Regime Switching in Fiscal Debt Targets and Policy Functions in the United States

James M. Murray, Ph.D.
Department of Economics
University of Wisconsin - La Crosse

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Describe fiscal policy dynamics

- Government expenditures
- Income tax rate
- Net transfer payments
- Deficits
- Debt

Describe debt service

1. How do these fiscal policy variables respond to \( \text{debt} / \text{GDP} \)?
2. What is the implied target for \( \text{debt} / \text{GDP} \)?
3. Is there switching in these fiscal policy responses?
4. Is there switching in the long-run debt target?

Describe stabilizing behavior

1. How do fiscal policy variables respond to \( \text{output gap} \)?
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Government expenditures  Deficits
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### Describe stabilizing behavior

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Fiscal Variables

1. Debt to GDP Ratio
2. Government Expenditures Ratio to GDP
3. Tax Revenue Ratio to GDP
4. Transfer Ratio to GDP

Images showing trends over time from 1970 to 2010.
Debt target and tax response matter

- Expected smaller debt/GDP target and/or expected larger response of taxes to debt,
  → Higher expected income taxes
  → lower consumption, investment, real GDP.
- Richter and Throckmorton (EER, 2015):
  - Unknown debt targets amplify impact of tax shocks
  - Uncertain long-run debt targets reduced impact of ARRA, extensions to Bush tax cut

Fiscal composition matters

Leeper, Plante, and Traum (JoE, 2010)

- Rich set of fiscal variables responding to debt fits data best
- Magnitude of fiscal shocks depend on composition
- Fiscal multipliers can have unexpected signs, depending on composition
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Gradual movement toward target

\[ G_t = \rho_g \left( \frac{Y_{t-1}}{Y_{t-2}} \right) G_{t-1} + (1 - \rho_g) G^*_t, \]

- \( \rho_g \in (0, 1) \): persistence parameter
- \( G_t \): Actual nominal government expenditures
- \( G^*_t \): Target level for government expenditures
- \( Y_t \): Nominal GDP, so \( Y_{t-1}/Y_{t-2} \), is lagged gross NGDP growth.

Divide by nominal GDP \( (Y_t) \)

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- \( g_t \equiv G_t/Y_t, \ g^*_t \equiv G^*_t/Y_t \): Actual / Target government expenditures to GDP ratio
- \( y_t \equiv Y_t/Y_{t-1} \): Gross growth rate of nominal GDP
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Regime Switching in Fiscal Policy functions
Target Policy Behavior

- Use government expenditures to stabilize business cycle
  → Decrease gov exp in response to output gap
- Decrease government expenditures in response to rising debt

Structure

\[ g_t^* = \bar{g}(s_t) + \psi_g(s_t)x_t + \gamma_g(s_t) [b_{t-1} - \bar{b}(s_t)] + u_{g,t}, \]

- \( s_t \in \{1, \ldots, M\} \): Fiscal regime... more later
- \( \bar{g}(s_t) \): Long-run government expenditures / GDP goal
- \( b_{t-1} \): Lagged government debt / GDP ratio
- \( \bar{b}(s_t) \): Long-run goal debt / GDP ratio
- \( \psi_g(s_t) < 0 \): Response to increase in output gap
- \( \gamma_g(s_t) < 0 \): Response to increase in government debt
- \( u_{g,t} \): Shock to government expenditures
Fiscal Policy: Government Expenditures Target

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Movement Toward Target

\[ \tau_t = \rho_{\tau} \left( \frac{y_{t-1}}{y_t} \right) \tau_{t-1} + (1 - \rho_{\tau}) \tau_t^* \]

- \( \tau, \tau^* \): Tax revenue / GDP, short-run target

Target Policy Behavior

- Use taxes to stabilize business cycle
  - \( \rightarrow \text{Increase taxes} \) in response to output gap
- Increase taxes in response to rising debt

Target Tax Policy

\[ \tau_t^* = \bar{\tau}(s_t) + \psi_{\tau}(s_t)x_t + \gamma_{\tau}(s_t) [b_{t-1} - \bar{b}(s_t)] + u_{\tau,t} \]

- \( \psi_{\tau}(s_t) > 0 \): Response to increase in output gap
- \( \gamma_{\tau}(s_t) > 0 \): Response to increase in government debt
- \( u_{\tau,t} \): Shock to tax policy
Fiscal Policy: Tax Revenue

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- $\psi_{\tau}(s_t) > 0$: Response to increase in output gap
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Fiscal Policy: Net Transfers

**Movement Toward Target**

\[ n_t = \rho_n \left( \frac{y_{t-1}}{y_t} \right) n_{t-1} + (1 - \rho_n) n_t^* \]

- \( n, n^* \): Net transfers / GDP, short-run target

**Target Policy Behavior**

- Use transfers to stabilize business cycle
  - \( \rightarrow \) Decrease transfers in response to output gap
- Decrease transfers in response to rising debt

**Target Transfers Policy**

\[ n_t^* = \bar{n}(s_t) + \psi_n(s_t)x_t + \gamma_n(s_t) \left[ b_{t-1} - \bar{b}(s_t) \right] + u_{n,t} \]

- \( \psi_n(s_t) < 0 \): Response to increase in output gap
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Primary Budget Deficit

\[ d_t = \tau_t - g_t - n_t + \tilde{d}_t \]

\( \tilde{d}_t \): Deficit residual

(Other expenditure or revenue items I did not include)

Deficit Residual Behavior

Gradual movement toward target:

\[ \tilde{d}_t = \rho_d \left( \frac{y_{t-1}}{y_t} \right) \tilde{d}_{t-1} + (1 - \rho_d) d^*_t \]

Short-run target:

\[ d^*_t = \tilde{d}(s_t) + \psi_d(s_t)x_t + \gamma_d(s_t) \left[ b_{t-1} - \bar{b}(s_t) \right] + u_{d,t} \]
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### Intertemporal government budget constraint

\[ B_t = (1 + r_{t-1})B_{t-1} + D_t - (M_t - M_{t-1}), \]

- \( B_t \): Nominal government debt
- \( r_{t-1} \): interest rate on past-issued debt
- \( D_t \): Nominal budget deficit
- \( M_t - M_{t-1} \): seigniorage

### Empirical government budget constraint

Divide both sides by \( Y_t \) and allow for measurement error \( (v_t) \)

\[ b_t = (1 + r_{t-1}) \left( \frac{1}{Y_t} \right) b_{t-1} + d_t - m_t + \left( \frac{1}{Y_t} \right) m_{t-1} + v_t \]
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Residual: \( u_{b,t} \)
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Budget constraint

- Budget constraint describes relationship between long-run targets for...
  1. Debt / GDP, \( \bar{b}(s_t) \), and
  2. deficits / GDP, \( \bar{d}(s_t) \)

- Evaluate budget constraint at steady state and a constant fiscal regime \( s_{t-1} = s_t = s \):

\[
\bar{d}(s) = \left( \frac{\bar{y} - \bar{r} - 1}{\bar{y}} \right) \bar{b}(s) - \bar{u}_b
\]

Long-run deficit dependencies

- Debt target
- Long-run nominal GDP growth
- Long-run nominal interest rate
- Long-run seigniorage

Jointly estimate these long-run targets
Relationship between deficits and debt

Budget constraint

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Long-run deficit dependencies

Debt target | Long-run nominal interest rate
Long-run nominal GDP growth | Long-run seigniorage

Jointly estimate these long-run targets
Regime-dependent variances for fiscal shocks

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Correlations of fiscal shocks

- Fiscal policy decisions are dependent on one another.
- Consider all possible correlations:
  \[ \varrho_{g,\tau}, \varrho_{\tau,n}, \varrho_{g,n}, \varrho_{\tau,d}, \varrho_{g,d}, \varrho_{n,d} \]
Regime-dependent variances for fiscal shocks

\[ \sigma^2_g(s_t): \text{Var(} \text{shock to gov exp)} \]
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### Long-run Debt Target Regimes

**Regime L:** *Low* long-run target for debt/GDP (low value for $\bar{b}(s_t)$)

**Regime H:** *High* long-run target for debt/GDP (high value for $\bar{b}(s_t)$)

### Fiscal Financing

- Targets for fiscal components: $\bar{g}(s_t)$, $\bar{\tau}(s_t)$, $\bar{n}(s_t)$, $\bar{d}(s_t)$
- Behavior toward output gap and debt: $\psi_f(s_t)$ and $\gamma_f(s_t)$, for $f \in \{g, \tau, n, d\}$

**Regime A:** Fiscal behavior A

**Regime B:** Fiscal behavior B

### Fiscal Volatility

Two regimes to determine variances, $\sigma^2_g(s_t)$, $\sigma^2_\tau(s_t)$, $\sigma^2_n(s_t)$, and $\sigma^2_d(s_t)$:

**Regime S:** *Stable*, relatively smaller variances

**Regime V:** *Volatile*, relatively larger variances
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Three Sources for Regime Switching

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**Markov regime switching**

Regime switches randomly, each source *independently* of other sources

- \( p_L = P(s_t = L|s_{t-1} = L) \) be prob policy remains in reg L
- \( p_H = P(s_t = H|s_{t-1} = H) \) be prob policy remains in reg H
- \( p_A = P(s_t = A|s_{t-1} = A) \) be prob policy remains in reg A
- \( p_A = P(s_t = B|s_{t-1} = B) \) be prob policy remains in reg B
- \( p_A = P(s_t = S|s_{t-1} = S) \) be prob policy remains in reg S
- \( p_A = P(s_t = V|s_{t-1} = V) \) be prob policy remains in reg V

**Rich Set of Regime-Switching Possibilities**

- Changes in priorities for taxes, transfers, spending, *without adjusting long-run targets for debt/GDP*
- Changes in debt-targets, *without adjusting purposes and priorities for fiscal components*
- Changes in volatility of fiscal outcomes, *without changing goals or purposes*
Regime Switching Procedure

Markov regime switching

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- \(p_B = P(s_t = B|s_{t-1} = B)\) be prob policy remains in reg B
- \(p_S = P(s_t = S|s_{t-1} = S)\) be prob policy remains in reg S
- \(p_V = P(s_t = V|s_{t-1} = V)\) be prob policy remains in reg V

Rich Set of Regime-Switching Possibilities

- Changes in priorities for taxes, transfers, spending, \textit{without adjusting long-run targets for debt/GDP}
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- Changes in volatility of fiscal outcomes, \textit{without changing goals or purposes}
Completing the model

Loose ends

- Relationship between $\bar{d}(s_t)$ and $\bar{b}(s_t)$ depends on...
  - long-run values for nominal GDP growth ($\bar{y}$)
  - long-run average interest rate ($\bar{r}$)
- Identify effects of output gap on fiscal policy behavior *from effects of fiscal policy actions on output gap.*

Next steps

- Specify monetary policy
- Specify inter-dependent behavior of macro variables: GDP growth, output gap, and inflation
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- Specify inter-dependent behavior of macro variables: GDP growth, output gap, and inflation
Taylor-like (1993) rule

\[ r_t = (1 - \rho_r) \bar{r} + \rho_r r_{t-1} + (1 - \rho_r) \left[ \phi_x x_t + \phi_\pi (\pi_t - \bar{\pi}) \right] + u_{r,t}, \]

\( \bar{r} \): long-run nominal interest rate
\( \rho_r \): Monetary policy persistence
\( \phi_x > 0 \): Response to output gap
\( \phi_\pi > 0 \): Response to inflation
\( \pi_t \): inflation rate
\( \bar{\pi} \): target inflation rate
\( x_t \): output gap
\( u_{r,t} \): shock to monetary policy

Policy shock

\[ u_{r,t} = \alpha_r u_{r,t-1} + e_{r,t}, \quad e_{r,t} \sim \mathcal{N}(0, \sigma_r^2) \]
Taylor-like (1993) rule

\[ r_t = (1 - \rho_r) \bar{r} + \rho_r r_{t-1} + (1 - \rho_r) [\phi_x x_t + \phi_\pi (\pi_t - \bar{\pi})] + u_{r,t}, \]

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\( \phi_x > 0 \): Response to output gap  
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\( \bar{\pi} \): target inflation rate  
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\( u_{r,t} \): shock to monetary policy

Policy shock

\[ u_{r,t} = \alpha_r u_{r,t-1} + e_{r,t}, \quad e_{r,t} \sim \mathcal{N} \left( 0, \sigma_r^2 \right) \]
Dependent variables

Augmented vector autoregression for...
1. nominal GDP growth, $y_t$,
2. output gap, $x_t$,
3. inflation, $\pi_t$

Explanatory variables

- One lag of all dependent variables: $y_{t-1}$, $x_{t-1}$, $\pi_{t-1}$
- Fiscal policy variables: $g_t$, $\tau_t$, $n_t$
- Monetary policy: $r_t$

Estimation Outcomes

- Long-run values for $\bar{y}$ and $\bar{r}$
- Predictive model for impact of fiscal policy on macro outcomes, $y_t$, $x_t$, $\pi_t$, $r_t$
### Dependent variables

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Output and Inflation Dynamics

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1. Nominal government expenditures: NIPA Table 1.1.5, Line 22
2. Tax revenue: NIPA Table 3.2, Line 3
3. Net transfers: Federal current transfer pmts - receipts
   - NIPA Table 3.2, (Line 25 - Line 18)
4. Primary budget deficit:
   - (-) net federal government saving - federal interest payments
   - NIPA Table 3.2, Line 36 - Line 32
5. Government debt: Federal debt held by the public (U.S. Dept of Treasury)

### Remaining variables

6. Nominal GDP: NIPA Table 1.1.5, Line 1
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8. Inflation: Growth GDP implicit price deflator (NIPA Table 1.1.9, Line 1)
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- Approximates probability in each regime over sample period, given parameters, including switching probabilities.

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- Metropolis-Hastings Markov-Chain Monte Carlo
- Impose $(0, 1)$ priors for a number of parameters (persistence, fiscal components ratio to GDP, et al.)
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  - Monetary policy responses to output gap
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- Ceteris paribus, an increase in output gap leads to higher taxes (captured by parameter $\psi_T(s_t)$ in fiscal policy equation)
- Ceteris paribus, an increase in taxes leads lower aggregate demand and therefore a lower output gap (captured by coef in augmented VAR for $x_t$)

Sign restrictions

- Faust (1998), Canova and De Nicolo (2002), and Uhlig (2005)
- MCMC parameter draw used to compute impulse response functions.
- Impulse response function examples:
  - Impulse = single shock to output gap
  - Response = time path of response to tax revenue
  - Response = time path of response to output gap
- Require some responses be non-negative or non-positive
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Example Sign Restrictions

**Impulse: Shock to output gap**
- Responses = resulting time paths for output gap, tax revenue
- Output gap response should be positive
- Tax revenue response should be positive

**Impulse: Shock to tax ratio**
- Responses = resulting time paths for output gap, tax revenue
- Output gap response should be negative
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**Time frame**
Restrict cumulative response over 2 quarters, including shock period.

James M. Murray, University of Wisconsin - La Crosse
Regime Switching in Fiscal Policy functions
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### Fiscal Policy Sign Restrictions

#### Fiscal policy sign restrictions

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<thead>
<tr>
<th>Response</th>
<th>Gov Exp</th>
<th>Taxes</th>
<th>Transfers</th>
<th>Deficit</th>
<th>Output gap</th>
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<tbody>
<tr>
<td>Output gap</td>
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<td>positive</td>
<td>positive</td>
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<tr>
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### Posterior Parameter Distributions Under Regimes A & B

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<th>Fiscal Regime B</th>
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<tbody>
<tr>
<td>$g$</td>
<td>Long-run gov target</td>
<td>Median: 0.19</td>
<td>Median: 0.31</td>
</tr>
<tr>
<td></td>
<td>90% Bounds: (0.18, 0.20)</td>
<td>90% Bounds: (0.29, 0.32)</td>
<td></td>
</tr>
<tr>
<td>$\psi_g$</td>
<td>Resp to output gap</td>
<td>Median: -0.32</td>
<td>Median: -0.43</td>
</tr>
<tr>
<td></td>
<td>90% Bounds: (-0.38, -0.28)</td>
<td>90% Bounds: (-0.45, -0.39)</td>
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<tr>
<td>$\gamma_g$</td>
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<td>Median: -0.55</td>
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<tr>
<td></td>
<td>90% Bounds: (-0.61, -0.49)</td>
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### Description
- Fiscal Regime A has lower long-run government expenditures
- Fiscal regime A has government expenditures less responsive to output gap
- Fiscal regime A has government expenditures more responsive to debt
### Posterior Parameter Distributions Under Regimes A & B

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### Results: Tax Behavior

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<td>( \bar{\tau} )</td>
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<td>0.28 (0.25, 0.29)</td>
</tr>
<tr>
<td>( \psi_{\tau} )</td>
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<td>(0.17, 0.20)</td>
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<tr>
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- Fiscal Regime A has **lower** long-run transfers.
- Regimes are **not different on responsiveness to output gap**.
- Fiscal regime A has transfers **less responsive to debt**.
### Posterior Parameter Distributions Under Regimes A & B

<table>
<thead>
<tr>
<th>Param. Description</th>
<th>Fiscal Regime A</th>
<th>Fiscal Regime B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long-run transfers</td>
<td>$\bar{n}$</td>
<td>Median: 0.11</td>
</tr>
<tr>
<td>Resp to output gap</td>
<td>$\psi_n$</td>
<td>Median: -0.46</td>
</tr>
<tr>
<td>Resp to debt</td>
<td>$\gamma_n$</td>
<td>Median: -0.33</td>
</tr>
</tbody>
</table>

### Description
- Fiscal Regime A has **lower long-run transfers**
- Regimes are **not different on responsiveness to output gap**
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### Posterior Parameter Distributions Under Low & High Debt Regimes

<table>
<thead>
<tr>
<th>Param. Description</th>
<th>Low Debt Regime</th>
<th>High Debt Regime</th>
</tr>
</thead>
<tbody>
<tr>
<td>$b$ Debt/GDP target</td>
<td>0.37 (0.34, 0.39)</td>
<td>0.60 (0.55, 0.64)</td>
</tr>
</tbody>
</table>

### Debt Regimes

- Low debt regime $\approx 37\%$ of GDP
- High debt regime $\approx 60\%$ of GDP
### Posterior Parameter Distributions Under Stable and Volatile Regimes

<table>
<thead>
<tr>
<th>Param.</th>
<th>Description</th>
<th>Stable Regime</th>
<th>Volatile Regime</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_g$</td>
<td>Gov stdev</td>
<td>0.10 (0.09, 0.11)</td>
<td>0.19 (0.17, 0.22)</td>
</tr>
<tr>
<td>$\sigma_T$</td>
<td>Tax stdev</td>
<td>0.10 (0.10, 0.11)</td>
<td>0.29 (0.28, 0.30)</td>
</tr>
<tr>
<td>$\sigma_n$</td>
<td>Transfers stdev</td>
<td>0.06 (0.06, 0.08)</td>
<td>0.22 (0.19, 0.26)</td>
</tr>
<tr>
<td>$\sigma_d$</td>
<td>Deficit stdev</td>
<td>0.08 (0.08, 0.10)</td>
<td>0.20 (0.19, 0.22)</td>
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All standard deviations are larger in volatile regime, most more than double.
Timing of Fiscal Regimes

- Probability in Fiscal Regime A
- Probability in High Debt Regime
- Probability in the Volatile Regime
Questions: Compare Differences in Regimes

- Do fiscal policy shocks have different effects on macroeconomic variables in different regimes?
- Do fiscal variables have different interdependent effects in different regimes?
- Do effects of fiscal policy shocks depend on long-run debt target?
- Can we visualize difference of shocks in stable vs. volatile fiscal regimes.

Left for Future Work

- Long-run effects of moving to a high-debt regime
- Long-run effects of a change in behavior regime in macroeconomic variables.
- Expectations, behavior, equilibrium effects given regime-switching possibilities.
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Fiscal Regimes: Gov Exp Shock

**Government Expenditures Shock**

- **Government Expenditures Ratio to GDP**
- **Tax Revenue Ratio to GDP**
- **Net Transfers Ratio to GDP**

**Output Gap**

**Inflation**

**Smaller response to Transfers in Fiscal Regime A**

No differences in macroeconomic dynamics

James M. Murray, University of Wisconsin - La Crosse

Regime Switching in Fiscal Policy functions
Fiscal Regimes: Tax Shock

Smaller response to **Transfers** in Fiscal Regime A
Larger response to **Government Expenditures** in Fiscal Regime A
No differences in macroeconomic dynamics
Larger responses to **Gov Exp** and **Taxes** in Fiscal Regime A
Smaller response to **Transfers** in Fiscal Regime A
No differences in macroeconomic dynamics
Debt regime affects neither fiscal or macroeconomic dynamics.
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Low/High Debt Regime: Output Gap Shock

Output Gap Shock

Government Expenditures Ratio to GDP

Tax Revenue Ratio to GDP

Net Transfers Ratio to GDP

Government Debt Ratio to GDP

Output Gap

Inflation

Debt regime affects neither fiscal or macroeconomic dynamics

High Debt Regime - Low Debt Regime
Much larger sized shocks and responses in volatile regime
Fiscal Volatility Regimes: Tax Shock

Much larger sized shocks and responses in volatile regime.
Fiscal Volatility Regimes: Transfer Shock

Much larger sized shocks and responses in volatile regime

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Regime Switching in Fiscal Policy functions
Evidence of switching in all three dimensions.

- Switch from low-debt to high-debt regime in 1989.
  - Government expenditures playing larger role in macroeconomic stabilization, smaller role in balancing budget.
  - Taxes play smaller role in macroeconomic stabilization, larger role in balancing budget.
- Many switches from stable to volatile fiscal regimes, usually around and following recessions.
- Differences in impulse response functions explained mostly by changing fiscal volatility.
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