Monetary Policy and Sovereign Risk in Emerging Economies (NK-Default)

Cristina Arellano
Federal Reserve Bank of Minneapolis and NBER

Yan Bai
University of Rochester and NBER

Gabriel Mihalache
Stony Brook University

20th Jacques Polak Annual Research Conference
International Monetary Fund

The views expressed here are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System
Motivation for NK-Default

- Many emerging markets adopted inflation targeting in early 2000s
  - Monetary policy targets nominal rates to keep inflation in band

- New Keynesian theory toolkit for monetary policy implementation
  - Theory for developed countries, mainly perfect capital markets
  - Useful for transmission of monetary policy to inflation and output

- Silent on monetary policy interactions with sovereign risk
  - Emerging markets history of recurring sovereign debt crises
  - Both policies affect consumption, output, inflation
Motivation for NK-Default

- Many emerging markets adopted inflation targeting in early 2000s
  - Monetary policy targets nominal rates to keep inflation in band
- New Keynesian theory toolkit for monetary policy implementation
  - Theory for developed countries, mainly perfect capital markets
  - Useful for transmission of monetary policy to inflation and output
- Silent on monetary policy interactions with sovereign risk
  - Emerging markets history of recurring sovereign debt crises
  - Both policies affect consumption, output, inflation

New Keynesian model with sovereign default risk

New toolkit for central banks in emerging markets
### Emerging Markets Inflation Targeters

<table>
<thead>
<tr>
<th></th>
<th>Inflation</th>
<th>Govt Spread</th>
<th>Correlation with Spread</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inflation</td>
<td>Domestic Rate</td>
<td>Output</td>
</tr>
<tr>
<td>Brazil</td>
<td>5.9</td>
<td>2.6</td>
<td>59</td>
</tr>
<tr>
<td>Chile</td>
<td>3.0</td>
<td>1.4</td>
<td>30</td>
</tr>
<tr>
<td>Colombia</td>
<td>5.2</td>
<td>3.2</td>
<td>74</td>
</tr>
<tr>
<td>Indonesia</td>
<td>6.6</td>
<td>2.8</td>
<td>17</td>
</tr>
<tr>
<td>Korea</td>
<td>2.6</td>
<td>1.1</td>
<td>44</td>
</tr>
<tr>
<td>Mexico</td>
<td>4.3</td>
<td>2.3</td>
<td>48</td>
</tr>
<tr>
<td>Peru</td>
<td>2.8</td>
<td>3.0</td>
<td>50</td>
</tr>
<tr>
<td>Philippines</td>
<td>3.9</td>
<td>2.9</td>
<td>17</td>
</tr>
<tr>
<td>Poland</td>
<td>3.0</td>
<td>1.7</td>
<td>59</td>
</tr>
<tr>
<td>South Africa</td>
<td>5.8</td>
<td>1.9</td>
<td>54</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>4.4</strong></td>
<td><strong>2.4</strong></td>
<td><strong>45</strong></td>
</tr>
</tbody>
</table>

- Single digit inflation and $ govt bonds carry spread over US bonds
- Govt spread **positively correlates with inflation and domestic rates**
- Govt spread **negatively correlates with output**
Default Risk Matters for Monetary Policy

- New Keynesian model with default risk, NK-Default
  - Govt borrows foreign-currency debt with default risk
  - Monetary policy is a nominal interest rate rule to target inflation

- Default Amplification: Govt default risk increases monetary frictions
  - High default risk depresses domestic consumption demand
  - Price rigidities keep nominal rates high
  - $\Rightarrow$ Lower output and larger monetary frictions

- Monetary Discipline: Monetary frictions discourage borrowing
  - Govt internalizes the effects of its policy on domestic outcomes
Quantitative Tool

- Model predictions consistent with emerging market data
  - Positive co-movement of spreads, nominal rates, inflation

- Properties of NK-Default
  - More volatile inflation and nominal rates than without default
    - Default amplification
  - Lower spreads and debt accumulation than real version
    - Monetary discipline

- Rationalize Brazilian experience with 2015 monetary tightening
  - Counterfactual low rates → moderate recession but increase in
    inflation and spreads

- Evaluate alternative interest rate rules and debt denomination
  - Large weight on inflation and local currency debt is best
Literature


Here optimal price setting (NKPC) + nominal rates to target inflation

**NK-Default: Monetary policy targets inflation with sovereign default risk**
Model

Small open economy: households, firms, monetary auth, fiscal govt

Households

- Values consumption of domestic $C$ and foreign goods $C_f$, supply labor $N$

\[
\frac{u_{C_f,t}}{u_{C,t}} = e_t, \quad \frac{u_{N,t}}{u_{C,t}} = w_t, \quad u_{C,t} = \beta t \mathbb{E}_t \left[ \frac{u_{C,t+1}}{\pi_{t+1}} \right]
\]

- Terms of trade $e_t$ (↑ depreciation), inflation $\pi_{t+1}$, nominal rate $i_t$

Monopolistic Intermediate Goods Firms

- Produce $y_{it} = z_t n_{it}$ and set prices subject to adjustment costs (Rotemberg)

- Dynamic choice of $n_{it}$ and prices $p_{it}$ (NKPC)

\[
\frac{w_t}{z_t} = 1 + \frac{\varphi}{\eta - 1} (\pi_t - \bar{\pi}) \pi_t - \frac{\varphi}{\eta - 1} \mathbb{E}_t \left[ \beta \frac{u_{C,t+1}}{u_{c,t}} \frac{Y_{t+1}}{Y_t} \frac{\pi_{t+1}}{\pi_{t+1}} \right]
\]

- Monetary frictions hinder efficient production, reflected in inflation

\[
1 + \text{monetary wedge} = \frac{z_t}{w_t} = \frac{z_t u_{C,t}}{u_{N,t}}, \quad (> 0 \text{ depressed output})
\]
Goods Market

- Domestic good used for consumption and exports
  \[ z_tN_t = C_t + X_t + \langle \text{price-setting costs} \rangle_t \]

- Elastic demand for export \( X_t = e^\rho_t \xi \)

Monetary Policy

- Interest rate rule targets inflation \( \bar{\pi} \)
  \[ i_t = \bar{i} \left( \frac{\pi_t}{\bar{\pi}} \right)^{\alpha_p} \]

Government

- Borrows abroad foreign-currency bonds (later long-term bonds)
- Finance imports net of exports with capital flows
  \[ C^f_t = X_t/e_t + q_lB_{t+1} - B_t \]

- Govt can default on its debt
  - Debt eliminated, productivity reduced \( z^d_t \leq z_t \), temporary exclusion

- Bond price schedule \( q(z_t, B_{t+1}) \) compensates for default risk
Recursive Markov Equilibrium

- Government with state \((z, B)\) chooses its fiscal policies

  Default \(D\):
  \[
  V(z, B) = \max \{W(z, B), W^d(z^d)\}
  \]

  Borrowing \(B'\):
  \[
  W(z, B) = \max_{B'} \{u(C, C^f, N) + \beta E V(z', B')\}
  \]

- Understands that its policies impact equilibrium

  Domestic Euler:
  \[
  u_C = \beta i E \left[ \frac{u_C'}{\pi'} \right]
  \]

  Pricing condition:
  \[
  \frac{u_N}{zu_C} = 1 + \frac{\phi}{\eta - 1} \left[ (\pi - \bar{\pi}) \pi - \beta E \frac{z'N'u_C'}{zNu_C} (\pi' - \bar{\pi}) \pi' \right]
  \]

  Interest rate rule:
  \[
  i = \tilde{i} \left( \frac{\pi}{\bar{\pi}} \right)^{\alpha p}
  \]

  Relative consumption:
  \[
  \frac{u_{C^f}}{u_C} = e
  \]

  Balance of payments:
  \[
  X/e = e^{\rho - 1} \bar{\pi} = C^f + B - q(z, B')B'
  \]

  Resource constraint:
  \[
  C + X = \left[ 1 - \frac{\varphi}{2} (\pi - \bar{\pi})^2 \right] zN
  \]

- Bond price schedule that reflects default

  \[
  q(z, B') = \frac{1}{1 + r^*} E \left[ 1 - D(z', B') \right]
  \]
Default Amplification
(With rigid prices and log separable preferences)

Large borrowing $B'$ and high default risk $D'$ affect monetary friction

Domestic Euler:  \[
\frac{1}{C} = \beta \bar{\bar{i}} \left( \mathbb{E}_{D'(B')} = 0 \frac{1}{C'(B')} + \mathbb{E}_{D'(B')} = 1 \frac{1}{C_d'} \right)
\]

Relative consumption:  \[
\frac{C}{C'} \propto e
\]

Balance of payments:  \[
\frac{X}{e} = e^{\rho-1} \xi = C' + B - q(B')B'
\]

Resource constraint:  \[
C + X = zN
\]

**Proposition.** A higher $B'$ increases default risk $D'$ and increases the monetary wedge

- Consumption: Lower expected consumption, more likely low $C_d'$ and lower $C(B')$
  - Domestic Euler calls for decline in current domestic consumption $C$

- Export-Import: More capital inflows appreciate $e$, lower exports

- Lower $(C + X)$ lowers labor $N \rightarrow$ increases monetary wedge

Large borrowing and default risk increase monetary frictions
Monetary Discipline

- Govt borrowing smooths consumption, responds to default risk

\[ u_{Cf} \left[ q + q_{B'B'} \right] = \beta E (1 - D') u'_{Cf} \]
Monetary Discipline

- Govt borrowing smooths consumption, responds to default risk

\[ u_{Cf} [q + q_{B'B'}] (1 - \tau_m^X) - \tau_m^C = \beta E (1 - D') u_{Cf}' (1 - \tau_m^{X'}) \]

- With borrowing wedges \( \tau_m^C \) and \( \tau_m^X \) from monetary frictions

\[ \tau_m^C \propto \text{monetary wedge} \times \frac{\partial E u_C(s', B')}{\partial B'} \frac{\beta i}{G} \quad [\text{consumption channel}] \]
\[ \tau_m^X \propto \text{monetary wedge} \times u_C G^X \quad [\text{exports-imports channel}] \]

- Reduce \( B' \) to improve monetary wedge (from proposition)
  - \( \tau_m^C \): to reduce default risk and boost domestic consumption
  - \( \tau_m^X \): to depreciate terms of trade and boost exports

Monetary frictions reduce govt’s incentive to borrow
Quantitative Analysis

- Parameterize model to Brazil (output, inflation, nominal rates, spreads)

- Compare NK-Default to two reference models
  - **NK-Reference model**: similar as Gali-Monacelli (2005)
    \[ u_C q = \beta E u_C' \]
    (only monetary frictions)
  - **Default-Reference model**: real model with default
    \[ u_C \left[ q + q_B' B' \right] = \beta E (1 - D') u_C' \]
    (only default risk frictions)
Default Amplification on Monetary Wedge

- High default zone: increasing monetary wedge
  - Default tomorrow associated with low $C'$ and high $\pi'$ $\rightarrow$ depresses $C$

- Low default zone: decreasing monetary wedge
  - Labor increases to export, pay debt, avoid default
Default Amplification on Monetary Wedge

NK-Reference: Monetary friction and nominal rates not responsive to debt (lax borrowing)
Default Amplification on Nominal Rates

- NK-Default: High nominal rates with high default risk
- Default risk induces variability in inflation and nominal rates
Monetary Discipline on Borrowing

(a) Debt Accumulation

(b) Spread Schedule

- Debt accumulates more slowly in NK-Default model relative to real
- Lower borrowing makes spread schedules looser in NK-Default


## Business Cycle Moments

<table>
<thead>
<tr>
<th>Mean</th>
<th>Data (%)</th>
<th>NK-Default</th>
<th>NK-Reference</th>
<th>Default-Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spread</td>
<td>2.6</td>
<td>2.6</td>
<td>—</td>
<td>3.2</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inflation</td>
<td>1.8</td>
<td>1.8</td>
<td>1.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Domestic Rate</td>
<td>2.2</td>
<td>2.5</td>
<td>1.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Spread</td>
<td>0.9</td>
<td>0.9</td>
<td>—</td>
<td>0.8</td>
</tr>
<tr>
<td>Trade Balance</td>
<td>0.9</td>
<td>0.3</td>
<td>1.9</td>
<td>0.5</td>
</tr>
</tbody>
</table>

### Correlation with Spread

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation</td>
<td>59</td>
<td>60</td>
<td>—</td>
<td>−1</td>
</tr>
<tr>
<td>Domestic Rate</td>
<td>59</td>
<td>64</td>
<td>—</td>
<td>18</td>
</tr>
<tr>
<td>Trade Balance</td>
<td>61</td>
<td>35</td>
<td>—</td>
<td>33</td>
</tr>
</tbody>
</table>

- **NK-Default**: positive co-movement of inflation, nominal rates, and spreads
- **NK-Reference**: silent on spread and volatile trade balance
  - Less volatile inflation & nominal rates
- **Default-Reference**: higher spreads without disciplining monetary friction
## Business Cycle Moments

<table>
<thead>
<tr>
<th>Mean</th>
<th>Data (%)</th>
<th>NK-Default</th>
<th>NK-Reference</th>
<th>Default-Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spread</td>
<td>2.6</td>
<td>2.6</td>
<td>—</td>
<td>3.2</td>
</tr>
</tbody>
</table>

### Standard Deviation

<table>
<thead>
<tr>
<th></th>
<th>Data (%)</th>
<th>NK-Default</th>
<th>NK-Reference</th>
<th>Default-Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation</td>
<td>1.8</td>
<td>1.8</td>
<td>1.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Domestic Rate</td>
<td>2.2</td>
<td>2.5</td>
<td>1.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Spread</td>
<td>0.9</td>
<td>0.9</td>
<td>—</td>
<td>0.8</td>
</tr>
<tr>
<td>Trade Balance</td>
<td>0.9</td>
<td>0.3</td>
<td>1.9</td>
<td>0.5</td>
</tr>
</tbody>
</table>

### Correlation with Spread

<table>
<thead>
<tr>
<th></th>
<th>Data (%)</th>
<th>NK-Default</th>
<th>NK-Reference</th>
<th>Default-Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation</td>
<td>59</td>
<td>60</td>
<td>—</td>
<td>−1</td>
</tr>
<tr>
<td>Domestic Rate</td>
<td>59</td>
<td>64</td>
<td>—</td>
<td>18</td>
</tr>
<tr>
<td>Trade Balance</td>
<td>61</td>
<td>35</td>
<td>—</td>
<td>33</td>
</tr>
</tbody>
</table>

- **NK-Default**: positive co-movement of inflation, nominal rates, and spreads
- **NK-Reference**: silent on spread and volatile trade balance
  - Less volatile inflation & nominal rates
- **Default-Reference**: higher spreads without disciplining monetary friction
## Business Cycle Moments

<table>
<thead>
<tr>
<th>Mean</th>
<th>Data (%)</th>
<th>NK-Default</th>
<th>NK-Reference</th>
<th>Default-Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spread</td>
<td>2.6</td>
<td>2.6</td>
<td>—</td>
<td>3.2</td>
</tr>
<tr>
<td><strong>Standard Deviation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inflation</td>
<td>1.8</td>
<td>1.8</td>
<td>1.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Domestic Rate</td>
<td>2.2</td>
<td>2.5</td>
<td>1.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Spread</td>
<td>0.9</td>
<td>0.9</td>
<td>—</td>
<td>0.8</td>
</tr>
<tr>
<td>Trade Balance</td>
<td>0.9</td>
<td>0.3</td>
<td>1.9</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Correlation with Spread</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inflation</td>
<td>59</td>
<td>60</td>
<td>—</td>
<td>−1</td>
</tr>
<tr>
<td>Domestic Rate</td>
<td>59</td>
<td>64</td>
<td>—</td>
<td>18</td>
</tr>
<tr>
<td>Trade Balance</td>
<td>61</td>
<td>35</td>
<td>—</td>
<td>33</td>
</tr>
</tbody>
</table>

- NK-Default: positive co-movement of inflation, nominal rates, and spreads
- NK-Reference: silent on spread and volatile trade balance
  - Less volatile inflation & nominal rates
- Default-Reference: higher spreads without disciplining monetary friction
Event Study

- Use Brazil data from 2012 to 2017
- Feed in a sequence of productivity shocks to replicate output path
- Model implications on inflation, spreads, and nominal rates
- Simulate counterfactual: loose monetary policy with low nominal rates throughout
Sequence of productivity shocks such that model matches output
Event: Spread

- Model generates similar increase in spreads
Model generates similar increase in inflation as in the data (higher than without default)
Event: Nominal Rate

- Nominal rate increases to fight inflation
  (more aggressive than without default)
Counterfactual: Nominal Rate

- Feed in same productivity sequence
- Keep nominal rates low
Output falls by less with expansionary monetary policy
Counterfactual: Inflation

- Inflation increases by more with expansionary monetary policy
- Expansionary monetary policy worsens the debt crisis
- Brazil’s tight monetary policy helped with inflation and debt crisis
Robustness: Extended Rules and Local Currency

<table>
<thead>
<tr>
<th>Mean</th>
<th>Benchmark</th>
<th>Local currency</th>
<th>Rule with larger $\alpha_p$</th>
<th>Rule with output gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spread</td>
<td>2.6</td>
<td>1.9</td>
<td>2.9</td>
<td>2.7</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inflation</td>
<td>1.8</td>
<td>1.9</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Domestic Rate</td>
<td>2.5</td>
<td>2.5</td>
<td>1.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Spread</td>
<td>0.9</td>
<td>0.4</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Correlation with Spread</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inflation</td>
<td>60</td>
<td>57</td>
<td>54</td>
<td>72</td>
</tr>
<tr>
<td>Domestic Rate</td>
<td>64</td>
<td>61</td>
<td>66</td>
<td>76</td>
</tr>
<tr>
<td>Welfare rel to no monetary frictions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>−.02</td>
<td>+.02</td>
<td>+.01</td>
<td>−.01</td>
<td></td>
</tr>
</tbody>
</table>

Robust predictions for default amplification and monetary discipline

- Nominal nominal rates always more volatile with default (NK-reference 1.3)
- Spreads always lower with monetary frictions (Default-reference 3.2)

Welfare: Tradeoff between monetary frictions and default risk frictions

- Strict inflation targeting (no monetary frictions) not optimal
- High weight on inflation $\alpha_p$ and local currency debt are best
Conclusion

- Integrated framework of monetary policy and sovereign risk
  New Keynesian model with default

- Important interactions between monetary frictions and default risk
  - Default risk amplifies monetary frictions and response
  - Monetary frictions discipline borrowing

- Model consistent with emerging market data

- Framework potentially useful for central banks
Robustness

- Local currency government debt
  balance of payment condition becomes

\[ e_t^\rho \xi = e_t C_t + \frac{B_t}{\pi_t} - q_t \left( B_{t+1} - \delta \frac{B_t}{\pi_t} \right) \]

bond price schedule becomes

\[ q_t = \frac{1}{1 + r^*} E \left[ \frac{e_t}{e_{t+1} \pi_{t+1}} (1 - D_{t+1})(1 + \delta q_{t+1}) \right]. \]

- Variants on the interest rate rule
  - Larger weight on inflation
  - Weight on output gap

\[ i = \tilde{i} \left( \frac{\pi_t}{\pi} \right)^{\alpha_p} \left( \frac{Y_t}{Y_t^{\text{flex}}} \right)^{0.5} m_t \]
Parameter Values

### Assigned Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share domestic in consumption ( \theta )</td>
<td>0.62</td>
</tr>
<tr>
<td>Frisch elasticity ( \zeta )</td>
<td>0.33</td>
</tr>
<tr>
<td>Persistence of productivity ( \rho_z )</td>
<td>0.9</td>
</tr>
<tr>
<td>Trade elasticity ( \rho )</td>
<td>5</td>
</tr>
<tr>
<td>Export demand level ( \tilde{\zeta} )</td>
<td>1</td>
</tr>
<tr>
<td>Varieties elasticity ( \eta )</td>
<td>6</td>
</tr>
<tr>
<td>Interest rate rule intercept ( \tilde{i} )</td>
<td>( \bar{\pi} / \beta )</td>
</tr>
<tr>
<td>International rate ( r^* )</td>
<td>0.5%</td>
</tr>
<tr>
<td>Market reentry probability ( \iota )</td>
<td>4.17%</td>
</tr>
<tr>
<td>Price adjustment cost ( \varphi )</td>
<td>58</td>
</tr>
</tbody>
</table>

### Parameters from Moment Matching

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private discount factor ( \beta )</td>
<td>0.9866</td>
</tr>
<tr>
<td>Government discount factor ( \beta_g )</td>
<td>0.9766</td>
</tr>
<tr>
<td>Inflation target ( \bar{\pi} )</td>
<td>1.015</td>
</tr>
<tr>
<td>Interest rate rule ( \rho )</td>
<td>1.4</td>
</tr>
<tr>
<td>Std of productivity shock ( \sigma_z )</td>
<td>0.95%</td>
</tr>
<tr>
<td>Productivity in default ( \lambda_0 )</td>
<td>-0.17</td>
</tr>
<tr>
<td></td>
<td>( \lambda_1 = 0.19 )</td>
</tr>
<tr>
<td>Enforcement shock ( \varrho_D )</td>
<td>( 1e^{-4} )</td>
</tr>
</tbody>
</table>
Policy Rules

(c) Spreads and Default Risk

(d) Nominal Rate and Inflation

(e) Output
Policy Rules

(f) Domestic Consumption

(g) Imported Consumption

(h) Terms of Trade
Impulse Responses to Productivity Shock

(a) Output  
(b) Domestic Consumption (C)  
(c) Imported Consumption (C^f)  
(d) Terms of Trade (e)

- Decline in domestic and imported consumption
- Smaller appreciation in benchmark ⇒ more muted decline in export
Impulse Responses to Productivity Shock

(a) Inflation ($\pi$)

(b) Nominal Interest Rate ($i$)

(c) Spread

(d) Debt ($B$)

- High nominal rates and spreads
  - Associated with recession and high inflation
- Nominal rates respond more forcefully with default risk
Impulse Responses to Money Shock

(a) Nominal Interest Rate

(b) Inflation

(c) Domestic Consumption

(d) Output

- High nominal rates depress inflation, consumption, and output (standard)
- NK-Default larger response of nominal rates
Impulse Responses to Money Shock

(a) Labor wedge

(b) Borrowing

(c) Spread

(d) Terms of Trade

- High $i$ increases labor wedge $\Rightarrow$ reduces borrowing and spread (new)
- Monetary friction disciplines borrowing
- Low borrowing leads to depreciation (UIP violated in our model)
Impulse Responses to Productivity Shock

(e) Output

(f) Domestic Consumption (C)

(g) Imported Consumption (C^f)

(h) Terms of Trade (e)
Impulse Responses to Productivity Shock

(i) Inflation ($\pi$)

(j) Nominal Interest Rate ($i$)

(k) Spread

(l) Debt ($B$)

Real model: More muted response of inflation and nominal rates