EME Business Cycles: Evidence and Theory - II

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July 2015

Interest Rate Shock Models: NP 2005

- Neumeyer and Perri (2005) build a SOE-RBC model where interest rate shocks play a crucial role (see also Uribe and Yue (2006))
- Compared to Advanced Economies (AEs), in Emerging Market Economies (EMEs)
    - output (Y) is more volatile
    - consumption (C) is pro-cyclical and more volatile
    - net exports (NX) are more volatile than output and are more counter-cyclical than in AEs
- In addition
    - Interest rates (R) are also counter-cyclical

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Brief digression 1

- One difference from AG (2007) is

$$\frac{1}{q_t} = R_t + \kappa \left(\frac{B_{t+1}}{\Gamma_t} \right)$$

- where

$$R_t = S_t R_t^*.$$

- Second difference is

$$\ln \left(\frac{R_t^*}{R^*} \right) = \rho_A \left(\frac{R_{t-1}^*}{R^*} \right) + \varepsilon_t^R.$$

- Third difference is

$$\ln \left(\frac{S_t}{S} \right) = -\eta E_t \left[\ln A_{t+1} \right]$$

Brief digression 2 - solving linear rational expectations models

- Follows Uhlig (1999)
- Uhlig shows how to find the conditions for solving the log-linearized version of the model once it has been divided into a set of equations without expectations and a set of equations in expectations (also see, McCandelles, Chapter 6, 2008).
- The model is divided into a set of matrix equations

$$
\begin{aligned}
0 &= Ax_t + Bx_{t-1} + Cy_t + Dz_t \\
0 &= E_t \left\{ Fx_{t+1} + Gx_t + Hx_{t-1} + Jy_{t+1} + Ky_t + Lz_{t+1} + Mz_t \right\}
\end{aligned}
$$

and a stochastic process

$$
\begin{aligned}
z_{t+1} &= Pxt - 1 + Qz_t \\
y_t &= Rx_{t-1} + Sz_t .
\end{aligned}
$$

- Problem is to find the values for the matrices P, Q, R, and S

NP 2005 - A snapshot

- Firms face a working capital constraint + preferences are GHH.
- $R \uparrow \Rightarrow L^D \downarrow$
- Agents face GHH preferences $\Rightarrow L^S$ remain unchanged $\Rightarrow$ equilibrium labor falls, Y falls $\Rightarrow \rho(R, Y)_{EME} < 0$
- Intertemporal substitution effect $\Rightarrow C \downarrow$ instantaneously, $S \uparrow$
- $R \uparrow \Rightarrow X \downarrow$
- $(S - X) \uparrow \Rightarrow \rho(NX, Y) < 0$

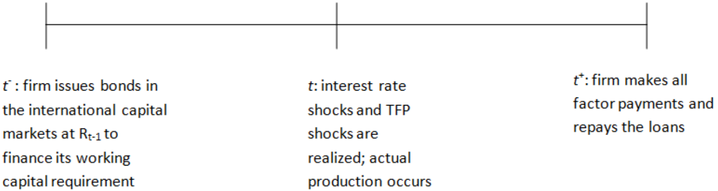
NP 2005 - A snapshot

- In their model, real interest rates are decomposed into two components
$$R_t = R_t^* D_t$$
where R is the domestic real interest rate, R^* is the international real interest rate (US real interest rates), and D is the country spread risk component
- They model D in two ways – the exogenous case, and the induced case (more on this later).
- They calibrate their model to match the Argentine data and they show that lowering the country spread risk shocks can lower output volatility by around 27%.

NP 2005 - Solution Procedure

- Setup of the model
- FOCs
- Steady state
- Log-linearization
- Impulse responses

NP 2005 - Timeline



Firms

- The firm maximizes

$$\pi_t = A_t k_{t-1}^{\alpha} \left[(1+\gamma)^t l_t \right]^{1-\alpha} - w_t l_t - r_t k_{t-1} - (R_{t-1} - 1)\, \theta w_t l_t. \quad (1)$$

- w_t and r_t are obtained

Firms

- We transform all variables to their stationary values. For any variable x_t, we define it's stationary transformation as $\widetilde{x}_t$ such that,

$$\widetilde{x}_t = \frac{x_t}{(1+\gamma)^t}.$$

All variables in our model grow at the same exogenous rate $(1+\gamma)$. All variables are therefore transformed to their corresponding stationary values except l_t, which is assumed to be at the stationary.

- Further, as in Uhlig (1997), any stationary variable $\widetilde{x}_t$ can be log-linearized as

$$\begin{aligned} \widetilde{x}_t &= \overline{x} e^{\widehat{x}_t} \\ &\simeq \overline{x}(1+\widehat{x}_t). \end{aligned}$$

Firms

- Therefore

$$\widetilde{y}_t = \frac{y_t}{(1+\gamma)^t} = \frac{A_t k_{t-1}^{\alpha} l_t^{1-\alpha} (1+\gamma)^{t(1-\alpha)}}{(1+\gamma)^t} \tag{2}$$

$$= \frac{A_t}{(1+\gamma)^{\alpha}} \widetilde{k}_{t-1}^{\alpha} l_t^{1-\alpha}.$$

- Hence profits can be re-written as

$$\widetilde{\pi}_t = \widetilde{y}_t - \frac{r_t \widetilde{k}_{t-1}}{(1+\gamma)} - (1-\theta)\, \widetilde{w}_t l_t - \widetilde{w}_t l_t R_{t-1} \theta.$$

- The firm's profit maximization yields the following first order conditions for labor, l_t, and capital, $\widetilde{k}_{t-1}$, respectively.

$$\{l_t\} : \frac{(1-\alpha)\widetilde{y}_t}{l_t} = \widetilde{w}_t \left[(1-\theta) + \theta R_{t-1}\right] \tag{3}$$

$$\left\{\widetilde{k}_{t-1}\right\} : \frac{\alpha \widetilde{y}_t}{\widetilde{k}_{t-1}} = \frac{r_t}{(1+\gamma)}.$$

Firms – steady state

- In steady state,

$$\frac{(1-\alpha)\overline{y}}{\overline{l}} = \overline{w}\left[(1-\theta)+\theta\overline{R}\right]$$

$$\frac{\alpha\overline{y}}{\overline{k}} = \frac{\overline{r}}{(1+\gamma)}$$

Firms – Log-linear expressions

- Log-linearizing the output yields

$$\widehat{y}_t = \widehat{A}_t + \alpha \widehat{k}_{t-1} + (1-\alpha)\widehat{l}_t \tag{4}$$

- Log-linearizing $\{k_{t-1}\}$ yields

$$\widehat{y}_t = \widehat{r}_t + \widehat{k}_{t-1}. \tag{5}$$

- Log-linearizing $\{l_t\}$ yields

$$\widehat{y}_t = (\widehat{w}_t + \widehat{l}_t) + \frac{\theta \overline{R}}{\left[(1-\theta) + \theta \overline{R}\right]} \widehat{R}_{t-1}. \tag{6}$$

Households

- Households supply labor and rend out capital in the competitive labor and capital markets respectively
- A stand-in representative agent maximizes

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left[c_t - \psi (1+\gamma)^t l_t^v\right]^{(1-\sigma)}}{(1-\sigma)}, \tag{7}$$

where

$$v > 1, \text{ and } \psi > 0$$

- subject to

$$c_t + x_t + b_t + \kappa(b_t) \leq w_t l_t + r_t k_{t-1} + R_{t-1} b_{t-1}. \tag{8}$$

- Note that

$$\begin{aligned} w_t l_t + r_t k_{t-1} + R_{t-1} b_{t-1} &= y_t - c_t - x_t = s_t - x_t \\ &= b_t + \kappa(b_t) - R_{t-1} b_{t-1} = nx_t. \end{aligned}$$

Households

- $\kappa(b_t)$ is the bond holding cost such that

$$\kappa(b_t) = \frac{\kappa}{2} y_t \left[\left(\frac{b_t}{y_t} \right) - \left(\frac{b}{y} \right) \right]^2 \quad (9)$$

  which is required for ensuring stationarity

- x_t is private investment such that;

$$x_t = k_t - (1 - \delta) k_{t-1} + \Phi(k_t, k_{t-1}), \quad (10)$$

- where $\Phi(k_t, k_{t-1})$ is the investment adjustment cost.

$$\Phi(k_t, k_{t-1}) = \frac{\phi}{2} k_{t-1} \left[\left(\frac{k_t}{k_{t-1}} \right) - (1 + \gamma) \right]^2 . \quad (11)$$

  which is required for keeping the relative volatility of x_t under check.

Households

- The agent therefore maximizes the following utility function

$$E_0 \sum_{t=0}^{\infty} \widetilde{\beta}^t \frac{\left[\widetilde{c}_t - \psi l_t^v\right]^{(1-\sigma)}}{(1-\sigma)},$$

$$\text{where } \widetilde{\beta} \quad = \quad \beta (1+\gamma)^{(1-\sigma)},$$

subject to (2), (8), (9), (10) and (11).

Households – Lagrangian

- Therefore the Lagrangian is given by

$$E_0 \sum_{t=0}^{\infty} \left[\widetilde{\beta}^t \frac{\left[\widetilde{c}_t - \psi l_t^v\right]^{(1-\sigma)}}{(1-\sigma)} + \lambda_t \left\{ CONSTRAINT \right\} \right]$$

Households – Lagrangian

- where the constraint is given by
- $$0 \leq \left\{ \begin{array}{c} \widetilde{w}_t l_t + \frac{r_t \widetilde{k}_{t-1}}{1+\gamma} + \frac{R_{t-1} \widetilde{b}_{t-1}}{1+\gamma} - \widetilde{c}_t - \widetilde{k}_t - \widetilde{b}_t \\ + (1-\delta) \frac{\widetilde{k}_{t-1}}{1+\gamma} \\ -\frac{\phi}{2} (1+\gamma) \widetilde{k}_{t-1} \left[\frac{\widetilde{k}_t}{\widetilde{k}_{t-1}} - 1 \right]^2 \\ -\frac{\kappa}{2} \widetilde{y}_t \left[\frac{\widetilde{b}_t}{\widetilde{y}_t} - \frac{b}{y} \right]^2 \end{array} \right\}$$

Households - First Order Conditions

- The first order condition with respect to consumption is given by

$$\{\widetilde{c}_t\} : \lambda_t = \left[\widetilde{c}_t - \psi l_t^{\nu}\right]^{-\sigma} \tag{12}$$

- The first order condition with respect to labor supply is given by

$$\{l_t\} : \lambda_t \widetilde{w}_t = \left[\widetilde{c}_t - \psi l_t^{\nu}\right]^{-\sigma} \psi \nu l_t^{\nu-1} \tag{13}$$

Households - First Order Conditions

- Other FOCs are as follows

$$\left\{\widetilde{b}_t\right\}: 1+\kappa\left[\frac{\widetilde{b}_t}{\widetilde{y}_t}-\frac{b}{y}\right]=E_t\left[\frac{\widetilde{\beta}}{(1+\gamma)}\frac{\lambda_{t+1}}{\lambda_t}R_t\right] \tag{14}$$

$$\left\{\widetilde{k}_t\right\}: 1+\phi\left(1+\gamma\right)\left[\left(\frac{\widetilde{k}_t}{\widetilde{k}_{t-1}}\right)-1\right]=E_t\left[\widetilde{\beta}\frac{\lambda_{t+1}}{\lambda_t}F\right]. \tag{15}$$

where,

$$F=\frac{(1-\delta)+r_{t+1}}{(1+\gamma)}+\frac{\phi}{2}\left(1+\gamma\right)\left\{\left(\frac{\widetilde{k}_{t+1}}{\widetilde{k}_t}\right)^2-1\right\}$$

Households – steady state

- From $\left\{\widetilde{b}_t\right\}$:

$$\frac{\widetilde{\beta}\overline{R}}{(1+\gamma)} = 1$$

- We get the following "No-Arbitrage" condition combining the FOCs $\left\{\widetilde{b}_t\right\}$ and $\left\{\widetilde{k}_t\right\}$:

$$\overline{r} = \overline{R}^P - (1-\delta)$$

- We get the following labor supply equation combining the FOCs $\{\widetilde{c}_t\}$ and $\left\{\widetilde{l}_t\right\}$:

$$\overline{w} = \psi v \overline{l}^{v-1}$$

Households – steady state

- Other steady state equations

$$\begin{aligned}
\overline{x} &= \frac{\gamma+\delta}{1+\gamma}\overline{k} \\
\Phi\left(\overline{k},\overline{k}\right) &= 0 \\
\kappa\left(\overline{b}\right) &= 0 \\
\overline{c}+\frac{\gamma+\delta}{1+\gamma}\overline{k}+\overline{b} &= \overline{w}\overline{l}+\frac{\overline{r}\overline{k}}{1+\gamma}+\frac{\overline{Rb}}{1+\gamma}
\end{aligned}$$

Households – Log-linear expressions

- From (12) and (13), labor supply is given by

$$l_t = (\psi v)^{\frac{1}{1-v}} (\widetilde{w}_t)^{\frac{1}{v-1}} \tag{16}$$

- Log-linearizing (16) gives us

$$\widehat{l}_t = \frac{\widehat{w}_t}{v-1}. \tag{17}$$

- Therefore equilibrium labor supply in log-linear terms is obtained by combining (4), (6), and (17) to yield

$$\widehat{l}_t = \frac{1}{(\alpha + v - 1)} \left\{ \widehat{A}_t + \alpha \widehat{k}_{t-1} - \frac{\theta \overline{R}}{\left[(1-\theta) + \theta \overline{R}\right]} \widehat{R}_{t-1} \right\} \tag{18}$$

Households – Log-linear expressions

- On log-linearizing $\left\{\widetilde{b}_t\right\}$ we get

$$1 - \frac{\kappa b}{y} + \frac{\kappa b}{y}\left(1 + \widehat{b}_t - \widehat{y}_t\right) = \frac{\widetilde{\beta}}{(1+\gamma)}\overline{R}^P E_t\left[1 + \widehat{\lambda}_{t+1} - \widehat{\lambda}_t + \widehat{R}_t\right]$$

- This implies

$$1 + \frac{\kappa b}{y}\left(\widehat{b}_t - \widehat{y}_t\right) = E_t\left[1 + \widehat{\lambda}_{t+1} - \widehat{\lambda}_t + \widehat{R}_t\right] \quad (19)$$

$$\Rightarrow \frac{\kappa b}{y}\left(\widehat{b}_t - \widehat{y}_t\right) = E_t\left[\widehat{\lambda}_{t+1} - \widehat{\lambda}_t + \widehat{R}_t\right]$$

Households – Log-linear expressions

- On log-linearizing $\left\{\widetilde{k}_t\right\}$ we get

$$\begin{aligned} & \phi\left(1+\gamma\right)\left(\widehat{k}_t-\widehat{k}_{t-1}\right) & (20) \\ = \quad & E_t\left\{\widehat{\lambda}_{t+1}-\widehat{\lambda}_t\right\}+\frac{\widetilde{\beta}\overline{r}}{\left(1+\gamma\right)}E_t\widehat{r}_{t+1}+\widetilde{\beta}\phi\left(1+\gamma\right)E_t\left\{\widehat{k}_{t+1}-\widehat{k}_t\right\}. \end{aligned}$$

- where

$$\begin{aligned} E_t\left\{\widehat{\lambda}_{t+1}-\widehat{\lambda}_t\right\} \quad = \quad & -\left(\frac{\overline{c}\sigma}{\overline{c}-\psi\overline{l}^v}\right)E_t\left\{\widehat{c}_{t+1}-\widehat{c}_t\right\} & (21) \\ & +\left(\frac{\psi v\sigma\overline{l}^v}{\overline{c}-\psi\overline{l}^v}\right)E_t\left\{\widehat{l}_{t+1}-\widehat{l}_t\right\} \end{aligned}$$

Households – Log-linear expressions

- Note that log-linear approximations of $\kappa(b_t)$ and $\Phi(k_t, k_{t-1})$ are equal to zero!
- Therefore the law of motion of capital can be log-linearized as

$$\widehat{x}_t = \frac{\overline{k}}{\overline{x}}\widehat{k}_t - \frac{(1-\delta)}{(1+\gamma)}\frac{\overline{k}}{\overline{x}}\widehat{k}_{t-1} \tag{22}$$

- and finally the CBC is log-linearized as

$$\begin{aligned} & \overline{w}\overline{l}\left(\widehat{w}_t + \widehat{l}_t\right) + \frac{\overline{r}\overline{k}\left(\widehat{r}_t + \widehat{k}_{t-1}\right)}{(1+\gamma)} + \frac{\overline{Rb}\left(\widehat{R}_t + \widehat{b}_{t-1}\right)}{(1+\gamma)} \\ = \quad & \overline{c}\widehat{c}_t + \overline{k}\widehat{k}_t - \frac{(1-\delta)\overline{k}\widehat{k}_{t-1}}{(1+\gamma)} + \overline{b}\widehat{b}_t \end{aligned} \tag{23}$$

Shocks

- TFP

$$\widehat{A}_t = \rho_A \widehat{A}_{t-1} + \varepsilon_{At}. \tag{24}$$

- For interest rates,

$$R_t = R_t^* D_t. \tag{25}$$

- R_t^* is the US real interest rate. Therefore,

$$\widehat{R}_t = \widehat{R}_t^* + \widehat{D}_t. \tag{26}$$

Interest rates and country spreads

- $\widehat{R}_t^*$ is estimated as

$$\widehat{R}_t^* = \rho_R \widehat{R}_{t-1}^* + \varepsilon_{Rt}. \quad (27)$$

- There are two different models for country spreads
  - The Exogenous Case

$$\widehat{D}_t = \rho_D \widehat{D}_{t-1} + \varepsilon_{Dt}. \quad (28)$$

  - The Induced Case

$$\widehat{D}_t = -\eta E_t \widehat{A}_{t+1} + u_t. \quad (29)$$

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Calibration of Parameters

- For persistence of TFP, NP assume $\widehat{A}_t$ to follow the same persistence as in the US. Hence $\rho_A = 0.95$ and $\sigma(\varepsilon_{At})$ is set so as to match the moments of the Argentine data.
- $\widehat{R}_t$ is obtained from the 3-month real yield on Argentine dollar denominated sovereign bonds, $\widehat{R}_t^*$ is obtained from 90 day-US treasury bill rates.
- The values of η and $\sigma(\varepsilon_{ut})$ are again chosen so as to match the moments of the Argentine data.

Calibration of Parameters

- The value of the parameters v and σ of the GHH utility function have been chosen from the literature.
- The value of θ is set to be equal to 1
- The cost parameters κ and ϕ are set to match the moments of the Argentine data

Calibration of Parameters

- Other parameters such as $\gamma, \alpha, \beta, \delta, \mu$, and ψ are set so that the balanced growth paths in the model are consistent with the long run Argentine data.
  - $\gamma = 0.025$ to match the average long-run Argentine growth rate of real output
  - From (14) in steady state, $\widetilde{\beta} = \frac{\overline{R}}{1+\gamma}$. Therefore β is chosen to match the average real interest rate of $\overline{R} = 14.8\%$ during the sample of their study
  - The parameter values of μ and ψ are so as to match $\bar{l} = 0.2$.
  - The parameter α is chosen such that from (3) in steady state, $\frac{(1-\alpha)}{\left[(1-\theta)+\theta\overline{R}\right] l_t} = \frac{\overline{wl}}{\overline{y}} = 0.6$
  - δ is obtained by matching the the average investment/output ratio of 0.21 during the period of 1983-2001
  - Finally $\frac{\bar{b}}{\bar{y}}$ is obtained from

$$NFA = \theta\frac{\overline{wl}}{\overline{y}} - \frac{\overline{b}}{\overline{y}} = -0.42$$

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Summarizing the equations

- Equations (30) to (37) below (obtained from (4), (5), (18), (19), (20), (21), (22), (23), (24), (26), (27)) and (28), or (29) represent our system of equations.

$$0 = -\widehat{y}_t + \widehat{A}_t + \alpha \widehat{k}_{t-1} + (1-\alpha)\widehat{l}_t \tag{30}$$

$$0 = -\widehat{y}_t + \widehat{r}_t + \widehat{k}_{t-1} \tag{31}$$

$$0 = -\widehat{l}_t + \frac{1}{(\alpha + v - 1)}\left\{\widehat{A}_t + \alpha \widehat{k}_{t-1} - \frac{\theta \overline{R}}{\left[(1-\theta) + \theta \overline{R}\right]}\widehat{R}_{t-1}\right\} \tag{32}$$

$$\begin{aligned} 0 \quad = \quad & -\overline{w}\overline{l}v\widehat{l}_t - \frac{\overline{r}\overline{k}\left(\widehat{r}_t + \widehat{k}_{t-1}\right)}{(1+\gamma)} - \frac{\overline{R}\overline{b}\left(\widehat{R}_t + \widehat{b}_{t-1}\right)}{(1+\gamma)} \\ & + \overline{c}\widehat{c}_t + \overline{k}\widehat{k}_t - \frac{(1-\delta)\overline{k}\widehat{k}_{t-1}}{(1+\gamma)} + \overline{b}\widehat{b}_t \end{aligned} \tag{33}$$

$$
\begin{aligned}
0 &= -\frac{\kappa b}{y}\left(\widehat{b}_t - \widehat{y}_t\right) - \left(\frac{\overline{c}\sigma}{\overline{c} - \psi \overline{l}^{v}}\right) E_t\left\{\widehat{c}_{t+1} - \widehat{c}_t\right\} \qquad (34) \\
&+ \left(\frac{\psi v \sigma \overline{l}^{v}}{\overline{c} - \psi \overline{l}^{v}}\right) E_t\left\{\widehat{l}_{t+1} - \widehat{l}_t\right\} + \widehat{R}_t
\end{aligned}
$$

$$
\begin{aligned}
0 &= -\left(\frac{\overline{c}\sigma}{\overline{c} - \psi \overline{l}^{v}}\right) E_t\left\{\widehat{c}_{t+1} - \widehat{c}_t\right\} + \left(\frac{\psi v \sigma \overline{l}^{v}}{\overline{c} - \psi \overline{l}^{v}}\right) E_t\left\{\widehat{l}_{t+1} - \widehat{l}_t\right\} \qquad (35) \\
&+ \frac{\widetilde{\beta}\overline{r}}{(1+\gamma)} E_t \widehat{r}_{t+1} + \widetilde{\beta}\phi(1+\gamma) E_t\left\{\widehat{k}_{t+1} - \widehat{k}_t\right\} \\
&- \phi(1+\gamma)\left(\widehat{k}_t - \widehat{k}_{t-1}\right)
\end{aligned}
$$

Summarizing the equations (contd)

And finally the shocks

$$0 = -\widehat{A}_t + \rho_A \widehat{A}_{t-1} + \varepsilon_{At} \tag{36}$$

$$0 = -\widehat{R}^*_t + \rho_R \widehat{R}^*_{t-1} + \varepsilon_{Rt}. \tag{37}$$

with either exogenous shocks to $\widehat{D}_t$ or induced shocks to $\widehat{D}_t$ as given in equations (28) and (29) respectively.

Uhlig's Method applied

- The above equations (30) to (37) along with (28) or (29) are then re-written in the following form

$$
\begin{aligned}
0 &= Ax_t + Bx_{t-1} + Cy_t + Dz_t \\
0 &= E_t \left\{ Fx_{t+1} + Gx_t + Hx_{t-1} + Jy_{t+1} + Ky_t + Lz_{t+1} + Mz_t \right\}
\end{aligned}
$$

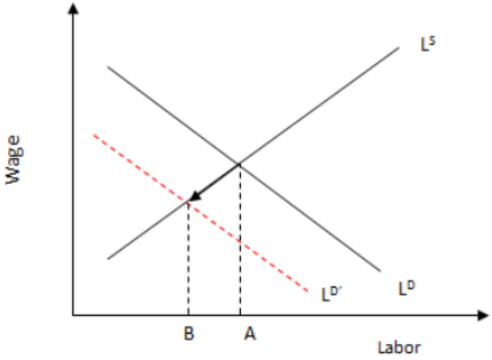
- where

$$
\begin{aligned}
x_t &= \left[\begin{array}{cc} \widehat{k}_t & \widehat{b}_t \end{array} \right]' \\
y_t &= \left[\begin{array}{cccc} \widehat{y}_t & \widehat{c}_t & \widehat{l}_t & \widehat{r}_t \end{array} \right]' \\
z_t &= \left[\begin{array}{ccc} \widehat{A}_t & \widehat{R}^*_{t-1} & \widehat{D}_{t-1} \end{array} \right]'.
\end{aligned}
$$

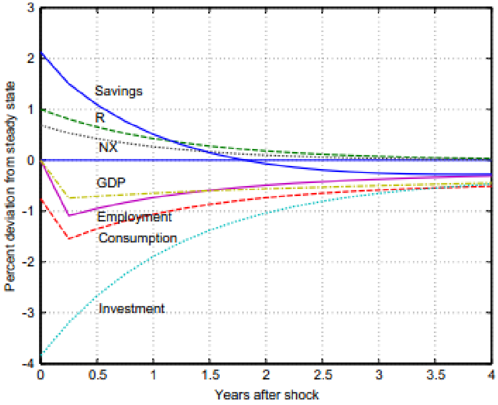
- The structural model is then obtained using Uhlig's approach such that each y_t variable is a linear policy function of x_{t-1} and z_t.
- We then use Uhlig's toolkit to generate the impulse response functions and the second order moments.

A Single Period interest rate shock

Note from equations (6) and (17), labor supply does not change due to an interest rate shock since it is independent of consumption and labor demand at t depends on the interest rates of $t-1$.



Impulse responses



Transmission of the interest rate shock

- $R \uparrow \Rightarrow C \downarrow$ instantaneously, $S \uparrow$ due to the intertemporal substitution effect
- $R \uparrow \Rightarrow L^D \downarrow$ after one time period; L^S remains unchanged due to GHH preferences $\Rightarrow$ equilibrium labor falls, Y falls after one time period (k is brought forward from $t-1$) $\Rightarrow \rho(R, Y) < 0$
- $R \uparrow \Rightarrow X \downarrow \Rightarrow (S - X) \uparrow \Rightarrow NX \uparrow \Rightarrow \rho(NX, Y) < 0$

Calibration results

Simulated and actual Argentine business cycles

	% Standard dev.			% Standard dev. of x / % Standard dev. of GDP		
	GDP	R	NX	TC	INV	HRS
Argentine data	4.22	3.87	1.42	1.17	2.95	0.57
	(0.36)	(0.52)	(0.11)	(0.03)	(0.13)	(0.08)
No country risk						
(a) R^* shocks	1.24	1.08	1.43	1.12	8.65	1.00
(b) R^* and A shocks	4.22	1.08	1.44	0.80	2.95	0.66
Independent country risk						
(c) R^* and D shocks	2.33	3.87	2.06	1.69	5.26	1.41
(d) R^*, D and A shocks	4.22	3.87	2.12	1.13	2.95	0.90
Induced country risk						
(e) R^* and A shocks	4.22	3.87	1.95	1.54	2.95	0.89

	Correlation of GDP with				
	R	NX	TC	INV	HRS
Argentine data	−0.63	−0.89	0.97	0.94	0.52
	(0.08)	(0.02)	(0.01)	(0.01)	(0.11)
No country risk					
(a) R^* shocks	−0.36	−0.17	0.82	0.35	0.94
(b) R^* and A shocks	−0.10	0.03	0.97	0.56	0.98
Independent country risk					
(c) R^* and D shocks	−0.54	−0.48	0.88	0.57	0.97
(d) R^*, D and A shocks	−0.29	−0.08	0.87	0.44	0.90
Induced country risk					
(e) R^* and A shocks	−0.54	−0.80	0.97	0.90	0.98

	Correlation of R with			
	NX	TC	INV	HRS
Argentine data	0.71	−0.67	−0.59	−0.58
	(0.06)	(0.07)	(0.09)	(0.12)
No country risk				
(a) R^* shocks	0.96	−0.80	−0.98	−0.66
(b) R^* and A shocks	0.95	−0.31	−0.84	−0.27
Independent country risk				
(c) R^* and D shocks	0.99	−0.86	−0.99	−0.78
(d) R^*, D and A shocks	0.96	−0.70	−0.97	−0.62
Induced country risk				
(e) R^* and A shocks	0.65	−0.60	−0.66	−0.69

An Extension of NP (2005)

- Usually, $\rho(R, Y)_{AE} \geqslant 0$
- In EMEs, R is more volatile than output, but there is mixed evidence on $\rho(R, Y)_{EME}$
- $\rho(R, Y) < 0$ in Latin American economies, but $\rho(R, Y) > 0$ in Eastern Europe, Africa and Asia (Male (2010)).
    - Also in India (Ghate et al. (2013)).

Government expenditures - EMEs

- In EMEs government expenditures are more volatile (Male (2010)) and fiscal policy is less stabilizing and less counter-cyclical (Talvi and Vegh (2005)) although there is no clear consensus.
    - Political pressures/temptations during boom-time – governments can't lower expenditures or raise taxes.
    - Pressure to reduce spendings during recessions – lack of access to credit.
- Several EMEs in the last decade have "graduated" from pro-cyclical to counter-cyclical fiscal policy – improvements in institutional quality (Frankel et. al (2013)).
    - Government expenditure has been counter-cyclical in India post reforms (Ghate et al. (2013)).

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Mixed experience

Country	Sample	$\frac{\sigma(G)}{\sigma(Y)}$	$\frac{\sigma(R)}{\sigma(Y)}$	$\rho(G, Y)$	$\rho(R, Y)$
Chile	1980:1-2004:4	11.3	1.7	–	−0.22
Colombia	1980:1-2004:4	2.2	3.7	0.35	0.27
Hong Kong	1980:1-2004:4	2.5	3.1	−0.21	0.33
Hungary	1980:1-2004:4	1.7	2.6	−0.63	−0.01
Israel	1980:1-2004:4	20.7	8.7	–	−0.02
Korea	1980:1-2004:4	2.4	2.1	−0.04	−0.36
Mexico	1980:1-2004:4	4.0	8.5	−0.11	−0.48
Slovak Rep.	1980:1-2004:4	2.3	5.1	–	0.45
Slovenia	1980:1-2004:4	1.5	11.1	0.27	0.25
South Africa	1980:1-2004:4	1.9	3.9	0.04	0.13
Turkey	1980:1-2004:4	8.3	–	0.74	–
India	1999:2-2010:2	5.53	1.77	−0.35	0.38

The Indian business cycle

Ghate et al. (2013)

Business cycle stylized facts using quarterly data (1999 Q2–2010 Q2).

	Std. dev.	Rel. std. dev.	Cont. corr.	First ord. auto corr.
Real GDP	1.18	1.00	1.00	0.73
Private consumption	1.54	1.31	0.51	0.67
Investment	4.08	3.43	0.69	0.80
CPI	1.30	1.09	−0.29	0.70
Exports	8.79	7.40	0.31	0.77
Imports	8.93	7.52	0.45	0.54
Govt expenditure	6.69	5.53	−0.35	0.005
Net exports	1.24	1.04	−0.15	0.45
Real interest rate	2.11	1.77	0.38	0.372
Nominal exchange rate	4.61	3.88	−0.54	0.82
M1 (narrow money)	3.13	2.64	0.5	0.105
M3 (broad money)	1.79	1.50	0.06	0.40
Reserve money	4.53	3.82	0.47	0.50
CPI inflation	0.88	0.74	0.05	0.66

Is there a unified BC model for EMEs?

- In Ghate, Gopalakrishnan, and Tarafdar (2014), we extend Neumeyer and Perri (2005) to capture this disparity. To do this
  - we add fiscal policy.
  - we make preferences Cobb-Douglas - enables $\rho(R, Y) \lesseqgtr 0$.
- We then calibrate the model to qualitatively match Indian business cycles using
  - TFP shocks
  - interest rate and country spread shocks.

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Main result of the paper

- By adding fiscal policy, we are able to explain the disparity in $\rho\left(R, Y\right)_{EME}$ and in $\rho\left(G, Y\right)_{EME}$
- **Key Feature** : Fiscal policy also acts as a stabilizer in our framework, which makes real interest rates a-cyclical/pro-cyclical in our framework. This is because
    - a time varying tax wedge affects the labor supply and,
    - a subsidy on the interest rate on a portion of the firm's total borrowings affects the labor demand.

Causal Mechanism: Interest rate shocks – stabilizing fiscal policy – the labor market

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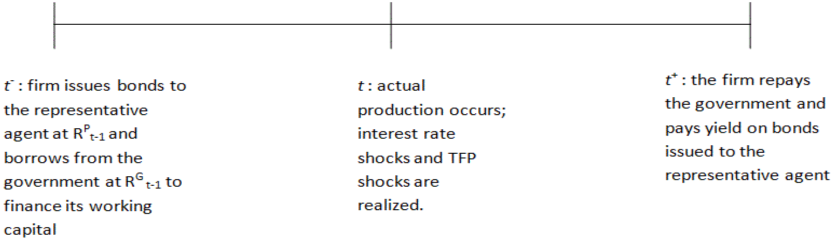
The Model: Firms



The Model: Firms

- The firm maximizes

$$\begin{aligned}\pi_t &= A_t k_{t-1}^{\alpha}\left[(1+\gamma)^t l_t\right]^{1-\alpha} - w_t l_t - r_t k_{t-1} \qquad (38)\\ &- \left(R_{t-1}^G - 1\right)\theta_G w_t l_t - \left(R_{t-1}^P - 1\right)(\theta - \theta_G)\, w_t l_t.\end{aligned}$$

- The government lends $\theta_G < \theta$ portion of the working capital at

$$R_{t-1}^G = R_{t-1}^P (1-s) > 1, \quad 0 < s < 1. \qquad (39)$$

- We obtain w_t and r_t.

The Model: Households

- A stand-in representative agent maximizes

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left[(c_t^*)^{\mu} (1 - l_t)^{(1-\mu)} \right]^{(1-\sigma)}}{(1-\sigma)}, \tag{40}$$

$$\text{where } \forall t \; c_t^* = c_t + \Theta G_t, \text{ such that } \Theta > 1$$

- subject to

$$\begin{aligned} (1+\tau_c)c_t + x_t + b_t + \kappa(b_t) \leq & \; (1-\tau_w)w_t l_t \\ & + (1-\tau_k)r_t k_{t-1} + R_{t-1}^P b_{t-1}. \end{aligned} \tag{41}$$

- $\kappa(b_t)$ is the bond holding cost, x_t is private investment such that;

$$x_t = k_t - (1-\delta)k_{t-1} + \Phi(k_t, k_{t-1}). \tag{42}$$

- $\Phi(k_t, k_{t-1})$ is the investment adjustment cost.

The Model: Government

- The government balances it's budget $\forall t$

$$\underbrace{TR_t}_{\text{After Prod.}} + \underbrace{R^G_{t-1}\theta_G w_t l_t}_{\text{After Prod}} = \underbrace{G_t}_{\text{After Prod.}} + \underbrace{S_t}_{\text{Before Prod.}}$$

- where TR_t is

$$TR_t = \tau_c c_t + \tau_w w_t l_t + \tau_k r_t k_{t-1}. \tag{43}$$

- S_t is the loan extended to firms

$$S_t = \theta_G w_t l_t.$$

- Therefore

$$G_t = \tau_c c_t + \left\{ \left[R^P_{t-1}(1-s) - 1 \right] \theta_G + \tau_w \right\} w_t l_t + \tau_k r_t k_{t-1}. \tag{44}$$

First Order Conditions

$$\{\widetilde{c}_t\} : \lambda_t(1+\tau_c) = \left[(\widetilde{c}_t^*)^{\mu}(1-l_t)^{(1-\mu)}\right]^{-\sigma} \mu(\widetilde{c}_t^*)^{\mu-1}(1-l_t)^{(1-\mu)}$$

where λ_t is the Lagrangian multiplier

$$\{l_t\} : \lambda_t(1-\tau_w)\widetilde{w}_t = \left[(\widetilde{c}_t^*)^{\mu}(1-l_t)^{(1-\mu)}\right]^{-\sigma} (1-\mu)(\widetilde{c}_t^*)^{\mu}(1-l_t)^{-\mu}$$

First Order Conditions

$$\left\{\widetilde{b}_t\right\}: 1+\kappa\left[\frac{\widetilde{b}_t}{\widetilde{y}_t}-\frac{b}{y}\right]=E_t\left[\frac{\widetilde{\beta}}{(1+\gamma)}\frac{\lambda_{t+1}}{\lambda_t}R_t^P\right]$$

$$\left\{\widetilde{k}_t\right\}: 1+\phi(1+\gamma)\left[\left(\frac{\widetilde{k}_t}{\widetilde{k}_{t-1}}\right)-1\right]=E_t\left[\widetilde{\beta}\frac{\lambda_{t+1}}{\lambda_t}F\right].$$

where,

$$F=\frac{(1-\delta)+(1-\tau_k)r_{t+1}}{(1+\gamma)}+\frac{\phi}{2}(1+\gamma)\left\{\left(\frac{\widetilde{k}_{t+1}}{\widetilde{k}_t}\right)^2-1\right\}$$

The Labor Market – Supply side

Proposition

Labor supply, l_t^S, is given by:

$$l_t^S = 1 - \frac{\widetilde{c}_t}{\widetilde{w}_t}\left(\frac{1-\mu}{\mu}\right)\Gamma_t \tag{45}$$

where

$$\Gamma_t = \left(\frac{1+\tau_c}{1-\tau_w}\right)\frac{\Psi_t}{D_{t-1}} \tag{46}$$

And $\tau_c > \tau_w$, $\tau_c > \left[R_{t-1}^P(1-s)-1\right]\theta_G$, *and* $\mu > 0.5 \Longrightarrow \Gamma_t > 1$.

- Γ_t is the "fiscal policy wedge" where

$$\Gamma_t = \left(\frac{1+\tau_c}{1-\tau_w}\right)\frac{\Psi_t}{D_{t-1}}$$

such that

$$D_{t-1} = 1 + \Theta\left(\frac{1-\mu}{\mu}\right)\left(\frac{1+\tau_c}{1-\tau_w}\right)\left\{\left[R^P_{t-1}(1-s)-1\right]\theta_G + \tau_w\right\}$$

and

$$\Psi_t = \left[1 + \Theta\tau_c + \frac{\Theta\tau_k r_t \widetilde{k}_{t-1}}{(1+\gamma)\widetilde{c}_t} + \frac{\Theta\left\{\left[R^P_{t-1}(1-s)-1\right]\theta_G + \tau_w\right\}\widetilde{w}_t}{\widetilde{c}_t}\right]$$

- Clearly, when $\Theta = 0$,

$$\Gamma_t = \overline{\Gamma} = \left(\frac{1+\tau_c}{1-\tau_w}\right).$$

The Labor Market – Supply side

- Note that

$$
\begin{aligned}
D_{t-1} &= D\left(\overset{+}{R^P_{t-1}};\ \text{parameters}\right) \\
\Psi_t &= \Psi\left(\overset{+}{r_t}, \overset{-}{\widetilde{c}_t}, \overset{+}{\widetilde{k}_{t-1}}, \overset{+}{R^P_{t-1}}, \overset{+}{\widetilde{w}_t};\ \text{parameters}\right).
\end{aligned}
$$

The Labor Market – Supply side

- D_{t-1}, does not change on impact. $\Psi_t \uparrow$ in time period t because $\widetilde{c}_t \downarrow$ and $r_t \uparrow$ (no-arbitrage condition).
- Therefore $\Gamma_t \uparrow$ on impact due to a positive interest rate shock.
- Hence the outward shift of l_t^S due to a positive interest rate shock is dampened by an increase in Γ_t.

The Labor Market – Supply side

Proposition

For a positive shock to R_t^P

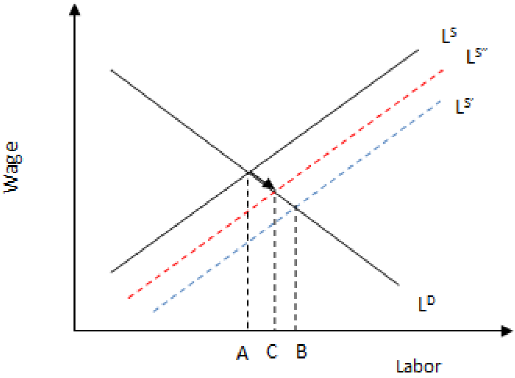
$$\frac{\partial \widetilde{c}_t}{\partial R_t^P} < 0 \Longrightarrow \frac{\partial l_t^S}{\partial R_t^P} > 0$$

Further, a positive interest rate shock always increases the fiscal policy wedge,i.e., $\frac{\partial \Gamma_t}{\partial R_t^P} > 0$ *An increase in* Γ_t *therefore dampens the outward shift of the labor supply:*

$$\left| \frac{\partial l_t^S}{\partial R_t^P} \right|_{\Gamma_t = 0} > \left| \frac{\partial l_t^S}{\partial R_t^P} \right|_{\Gamma_t \neq 0} > 0.$$

Labor supply – interest rate shocks

From a one period shock in R at time period t



$L^s_t \uparrow$ to $L^{s'}_t$ because $\widetilde{c}_t$ instantaneously falls due to the intertemporal substitution effect. However, L^s_t shifts to $L^{s''}_t$ with $\Gamma_t \uparrow$.

The Labor Market Equilibrium – Demand side

- We get l_t^d from the firm's FOC

$$l_t^D = \left[\frac{(1-\alpha)A_t}{\widetilde{w}_t \left[(1-\theta) + R_{t-1}^P \left(\theta - s\theta_G \right) \right]} \right]^{\frac{1}{\alpha}} \frac{\widetilde{k}_{t-1}}{(1+\gamma)}.$$

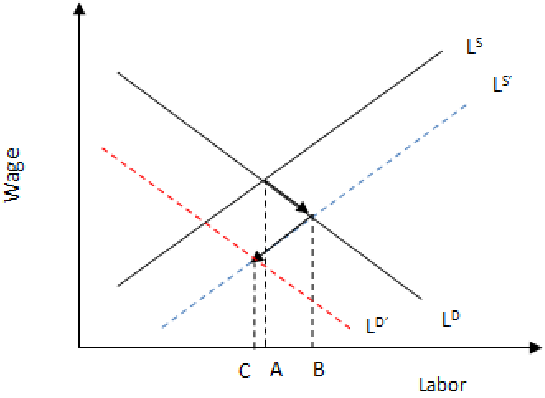
Proposition

A positive shock to interest rate R_t^P lowers labor demand only in time period $t+1$. However, the presence of θ_G and s, dampens the reduction in l_{t+1}^D. That is

$$\left| \frac{\partial l_{t+1}^D}{\partial R_t^P} \right|_{s \neq 0, \theta_G \neq 0} < \left| \frac{\partial l_{t+1}^D}{\partial R_t^P} \right|_{s=0, \theta_G=0}.$$

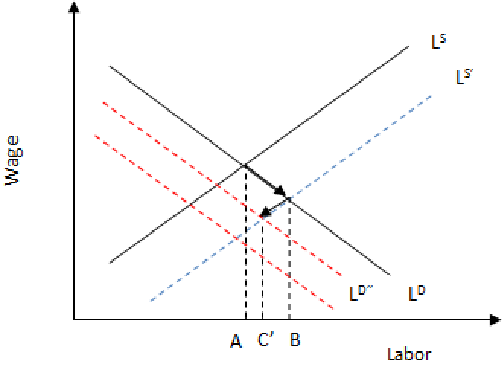
Labor Demand – interest rate shocks

At time period $t+1$



$l_{t+1}^d \downarrow$ because it depends on R_t^P

At time period $t+1$ - with a working capital loan subsidy



Nota Bene: GHH preferences

- Under GHH preferences,

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left[\widetilde{c}_t^* - \psi l_t^v\right]^{(1-\sigma)}}{(1-\sigma)},$$

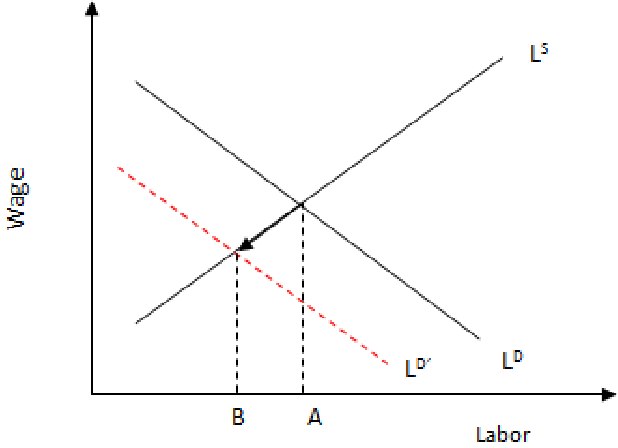
- focs from $\{\widetilde{c}_t\}$ and $\{l_t\}$ will give us l_t^s from

$$\underbrace{\left(\frac{1-\tau_w}{1+\tau_c}\right)}_{\text{tax wedge}} \widetilde{w}_t = \psi v \left(l_t^s\right)^{v-1}.$$

- l_t^s is not affected by private or public consumption, although the tax wedge $\left(\frac{1-\tau_w}{1+\tau_c}\right)$ affects the slope of the labor supply.

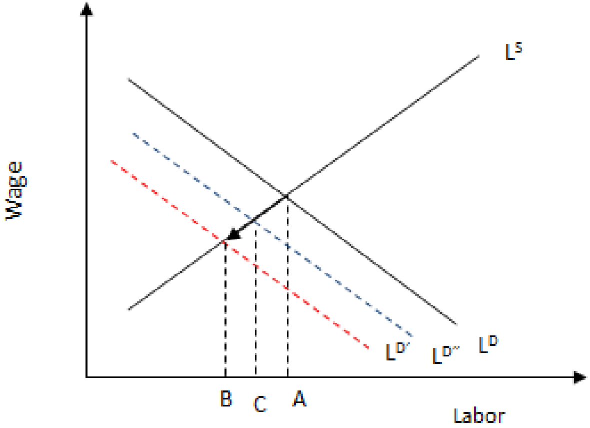
Nota Bene: GHH preferences

Without working capital loan subsidy



Nota Bene: GHH preferences

With working capital loan subsidy



Calibration

- We estimate the DGP for India assuming annual HP-filtered de-trended series from 1980 - 2008. All shocks are for the moment assumed to be uncorrelated.
- TFP (Penn World Tables Version 8.0 (2014))

$$\begin{aligned} \widehat{A}_t &= \rho_A \widehat{A}_{t-1} + \varepsilon_{At}. \\ \rho_A &= 0.42\ (0.012) \end{aligned}$$

- We use annual World Bank data on real lending rates, i.e.,

$$R_t^P = R_t^* D_t. \tag{47}$$

- R_t^* is the US real interest rate. Therefore,

$$\widehat{R}_t^P = \widehat{R}_t^* + \widehat{D}_t.$$

Interest rates and country spreads

- $\widehat{R}_t^*$ is estimated as

$$\widehat{R}_t^* = \rho_R \widehat{R}_{t-1}^* + \varepsilon_{Rt}.$$
$$\rho_R = 0.462\ (0.004)$$

- Country spreads are modelled as

$$\widehat{D}_t = -\eta E_t \widehat{A}_{t+1} + u_t.$$
$$\eta = 0.4425\ (0.006)$$
$$u_t \text{ is a random shock}$$

- This is the "*Induced Case*" as in Neumeyer and Perri (2005), which is the relevant case for India.

Parameters

Table 3: Parameters

Parameter Name	Symbol	Value
Coefficient of risk aversion (calibrated)	σ	2.3
Share of consumption in utility function (calibrated)	μ	0.75
Depreciation rate	δ	0.025
Rate of technical progress (Bhattacharya et al. (2013))	γ	0.047
Ratio of wage bill to be paid in advance	θ	1
Discount rate (calibrated)	β	0.99
Effective discount rate (calibrated)	$\widetilde{\beta}$	$\beta(1+\gamma)^{\mu(1-\sigma)}$
Real interest rate (calibrated)	$\overline{R}^P$	$\frac{(1+\gamma)}{\beta}$
Share of capital in production (Ghate et al. (2012))	α	0.4
Bond holding costs (Tiryaki (2012))	κ	0.0001
Capital adjustment costs	ϕ	60
Subsidized portion of the advance wage bill ratio	θ_G	$\leq \theta$
Subsidy on working capital loans	s	0.11
Tax on consumption (Vat rate in India)	τ_c	0.12
Tax on labor income	τ_w	0.01
Tax on capital income	τ_k	0.01
Edgeworth substitutability of government consumption	Θ	$\gtreqless 1$
Steady state TFP	$\overline{A}$	1

Fiscal policy parameters

- We assume:
  - $\theta = \theta_G = 1$
  - $\tau_c = 0.12$
  - $\tau_k = \tau_w = 0.01$
  - $s = 0.11, \Theta = 75$

Fiscal policy parameters

- We assume:
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Experiment 1: Single period TFP shock

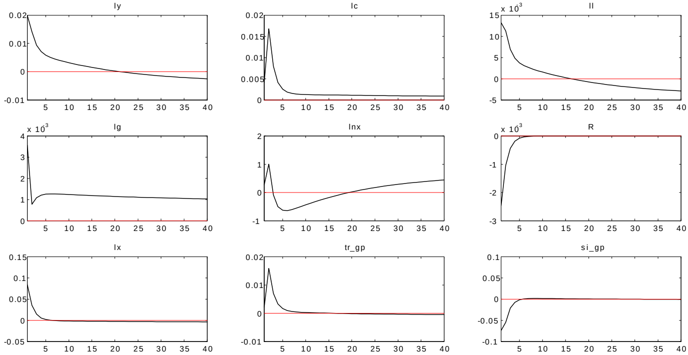

Figure: Single period TFP ($\widehat{A}$) shock

Experiment 2: Single period interest rate shock

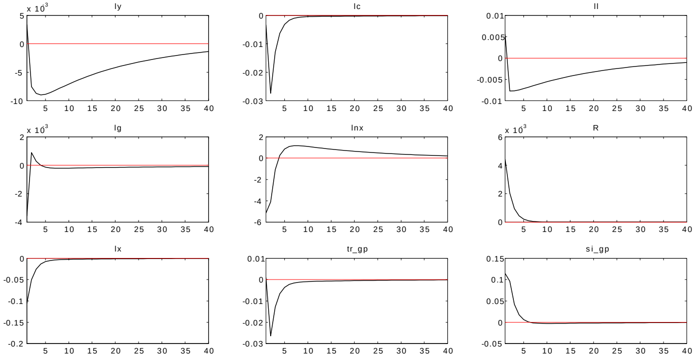

Figure: Single period TFP ($\widehat{R}^*$) shock

Experiment 3: Single period u-shock

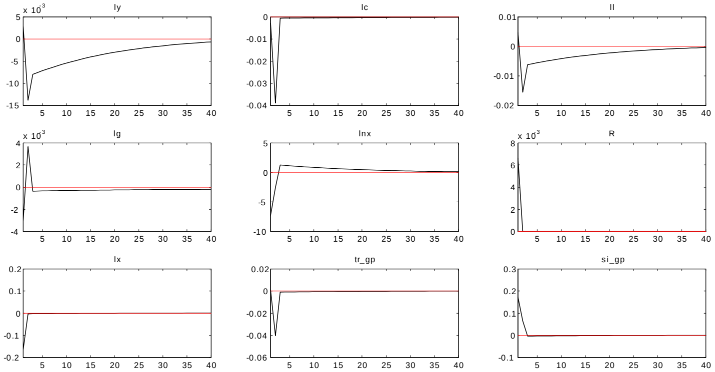

Figure: Single period TFP ($\widehat{D}$) shock

Calibration Results

Moments	No Fiscal Policy	Only G	G and S	Actual Data
(1)	(2)	(3)	(4)	(5)
$\rho(C, Y)$	0.6033	0.4586	0.5126	0.51
$\rho(X, Y)$	0.1330	0.1022	0.1103	0.69
$\rho(R, Y)$	-0.0832	-0.0458	-0.0546	0.38
$\rho(\frac{NX}{Y}, Y)$	0.1912	0.2562	-0.1505	-0.15
$\rho(G, Y)$	–	0.6882	-0.32	-0.35
$\sigma(C)/\sigma(Y)$	0.3548	0.3236	1.20	1.31
$\sigma(X)/\sigma(Y)$	10.9	10.11	10.23	3.43
$\sigma(R)/\sigma(Y)$	0.48	0.439	0.44	1.77
$\sigma(NX)/\sigma(Y)$	11.13	10.57	10.64	1.04
$\sigma(G)/\sigma(Y)$	–	0.358	1.55	5.53

Calibration Results

Moments	G and S	G and S (with high Θ)	Actual Data
(1)	(2)	(3)	(4)
$\rho(C, Y)$	0.5126	0.5045	0.51
$\rho(X, Y)$	0.1103	0.0247	0.69
$\rho(R, Y)$	-0.0546	0.0754	0.38
$\rho(\frac{NX}{Y}, Y)$	-0.1505	-0.1792	-0.15
$\rho(G, Y)$	-0.32	-0.0229	-0.35
$\sigma(C)/\sigma(Y)$	1.20	1.69	1.31
$\sigma(X)/\sigma(Y)$	10.23	7.23	3.43
$\sigma(R)/\sigma(Y)$	0.44	0.28	1.77
$\sigma(NX)/\sigma(Y)$	10.64	7.82	1.04
$\sigma(G)/\sigma(Y)$	1.55	0.23	5.53

Takeaway

- Counter-cyclical government expenditures act as stabilizers
- Interest rate shocks have implications for labor market dynamics and therefore in EME business cycles
    - However, fiscal policy dampens the transmission of interest rate shocks to labor market dynamics
    - Goodness of fit improves for the Indian business cycles when we add government expenditures and subsidies.
    - Government expenditure is counter-cyclical for high subsidies and low tax rates
- But,
    - Our fit needs to improve – knife-edge!
    - Government debt; effect on spreads?

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Thank you!