Fiscal and monetary policy interaction: a simulated based analysis of a two-country New Keynesian DSGE model with heterogeneous households*

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* The views expressed here are those of the authors and not necessarily those of the Central Bank of Brazil.
Model specification: main references

NAWM (ECB)

- JEDC, de 2008: Tax reform and labour-market performance in the euro area: a simulation-based analysis using the New Area-Wide Model, by Coenen, McAdam e Straub

- WP ECB # 944, de 2008: The New Area-Wide Model of the euro area: a micro-founded open-economy model for forecasting and policy analysis, by Christoffel, Coenen e Warne
An ECB/NAWM extension:

- government investment
- primary surplus (debt commitment)
- forward looking monetary policy
- labor specialization
- CPI specification (aggregated resources)
An ECB/NAWM extension (cont.):

- calibration:
  - small size open economy
  - risk premium
  - different inflations
  - non-zero trade balance (external debt)
- equations direct into DYNARE
  (not log-linearized)
Model specification: core structure

**Households**
- Type 1
  - more specialized labor
  - consume goods
  - invest: government domestic bonds, international private bonds, rent capital to firms and money
- Type 2
  - less specialized labor
  - consume goods
  - invest: money

**Capital market:** perfect competition
**Labor services market:** monopolistic comp. / wage rigidities

**Intermediary goods firms**
- combine labor and capital (private + public)

**Domestic market**

**Exports**

**Intermediary goods market:** monopolistic comp. w/ price rigidities

**Final goods firms**
- combine domestic and imported intermediary goods

**Private consumption**

**Government consumption**

**Investment**

**Final goods market:** perfect competition (zero profit/price index)

**Domestic bonds market:** households take IR

**Government**
- consume goods
- investment (buy investment goods)
- issue domestic bonds
- taxes: consumption, social security and payroll
- transfers to households (with bias)

**Monetary Policy**
- Forward looking
- Taylor rule

**Fiscal Policy**
- Primary surplus with debt commitment

**International markets:**
- international bonds: households take IRs
- intermediary goods: monopolistic comp. w/ price rigidities

**Rest of the world:**
- modeled symmetrically, except:
  - monetary rule (backward looking)
  - fiscal rules (consumption/lump-sum taxes)
  - calibration (spread/inflation/trade balance)
Model specification: frictions

- several nominal and real frictions (same of NAWN):
  - price and wage rigidity
  - habit on consumption
  - variable capital utilization
  - cost on adjustment of investment level
  - cost on transaction on consumption (velocity of money)
  - cost on adjustment of imports utilization
  - fixed cost on intermediate goods production
  - risk spread/intermediation costs on international bonds negotiation
Model specification: Taylor rule

\[ R_t^4 = \phi_{R1}.R_{t-1}^4 + \phi_{R2}.R_{t-2}^4 + (1 - \phi_{R1} - \phi_{R2}).\left[ R^4 + \phi_{\Pi}.\left( \frac{P_{C,t+3}}{P_{C,t-1}} - \Pi \right) \right] + \epsilon_{R,t} \]

where

- \( \Pi \): s.s. inflation (annual)
- \( R \): s.s. nominal interest rate (quarter)
- \( \phi_{R1}, \phi_{R2} \): gradualism
- \( \phi_{\Pi} \): s.s. inflation commitment
- \( \epsilon_{R,t} \): exogenous shock (white noise)
Model specification: primary surplus rule

\[
\frac{SP_t}{P_{Y,t} \cdot Y_t} = \rho_{sp} \cdot \frac{SP_{t-1}}{P_{Y,t-1} \cdot Y_{t-1}} + (1 - \rho_{sp}) \left\{ sp + \phi_{By} \left( \left( \frac{R_{t-1} \cdot B_{t+1}}{P_{Y,t} \cdot Y_t} \right) - B_Y \right) \right\} + \varepsilon_{sp,t}
\]

where

\[
SP_t = \left( B_t - R_{t-1} \cdot B_{t+1} \right) + \left( M_{t-1} - M_t \right)
\]

- \( B_Y \): s.s. government debt (% of nom. product)
- \( \rho_{sp} \): gradualism
- \( \phi_{By} \): s.s. debt commitment
- \( \varepsilon_{sp,t} \): exogenous shock (white noise)
Minimization of costs by final-goods firms (as in CMS):

$$\min_{H_t^C, IM_t^C} \ P_{H,t} \cdot H_t^C + P_{IM,t} \cdot IM_t^C$$

s.t.

$$Q_t^C := \left\{ \begin{array}{l} (V_C)^{1/\mu_C} \left[ H_t^C \right]^{(\mu_c-1)/\mu_c} + \\
(1-V_C)^{1/\mu_C} \left[ (1-\Gamma_{IM}^C (IM_t^C / Q_t^C)) \cdot IM_t^C \right]^{(\mu_c-1)/\mu_c} \end{array} \right\} \mu_c / (\mu_c-1)$$

where

$$\Gamma_{IM}^C \left( \frac{IM_t^C}{Q_t^C} \right) := \gamma_{IM}^C \left( \frac{IM_t^C}{Q_t^C} \right)^2$$

is the adjustment cost of imported share of inputs
Model specification: consumer price index

Demand functions

\[ H_t^C = \nu_C \left( \frac{P_{H,t}}{\lambda_t^C} \right)^{-\mu_c} \cdot Q_t^C \]

\[ IM_t^C = (1-\nu_C) \left( \frac{P_{IM,t}}{\Gamma_{IM}^C (IM_t^C / Q_t^C)} \right)^{-\mu_c} \cdot \left( 1 - \Gamma_{IM}^C (IM_t^C / Q_t^C) \right) \]

where

\[ \Gamma_{IM}^C (IM_t^C / Q_t^C) := 1 - \Gamma_{IM}^C (IM_t^C / Q_t^C) - \Gamma'_{IM} (IM_t^C / Q_t^C) \cdot (IM_t^C / Q_t^C) \]

and

\[ \lambda_t^C = \left[ \nu_C P_{H,t}^{1-\mu_c} + (1-\nu_C) \left( P_{IM,t} / \Gamma_{IM}^C (IM_t^C / Q_t^C) \right)^{1-\mu_c} \right]^{\frac{1}{1-\mu_c}} \]

is the Lagrange multiplier
Model specification: consumer price index

\[
P_{H,t}H_t^C + P_{IM,t}IM_t^C = \\
= \left\{ v_c \left( \frac{P_{H,t}}{X_t^C} \right)^{1-\mu_c} + (1-v_c) \left( \frac{P_{IM,t}}{\Gamma_{IM}^C (IM_t^C/Q_t^C)} \right)^{1-\mu_c} \left\{ \frac{\Gamma_{IM}^C (IM_t^C/Q_t^C)}{1-\Gamma_{IM}^C (IM_t^C/Q_t^C)} \right\} \right\} \cdot \lambda_t^C \cdot Q_t^C \\
= v_c \cdot P_{H,t} \cdot X_t^C^{1-\mu_c} + (1-v_c) \left( \frac{P_{IM,t}}{\Gamma_{IM}^C (IM_t^C/Q_t^C)} \right)^{1-\mu_c} \left\{ \frac{\Gamma_{IM}^C (IM_t^C/Q_t^C)}{1-\Gamma_{IM}^C (IM_t^C/Q_t^C)} \right\} \left( \lambda_t^C \right)^{\mu_c} \cdot Q_t^C \\
= P_{C,t}Q_t^C
\]
Model specification: consumer price index

\[ P_t^C = (\lambda_t^C)^{\mu_C} (\Omega_t^C)^{1-\mu_C} \]

where

\[ \lambda_t^C = \left[ \nu_C \cdot P_{H,t}^{1-\mu_C} + (1-\nu_C) \left( P_{IM,t} / \Gamma_{IM}^3 (IM_t^C / Q_t^C) \right)^{1-\mu_C} \right]^{1-\mu_C} \]

\[ \Omega_t^C = \left\{ \nu_C \left( P_{H,t} \right)^{1-\mu_C} + (1-\nu_C) \left[ \frac{\Gamma_{IM}^3 (IM_t^C / Q_t^C)}{1-\Gamma_{IM}^3 (IM_t^C / Q_t^C)} \right] (P_{IM,t} / \Gamma_{IM}^3 (IM_t^C / Q_t^C))^{1-\mu_C} \right\}^{1-\mu_C} \]
Model specification: aggregate resources

Using our price indexes

\[ P_{Y,t} \cdot Y_t = P_{C,t} \cdot Q_t^C + P_{I,t} \cdot Q_t^I + P_{G,t} Q_t^G + S_t \cdot P_{X,t} \cdot X_t - P_{IM,t} IM_t \]

Different from CMS

\[ P_{Y,t} \cdot Y_t = P_{C,t} \cdot Q_t^C + P_{I,t} \cdot Q_t^I + P_{G,t} Q_t^G + S_t \cdot P_{X,t} \cdot X_t - P_{IM,t} IM_t \cdot \left[ \frac{1 - \Gamma_{IM,t}^C (IM_t^C / Q_t^C)}{\Gamma_{IM,t}^C (IM_t^C / Q_t^C)} \right] + IM_t^I \cdot \frac{1 - \Gamma_{IM,t}^I (IM_t^I / Q_t^I)}{\Gamma_{IM,t}^I (IM_t^I / Q_t^I)} \]
Model specification: size of the model

- 137 (+ 137) endogenous domestic (foreign) variables
- 274 equations
- 6 (+6) exogenous shocks to domestic (foreign) economy:
  - monetary policy
  - fiscal policy (primary surplus / consumption)
  - government investment
  - government transfers
  - total productivity
  - trend of labor productivity
Calibration

- global real growth trend (labor productivity)
- risk premium
- small open domestic economy
- positive trade balance (external debt)
- historical averages during IT regime (1999)
Simulations: impulse-responses

1. monetary policy shock (interest rate)
2. fiscal policy shock (primary surplus)
3. fiscal and monetary policy interaction (after MP shock)
   - debt commitment → effective MP instrument
4. shock to government transfers
5. shock to government investment
## Monetary Policy Rule: alternative specifications

<table>
<thead>
<tr>
<th></th>
<th>Reaction to deviation from IT</th>
<th>Reaction to product growth</th>
<th>Gradualism Additional terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic: base model*</td>
<td>1.57</td>
<td>0</td>
<td>(-1): 1.13 (-2): 0.51</td>
</tr>
<tr>
<td></td>
<td><em>(expected inflation)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic: Alternative 1**</td>
<td>1.4354</td>
<td>0.79</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td><em>(current inflation)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic: Alternative 2</td>
<td>1.57</td>
<td>0</td>
<td>(-1): 1.13 (-2): 0.51</td>
</tr>
<tr>
<td></td>
<td><em>(past inflation)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic: Alternative 3</td>
<td>1.57</td>
<td>0</td>
<td>(-1): 1.13 (-2): 0.51</td>
</tr>
<tr>
<td></td>
<td><em>(expected inflation)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rest of the world</strong></td>
<td>2.0</td>
<td>0.10</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td><em>(past inflation)</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Nelson & Minella (BCB)  ** Silveira (IPEA)
Monetary Policy Shock: output & inflation

Output ($y/y^e$)

Output Growth Rate ($gy^4-1 \times 100$)

Nominal Exchange Rate ($s/s^e$)

Consumer Price Index ($pc/pc^e$)

Consumer Price Inflation ($inpc^4-1 \times 100$)

Nominal Interest Rate ($r^4-1 \times 100$)
Monetary Policy Shock: government & households

- **Government Bonds (b)**
  - Primary Surplus (sp)
  - Range from 2.15 to 2.2

- **Households Consumption (c/c^e)**
  - Labor Services (n_t)
  - Range from 0.99 to 1

- **Government Consumption (g^p)**
  - Range from 0.04 to 0.05

- **Wage Rate (w/w^e)**
  - Range from 0.835 to 0.85
Monetary Policy Shock: capital

- Rental Rate of Capital \( ((1+rk)^4-1)^*100 \)
- Capital Stock \( (k/k^e) \)
- Intensity of Capital Utilization \( (ui) \)
- Marginal Cost \( (mc) \)
- Price of Capital \( (qi = pi/pc) \)
- Dividends \( (d) \)
Monetary Policy Shock: trade balance

- **Trade Balance (tb)**
- **Imports (im/im°)**
- **Exports (x/x°)**
- **Nominal Exchange Rate (s/s°)**
- **Import Price (pm/pm°)**
- **Export Price (px/px°)**
 Monetary Policy Shock: distributional effects

- Consumption $I \times J (c_i/c_j)$
- Labor Services $L \times J (n_i/n_j)$
- Wages $W \times J (w_i/w_j)$
### Fiscal Policy Rules: alternative specification

<table>
<thead>
<tr>
<th>Primary surplus target</th>
<th>Weight of the target</th>
<th>Gradualism</th>
<th>Reaction to debt deviation: debt commitment (into the rule)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic: base model</td>
<td>0.55</td>
<td>0.45</td>
<td>0.20</td>
</tr>
<tr>
<td>Domestic: alternative</td>
<td>0.55</td>
<td>0.45</td>
<td>0.10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consumption target</th>
<th>Weight of the target</th>
<th>Gradualism</th>
<th>Reaction to debt deviation: lump-sum taxes (out of the rule)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest of the world</td>
<td>0.10</td>
<td>0.90</td>
<td>0.10</td>
</tr>
</tbody>
</table>
Fiscal Policy Shock: primary surplus

Primary Surplus (sp)

Government Bonds (b)

Government Consumption (gp)
Fiscal Policy Shock: output & inflation

- Output (\(y/y^e\))
- Output Growth Rate (\(g_y^{4-1} \times 100\))
- Nominal Exchange Rate (\(s/s^e\))
- Consumer Price Index (\(pc/pc^e\))
- Consumer Price Inflation (\(inpc^{4-1} \times 100\))
- Nominal Interest Rate (\(r^{4-1} \times 100\))
Fiscal Policy Shock: households

Households Consumption ($c/c^e$)

Consumption I x J ($c_i/c_j$)

Labor Services (nto)

Labor Services I x J (nio/njo)

Wage Rate ($w/w^e$)

Wages I x J ($w_i/w_j$)
Fiscal and Monetary Interaction: interest & inflation

MONETARY POLICY SHOCK

HIGH COMMITMENT TO STEADY STATE DEBT

LOW COMMITMENT TO STEADY STATE DEBT

Nominal Interest Rate \((r^4-1) \times 100\)

Consumer Price Inflation \((\text{inpc}^4-1) \times 100\)
Fiscal and Monetary Interaction: government

MONETARY POLICY SHOCK

HIGH COMMITMENT TO STEADY STATE DEBT

LOW COMMITMENT TO STEADY STATE DEBT

Graphs showing the effects of monetary policy shocks on government bonds, primary surplus, government consumption, and other economic indicators for high and low commitment to steady state debt.
Fiscal and Monetary Interaction: output & welfare

MONETARY POLICY SHOCK
HIGH COMMITMENT TO STEADY STATE DEBT

LOW COMMITMENT TO STEADY STATE DEBT

Output \( (y/y^e) \)

Households Consumption \( (c/c^e) \)

Labor Services \( (nto) \)
Shock to gov. transfers: primary surplus
Shock to gov. transfers: output & inflation

Output ($y/y^e$)

Consumer Price Index ($pc/pce^e$)

Output Growth Rate ($gy^{4-1}*100$)

Consumer Price Inflation ($inpc^{4-1}*100$)

Nominal Exchange Rate ($s/s^e$)

Nominal Interest Rate ($r^{4-1}*100$)

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Shock to gov. transfers: distributional effects

- Households Consumption ($c/c^e$)
- Consumption $I \times J$ ($c_i/c_j$)
- Labor Services $I \times J$ ($n_i/n_j$)
- Wage Rate ($w/w^e$)
- Wages $I \times J$ ($w_i/w_j$)
Shock to gov. investment: private investment

Public Investment/Output (ig)

Total Investment \((iv+ivg)/(iv^e+ivg^e)\)

Public Investment \((ivg/ivg^e)\)

Private Investment \((iv/iv^e)\)
Shock to gov. investment: primary surplus

- Graph showing government bonds (b) against primary surplus (sp)
- Graph showing government consumption (gp) against primary surplus (sp)
Shock to gov. investment: output & inflation

- Output (y/y^e) vs. Output Growth Rate (g(y^4-1)*100)
- Consumer Price Index (pc/pc^e) vs. Consumer Price Inflation (inpc^4-1)*100
- Nominal Exchange Rate (s/s^e)
- Nominal Interest Rate (r^4-1)*100
Shock to gov. investment: distributional effects

Households Consumption (c/c^e)

Labor Services (n/to)

Wage Rate (w/w^e)

Consumption | x | J (c_i/c_j)

Labor Services | x | J (n_i/n_j)

Wages | x | J (w_i/w_j)
To do next…

- Estimate (Bayesian approach and IR-VAR approximation)
  - identify the shocks to the Brazilian economy during the IT regime
- Financial frictions
  - Christiano, Eichenbaum e Evans (2005)
  - Chari, Christiano e Eichenbaum (1995)
  - Bernanke, Gertler e Gilchrist (1999)
- Labor market improvements
  - Gertler, Sala e Trigari (2006)
  - Christiano, Motto e Rostagno (2008)
- Optimal policy analysis (Ramsey)