>
<td>$\rho_\varepsilon$</td>
<td>0.95</td>
</tr>
<tr>
<td>Productivity innovations std.</td>
<td>$\sigma_\varepsilon$</td>
<td>1.70%</td>
</tr>
<tr>
<td>Intermediate goods TFP</td>
<td>$A$</td>
<td>0.31</td>
</tr>
<tr>
<td>Subjective discount factor</td>
<td>$\beta$</td>
<td>0.88</td>
</tr>
<tr>
<td>Working capital parameter</td>
<td>$\theta$</td>
<td>0.70</td>
</tr>
<tr>
<td>Sensitivity of payment to IFOs</td>
<td>$\zeta$</td>
<td>-0.67</td>
</tr>
</tbody>
</table>

- Adjustment to account for capital outflows during default (repayments to IFOs)

$$x_t = \zeta \ln \varepsilon_t$$
Dynamics of Output **Before** and **After** Default Events

- Deep recession following default
- Gradual recovery after default
Default triggered by “typical” TFP shock -7.67% (≈1.3 std).
81% amplification in output drop due to default
Gradual recovery driven by TFP recovery and re-entry
## Business Cycle Moments

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Data</th>
<th>Model</th>
<th>Model w/o $x_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average debt/GDP ratio</td>
<td>35%</td>
<td>22.88%</td>
<td>21.34%</td>
</tr>
<tr>
<td>Average bond spreads</td>
<td>1.86%</td>
<td>0.74%</td>
<td>1.68%</td>
</tr>
<tr>
<td>Std. dev. of bond spreads</td>
<td>0.78%</td>
<td>1.23%</td>
<td>1.63%</td>
</tr>
<tr>
<td>Consumption std./GDP std.</td>
<td>1.44</td>
<td>1.05</td>
<td>1.05</td>
</tr>
<tr>
<td>Correlations with GDP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bond spreads</td>
<td>-0.62</td>
<td>-0.17</td>
<td>-0.21</td>
</tr>
<tr>
<td>trade balances</td>
<td>-0.87</td>
<td>-0.54</td>
<td>-0.31</td>
</tr>
<tr>
<td>labor</td>
<td>0.39</td>
<td>0.52</td>
<td>0.52</td>
</tr>
<tr>
<td>intermediate goods$^1$</td>
<td>0.90</td>
<td>0.99</td>
<td>0.99</td>
</tr>
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</table>
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</tr>
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<tbody>
<tr>
<td><strong>Correlations with bond spreads</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trade balances</td>
<td>0.82</td>
<td>0.15</td>
<td>0.12</td>
</tr>
<tr>
<td>labor$^1$</td>
<td>-0.42</td>
<td>-0.19</td>
<td>-0.26</td>
</tr>
<tr>
<td>intermediate goods$^1$</td>
<td>-0.39</td>
<td>-0.16</td>
<td>-0.18</td>
</tr>
<tr>
<td><strong>Historical default-output co-movements</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>correlation between default and GDP$^1$</td>
<td>-0.11$^2$</td>
<td>-0.09</td>
<td>-0.12</td>
</tr>
<tr>
<td>frac. of defaults with GDP below trend$^1$</td>
<td>61.5%$^2$</td>
<td>83%</td>
<td>82%</td>
</tr>
<tr>
<td>frac. of defaults with large recessions$^1$</td>
<td>32.0%$^2$</td>
<td>21.1%</td>
<td>20%</td>
</tr>
</tbody>
</table>

Note 1: Statistical moment computed at annual frequency.

Note 2: Cross-country historical estimate for 1820-2004 from Tomz and Wright (2007).
Macro Dynamics Around Default Events

a. GDP

b. Consumption

c. Trade balance/GDP

d. Imported intermediate goods

- Model Mean
- Error Band
- Argentina
- All-Country Median
Macro Dynamics Around Default Events

e. Intermediate Goods

f. Labor

g. Interest Rate

h. Debt/GDP*

- Model Mean
- Error Band
- Argentina
- All-Country Median
## Sensitivity Analysis

<table>
<thead>
<tr>
<th></th>
<th>Output drop at default</th>
<th>Mean Debt/GDP ratio</th>
<th>Mean spread</th>
<th>Std. dev of spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Data</td>
<td>13%</td>
<td>35%</td>
<td>1.86%</td>
<td>0.78%</td>
</tr>
<tr>
<td>(2) Baseline</td>
<td>13%</td>
<td>22.88%</td>
<td>0.74%</td>
<td>1.23%</td>
</tr>
<tr>
<td>Working capital</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) $\theta = 0$</td>
<td>13%</td>
<td>8.99%</td>
<td>0.05%</td>
<td>0.08%</td>
</tr>
<tr>
<td>(4) $\theta = 0.6$</td>
<td>13.9%</td>
<td>20.39%</td>
<td>0.59%</td>
<td>1.17%</td>
</tr>
<tr>
<td>(5) $\theta = 0.8$</td>
<td>14.3%</td>
<td>26.84%</td>
<td>0.61%</td>
<td>1.19%</td>
</tr>
<tr>
<td>Armington elasticity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armington elasticity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6) $2.63 \ (\mu = 0.62)$</td>
<td>14.6%</td>
<td>31.25%</td>
<td>0.55%</td>
<td>0.99%</td>
</tr>
<tr>
<td>(7) $3.10 \ (\mu = 0.68)$</td>
<td>12.9%</td>
<td>16.15%</td>
<td>1.14%</td>
<td>1.36%</td>
</tr>
<tr>
<td>Armington share</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8) $\lambda = 0.58$</td>
<td>17.20%</td>
<td>39.01%</td>
<td>0.28%</td>
<td>0.79%</td>
</tr>
<tr>
<td>(9) $\lambda = 0.66$</td>
<td>12.7%</td>
<td>14.16%</td>
<td>0.99%</td>
<td>1.42%</td>
</tr>
</tbody>
</table>
## Sensitivity Analysis

<table>
<thead>
<tr>
<th></th>
<th>GDP corr. with spread</th>
<th>GDP corr. with default</th>
<th>frequency of default w. GDP below trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Data</td>
<td>-0.62</td>
<td>-0.11</td>
<td>62%</td>
</tr>
<tr>
<td>(2) Baseline</td>
<td>-0.17</td>
<td>-0.09</td>
<td>83%</td>
</tr>
<tr>
<td>Working capital</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) $\theta = 0$</td>
<td>0.24</td>
<td>-0.02</td>
<td>75%</td>
</tr>
<tr>
<td>(4) $\theta = 0.6$</td>
<td>-0.11</td>
<td>-0.11</td>
<td>88%</td>
</tr>
<tr>
<td>(5) $\theta = 0.8$</td>
<td>-0.14</td>
<td>-0.10</td>
<td>84%</td>
</tr>
<tr>
<td>Armington elasticity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6) $2.63 (\mu = 0.62)$</td>
<td>-0.16</td>
<td>-0.09</td>
<td>90%</td>
</tr>
<tr>
<td>(7) $3.10 (\mu = 0.68)$</td>
<td>-0.11</td>
<td>-0.09</td>
<td>78%</td>
</tr>
<tr>
<td>Armington share</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8) $\lambda = 0.58$</td>
<td>-0.08</td>
<td>-0.04</td>
<td>83%</td>
</tr>
<tr>
<td>(9) $\lambda = 0.66$</td>
<td>-0.11</td>
<td>-0.08</td>
<td>77%</td>
</tr>
</tbody>
</table>
## Sensitivity Analysis

<table>
<thead>
<tr>
<th></th>
<th>Output drop at default</th>
<th>Mean Debt/GDP ratio</th>
<th>Mean spread</th>
<th>Std. dev of spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Data</td>
<td>13%</td>
<td>35%</td>
<td>1.86%</td>
<td>0.78%</td>
</tr>
<tr>
<td>(2) Baseline</td>
<td>13%</td>
<td>22.88%</td>
<td>0.74%</td>
<td>1.23%</td>
</tr>
<tr>
<td>Within-variety elasticity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10) $2.22 \ (\nu = 0.55)$</td>
<td>14.1%</td>
<td>25.83%</td>
<td>0.60%</td>
<td>1.17%</td>
</tr>
<tr>
<td>(11) $2.89 \ (\nu = 0.65)$</td>
<td>12.8%</td>
<td>19.81%</td>
<td>0.72%</td>
<td>1.22%</td>
</tr>
<tr>
<td>Frisch elasticity of labor supply</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(12) $1.67 \ (\omega = 1.6)$</td>
<td>12.8%</td>
<td>22.34%</td>
<td>0.91%</td>
<td>1.29%</td>
</tr>
<tr>
<td>(13) $2.5 \ (\omega = 1.4)$</td>
<td>14.3%</td>
<td>24.46%</td>
<td>0.45%</td>
<td>1.05%</td>
</tr>
<tr>
<td>Probability of re-entry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(14) $\phi = 0.05$</td>
<td>14.3%</td>
<td>37.02%</td>
<td>0.39%</td>
<td>0.88%</td>
</tr>
<tr>
<td>(15) $\phi = 0.1$</td>
<td>13.5%</td>
<td>19.78%</td>
<td>0.65%</td>
<td>1.21%</td>
</tr>
</tbody>
</table>
## Sensitivity Analysis

<table>
<thead>
<tr>
<th>Description</th>
<th>GDP corr. with spread</th>
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</thead>
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<tr>
<td>(1) Data</td>
<td>-0.62</td>
<td>-0.11</td>
<td>62%</td>
</tr>
<tr>
<td>(2) Baseline</td>
<td>-0.17</td>
<td>-0.09</td>
<td>83%</td>
</tr>
<tr>
<td><strong>Within-variety elasticity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10) ( \nu = 0.55 )</td>
<td>-0.11</td>
<td>-0.09</td>
<td>84%</td>
</tr>
<tr>
<td>(11) ( \nu = 0.65 )</td>
<td>-0.12</td>
<td>-0.07</td>
<td>82%</td>
</tr>
<tr>
<td><strong>Frisch elasticity of labor supply</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(12) ( \omega = 1.6 )</td>
<td>-0.17</td>
<td>-0.13</td>
<td>85%</td>
</tr>
<tr>
<td>(13) ( \omega = 1.4 )</td>
<td>-0.02</td>
<td>-0.06</td>
<td>68%</td>
</tr>
<tr>
<td><strong>Probability of re-entry</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(14) ( \phi = 0.05 )</td>
<td>-0.11</td>
<td>-0.05</td>
<td>82%</td>
</tr>
<tr>
<td>(15) ( \phi = 0.1 )</td>
<td>-0.11</td>
<td>-0.12</td>
<td>94%</td>
</tr>
</tbody>
</table>
Concluding Remarks

- Proposed default model with endogenous output dynamics that solves country risk-business cycle disconnect
- Increasing endogenous cost of default driven by efficiency loss due to factor substitution/reallocation
- Strong financial amplification mechanism linking default with deep recessions
- Model explains three key stylized facts of sov. default & key business cycle features
- Hints at important connection between trade structure/openness, default incentives and debt dynamics