Fiscal Policy in an Estimated DSGE Model of the Japanese Economy
Do Non-Ricardian Households Explain All?

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Motivation

- Studies on Bayesian estimation of DSGE models of the Japanese economy are growing (cf. Iiboshi, Nishiyama, and Watanabe (2008) (INW) and Sugo and Ueda (2008) (SU)), but almost no attention has been paid to fiscal policy.

- Inclusion of non-Ricardian Households is currently the most popular way to generate a positive response of consumption.

- Seemingly contradictory observation in Japan:
  - Hatano (2004): Japan’s non-Ricardian share stays in 0.2-0.3 throughout the 1980s and the 1990s.
Introduce non-Ricardian households and three distortionary taxes to the Smets and Wouters (2003) model.

Introduce feedback rules for each tax following Forni, Monteforte, and Sessa (2009) (FMS).

Estimate the model via MCMC using Japanese fiscal data:
- The aggregate effective tax rates are calculated following Mendoza, Razin, and Tesar (1994).
- Only quarterly data are utilized.
- Capital income tax series was, however, too volatile and not used.

Examine the role of tax rules in fiscal policy effectiveness by conducting fiscal policy simulations under various tax rule combinations.
Main Findings

- Non-Ricardian share in Japan is smaller than those in the euro area and the United States.
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- The model successfully delivers the crowding-in effect on consumption regardless of its low share of non-Ricardian households.

- Fiscal policy becomes more effective if its finance is allocated lightly on labor-dampening taxes.

- A choice of tax rule combination can dominate the non-Ricardian share in its effect on fiscal multipliers.
Ricardian household $i$ maximizes its lifetime utility:

$$E_t \sum_{t=0}^{\infty} \beta^t \varepsilon_t \left( \frac{1}{1-\sigma_c} \left( C_t^R(i) - hC_{t-1}^R \right)^{1-\sigma_c} - \frac{\varepsilon_t^l}{1+\sigma_l} L_t^R(i)^{1+\sigma_l} \right)$$

subject to

$$(1 + \tau_c^c) C_t^R(i) + I_t(i) + \Psi(z_t(i))K_{t-1}(i) + \frac{B_t(i)}{P_t} = (1 - \tau_d^d)w_t(i)L_t^R(i) + (1 - \tau_k^k)r_t^k z_t(i)K_{t-1}(i) + (1 - \tau_t^k) \frac{D_t(i)}{P_t} + \frac{B_{t-1}(i)}{P_t},$$

$$K_t(i) = (1 - \delta) K_{t-1}(i) + \left[ 1 - S \left( \frac{\varepsilon_t^l I_t(i)}{I_{t-1}(i)} \right) \right] I_t(i).$$

Non-Ricardian household $j$ simply consumes its after tax income:

$$(1 + \tau_c^c) C_t^{NR}(j) = (1 - \tau_d^d) w_t(j) L_t^{NR}(j).$$

Aggregate consumption:

$$C_t = (1 - \omega) C_t^R(i) + \omega C_t^{NR}(j).$$
Non-Ricardian households are assumed to set their wages equal to the average wage of Ricardian households. Both wages and labor hours will be equal for all households:
\[ W^R_t(i) = W^{NR}_t(j) = W_t(n), \quad L^R_t(i) = L^{NR}_t(j) = L_t(n). \]

Ricardian households reset their wages optimally with probability \( 1 - \xi_w \), otherwise adjust them according to an indexation scheme
\[ W^R_t(i) = \left( \frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_w} W^R_{t-1}(i). \]

Aggregate nominal wage law of motion is then expressed as:
\[
W_t = 1 - \xi_w \left( W^*_t(n) \right)^{-\frac{1}{\lambda_{w,t}}} + \xi_w \left( \left( \frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_w} W_{t-1}(n) \right)^{-\frac{1}{\lambda_{w,t}}} - \lambda_{w,t}.
\]
$W_t^*(n) = W_t^{R*}(i)$ is chosen such that maximizes:

$$E_t \sum_{s=0}^{\infty} (\beta \xi_w)^s \left[ \frac{1}{1-\sigma_c} \left( C_{t+s}^R(i) - hC_{t+s-1}^R \right)^{1-\sigma_c} - \frac{\epsilon_t^l}{1+\sigma_l} L_{t+s}(i)^{1+\sigma_l} \right]$$

subject to

$$(1 + \tau^c_{t+s}) C_{t+s}^R(i) + I_{t+s}(i) + \Psi(z_{t+s}(i)) K_{t+s-1}(i) + \frac{B_{t+s}(i)}{P_{t+s}^R} =$$

$$(1 - \tau^d_{t+s}) \frac{W_t^{R*}(i)}{P_{t+s}} L_{t+s}(i) + (1 - \tau^k_{t+s}) r_t^k z_{t+s}(i) K_{t+s-1}(i) + (1 - \tau^k_{t+s}) \frac{D_{t+s}(i)}{P_{t+s}} + \frac{B_{t+s-1}(i)}{P_{t+s}},$$

where $L_{t+s}(i) = \left( \frac{W_t^{R*}(i)}{W_{t+s}} \right)^{-\frac{1+\lambda_{w,t+s}}{\lambda_{w,t+s}}} L_{t+s}$. 
Government budget constraint:
\[ G_t + \frac{B_{t-1}}{P_t} = \tau_c^t C_t + \tau_d^t w_t L_t + \tau_k^k r^k_t z_{t-1} + \tau_t^t \frac{D_t}{P_t} + \frac{1}{R_t} \frac{B_t}{P_t}. \]

Fiscal policy feedback rules (log-linearized):
\[ \hat{\tau}_t^c = \rho_{tc} \hat{\tau}_{t-1}^c + (1 - \rho_{tc}) \phi_{tcb} (\hat{b}_{t-1} - \hat{Y}_{t-1}) + \eta_{tc}^t, \]
\[ \hat{\tau}_t^d = \rho_{td} \hat{\tau}_{t-1}^d + (1 - \rho_{td}) \phi_{tdb} (\hat{b}_{t-1} - \hat{Y}_{t-1}) + \eta_{td}^t, \]
\[ \hat{\tau}_t^k = \rho_{tk} \hat{\tau}_{t-1}^k + (1 - \rho_{tk}) \phi_{tkb} (\hat{b}_{t-1} - \hat{Y}_{t-1}) + \eta_{tk}^t, \]
\[ \hat{G}_t = \rho_g \hat{G}_{t-1} + (1 - \rho_g) \phi_{gy} \hat{Y}_{t-1} + \eta_g^t. \]

Monetary policy feedback rule (log-linearized):
\[ \hat{R}_t = \rho_r \hat{R}_{t-1} + (1 - \rho_r) \phi_{r\pi} \hat{\pi}_{t-1} + (1 - \rho_r) \phi_{ry} \hat{Y}_t + \eta_R^t. \]
Overall, the values of posterior mean estimates are not so different from those reported in previous studies.

- The estimated mean value of non-Ricardian share ($\omega$) 0.25 is very much consistent with the Kalman filter estimates of Hatano (2004).
- The Calvo parameters ($\xi_w = 0.82, \xi_p = 0.43$) are in line with the results of Koga and Nishizaki (2005).
- Parameter values for habit persistency ($h = 0.47$) and labor supply elasticity ($\sigma_l = 2.11$) are in between INW and SU.
- All in all, posterior means of structural parameters do not suggest large fiscal multipliers in this economy.
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The estimated response of monetary policy to inflation is weak ($\rho_r = 0.93$, $\phi_{r\pi} = 1.53$) but close to the results of Ichiu, Kurozumi, and Sunakawa (2008) ($\rho_r = 0.85$, $\phi_{r\pi} = 1.49$).
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Posterior mean estimates of tax rule parameters ($\phi_{tcb} = 0.013$, $\phi_{tdb} = 0.005$, $\phi_{tkb} = 0.123$) suggest that capital income taxation played a central role in stabilizing the government debt in Japan.
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The estimated persistence parameters in tax rules ($\rho_{tc} = 0.51$, $\rho_{td} = 0.57$, $\rho_{tk} = 0.66$) are all substantially smaller than those of FMS ($\rho_{tc} = 0.96$, $\rho_{td} = 0.91$, $\rho_{tk} = 0.97$).
The model successfully delivers the crowding-in effect on consumption, regardless of its relatively small non-Ricardian share, price stickiness, and habit persistency.
Fiscal Multipliers

<table>
<thead>
<tr>
<th>Quarters</th>
<th>Japan</th>
<th>Euro Area</th>
<th></th>
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<td></td>
<td>This paper†</td>
<td>ESRI††</td>
<td>FMS</td>
<td>NAWM</td>
<td>QUEST III</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.23</td>
<td>1.21</td>
<td>1.21</td>
<td>1.07</td>
<td>0.73</td>
</tr>
<tr>
<td>4 (1st yr)</td>
<td>0.28 (0.72)</td>
<td>(1.00)</td>
<td>0.85</td>
<td>1.04</td>
<td>0.45</td>
</tr>
<tr>
<td>8 (2nd yr)</td>
<td>-0.16 (-0.04)</td>
<td>(0.06)</td>
<td>0.54</td>
<td>0.99</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.19</td>
<td>0.05</td>
<td>0.05</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>4 (1st yr)</td>
<td>-0.06 (0.05)</td>
<td>(0.09)</td>
<td>-0.03</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>8 (2nd yr)</td>
<td>-0.15 (-0.12)</td>
<td>(0.23)</td>
<td>-0.09</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.70</td>
<td>-0.04</td>
<td>-0.04</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>4 (1st yr)</td>
<td>-0.62 (0.07)</td>
<td>(-0.73)</td>
<td>-0.07</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>8 (2nd yr)</td>
<td>-1.19 (-1.06)</td>
<td>(-0.24)</td>
<td>-0.10</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

† Values in parentheses are yearly average effects.

†† Yearly effects of a one year-long increase in government investment.
The output multiplier in the first period is larger than those of other DSGE models for the euro area, reflecting the strong increase in investment and successfully crowded-in consumption.
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The yearly averages of the multipliers are not so different from those of Japan’s ESRI model, regardless of DSGE model structure.
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In later periods, the model exhibits large decreases in consumption, investment, and, hence, in output.
Policy Experiments (1)

- Under the estimated tax rules (*baseline specification*, $\phi_{tcb} = 0.013$, $\phi_{tdb} = 0.005$, $\phi_{tkb} = 0.123$), both consumption and investment multipliers in initial periods are larger than those under *FMS specification* ($\phi_{tcb} = 0.041$, $\phi_{tdb} = 0.058$, $\phi_{tkb} = 0.050$).

- It seems that investment serves as a major driving force for the stronger output response of *baseline specification*. 

![Graph showing consumption and investment response under baseline and FMS specifications](image)
Policy Experiments (2)

- Ricardian consumption shows a similar pattern to investment.
- The initial declines of Ricardian consumption in anti-inflationary monetary policy case ($\phi_{r\pi} = 1.7$) and in specification 1 ($\phi_{tcb} = \phi_{tdb} = \phi_{tkb} = 0.2$) are both smaller than that of FMS spec.
- Suggests that the greater multipliers in baseline owe much to its tax rule combination.
Policy Experiments (3)

- Investment responses under *specification 4* ($\phi_{tkb} = 0.2$, $\phi_{tcb} = \phi_{tdb} = 0.01$) show similar patterns to those under *baseline*.
- The responses under *specification 2* ($\phi_{tcb} = 0.2$, $\phi_{tdb} = \phi_{tkb} = 0.01$) and *specification 3* ($\phi_{tdb} = 0.2$, $\phi_{tcb} = \phi_{tkb} = 0.01$) show similar patterns to those under *FMS specification*. 

![Graph showing investment responses under different specifications.](image)
Again, Ricardian consumption shows a similar pattern to investment. Recall that initial output increase after a government spending shock in general equilibrium models is brought about by a labor hour increase and following an investment rise.
Both consumption and labor income taxes have labor-dampening effects.

In fact, labor hour increases are prevented to a larger extent under specifications 2 and 3.
### Fiscal Multipliers under Different Non-Ricardian Shares

<table>
<thead>
<tr>
<th>Qrts</th>
<th>SP4</th>
<th>SP3</th>
<th>SP2</th>
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<tr>
<td></td>
<td>$\omega = 0.0$</td>
<td>$\omega = 0.1$</td>
<td>$\omega = 0.2$</td>
</tr>
<tr>
<td>$\hat{Y}$</td>
<td>1.17</td>
<td>1.21</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>-0.23</td>
<td>-0.23</td>
<td>-0.24</td>
</tr>
<tr>
<td>$\hat{C}$</td>
<td>0.02</td>
<td>0.09</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>-0.08</td>
<td>-0.07</td>
<td>-0.05</td>
</tr>
<tr>
<td></td>
<td>-0.16</td>
<td>-0.17</td>
<td>-0.18</td>
</tr>
<tr>
<td>$\hat{I}$</td>
<td>0.99</td>
<td>0.96</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>-0.37</td>
<td>-0.42</td>
<td>-0.47</td>
</tr>
<tr>
<td></td>
<td>-1.40</td>
<td>-1.40</td>
<td>-1.40</td>
</tr>
</tbody>
</table>
The model under specification 4 delivers the crowding-in effect on consumption even in the case where all households are Ricardian ($\omega = 0.0$).
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Specification 4 with $\omega = 0.1$ exhibits larger multipliers than specifications 1-3 with $\omega = 0.3$. 

A choice of tax rule combination can alter the consequences of fiscal policy anticipated by the given non-Ricardian share. Non-Ricardian households do NOT explain all!
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A choice of tax rule combination can alter the consequences of fiscal policy anticipated by the given non-Ricardian share.

Non-Ricardian households do NOT explain all!
This paper presents an estimated medium-scale DSGE model of the Japanese economy detailed in fiscal policy.

Although there is little consensus with respect to modeling fiscal policy rules, we confirm that it affects fiscal policy effectiveness considerably.

Therefore proper modeling of the government’s financing behavior is fairly important to assess the quantitative effects of fiscal policy.

Direction for future research:
- Proper modeling of the spending side (e.g., productive public capital)
- Empirical evaluation of the model (e.g., comparison with VAR models)
- Obtaining an appropriate capital income tax series
- Considering the possibility that policy rules may change over time
- Dealing with the zero-interest-rate period of Japan
Related Literature

**Empirical**

- Forni, Monteforte, and Sessa (2009) (FMS) first examine fiscal policy effectiveness in an estimated DSGE model augmented with multiple distortionary tax rules, utilizing (annual) fiscal data of the euro area.
- Coenen and Straub (2005) introduce distortionary taxes to the canonical Smets and Wouters (2003) model of the euro area, but in a time-invariant manner. The model is estimated without using fiscal data.

**Theoretical**

- Aiyagari, Christiano, and Eichenbaum (1992) and Baxter and King (1993) both show that the negative wealth effect of fiscal policy increases the labor supply and accordingly investment, while decreasing consumption in a neoclassical framework.
- Galí, López-Salido, and Vallés (2007) introduce non-Ricardian households to a simple DSGE model and show that it is possible to have the empirically-supported crowding-in effect on consumption.
(Ricardian) households’ utility function is additively separable between consumption and labor.

(Ricardian) households supply labor and capital, and have access to government bond market.

(Ricardian) households act as wage setters in monopolistically competitive labor market.

There are two types of firms: perfectly competitive final-good firms and monopolistically competitive intermediate-good firms.

Nominal profits for intermediate-good firms are distributed to (Ricardian) households as dividends.

The monetary authority follows a Taylor-style feedback rule.

Real rigidities: habit formation, investment adjustment cost, variable capital utilization

Nominal rigidities: sticky price and wage à la Calvo (1983), indexation in prices and wages
The final-good producing firms combine the intermediate goods using the following bundler technology:

\[ Y_t = \left[ \int_0^1 y_t(f) \frac{1}{1+\lambda_{p,t}} df \right]^{1+\lambda_{p,t}}. \]

Each intermediate-good firm \( f \) produces its differentiated output using a Cobb-Douglas technology:

\[ y_t(f) = \varepsilon_t^a \tilde{k}_{t-1}(f)^\alpha l_t(f)^{1-\alpha} - \Phi, \]

where \( \tilde{k}_{t-1}(f) \) is the effective capital stock given by \( \tilde{k}_{t-1}(f) = z_t k_{t-1}(f) \), \( l_t(f) \) is the effective labor input bundled by an independent and perfectly competitive employment agency, which has a technology \( L_t = \left[ \int_0^1 L_t(n) \frac{1}{1+\lambda_{w,t}} dn \right]^{1+\lambda_{w,t}}. \)
Intermediate-good firms reset their prices optimally with probability $1 - \xi_p$, otherwise adjust them according to an indexation scheme $p_t(f) = \left( \frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_p} p_{t-1}(f)$. Aggregate price law of motion is then expressed as:

$$P_t = \left[ (1 - \xi_p) (p^*_t(f))^{-\frac{1}{\lambda_{p,t}}} + \xi_p \left( \left( \frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_p} p_{t-1}(f) \right)^{-\frac{1}{\lambda_{p,t}}} \right]^{-\lambda_{p,t}}.$$

$p^*_t(f)$ is chosen such that maximizes:

$$E_t \sum_{s=0}^{\infty} (\beta \xi_p)^s [(p^*_t(f) - P_{t+s}mc_{t+s}) y_{t+s}(f) - P_{t+s}mc_{t+s} \Phi]$$

where $y_{t+s}(f) = \left( \frac{p^*_t(f)}{P_{t+s}} \right)^{-\frac{1+\lambda_{p,t+s}}{\lambda_{p,t+s}}} Y_{t+s}$. 
Estimation Overview

- Conduct Bayesian estimation using a MCMC method.
  - The model is log-linearized around the deterministic steady state.
  - The DYNARE software for MATLAB is applied.
  - The draws from the posterior distribution have been obtained by taking two parallel chains of 1,000,000 replications for Metropolis-Hastings algorithm.

  - The zero-interest-rate period is not included.

- Use 10 data series: Other than the ordinary seven series (output, consumption, investment, labor hour, wage, inflation rate, and interest rate), I utilize government spending (as a sum of government consumption and investment) and aggregate effective tax rates on consumption and labor income.
  - Only quarterly data are utilized for the tax rate calculation, which is available from the *National Accounts of Japan* from 1980:Q1.

- Estimate 25 parameters assuming 12 stochastic shocks.
### Estimation Results (Structural parameter means)

<table>
<thead>
<tr>
<th></th>
<th>Euro Area</th>
<th></th>
<th>U.S.</th>
<th></th>
<th>Japan</th>
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<td></td>
<td>SW</td>
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<td>LOWW</td>
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<td>SU</td>
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<td>h</td>
<td>0.592</td>
<td>0.412</td>
<td>0.73</td>
<td>0.29</td>
<td>0.795</td>
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<tr>
<td>$\sigma_c$</td>
<td>1.391</td>
<td>1.101</td>
<td>(1.00)^{††}</td>
<td>2.19</td>
<td>1.912</td>
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<td>$\sigma_l$</td>
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<td>2.343</td>
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<td>$1/\zeta^‡$</td>
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<td>(6.319)^{††}</td>
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<td>$\zeta_w$</td>
<td>0.742</td>
<td>0.747</td>
<td>n.a.</td>
<td>0.79</td>
<td>0.275</td>
<td>0.516</td>
<td>0.824</td>
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<tr>
<td>$\zeta_p$</td>
<td>0.905</td>
<td>0.914</td>
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<td>0.83</td>
<td>0.791</td>
<td>0.875</td>
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<td>$\gamma_w$</td>
<td>0.728</td>
<td>0.724</td>
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<td>0.79</td>
<td>0.581</td>
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<td>$\gamma_p$</td>
<td>0.477</td>
<td>0.456</td>
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<td>0.579</td>
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<td>0.595</td>
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<td>$\omega$</td>
<td>n.a.</td>
<td>0.370</td>
<td>0.34</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>0.248</td>
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</table>

† Estimates for the specification in which distortionary taxation is considered.

‡ Values in parentheses are calibrated.

[^‡]: $\zeta \equiv 1/S''(1)$, $\varphi \equiv 1 + \Phi/\bar{Y}$, $\psi \equiv \Psi'(1)/\Psi''(1)$. 

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## Estimation Results (Policy parameter means)

<table>
<thead>
<tr>
<th></th>
<th>Euro Area</th>
<th>U.S.</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SW</td>
<td>CS†</td>
<td>FMS</td>
</tr>
<tr>
<td>( \rho_r )</td>
<td>0.956</td>
<td>0.964</td>
<td>0.92</td>
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<tr>
<td>( \phi_{\pi} )</td>
<td>1.688</td>
<td>1.692</td>
<td>1.72</td>
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<tr>
<td>( \phi_{y} )</td>
<td>0.098</td>
<td>0.103</td>
<td>0.13</td>
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<tr>
<td>( \rho_g )</td>
<td>0.943</td>
<td>0.944</td>
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<tr>
<td>( \phi_{y} )</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>( \rho_{tc} )</td>
<td>n.a.</td>
<td>n.a.</td>
<td>0.96</td>
</tr>
<tr>
<td>( \phi_{tc} )</td>
<td>n.a.</td>
<td>n.a.</td>
<td>0.50</td>
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<td>( \rho_{td} )</td>
<td>n.a.</td>
<td>n.a.</td>
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<td>( \phi_{td} )</td>
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<td>( \rho_{tk} )</td>
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<td>n.a.</td>
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<td>( \phi_{tk} )</td>
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<td>n.a.</td>
<td>0.57</td>
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</tbody>
</table>

† Estimates for the specification in which distortionary taxation is considered.
‡‡ As regards monetary policy rule, feedback from the current changes in inflation and output gap are not considered.
## Tax Rule Specifications

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>FMS spec.</th>
<th>SP1</th>
<th>SP2</th>
<th>SP3</th>
<th>SP4</th>
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<tbody>
<tr>
<td>( \hat{\tau}_c ) rule</td>
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<tr>
<td>( 1 - \rho_{tc} )</td>
<td>0.4931</td>
<td>0.4931</td>
<td>0.4931</td>
<td>0.4931</td>
<td>0.4931</td>
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<tr>
<td>( \phi_{tcb} ) coeff.</td>
<td>0.0125</td>
<td>0.0406</td>
<td>0.2000</td>
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<tr>
<td>( \hat{\tau}_d ) rule</td>
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<td>( 1 - \rho_{td} )</td>
<td>0.4323</td>
<td>0.4323</td>
<td>0.4323</td>
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<td>( \phi_{tdb} ) coeff.</td>
<td>0.0052</td>
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<tr>
<td>( 1 - \rho_{tk} )</td>
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<td>0.3453</td>
<td>0.3453</td>
<td>0.3453</td>
<td>0.3453</td>
<td>0.3453</td>
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<td>( \phi_{tkb} ) coeff.</td>
<td>0.1230</td>
<td>0.0496</td>
<td>0.2000</td>
<td>0.0100</td>
<td>0.0100</td>
<td>0.2000</td>
</tr>
</tbody>
</table>

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