slides
chapter 6
Interest Rate Shocks
Motivation

- Interest-rate shocks are generally believed to be a major source of fluctuations for emerging countries.
- Why is there one interest rate per country, as opposed to just one world interest rate? One reasons is that each country has a different default risk, which is reflected in a country-specific interest-rate premium. The most commonly-used measure of country spreads is J.P. Morgan’s EMBI+ bond index (Emerging Market Bond Index).
- The figure suggests that output and country interest rates are negatively correlated.

- **Primary References:** Neumeyer and Perri (JME, 2005) and Uribe and Yue (JIE, 2006).
Negative Comovement Between Interest Rates and Output

Correlations: Argentina -0.67; Brazil -0.51, Ecuador -0.80, Mexico -0.58, Peru -0.37, The Philippines -0.02, South Africa -0.07.
Who Drives Whom?

• The observed negative correlation between output and the interest rate does not necessarily indicate that movements in the interest rate cause movements in output.

• Addressing this question requires a combination of data and theory.

• We will study two ways of combining data and theory:
  (1) SVAR analysis: here the emphasis is in the S. Converting a simple VAR into an SVAR requires the imposition of identifying assumptions, which are necessarily theoretical in nature.
  (2) Estimated DSGE model.

The main difference between these two approaches is how much weight they place on data and theory. We begin with approach (1).
SVAR Analysis, Uribe and Yue (2006)

\[ A \begin{bmatrix} \hat{y}_t \\ \hat{i}_t \\ tbyt \\ \hat{R}_{us}^t \\ \hat{R}_t \\ \end{bmatrix} = B \begin{bmatrix} \hat{y}_{t-1} \\ \hat{i}_{t-1} \\ tbyt_{t-1} \\ \hat{R}_{us}^{t-1} \\ \hat{R}_{t-1} \\ \end{bmatrix} + \begin{bmatrix} \epsilon^y_t \\ \epsilon^i_t \\ \epsilon^{tby}_t \\ \epsilon^{rus}_t \\ \epsilon^r_t \\ \end{bmatrix}, \]

where \( y_t = \) output, \( i_t = \) investment, \( tbyt = \) trade-balance-to-GDP ratio, \( R_{us}^t = \) U.S. interest rate, and \( R_t = \) country interest rate.

- **Identification Assumptions:**
  - \( A \) is lower triangular (\( A(i, j) = 0 \ \forall \ j > i \)).
  - \( R_{us}^t \) follows a univariate process (\( A(4, j) = B(4, j) = 0 \ \forall \ j \neq 4 \)).
- **Countries:** Argentina, Brazil, Ecuador, Mexico, Peru, The Philippines, South Africa.
Comments On Identification

- A lower triangular implies that shocks to real variables (output, investment, and the trade balance) affect the country interest rate contemporaneously, but shocks to the U.S. interest rate or to the country interest rate affect real variables with a lag. This makes sense, because real variables (think about starting investment projects, hiring and firing decisions, etc.) should respond more slowly than financial variables.

- Assuming that $R_t^{us}$ is univariate is sensible because one should not expect individual emerging countries to affect interest rates in the U.S.

- Implications of Identifying Restrictions:
  - $\epsilon_t^{rus}$ and $\epsilon_t^r$ can be interpreted as exogenous U.S.-interest-rate and country-spread shocks, respectively.
  - The identification scheme is vague about the nature of $\epsilon_t^y$, $\epsilon_t^i$, and $\epsilon_t^{tby}$. This is not a problem, because our interest is to understand the effects of interest-rate shocks.
Impulse Response To A Country-Spread Shock, $\epsilon^p_t$
Impulse Response To A U.S. Interest-Rate Shock, $\epsilon_t^{rus}$

**Output**

- % dev. from trend
- quarters after shock
- U.S. Interest Rate

**Investment**

- % dev. from trend
- quarters after shock
- Country Interest Rate

**Trade Balance-to-GDP Ratio**

- dev. from mean
- quarters after shock
- Country Interest Rate

**Country Interest Rate**

- dev. from mean
- quarters after shock

**Country Spread**

- dev. from mean
- quarters after shock

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Point Estimate \hspace{1cm} 2-std. Error Band
Observations on Responses to $\epsilon^r_t$ and $\epsilon^{rus}_t$

- Country-spread and US-interest-rate shocks cause sizable contractions in output and investment and a sizable improvement in the trade-balance-to-GDP ratio (i.e., domestic absorption contracts relatively more than output).
- The response to US-interest-rate shocks is estimated with significant uncertainty. One reason is that by design, $R^{us}_t$ does not vary across countries.
- US-interest-rate shocks cause a large, delayed overshooting of country spreads.
Impulse Response To An Output Shock, $\epsilon^y_t$

- **Output**
  - % dev. from trend vs. quarters after shock
  - U.S. Interest Rate

- **Investment**
  - % dev. from trend vs. quarters after shock
  - Country Interest Rate

- **Trade Balance–to–GDP Ratio**
  - dev. from mean vs. quarters after shock
  - Country Spread

- **Country Spread**
  - dev. from mean vs. quarters after shock

**Point Estimate** and **2-std. Error Band**
Observations on Response to $\epsilon_y^t$

- An output shock causes expansions in output and investment, and a deterioration of the trade-balance-to-GDP ratio, resembling a technology shock or a terms-of-trade shock in the SOE-RBC model.
- More importantly for the purpose of the present analysis, the output shock drives down the country spread, thus lowering the country’s cost of borrowing.
- Recall that the present identification scheme is vague with respect to the precise nature of $\epsilon_y^t$. It could represent a mix of shocks of diverse natures, such as technology shocks, terms-of-trade shocks, etc.
Robustness To Expanding The Temporal And Country Coverage of the Data


Expanded Country Set: Argentina, Brazil, Bulgaria, Chile, Colombia, Ecuador, Hungary, South Korea, Malaysia, Mexico, Peru, South Africa, Thailand, Turkey, and Uruguay.
Responses to Country-Spread and U.S.-Interest-Rate Shocks: Expanded Data

1% increase in country-spread (solid) and US-int.-rate (broken). Output and investment in % dev. from trend; TB/GDP and country int. rate in percentage point dev. from mean.
1% output shock. Output and investment in % dev. from trend; TB/GDP and country int. rate in percentage point dev. from mean.
Observations on Robustness Analysis
The preceding two figures show that the baseline empirical results are robust to extending the temporal and cross-sectional dimensions of the panel, especially along the following dimensions:

- Increases in the U.S.-interest-rate and country-spread cause contractions in output and investment.
- Increases in the U.S.-interest-rate and country-spread cause an improvement in the trade-balance-to-GDP ratio (or, equivalently, a proportionally larger contraction in domestic absorption than in output).
- U.S.-interest-rate shocks cause a delayed increase in country spreads.
- Output shocks cause an expansion in investment, a deterioration of the trade-balance-to-GDP ratio, and, more importantly, a fall in country spreads.
Decomposition of Forecast-Error Variances

Let $x_t \equiv [\hat{y}_t \hat{\imath}_t \hat{b}_t \hat{y}_{t+1} \hat{R}_t^{us} \hat{R}_t]'$. Then the SVAR can be written as

$$Ax_{t+h} = Bx_{t+h-1} + \epsilon_{t+h}$$

And its MA($\infty$) representation is

$$x_{t+h} = \sum_{j=0}^{\infty} C_j \epsilon_{t+h-j}, \text{ with } C_j \equiv (A^{-1}B)^j A^{-1}$$

The forecast of $x_{t+h}$ in $t$ is

$$E_t x_{t+h} = \sum_{j=h}^{\infty} C_j \epsilon_{t+h-j}$$

And the associated forecast error, denoted $FE_t^h$, is

$$FE_t^h = \sum_{j=0}^{h-1} C_j \epsilon_{t+h-j}$$
Then the forecast-error variance at horizon $h$, denoted $FEV^h$, is

$$FEV^h = \sum_{j=0}^{h-1} C_j \Sigma \epsilon C'_j,$$

where $\Sigma \epsilon \equiv E[\epsilon_t \epsilon'_t]$.

The forecast-error variance attributable to shock $i$ (the $i$-th element of $\epsilon_t$), denoted $FEV^{h,i}$, is

$$FEV^{h,i} = \sum_{j=0}^{h-1} (C_j \Lambda_i) \Sigma \epsilon (C_j \Lambda_i)' ,$$

where $\Lambda_i$ is a square conformable matrix with all zeros except for diagonal element $(i, i)$ which equals unity.
The share of forecast-error variance of variable $k$ (i.e. $k$-th element of $x_t$) at horizon $h$ attributable to shock $i$, denoted $SFEV_{k}^{h,i}$, is given by

$$SFEV_{k}^{h,i} = \frac{FEV_{k_{kk}}^{h,i}}{FEV_{k_{kk}}^{h}}$$

where $k_{kk}$ denotes the $k$-th diagonal element. This is called a forecast-error variance decomposition. As the horizon become large, $h \to \infty$, the forecast-error variance of variable $k$ due to shock $i$ converges to the unconditional variance of $k$ due to $i$. The next slide presents the forecast-error variance decomposition implied by the estimated SVAR system.
Estimated Forecast-Error Variance Decomposition

**Output**

- U.S. Interest Rate
- Country Interest Rate

**Investment**

- Country Interest Rate

**Trade Balances−to−GDP Ratio**

- Country Spread

\[ \epsilon_t^{rus} \quad \epsilon_t^{rus} + \epsilon_t \]
Observations on the Forecast-Error Variance Decompositions

- Jointly, country-spread and US-interest-rate shocks ($\epsilon^r_t$ and $\epsilon^{rus}_t$) explain
  - 30% of movements in output.
  - 32% of movements in investment.
  - 44% of movements in the trade-balance-to-GDP ratio.
  - 85% of movements in country-spreads.

- About 60% of movements in country spreads is explained by country-spread shocks.
Alternative Identification Scheme: Why Not Place the Country Spread First in the SVAR System?

SVAR Prediction Under This Specification: Output and investment expand in response to an increase in the U.S. interest rate.

Problematic: It’s difficult to rationalize this implication on theoretical grounds.
DSGE Analysis

Motivation

• The SVAR analysis is based on loose theoretical restrictions.

• Does the propagation mechanism of interest rate shocks ($\epsilon_t^{rus}$ and $\epsilon_t^r$) implied by the estimated SVAR model concur with the one implied by an optimizing DSGE open economy model?

• If so, the identified interest-rate shocks would be more compelling since the effects they generate would be consistent with the optimizing behavior of households and firms.

Strategy: (1) Build a DSGE model of the open economy. (2) Feed the model with the estimated processes for $R_t^{rus}$ and $R_t$ (the last 2 equations of the SVAR). (3) Compare the impulse responses predicted by the SVAR and DSGE models.
The Theoretical Model (Uribe and Yue, 2006)

Open economy model with three frictions:

- Working-capital constraint on firms
- Gestation lags and convex adjustment costs in investment
- Habit formation
Firms and Working Capital Constraints

\[
\max F(k_t, h_t) - u_t k_t - w_t h_t \left[ 1 + \frac{\eta (R_{td} - 1)}{R_{td}} \right]
\]

where \( F(\cdot, \cdot) \) is a production function, \( h_t \) = labor, \( k_t \) = capital, \( w_t \) = wage rate, and \( R_{td} \) = gross interest rate. The parameter \( \eta \) governs the strength of the working-capital constraint. The implied demand for labor is

\[
F_h(k_t, h_t) = w_t \left[ 1 + \eta \left( \frac{R_{td} - 1}{R_{td}} \right) \right]
\]

The working-capital constraint is a financial friction that allows for a supply-side effect of interest rate shocks. An increase in the interest rate increases the (financial) cost of labor, inducing a contraction in labor demand.
Capital Accumulation: Gestation Lags and Convex Adjustment Costs

\[ i_t = \frac{1}{4} \sum_{i=0}^{3} s_{it}. \]

\[ s_{i+1t+1} = s_{it}, \quad i = 0, 1, 2 \]

\[ k_{t+1} = (1 - \delta)k_t + k_t\Phi\left(\frac{s_{3t}}{k_t}\right) \]

where \( i_t \) = investment, \( s_{it} \) = number of investment projects started in period \( t - i \), for \( i = 0, 1, 2, 3 \) (4-period gestation lag); \( k_t \) = capital stock. Function \( \Phi(\cdot) \) captures convex adjustment costs (note that \( \Phi(\cdot) \) must be concave).
Households and Habit Formation

\[
\max E_0 \sum_{t=0}^{\infty} \beta^t U(c_t - \mu \tilde{c}_{t-1}, h_t),
\]

subject to

\[
d_t = R_{t-1} d_{t-1} - w_t h_t - u_t k_t + c_t + i_t + \Psi(d_t)
\]

\[
\lim_{j \to \infty} E_t \frac{d_{t+j+1}}{\prod_{s=0}^{j} R_{t+s}} \leq 0
\]

The function \( \Psi(d_t) \) is convex; it introduces portfolio adjustment costs and gives rise to an effective interest rate, \( R_t^d \), satisfying

\[
R_t^d = \frac{R_t}{1 - \Psi'(d_t)}.
\]
Driving Forces

\[ \hat{R}_t = 0.63 \hat{R}_{t-1} + 0.50 \hat{R}^{us}_{t} + 0.35 \hat{R}^{us}_{t-1} - 0.79 \hat{y}_t \\
+ 0.61 \hat{y}_{t-1} + 0.11 \hat{i}_t - 0.12 \hat{i}_{t-1} + 0.29 tby_t \\
- 0.19 tby_{t-1} + \epsilon^r_t, \]

\[ \hat{R}^{us}_t = 0.83 \hat{R}^{us}_{t-1} + \epsilon^{rus}_t, \]

where \( \epsilon^r_t \) and \( \epsilon^{rus}_t \) are mean-zero, iid, innovations with standard deviations equal to 0.031 and 0.007, respectively.
Functional Forms

\[ U(c - \mu\tilde{c}, h) = \frac{[c - \mu\tilde{c} - \omega^{-1}h^\omega]^{1-\gamma} - 1}{1 - \gamma} \]

\[ F(k, h) = k^\alpha h^{1-\alpha} \]

\[ \Phi(x) = x - \frac{\phi}{2}(x - \delta)^2; \quad \phi > 0 \]

\[ \Psi(d) = \frac{\psi}{2}(d - \bar{d})^2 \]
Calibrated Parameters (Quarterly)

\[ \omega = 1.45 \]
\[ \gamma = 2 \]
\[ \alpha = 0.32 \]
\[ R = \beta^{-1} = 1.0277 \]
\[ \delta = 0.025 \]
\[ \frac{tb}{y} = 0.02 \]
Estimating $\phi$, $\psi$, $\eta$, and $\mu$

**Criterion:** Minimize the distance between empirical and theoretical impulse response functions.

Formally, $\phi$, $\psi$, $\eta$, and $\mu$ are set so as to minimize

$$[IR^e - IR^m(\psi, \phi, \eta, \mu)]'\Sigma^{-1}_{IR^e}[IR^e - IR^m(\psi, \phi, \eta, \mu)],$$

Result of estimation:

$$\psi = 0.00042$$

$$\phi = 72.8$$

$$\eta = 1.20$$

$$\mu = 0.20$$
Theoretical and Estimated Impulse Response Functions

IR of Output to $\varepsilon^{rus}$

IR of Investment to $\varepsilon^{rus}$

IR of TB/GDP to $\varepsilon^{rus}$

IR of Country Int. Rate to $\varepsilon^{rus}$

IR of Output to $\varepsilon^r$

IR of Investment to $\varepsilon^r$

IR of TB/GDP to $\varepsilon^r$

IR of Country Int. Rate to $\varepsilon^r$

Empirical IR  ----- Error Band  -x-x Theoretical IR
Observations on the Theoretical Impulse Responses

• The theoretical model replicates well a number of key features of the estimated IRFs:
  – Output and investment contract in response to an increase in $\epsilon_{t}^{rus}$ or $\epsilon_{t}^{r}$.
  – The trade balance improves in response to an increase in $\epsilon_{t}^{rus}$ or $\epsilon_{t}^{r}$.
  – The country interest rate, $R_{t}$, displays a hump-shaped response to an increase in $\epsilon_{t}^{rus}$.

• These findings suggest that the identification assumptions imposed in the SVAR analysis are successful in isolating U.S.-interest-rate and country-spread shocks.
## Conditional Standard Deviations

**Implied by the SVAR and Theoretical Models**

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\hat{\epsilon}_{t}^{rus}$</th>
<th>$\hat{\epsilon}_{t}^{r}$</th>
<th>Unconditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{y}$</td>
<td>1.5</td>
<td>1.6</td>
<td>1.3</td>
</tr>
<tr>
<td>$\hat{i}$</td>
<td>6.4</td>
<td>3.6</td>
<td>5.0</td>
</tr>
<tr>
<td>$tby$</td>
<td>2.1</td>
<td>1.6</td>
<td>2.0</td>
</tr>
<tr>
<td>$\hat{R}_{us}$</td>
<td>1.3</td>
<td>1.3</td>
<td>0</td>
</tr>
<tr>
<td>$\hat{R}$</td>
<td>3.8</td>
<td>3.5</td>
<td>4.7</td>
</tr>
</tbody>
</table>
Observations on Conditional Volatilities

• SOE model does well at capturing the importance of U.S.-interest-rate and country-spread shocks in explaining movements in output and country interest rates.
• The SOE model does a good job at accounting for variations in the trade balance due to U.S.-interest-rate shocks.
• But the SOE model underpredicts the volatilities of investment and the trade balance caused by country-spread shocks.
• SOE model implies that $\epsilon^r_{\text{us}}$ and $\epsilon^r_t$ jointly explain 32 percent of fluctuations in output ($(1.6311^2 + 1.2779^2)/3.6583^2 = 0.32$), almost same as SVAR ($(1.5274^2 + 1.3030^2)/3.6583^2 = 0.30$). But SOE model assigns less importance to $\epsilon^r_{\text{us}}$ and $\epsilon^r_t$ in accounting for variations in $i_t$ and $tby_t$ than does the SVAR.
• Overall, identified $\epsilon^r_{\text{us}}$ and $\epsilon^r_t$ shocks are sensible and economically important.
Shocks to Global Risk Premia

• What is the effect of movements in global risk premia on real and financial variables in emerging economies?

• Akinci (2013) expands the SVAR studied above to include the spread between the U.S. Baa corporate bond rate and the 20-year U.S. Treasury bond yield.

• Baa corporate bonds carry a medium degree of default risk: 13% cumulative default risk over 20 years, compared with less than 1% for Aaa rated bonds (highest rating by Moody's) and more than 70% for C rated bonds (lowest rating).
The Augmented SVAR

\[
A \begin{bmatrix}
\hat{y}_t \\
\hat{i}_t \\
tbyt_t \\
\hat{R}^{us}_t \\
\hat{S}^{us}_t \\
\hat{R}_t
\end{bmatrix} = B(L) \begin{bmatrix}
\hat{y}_{t-1} \\
\hat{i}_{t-1} \\
tbyt_{t-1} \\
\hat{R}^{us}_{t-1} \\
\hat{S}^{us}_{t-1} \\
\hat{R}_{t-1}
\end{bmatrix} + \begin{bmatrix}
\epsilon^y_t \\
\epsilon^i_t \\
\epsilon_{tby}^t \\
\epsilon^{rus}_t \\
\epsilon^{sus}_t \\
\epsilon^r_t
\end{bmatrix},
\]

\(S^{us}_t = \) U.S. corporate bond spread.

**Identification:** same as Uribe and Yue (2006). Pair \([R^{us}_t S^{us}_t]') follows bivariate process.

\(\Rightarrow \epsilon^{sus}_t\) can be interpreted as an innovation to the U.S. risk premium. Same interpretation as before for other innovations.

**Countries:** Argentina, Brazil, Mexico, Peru, South Africa, Turkey.

**Sample:** 1994:Q1 to 2011:Q3.
Predictions of SVAR with Global Risk Premium Shocks

- Interest rate shocks, i.e., \([\epsilon_{t}^{r,us} \epsilon_{t}^{sus} \epsilon_{t}^{r}]\), jointly explain 42% of the variance of output ⇒ reinforces the result obtained by Uribe and Yue (2006).
- The global risk-premium shock takes over the role previously played by the U.S. interest rate: \(\epsilon_{t}^{sus}\) explains 18% of the variance of output whereas \(\epsilon_{t}^{r,us}\) explains only 6%.
- The country spread shock, \(\epsilon_{t}^{r}\), continues to be an important driver of aggregate fluctuations in emerging countries, accounting for 18% of the observed variance of output.
- Effects of global risk-premium shocks is mediated by the country premium: a 1 percentage point increase in \(\epsilon_{t}^{sus}\) raises the country premium by 1.3 percentage points.
Chapter Summary

- Interest-rate shocks represent an important driver of business cycles in emerging countries, accounting for 30 to 42 percent of the variance of output.
- Of the 30 to 42 percent of output variance explained by interest rate shocks, half is due to a global component (U.S.-interest-rate shocks and U.S.-risk-premium shocks) and the other half is due to country-specific spread shocks.
- In response to an increase in the interest rate, output and investment contract and the trade balance improves.
- An increase in the U.S. interest rate or in the U.S. risk premium produces an overshooting in country spreads, that is, the country spread increases by more than one for one.
- The majority of movements in country spreads (more than 60 percent) is explained by country spread shocks.