Reserve Accumulation, Macroeconomic Stabilization and Sovereign Risk

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Conventional view: countries hold reserves to sustain pegs.
Motivation

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- Argument:
  - A peg precludes the active use of seigniorage and sustaining a deficit may require the use of reserves.
  - If reserves are not ‘large enough’, expansionary fiscal policy can induce ↓ of reserves and even the abandoning of the peg.
  - A fiscal argument.
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  - Fixers have more reserves than Floaters. plots
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- Data (for EMEs):
  - Fixers have more reserves than Floaters.
  - Floaters have non-trivial reserves, and
  - Seigniorage revenue is modest and has been ↓ over time.

To understand the role of the exc. rate regime in reserve accumulation we need a theory that goes beyond purely fiscal considerations.
Our paper

We provide an alternative view based on the interaction btw macro stabilization and sovereign risk.
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• Show that countries w/ limited exc. rate flexibility choose to ↑ reserves for macro-stabilization purposes.

• Our theory is not based on the need to ↑ reserves to defend the peg (purely fiscal concerns).

• It’s based on the desirability of ↑ reserves to manage macro stabilization when there is sovereign risk.

• We show this motive leads to a substantial demand for reserves, and can account for the patterns of reserve accumulation in the data.
What we do

Sovereign default model with long-term debt and foreign reserve accumulation, and downward wage rigidity.

- Rollover risk induces large fluctuations in borrowing costs
- When borrowing costs are high, aggregate demand contracts causing involuntary unemployment
- Holdings of reserves (liquid assets) help mitigate the fall in demand and the increase in unemployment
- In good times, government issues debt and buy reserves for macroeconomic stabilization

Key insight: when output depends on aggregate demand, more hedging via reserve accumulation allows for better consumption smoothing and also reduces the severity of recessions.
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**Key insight:** when output depends on aggregate demand, more hedging via reserve accumulation allows for better consumption smoothing and also reduces the severity of recessions.
Main Elements of the Model

• Small open economy (SOE) with $T − NT$ goods:
  • Stochastic endowment for tradables $y^T$
  • Non-tradables produced with labor: $y^N = F(h)$
• Wages are downward rigid in domestic currency
  • With fixed exchange rate, $\pi^* = 0$ and L.O.P., $\Rightarrow$ wages are rigid in tradable goods $w \geq \bar{w}$
• Government issues non-contingent long-duration bonds ($b$) and saves in one-period risk free assets ($a$), all in units of $T$
• Default entails one-period exclusion and utility loss $\psi_d(y^T)$
• Risk averse foreign lenders $\rightarrow$ “risk-premium shocks”
Households

- Households’ preferences over consumption

\[ E_0 \sum_{t=0}^{\infty} \beta^t \{ u(c_t) \} \]

\[ c \equiv C(c^T, c^N) = [\omega(c^T)^{-\mu} + (1 - \omega)(c^N)^{-\mu}]^{-1/\mu} \]

- Budget constraint in units of tradables

\[ c^T_t + p^N_t c^N_t = y^T_t + \phi^N_t + w_t h^s_t - \tau_t \]
Households

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  \]

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  \]

- Endowment of hours $\bar{h}$, but $h^s_t < \bar{h}$ when $w \geq \bar{w}$ binds.

- Optimality
  \[
  p^N_t = \frac{1 - \omega}{\omega} \left( \frac{c^T_t}{c^N_t} \right)^{1+\mu}
  \]
Firms

- Maximize profits given by

\[ \phi_t^N = \max_{h_t} p_t^N F(h_t) - w_t h_t \]

- \( p_t^N, w_t \): price of non-tradables and wages in units of tradables

- Firms’ optimality condition is

\[ p_t^N F'(h_t) = w_t \]
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Asset/Debt Structure

- Long-term bond:
  - Bond pays $\delta [1, (1 - \delta), (1 - \delta)^2, (1 - \delta)^3, ...]$
  - Law of motion for bonds $b_{t+1} = b_t (1 - \delta) + i_t$
  - price is $q$
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• Government’s budget constraint if repay:

$$g + q_a a_{t+1} + b_t \delta = \tau_t + a_t + q_t \left( b_{t+1} - (1 - \delta) b_t \right)$$

  $i_t$ debt issuance

• Government’s budget constraint in default:

$$g + q_a a_{t+1} = \tau_t + a_t$$
• Pricing kernel is a function of innovation to domestic output $\varepsilon$
  and a global factor $\nu = \{0, 1\}$ (assumed to be independent)

$$m_{t,t+1} = e^{-r-\nu_t(\kappa \varepsilon_{t+1} + 0.5\kappa^2\sigma^2_\varepsilon)}, \quad \text{with} \quad \kappa \geq 0,$$
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- Implies constant short-term risk free rate:

  $$\mathbb{E}_{s'|s} m(s, s') = e^{-r} = q_a, \quad \text{with} \quad s = \{y^T, \nu\}$$
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- Bond price given by:

$$q = \mathbb{E}_{s'|s} \left\{ m(s, s')(1 - d') \left[ \delta + (1 - \delta) q' \right] \right\}$$

$$d' = \hat{d}(a', b', s'), \quad q' = q(a'', b'', s')$$
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- Risk premium $\geq 0$ if default occurs with low $\varepsilon$ and $\nu = 1$
Recursive Problem

\[ V(b, a, s) = \max_{d \in \{0, 1\}} \left\{ (1 - d)V^r(b, a, s) + dV^d(a, s) \right\} \]
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Value of repayment:

\[ V^r(b, a, s) = \max_{b', a', h, c^T} \left\{ u(c^T, F(h)) + \beta \mathbb{E}_{s'|s} [V(b', a', s')] \right\} \]

subject to

\[ c^T + g + q_a a' = a + y^T + q(b', a', s)(b' - (1 - \delta)b) - \delta b \]  \[ \quad \text{[\lambda]} \]

\[ \bar{w} \leq \frac{1 - \omega}{\omega} \left( \frac{c^T}{F(h)} \right)^{1+\mu} F'(h) \]  \[ \quad \text{[\xi]} \]

\[ h \leq \bar{h} \]  \[ \quad \text{[\eta]} \]
Value of default:

\[
V^d(a, s) = \max_{c^T, h, a'} \left\{ u(c^T, F(h)) - \psi_d(y^T) + \beta \mathbb{E}_{s'|s}[V(0, a', s')] \right\}
\]

subject to

\[
c^T + g + qa' = y^T + a, \tag{\lambda}
\]

\[
\bar{w} \leq \frac{1 - \omega}{\omega} \left( \frac{c^T}{F(h)} \right)^{1+\mu} F'(h), \tag{\xi}
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\[
h \leq \bar{h}. \tag{\eta}
\]
Assume $F(h) = h^\alpha$ with $\alpha \in (0, 1)$.

Also assume (just for simplicity): $\mu = 0$.

Optimality in labor market implies:

$$h^d(w) = \left( \frac{1 - \omega}{\omega} \right) \frac{\alpha}{w} c^T$$
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Equilibrium employment:

$$h(w) = \begin{cases} 
(\frac{1-\omega}{\omega}) \frac{\alpha}{w} c^T & \text{for } w = \bar{w} \\
\bar{h} & \text{for } w > \bar{w}
\end{cases}$$
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Labor Market Equilibrium

The diagram illustrates the relationship between wage (w) and labor (h) in a market equilibrium. The curves $c_{low}^T$ and $c_{high}^T$ represent different levels of costs or benefits associated with labor supply at various wages. The points A and B on the graph represent equilibrium points where the supply and demand for labor intersect.

- $w_B$ and $\bar{w}$ denote specific wage levels.
- $h_A$ and $\bar{h}$ denote specific labor levels.
Optimality Conditions

FOC wrt $c^T$:

$$c^T : \ u_T + \xi \left( \frac{1 - \omega}{\omega} \right) \frac{\alpha}{\bar{w}} = \lambda$$

$\xi \rightarrow$ multiplier on the $w \geq \bar{w}$ constraint
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Tradable consumption has 2 benefits:

1. direct utility
2. reduction of unemployment
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For labor, we have:

$$h : u_N \alpha h^{\alpha - 1} = \eta + \xi,$$

$\eta \rightarrow$ multiplier on the $h \leq \bar{h}$ constraint
Let \( \tilde{a} \) denote reserves that can be purchased when issuing an additional unit of debt (for an initial state \( s \)):

\[
\tilde{a} = \frac{q(\tilde{a}, b', s) + \frac{\partial q(\tilde{a}, b', s)}{\partial b'}}{q_a - \frac{\partial q(\tilde{a}, b', s)}{\partial a'}}.
\]
Optimal Portfolio: gains from borrowing to buy reserves

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The effects on lifetime utility are:

$$\mathbb{E}_{s'|s} \left\{ \begin{array}{ll}
\text{Mg. utility benefits} & \text{Mg. utility costs} \\
\tilde{a} (u'(c') + \xi' \Delta) & [\delta + (1 - \delta) q'] (1 - d') (u'(c') + \xi' \Delta))
\end{array} \right\}$$

• Reserves pay-off in all states $\Rightarrow$ high marginal value when unemployment is high
• Debt repayments relatively less costly in bad times (when $q'$ is low)
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\tilde{a} (u'(c') + \xi' \Delta) \\
\text{Reserves} \\
\text{Mg. utility costs} \\
[\delta + (1-\delta)q''](1-d')(u'(c') + \xi' \Delta)) \\
\text{Debt repayments} \\
\end{cases}
$$

- Reserves pay-off in all states $\rightarrow$ high marginal value when unemployment is high $\Rightarrow$ macroeconomic stabilization
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\end{array} \right\} - \left\{ \begin{array}{l}
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\left[ \delta + (1 - \delta) q' \right] (1 - d') (u'(c') + \xi' \Delta)
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- Reserves pay-off in all states $\rightarrow$ high marginal value when unemployment is high $\Rightarrow$ macroeconomic stabilization
- Debt repayments relatively less costly in bad times (when $q'$ is low)
Benefits of reserve accumulation

• We want to highlight two benefits of reserves.

• Exercise:
  1. Fix a point in the s.s. \( \rightarrow \bar{c} \).
  2. Look at alternative \( a' \), and find \( b' \) that ensures \( c = \bar{c} \).
  3. Show:
     3.1 Higher reserves can reduce future unemployment.
     3.2 Reserve accumulation may not be costly.
Higher reserves can reduce future unemployment

Now consider a policy that issues debt to increase reserves, keeping current consumption constant.

\[ E(u|a' = 0.00, \cdot) = 3.87 \]
Higher reserves can reduce future unemployment

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Higher reserves can reduce future unemployment

Note: current consumption is constant across portfolios → higher reserves can reduce future unemployment.
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Reserves are not necessarily costly

\[ \exists a' > 0 \text{ such that } \text{Spread}(a' > 0) \leq \text{Spread}(a' = 0). \]
Reserves are not necessarily costly

Note: \( \exists a' > 0 \) such that \( \text{Spread}(a' > 0) \leq \text{Spread}(a' = 0) \).
Calibrate to the average of a panel of 17 EMEs (1993–2014).

Benchmark = economy with wage rigidity.

1 model period = 1 year.
Utility function:

\[ u(c) = \frac{c^{1-\gamma} - 1}{1-\gamma}, \text{ with } \gamma \neq 1 \]

Utility cost of defaulting:

\[ \psi_d(y^T) = \psi_0 + \psi_1 \log(y^T) \]

Tradable income process:

\[ \log(y^T_t) = (1 - \rho)\mu_y + \rho \log(y^T_{t-1}) + \epsilon_t \]

with \( |\rho| < 1 \) and \( \epsilon_t \sim N(0, \sigma^2_\epsilon) \)
## Quantitative Analysis (ctd)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r$</td>
<td>Risk-free rate</td>
<td>0.04</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Labor share in NT sector</td>
<td>0.75</td>
</tr>
<tr>
<td>$\beta$</td>
<td>Domestic discount factor</td>
<td>0.90</td>
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<tr>
<td>$\pi_{LH}$</td>
<td>Prob. of transiting to high risk-premium</td>
<td>0.15</td>
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<tr>
<td>$\pi_{HL}$</td>
<td>Prob. of transiting to low risk-premium</td>
<td>0.8</td>
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<tr>
<td>$\sigma_\epsilon$</td>
<td>Std. dev of innovation to $\log(y^T)$</td>
<td>0.034</td>
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<td>$\rho$</td>
<td>Autocorrelation of $\log(y^T)$</td>
<td>0.66</td>
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<tr>
<td>$\mu_y$</td>
<td>Mean of $\log(y^T)$</td>
<td>$-\frac{1}{2} \sigma_\epsilon^2$</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Coupon decaying rate</td>
<td>0.2845</td>
</tr>
<tr>
<td>$1/(1+\mu)$</td>
<td>Intratemporal elast. of subs.</td>
<td>.44</td>
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<tr>
<td>$\gamma$</td>
<td>Coefficient of relative risk aversion</td>
<td>2.273</td>
</tr>
<tr>
<td>$\bar{h}$</td>
<td>Time endowment</td>
<td>1</td>
</tr>
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</table>

Parameters set by simulation

<table>
<thead>
<tr>
<th>Parameter</th>
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<tr>
<td>$\omega$</td>
<td>Share of tradables</td>
<td>0.3</td>
</tr>
<tr>
<td>$g$</td>
<td>Government consumption</td>
<td>0.25</td>
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<tr>
<td>$\psi_0$</td>
<td>Default cost parameter</td>
<td>2.4</td>
</tr>
<tr>
<td>$\psi_1$</td>
<td>Default cost parameter</td>
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<tr>
<td>$\kappa$</td>
<td>Pricing kernel parameter</td>
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<tr>
<td>$\bar{w}$</td>
<td>Lower bound on wages</td>
<td>0.8</td>
</tr>
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Results

1. Simulations moments.
2. Default sets and spreads.
<table>
<thead>
<tr>
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<th>Model Benchmark</th>
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<tbody>
<tr>
<td><strong>Targeted</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean debt ((b/y))</td>
<td>42.0</td>
<td>42.5</td>
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<td>(\Delta r_s) w/ risk-prem. shock</td>
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<td>(\Delta UR) around crises</td>
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<td>12</td>
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<td>Mean (y^T/y)</td>
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<td>47</td>
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<td><strong>Non-Targeted</strong></td>
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<tr>
<td>(\sigma(c)/\sigma(y))</td>
<td>1.1</td>
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<tr>
<td>(\sigma(r_s)) (in %)</td>
<td>2.7</td>
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<tr>
<td>(\rho(r_s, y))</td>
<td>-0.4</td>
<td>-0.7</td>
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<td>(\rho(c, y))</td>
<td>0.8</td>
<td>1.0</td>
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<tr>
<td>Mean Reserves ((a/y))</td>
<td>16</td>
<td>17.9</td>
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<td>36</td>
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### Results: data and simulation moments

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<td>37.4</td>
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• Default incentives **increase** in debt and **decrease** in reserves.
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• Wage rigidity **increases** default incentives
• Default incentives **increase** in debt and **decrease** in reserves.
• Wage rigidity **increases** default incentives
• Gross positions matter for default.
Results: spreads, reserves and wage rigidity

- Wage rigidity increases spreads.
• Wage rigidity **increases** spreads.
• Reserves **decrease** spreads, and **more** when wages are rigid.
We’ll compute welfare gains of ‘moving’ from a baseline economy to an alternative economy:

\[
\text{Welfare gain} = 100 \times \left[ \left( \frac{(1 - \gamma)(1 - \beta)V_{\text{alternative}} + 1}{(1 - \gamma)(1 - \beta)V_{\text{baseline}} + 1} \right)^{1/(1 - \gamma)} - 1 \right]
\]
We’ll compute **welfare gains** of ‘moving’ from a **baseline** economy to an **alternative** economy:

\[
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\]

We’re interested in studying:

- Gains of eliminating wage rigidity
- Gains of having access to reserves

To do this: define a “No-Reserves” economy (which can have or not wage rigidity).
Eliminating wage rigidity is welfare enhancing, and more so when reserve accumulation is not possible.

Being able to accumulate reserves is welfare enhancing when facing wage rigidities.
Eliminating wage rigidity is *welfare enhancing*, and more so when *reserve accumulation is not possible*.

- Benchmark w/ rigid wages
  - 0.59
  - Benchmark w/ flexible wages
- No-Reserves w/ rigid wages
  - 0.62
  - No-Reserves w/ flexible wages
Eliminating wage rigidity is welfare enhancing, and more so when reserve accumulation is not possible.

Being able to accumulate reserves is welfare enhancing when facing wage rigidities.
Conclusions

- Studied use of foreign reserves for macro stabilization goals in a SOE with:
  1. nominal rigidities
  2. fixed exchange rates, and
  3. sovereign default risk

- When borrowing costs are high, aggregate demand contracts causing involuntary unemployment

- Holdings of reserves (liquid assets) allow to mitigate fall in demand and increase in unemployment

- In good times, government issues debt and buy reserves for macroeconomic stabilization
We found that:

- **Mechanism is quantitatively relevant**:  
  - Avg. reserves/GDP are 14pp larger.  
  - Avg. reserves/debt ratio is 29pp larger.

- Wage rigidity increases default incentives and spreads.

- Reserves decrease default incentives and spreads.

- **Reserves** help **reduce** future **unemployment risk** and need **not be costly**.

- There are **welfare gains** of accumulating reserves and eliminating wage rigidities.
Other implications:

- Maastrict clauses establish limits for gross debt positions in Eurozone.

- Analysis suggests that minimum holdings of assets could be a good idea.

  - A stock of foreign reserves might mitigate temptations to exit.
THANKS !
EMEs with fixed exchange rates hold more foreign reserves ...
... and have accumulated reserves faster.
## Reserve accumulation – Regressions

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMF ERR</td>
<td><strong>-0.0368</strong>*</td>
<td><strong>-0.0116</strong>*</td>
</tr>
<tr>
<td></td>
<td>(0.00564)</td>
<td>(0.00396)</td>
</tr>
<tr>
<td>Ilzetzki-Reinhart-Rogoff ERR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>year</td>
<td><strong>0.00560</strong>*</td>
<td><strong>0.00561</strong>*</td>
</tr>
<tr>
<td></td>
<td>(0.000475)</td>
<td>(0.000487)</td>
</tr>
<tr>
<td>Constant</td>
<td><strong>-10.95</strong>*</td>
<td><strong>-11.05</strong>*</td>
</tr>
<tr>
<td></td>
<td>(0.951)</td>
<td>(0.976)</td>
</tr>
<tr>
<td>Observations</td>
<td>614</td>
<td>614</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.229</td>
<td>0.187</td>
</tr>
</tbody>
</table>

**Table 1**: Regressions. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Data for MSCI Emerging Market countries from 1990 to 2016. Higher ERR means more flexibility exchange rate regimes.
Reserves around the world

Over the past 20 years massive increase in foreign reserves holdings by Central Banks around the world

(from Amador, Bianchi, Bocola and Perri, 2018)
We use the IMF Classif. of Exch. Rate Arrangements (as of 2016)

We follow Kondo and Hur (2016) and focus on 23 EMEs:

<table>
<thead>
<tr>
<th>Argentina</th>
<th>India</th>
<th>Poland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>Indonesia</td>
<td>Romania</td>
</tr>
<tr>
<td>Chile</td>
<td>Malaysia</td>
<td>Russia</td>
</tr>
<tr>
<td>China</td>
<td>Mexico</td>
<td>South Africa</td>
</tr>
<tr>
<td>Colombia</td>
<td>Morocco</td>
<td>South Korea</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>Pakistan</td>
<td>Thailand</td>
</tr>
<tr>
<td>Egypt</td>
<td>Peru</td>
<td>Turkey</td>
</tr>
<tr>
<td>Hungary</td>
<td>Philippines</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2:** EME classification: follow Financial Times and the London Stock Exchange (FTSE), Morgan Stanley Capital International (MSCI), the Economist, Standard & Poor’s (S&P), and Dow Jones Indexes.
### More simulations

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Benchmark</th>
<th>Model Flexible</th>
<th>Flexible w (no recal.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Targeted</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean debt ($b/y$)</td>
<td>42.0</td>
<td>42.5</td>
<td>42.0</td>
<td>61.2</td>
</tr>
<tr>
<td>Mean $r_s$</td>
<td>2.2</td>
<td>2.4</td>
<td>2.2</td>
<td>3.0</td>
</tr>
<tr>
<td>$\Delta r_s$ w/ risk-prem. shock</td>
<td>2.0</td>
<td>2.0</td>
<td>1.9</td>
<td>2.6</td>
</tr>
<tr>
<td>$\Delta UR$ around crises</td>
<td>3.0</td>
<td>3.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Mean $g/y$</td>
<td>12</td>
<td>12</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>Mean $y^T/y$</td>
<td>45</td>
<td>47</td>
<td>44</td>
<td>50</td>
</tr>
<tr>
<td><strong>Non-Targeted</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma(c)/\sigma(y)$</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>$\sigma(r_s)$ (in %)</td>
<td>2.7</td>
<td>2.0</td>
<td>1.8</td>
<td>2.4</td>
</tr>
<tr>
<td>$\rho(r_s, y)$</td>
<td>-0.4</td>
<td>-0.7</td>
<td>-0.9</td>
<td>-0.9</td>
</tr>
<tr>
<td>$\rho(c, y)$</td>
<td>0.8</td>
<td>1.0</td>
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<td>36</td>
<td>37.4</td>
<td>8.1</td>
<td>8.8</td>
</tr>
</tbody>
</table>
Initial debt = Avg. in simulations. Initial reserves = zero.

Benchmark w/ rigid wages

No-Reserves w/ rigid wages

3.18

Benchmark w/ flexible wages

No-Reserves w/ flexible wages

3.22

0.04

-0.00
Results: welfare gains of eliminating wage rigidity

**Figure 1:** Benchmark

**Figure 2:** No-Reserves
Figure 3: Spreads with and without access to reserves.