Macroeconomic Dynamics Under High Accumulation of Government Debt: Lessons from Japan

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Abstract

This paper applies Bayesian estimation to an open-economy DSGE model of Japan, to assess the effects of expanding government debt on interest rates, real exchange rate dynamics, and real sector performance. We find that the emergence of even a small risk premium on government debt will trigger considerable instability in the real and nominal variables. We show that a switch to an exchange-rate rule for monetary policy would considerably moderate the instability induced by a rising risk premium.

JEL Classificaltion: E52, E62,F41

1 Introduction

The overall debt/GDP ratio in Japan is approaching 200 percent, much larger than highly-indebted OECD countries like Greece and Italy, as Figure 1 shows. Unlike the United States, domestic Japanese residents hold more than 94% of Japanese government debt. Despite these high ratios, the government bond market in Japan remains relatively tranquil, with no risk premium demanded by financial institutions purchasing this debt.

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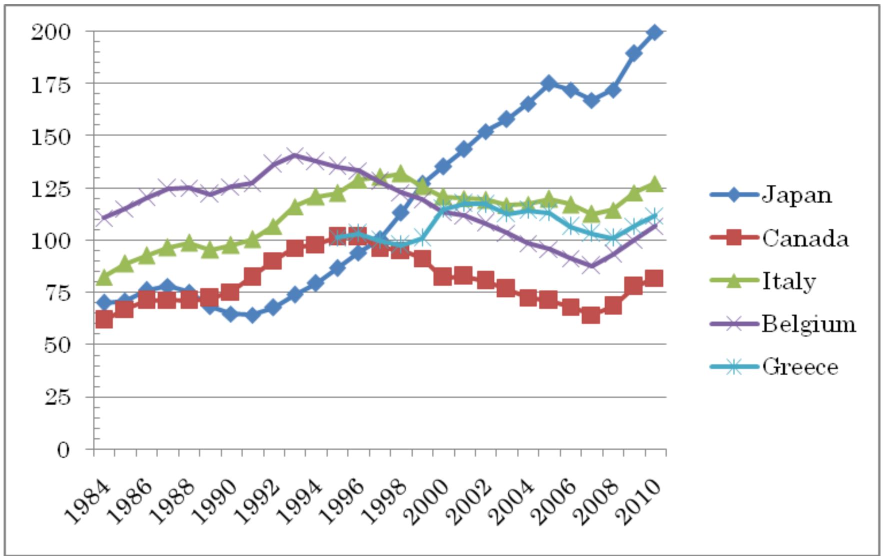
Figure 1



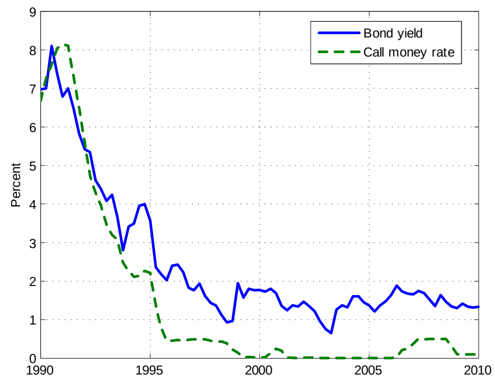
Domestic Debt/GDP Ratios, 1984-2010

This paper investigates the implications for macroeconomic adjustment when financial markets apply a risk premium to this debt. In this case, a wedge between the bond yield and the risk free rate emerges, with the bond yield rising as debt continues to mount. While the central bank manages the risk free rate, this rate will become less and less relevant for interest parity and exchange rate adjustment. Hypothetically, in a period of recession, trivial inflation, and zero interest rates, rising bond rates will trigger heightened volatility of the domestic currency.

At present, this scenario has not played out. Yen-denominated government bonds continue to remain attractive to overseas investors because of higher Euro-bond riskiness in the wake of the crisis in Greece. In addition Japanese banks are holding more government bonds because the demand for bank loans by Japanese firms has declined due to world-wide recession. With the central bank adopting an easy zero-interest rate monetary policy, deposits are continuously flowing into Japanese banks, facilitating the purchase of government bonds by the banking sector. Thus, there is little or no pressure for government bond yields to rise relative to the risk free rate.

Figure 2 shows the persistent stable wedge between the bond yield and the short-term risk-free call money rate since 1994. As Figure 1 shows, it was in 1994 that the debt/gdp ratio in Japan crossed the 100% threshold.

Figure 2



Bond Yield and Risk-Free Call Money Rate in Japan, 1990-2010

But how long can this scenario hold? If world demand increases, and there is an increased demand for loans by firms, then government bonds will not be as attractive to the financial institutions. In this case the government will be forced to pay a risk premium to the banks, thus increasing interest rates, appreciating the exchange, and thwarting recovery. Furthermore, as interest payments increase due to the risk premium, fiscal deficits will rise even further. In this case the government will be forced to raise taxes and reduce spending, further dampening economy-wide recovery.

This paper analyzes the transmission mechanism of these scenarios on consumption, investment, inflation, the real exchange rate, financial market volatility and welfare. We make use of a dynamic stochastic general equilibrium framework, with a traded and non-traded sector, a financial sector, and government spending which includes both consumption and investment.

The model is calibrated to replicate key long-run steady state characteristics of the Japanese economy. Stochastic volatility and dynamic adjustment parameters are estimated with Bayesian methods in a pure DSGE and hybrid DSGE/VAR framework. Then the model is simulated for a variety of shock distributions to evaluate the effects of a rising government bond risk premium. We show that a risk premium on government bonds implies great macroeconomic volatility across the board, in real and nominal variables. Finally, we show that a switch to an exchange-rate rule similar to the one used in Singapore would moderate the increase in volatility generated by an increased risk premium on government debt.

2 The Model

2.1 Household Preferences and Endowments

Households own capital, for rental to export-goods producing firms, and supply labor to both export and home-goods firms. Capital for rental to the firms depreciates at the rate δ. When households accumulate or decumulate capital beyond the steady state level, they pay adjustment costs. The following law of motion is specified for capital, with adjustment costs given by AC_t^x, and ϕ_h, ϕ_x are the adjustment cost parameters.

$$K_t^x = (1-\delta)K_{t-1}^x + I_t^x \tag{1}$$

$$AC_t^x = \left(\frac{\phi_x \left(I_t^x - \delta \overline{K}^x \right)^2}{2K_t^x} \right) \tag{2}$$

We assume that all of investment goods are imported from abroad, and that the price P^f is the relevant price for these goods. The variable $\overline{K}^x$ is the steady state level of the capital stock for export-goods producing firms.

The household consumption at time t, C_t, is a CES bundle of both domestic consumption goods, C_t^d and imported goods, C_t^f.

$$C_t = \left[(1-\gamma_1)^{\frac{1}{\theta_1}} \left(C_t^d \right)^{\frac{\theta_1 - 1}{\theta_1}} + (\gamma_1)^{\frac{1}{\theta_1}} \left(C_t^f \right)^{\frac{\theta_1 - 1}{\theta_1}} \right]^{\frac{\theta_1}{\theta_1 - 1}} \tag{3}$$

The demand for each component of consumption is a function of the overall consumption index and the price of the respective component relative to the general price level, P :

$$C_t^d = (1-\gamma_1) \left(\frac{P_t^d}{P_t} \right)^{-\theta_1} C_t \tag{4}$$

$$C_t^f = \gamma_1 \left(\frac{P_t^f}{P_t} \right)^{-\theta_1} C_t \tag{5}$$

The parameters γ_1 and $(1-\gamma_1)$ are the relative shares of foreign and domestic goods in the overall consumption index, while θ_1 is the price elasticity of demand for each consumption component.

Domestically-produced goods are both non-traded home goods and export goods (some of which are consumed domestically). The following CES aggregator is used for domestically-produced consumption goods:

$$C_t^d = \left[(1-\gamma_2)^{\frac{1}{\theta_2}} \left(C_t^h \right)^{\frac{\theta_2 - 1}{\theta_2}} + (\gamma_2)^{\frac{1}{\theta_2}} \left(C_t^x \right)^{\frac{\theta_2 - 1}{\theta_2}} \right]^{\frac{\theta_2}{\theta_2 - 1}} \tag{6}$$

The relative demands for the home non-traded goods and the export goods are given by the following equations:

$$C_t^h = (1-\gamma_2)\left(\frac{P_t^h}{P_t^d}\right)^{-\theta_2} C_t^d \tag{7}$$

$$C_t^x = \gamma_2 \left(\frac{P_t^x}{P_t^d}\right)^{-\theta_2} C_t^d \tag{8}$$

where the parameters γ_2 and $(1-\gamma_2)$ are the shares of the export and non-traded goods in domestic production of consumption goods, and θ_2 is the price elasticity of demand.

The domestically-produced price index is given by the following CES aggregator:

$$P_t^d = \left[(1-\gamma_2)\left(P_t^h\right)^{1-\theta_2} + \gamma_2\left(P_t^x\right)^{1-\theta_2}\right]^{\frac{1}{1-\theta_2}} \tag{9}$$

In the same manner, the overall price index, of course, is a CES function of the price of foreign and domestic consumption goods:

$$P_t = \left[(1-\gamma_1)\left(P_t^d\right)^{1-\theta_1} + \gamma_1\left(P_t^f\right)^{1-\theta_1}\right]^{\frac{1}{1-\theta_1}} \tag{10}$$

In addition to buying consumption goods, households put deposits M_t in the bank and receive dividends from the export and non-traded or home-goods producing firms. Total dividends is given by Π_t, with $\Pi_t = \Pi_t^x + \Pi_t^h$. The household pays taxes on labor income $\tau W_t L_t$ and on consumption $\tau_c C_t$. The following equation gives the household budget constraint (P_t^f is the price of imported goods):

$$\begin{aligned} & W_t L_t + (1+R_{t-1}^m)M_{t-1} + \Pi_t + P_t^{k^x} K_t^x \\ = \; & P_t C_t (1+\tau_c) + M_t + \tau W_t L_t + P_t^f I_t^x \\ & + P_t^f \left(\frac{\phi_x \left(I_t^x - \delta \overline{K}^x\right)^2}{2K_t^x}\right) \end{aligned} \tag{11}$$

We assume that government spending G is bundled with consumption for utility in CES aggregator. We do this to indicate that there is a reason for government spending to take place, that such spending creates externalities for consumption, in the form of infrastructure, public utilities and other services which enhance household utility:

$$\widetilde{C}_t = \left[\phi C_t^{-\varkappa} + (1-\phi) G_{t-1}^{-\varkappa}\right]^{-\frac{1}{\varkappa}} \tag{12}$$

However, household utility does not simply come from the current consumption bundle. Rather, habit persistence applies to this consumption index when it enters the specific utility function, so that the relevant consumption index is deflated by the Habit Stock, H_t. The Habit Stock is a function of the lagged average consumption bundle, raised to the power ρ, the habit persistence parameter:

$$H_t = \overline{\widetilde{C}}^{\varrho}_{t-1} \tag{13}$$

Overall utility is a positive function of the consumption bundle, and a negative function of labor and the habit stock:

$$U(\widetilde{C}_t/H_{t+\iota}, L_t) = Z_t^C \frac{\left(\widetilde{C}_t/H_t\right)^{1-\eta}}{1-\eta} - \gamma \frac{L_t^{1+\varpi}}{1+\varpi} \tag{14}$$

The parameter η is the relative risk aversion coefficient, while γ is the disutility of labor, and ϖ the Frisch labor supply elasticity. The variable Z_t^C is a shock to the utility of consumption and evolves according to the following process:

$$\ln(Z_t^C) = \rho_C \ln(Z_{t-1}^C) + (1-\rho_C)\ln(\overline{Z}^C) + \epsilon_{Z^C,t} \tag{15}$$

$$\epsilon_{Z^C,t} \sim N(0, \sigma^2_{\epsilon_{Z^C}}) \tag{16}$$

The household chooses the paths of consumption, labor, deposits, investment and capital, to maximize the expected present value of its utility function subject to the budget constraint and the law of motion for capital. Thus, the objective function of the household is given by the following expression:

$$\underset{\{C_t, L_t, M_t, I_t^h, K_t^h, I_t^x, K_t^x\}}{Max} \mathbf{E}_t \sum_{\iota=0}^{\infty} \beta^{\iota} U(\widetilde{C}_{t+\iota}/H_{t+\iota}, L_{t+\iota}) \tag{17}$$

where the parameter β represents the constant, exogenous discount factor. This optimization is subject to the two constraints:

$$\begin{aligned} & W_t L_t + (1+R_{t-1}^m)M_{t-1} + \Pi_t + P_t^{k^x} K_t^x \\ = \; & P_t C_t (1+\tau_c) + M_t + \tau W_t L_t + P_t^f I_t^x \\ & + P_t^f \left(\frac{\phi_x \left(I_t^x - \delta \overline{K}^x \right)^2}{2K_t^x} \right) \end{aligned} \tag{18}$$

$$K_t^x = (1-\delta)K_{t-1}^x + I_t^x \tag{19}$$

The variable $P_t^{k^x}$ the return to the export-goods producing firm,while W_t is the nominal wage rate.

The household optimization is represented by the intertemporal Lagrangean:

$$
\underset{\{C_t,L_t,M_t,I_t^h,K_t^h,I_t^x,K_t^x\}}{Max} \mathcal{L} = \sum_{\iota=0}^{\infty} \beta^{\iota} \left\{ \begin{array}{c} U(\widetilde{C}_{t+\iota}/H_{t+\iota}, L_{t+\iota}) \\ -\Lambda_{t+\iota} \left[\begin{array}{c} P_{t+\iota}C_{t+\iota}(1+\tau^C) + M_{t+\iota} \\ -(1+R^m_{t-1+\iota})M_{t-1+\iota} \\ +P^f_{t+i}I^x_{t+i}+ \\ P^f_{t+i}\frac{\phi_x\left(I^x_{t+i}-\delta\overline{K}^x\right)^2}{2K^x_{t+i}} \\ +(\tau-1)W_{t+\iota}L_{t+\iota} - \Pi_{t+i} \\ -P^k_{t+i}K^x_{t+i} \end{array} \right] \\ -Q^x_{t+i}\left(K^x_{t+i} - I^x_{t+i} - (1-\delta)K^x_{t-1+i}\right) \end{array} \right\} \tag{20}
$$

Note that there are three Lagrange multipliers, one, $\Lambda_{t+\iota}$, is the familiar marginal utility of income or wealth, while Q^s_{t+i}, known as Tobin's Q, is the shadow price of capital for the export-goods sector.

Optimizing the Bellman equation with respect to the decision variables $C_t, L_t, M_t, I_t^h, K_t^h$ yields the following set of First-Order Conditions for the representative household:

$$
\begin{aligned}
\Lambda_t P_t &= \left[\widetilde{C}_t/H_t\right]^{-\eta} \frac{1}{H_t}\left(\widetilde{C}_t\right)^{1-\varkappa} \phi\left(C_t\right)^{-\varkappa-1} Z^C_t && (21)\\
\gamma L_t^{\varpi} &= \Lambda_t(1-\tau^w)W_t && (22)\\
\Lambda_t &= \mathbf{E}_t\left[\beta\Lambda_{t+1}(1+R^m_t)\right] && (23)\\
Q^x_t &= \mathbf{E}_t\{\beta\Lambda_{t+1}P^{k^x}_{t+1} + \beta\Lambda_{t+1}P^f_{t+1}\frac{\left(\phi_x\left[I^x_{t+1}-\delta\overline{K}^x\right]\right)^2}{2\left(K^x_t\right)^2} && (24)\\
&\quad +\beta Q^x_{t+1}(1-\delta)\} && (25)\\
I^x_t &= \delta_1\overline{K}^x + \frac{K^x_t}{\phi_x}\left(\frac{Q^x_t}{\Lambda_t} - P^f_t\right) && (26)
\end{aligned}
$$

The first equation, 21, simply tells us that the marginal utility of wealth is equal to the marginal utility of consumption divided by the price level. The second equation, 22, states that the marginal disutility of labor is equal to the marginal utility of consumption provided by the after-tax wage. The third equation is the Keynes-Ramsey rule for optimal saving: the marginal utility of wealth today should be equal to the discounted marginal utility tomorrow, multiplied by the gross rate of return on saving (in the form of deposits).

The equation for Tobin's Q tells us that the value of capital today is the discounted marginal utility of capital tomorrow, multiplied by the return to capital, in addition to the reduced value of adjustment costs in the future (due to the higher level of capital) and the discounted value of capital tomorrow, net of depreciation.

Finally, the investment equation tells us that investment will be equal to the steady state investment, $\delta_1\overline{K}^x$, when $\frac{Q^x_t}{\Lambda_t} = P^f_t$. Any increase in Tobin's Q^x_t, relative to the marginal utility of income and the price of investment goods, will trigger increases in investment.

2.2 Production and Technology

2.2.1 Home-Goods Firms

The home-good producing firms use the following CES technology:

$$Y_t^h = A^h Z_t^h \left[(1-\alpha_1) \left(L_t^h \right)^{-\kappa_1} + \alpha_1 (\overline{K}^h)^{-\kappa_1} \right]^{-\frac{1}{\kappa_1}} \tag{27}$$

The parameter $(1-\alpha_1)$,α_1 are the shares of labor and fixed capital in the CES production function, while the coefficient κ_1 is the CES aggregator. The technology shock to home-goods production is given by Z_t^h. which follows the autoregressive process:

$$\ln(Z_t^h) = \rho_{Z^x} \ln(Z_{t-1}^h) + (1-\rho_{Z^h}) \ln(\overline{Z}^h) + \epsilon_{Zh,t} \tag{28}$$

$$\epsilon_{Z^h,t} \sim N(0, \sigma_{Z^h}^2 \quad) \tag{29}$$

The demand for the home goods can be both for domestic consumption, as well for government consumption spending:

$$Y_t^h = C_t^h + G_t \tag{30}$$

We assume that the firm faces a liquidity constraint, it must borrow an amount N_t^x from banks each quarter to pay a fraction μ_1 of its wage bill, at the borrowing rate R_t^n. We also assume that the amount of borrowing is subject to a collateral constraint proportional by a factor υ_1 to the total returns on capital:

$$N_t^h = \mu_h W_t L_t^h, \tag{31}$$

The total profits (or dividends) of the export firm is given by the following identity:

$$\Pi_t^h = P_t^h Y_t^h - (1 + \mu_h R_t^n) W_t L_t^h \tag{32}$$

Maximizing profits with respect to the use of capital and labor, we have the following first-order conditions for the firm:

$$\frac{\partial Y_t^h}{\partial L_t^h} = (1 + \mu_h R_t^n) \frac{W_t}{P_t^h} \tag{33}$$

In the CES technology, we have the following expressions:

$$\frac{\partial Y_t^h}{\partial L_t^x} = \left(A^h \right)^{\kappa_1} (1-\alpha_1) \left(\frac{Y_t^h}{L_t^h} \right)^{1+\kappa_1} \tag{34}$$

You can see that with $\kappa_1 = 0$, the first order conditions reduce to the Cobb-Douglas marginal productivity conditions.

2.2.2 Export Goods

The firm producing export goods faces a similar production function:

$$Y_t^x = A^x \left[(1-\alpha_2)\,(L_t^x)^{-\kappa_2} + \alpha_2\,(K_t^x)^{-\kappa_1} \right]^{-\frac{1}{\kappa_2}} \tag{35}$$

Export demand C_t^* depends on its own lag, as well as to the deviation of the real exchange rate from its steady state. It is also subject to a stochastic shock, $\epsilon_{C^*,t}$ at time t.

$$C_t^* = \rho_{C^*} C_{t-1}^* + (1-\rho_{C^*})\overline{C^*} + (1-\rho_{C^*})\rho_{C^*S} \left[S_t/P_t^h - \overline{S}/\overline{P}^h \right] + \epsilon_{C^*,t} \tag{36}$$

$$\epsilon_{C^*,t} \sim N(0, \sigma_{C^*}^2) \tag{37}$$

Under an open economy setting we also assume that the price of the export good in domestic currency is simply equal to the exchange rate S_t multiplied by the world export price, $P_t^{x^*}$. We assume that the world export price follows the following exogenous stochastic process:

$$\ln(P_t^{x^*}) = \rho_{P^{x*}} \ln(P_{t-1}^{x^*}) + (1-\rho_{P^{x*}}) \ln(\overline{P}_t^{x^*}) + \epsilon_{P^{x*},t} \tag{38}$$

$$\epsilon_{P^{x*},t} \sim N(0, \sigma_{P^*}^2) \tag{39}$$

Total demand for the export good is composed of the local demand (for consumption purposes) as well as the foreign demand:

$$Y_t^x = C_t^x + C_t^*$$

These firms also facing a liquidity constraint for meeting their wage bill:

$$N_t^x = \mu_x W_t L_t^x \tag{40}$$

The profits of the export-goods firms are given by the following relation:

$$\Pi_t^x = P_t^x Y_t^x - (1+\mu_x R_t^n) W_t L_t^x - P_t^{k^x} K_t^x \tag{41}$$

Optimizing profits implies the following first-order condition for cost minimization:

$$\frac{\partial Y_t^x}{\partial L_t^x} = (1+\mu_x R_t^n)\frac{W_t}{P_t^x} \tag{42}$$

$$\frac{\partial Y_t^x}{\partial K_t^x} = \frac{P_t^{k^x}}{P_t^x} \tag{43}$$

2.2.3 Labor Mobility

We assume that labor can move between the home-goods and export sectors. This implies the following equality for real labor productivity in each sector:

$$\frac{\partial Y_t^x}{\partial L_t^x}\frac{P_t^x}{(1+\mu_x R_t^n)} = \frac{\partial Y_t^h}{\partial L_t^h}\frac{P_t^h}{(1+\mu_h R_t^n)}$$

2.3 Calvo Pricing for Home Goods

The pricing for home-goods firms is different from that of export firms. We assume sticky monopolistically competitive firms in the home-goods market.

Let the marginal cost at time t be given by the following expression:

$$A_t = \frac{(1+\mu_1 R_t^n)W_t}{\left(A^h Z_t^h\right)^{\kappa_1}(1-\alpha_1)\left(\frac{Y_t^h}{L_t^h}\right)^{1+\kappa_1}} \tag{44}$$

In the Calvo price setting world, there are forward-looking price setters and backward looking setters. Assuming at time t a probability of persistence of the price at ξ , with demand for the product from firm j given by $Y_t^h\left(P_t^h\right)^{\zeta}$, the expected marginal cost, in recursive formulation, is presented by the expression for A_t^{num}. The expected demand, for the given price, is given by the variable A_t^{den}.

$$A_t^{num} = Y_t^h\left(P_t^h\right)^{\zeta}A_t + \beta\xi A_{t+1}^{num} \tag{45}$$

$$A_t^{den} = Y_t^h\left(P_t^h\right)^{\zeta} + \beta\xi A_{t+1}^{den} \tag{46}$$

$$P_t^o = \frac{A_t^{num}}{A_t^{den}} \tag{47}$$

$$P_t^{h,b} = P_{t-1}^h\left(\frac{P_{t-1}}{P_{t-2}}\right)^{\kappa^i}(1+\widetilde{\pi}_t)^{\kappa^\pi} \tag{48}$$

$$P_t^h = \left[\xi\left(P_t^{h,b}\right)^{1-\zeta} + (1-\xi)\left(P_t^o\right)^{1-\zeta}\right]^{\frac{1}{1-\zeta}} \tag{49}$$

The backward looking price setters do not keep the price fixed. They will set their price equal to the price at the previous period, P_{t-1}^h multiplied by the previous period's inflation, $\left(\frac{P_{t-1}}{P_{t-2}}\right)$ raised to an indexation parameter κ^i, and by the gross inflation target announced by the central bank, $(1+\widetilde{\pi}_t)$, representing monetary policy statements, relative to inflation targets, raised to a parameter κ^π.

2.4 Importing Firms

Imported goodsY^f are used for both consumption C^f and for investment in the export industry, I^x.

$$Y^f = C^f + I^x \tag{50}$$

The importing firms do not produce these goods. However, they have to borrow a fraction μ_f of the cost of these imported goods in order to bring them to the home market for domestic consumers and investors:

$$N_t^f = \mu_f (S_t P_t^{f^*} Y_t^f) \tag{51}$$

where $P_t^{f^*}$ is the world price of the import goods and S_t is the exchange rate. The domestic cost of the imported goods is given by:

$$\begin{aligned} P^f &= \left[\mu_f(1+R_t^n) + (1-\mu_f)\right](S_t P_t^*) \\ &= [1+\mu_f R_t^n] S_t P_t^* \end{aligned} \tag{52}$$

2.5 The Financial Sector

Banks lend to all three types of firms:

$$N_t = N_t^x + N_t^h + N_t^f \tag{53}$$

In addition to these firms, the banks lend to the government B_t^g and receive a risk-free interest rate $R_{t.}$

They borrow from foreign financial centers the amount B^f and pay a risk premium above the domestic interest rate when such foreign debt exceeds a steady-state level $\overline{B^f}$:

$$\Phi_t = \max\left\{0, \varphi\left[e^{(\left|B_{t-1}^f - \overline{B^f}\right|)} - 1\right] B_{t-1}^f\right\} \tag{54}$$

The banks thus pay a gross interest rate $R_t^* + \Phi_t$ on their outstanding dollar-denominated debt B_{t-1}^f to foreign financial centers.

In addition to paying deposits the interest rate R_t^m we assume that banks are also required to set aside a required ratio of reserves on outstanding deposits, $\phi_M M_t$. The relevant opportunity cost of holding these reserves is of course the amount the banks can earn by holding risk-free government bonds, $\phi_M R_t M_{t.}$ In addition banks are required to set aside a fraction of capital against their outstanding loans, $\phi_N N_{t.}$. As in the case of the required reserves against deposits, the opportunity cost is given by $\phi_N R_t N_{t.}$ We also assume that there is a cost in the form of risk to holding government bonds above the steady state, given by $\phi_B(B_{t-1} - \overline{B})$:

The gross profit of the banking sector is given by the following balance-sheet identity:

$$
\begin{aligned}
\Pi_t^B &= (1+R_{t-1}^g)B_{t-1}^g + (1+R_{t-1}^{ff})FF_{t-1} \\
&+(1+R_{t-1}^n)N_{t-1} \\
&-(1+R_{t-1}^* + \Phi_{t-1})B_{t-1}^f S_t \\
&-(1+R_{t-1}^m)M_{t-1} \\
&-B_t^g - FF_t - N_t + S_t B_t^f + M_t \\
&-\phi_M R_{t-1}^{ff} M_{t-1} - \phi_N R_{t-1}^{ff} N_{t-1} - \phi_B(B_{t-1} - \overline{B}) \qquad (55)
\end{aligned}
$$

where FF_t represents returns on bank lending or borrowing from the central bank, and R_t^{ff} is the risk-free rate of return on these loans or debts.

The bank maximizes its the present discounted value of its profits, given by V_t^B, with respect to its its portfolio of assets (loans to the government, to the federal funds market, and to firms, B_t^g , FF_t and N_t) and liabilities (deposits from households and borrowing from foreign financial centers M_t and B_t^f).

$$\underset{\{B_t^g, N_t, M_t, B,_t^f\}}{Max} V_t^B = \Pi_t^B + \beta V_{t+1}^B$$

The set of first-order conditions leads to the familiar set of spreads for interest rates, as well as the interest-parity equation:

$$
\begin{aligned}
R_t^g &= R_t^{ff} + \phi_B &(56)\\
R_t^n &= R_t^{ff} + \phi_N &(57)\\
R_t^m &= R_t^{ff} - \phi_M &(58)\\
(1+R_t^g)S_t &= (1+R_t^* + \Phi_t + \Phi_t' B_t^f)S_{t+1} &(59)
\end{aligned}
$$

The foreign interest rate evolves according to the following law of motion:

$$
\begin{aligned}
R_t^* &= \rho_{R^*} R_{t-1}^* + (1-\rho_{R^*})\overline{R}^* + \epsilon_{R^*,t} \\
&\epsilon_{R^*}\,\tilde{}\,N(0, \sigma_{R^8}^2)
\end{aligned}
$$

We assume an inflation targeting Taylor rule for setting the risk-free rate for banks borrowing or lending to the central bank:

$$
\begin{aligned}
R_t^{ff} &= \rho_r R_{t-1}^{ff} + (1-\rho_r)\rho_\pi \widehat{\pi}_t + (1-\rho_r)\rho_y \widehat{y}_t (1-\rho_r)\overline{R}^{ff} + \epsilon_{M,t} &(60)\\
&\epsilon_{M,t}\,\tilde{}\,N(0,\sigma_M^2) &(61)
\end{aligned}
$$

The coefficients ρ_r and ρ_π are the smoothing parameter and inflation coefficient, with $0 < \rho_r < 1$ and $\rho_\pi > 1.\overline{R}$ is the steady state interest rate, equal to the steady state foreign interest rate R^* and $\widehat{\pi}_t$ is the deviation of actual inflation from the target rate of inflation, and $\widehat{y}_t$ is the deviation of output from the target (steady-state) output in log-levels. Again we assume a shock to monetary policy given by $\epsilon_{M,t}$, normally distributed with variance σ_M^2. Given that the central bank sets the risk-free interest rate, it provides reserves (or takes out reserves) to the banking sector through open market operations to insure a balance-sheet equilibrium:

$$\begin{aligned} \Delta FF_t &= N_t + B_t - R_{t-1}^{ff} FF_{t-1} \\ &-(1 + R_{t-1}^{ff} + \phi_N - \phi_N R_{t-1}^{ff}) N_{t-1} \\ &+(1 + R_{t-1}^{ff} - \phi_M - \phi_M R_{t-1}^{ff}) M_{t-1} - M_t \\ &-(1 + R_{t-1}^{g}) B_{t-1} \\ &+(1 + R_{t-1}^{*} + \Phi_{t-1}) B_{t-1}^{f} S_{t-1} - B_t^f S_t \end{aligned} \tag{62}$$

2.6 Fiscal Policy

The government takes in taxes from the households and engages in spending on traded goods. We assume that spending may be either pro-cyclical or counter-cyclical, depending on the value of ρ_{GY}, that there is smoothing in government consumption, and there is a stochastic component to spending:

$$G_t = (1-\rho_G)\overline{G} + \rho_G G_{t-1} + (1-\rho_G)\rho_{GY}(Y_{t-1} - \overline{Y}) + \epsilon_{G,t} \tag{63}$$

$$\epsilon_{G,t}\tilde{\ } N(0, \sigma_G^2) \tag{64}$$

Given its source of labor and consumption tax revenue, the fiscal borrowing requirement is given by the following identities:

$$TAX_t = \tau W_t L_t + \tau_c P_t C_t \tag{65}$$

$$B_t^g = (1 + R_{t-1}) B_{t-1}^g + P_t^h G_t - TAX_t \tag{66}$$

2.7 Foreign Assets and Interest Rates

The aggregate foreign borrowing or asset accumulation evolves through the following identity:

$$S_t B_t^f = [1 + R_{t-1}^* + \Phi_{t-1}] S_t B_{t-1}^f + P_t^f (C_t^f + I_t^h + I_t^x) - P_t^x (C_t^*) \tag{67}$$

It should be noted that the risk premium embedded in the accumulation of foreign debt effected closes this open economy model, so that the domestic consumption and foreign debt levels do not become indeterminate. There are other ways to close the open economy model, such as adjustment costs on foreign debt accumulation, or an endogenous discount factor [see Schmitt-Grohé and

Uribe (2003)]. We feel that the incorporation of a time-varying endogenous risk premium is a more intuitive way to close this model. Schmitt-Grohé and Uribe have shown that the particular choice of closing the open economy makes little difference for the dynamics of the model.

3 Calibrated Parameters and Bayesian Estimation

Before turning to Bayesian estimation, we first calibrate the parameters which determine the steady state. Following Christiano, Motto and Rostagno (2007), we calibrate parameters that control the steady state, and estimate with Bayesian methods those parameters which affect the dynamics and stochastic properties of the model. The reason we simply calibrate and do not estimate the first set of parameters is that computation of the steady-state is very time intensive.

The parameters are set for a quarterly model. The discount parameter β is similar to most other models for quarterly data. The habit persistence parameter ϱ is within range of most models, such as Smets and Wouters (2003). The depreciation rate for capital δ_1 is relatively high. We assume that the capital in our model is specific to the non-traded sector. Since investment goods in this sector are imported goods, we assume that the depreciation is high, while the adjustment cost parameter ϕ_K would be relatively low.

The ratios of consumption of foreign goods in total consumption basket, γ_1 the the share of export-goods consumption in the total domestic consumption basket, γ_2, the tax parameters for labor income and consumption, τ,τ_C all come from national income accounts. The relative risk aversion coefficient, η, the labor supply elasticity, ϖ, and the disutility of labor γ_L are commonly used. We assume a higher intratemporal elasticity between consumption of home and foreign goods in the total consumption index than the elasticity of intratemporal substitution between consumption of export and home goods in the domestic consumption index. Hence, $\theta_1 > \theta_2$.

The financial friction parameters representing the borrowing needs of the export, home-goods and importing firms, were all set equal at a value of 1. We assume in such a financially developed economy as Singapore that firms in any of the sectors would have easy access to short term credit. The capital coefficient in the export production function, α_1, is set to to replicate the shares of capital and labor in the economy. Finally the banking reserve and lending cost parameters ϕ_M, ϕ_N, are set to replicate observed low spreads in the financial sector.

For the risk parameter on government bonds, in our base simulation, we assume that it is equal to zero. Thus the government bond rate and the risk-free rate are identical. In our counterfactual simulation we set the parameter at .3, with the assumption that for a percentage increase of government bonds above the steady state, the bond risk increases by 33 basis points.

Table 1: Calibrated Parameters

Symbol	Definition	Values
β	discount factor	0.99
ϱ	habit parameter	0.8
δ_1	capital depreciation	0.06
ϕ_{K^h}	adjustment cost	0.005
γ_1	foreign cons. in total cons. index	0.3
γ_2	con of export good in dom.cons. index	0.1
η	relative risk aversion parameter	5.0
ϖ	labor supply elasticity	0.5
γ_L	disutility of labor	0.5
ϕ_C	consumption in CES utility	0.95
$\varkappa$	CES utility coefficient	-0.1
θ_1	intratemporal substitution elasticity, total cons	2.5
θ_2	intratemporal substitution elasticity, domestic cons	1.5
τ, τ_C	tax rates on labor income and consumption	0.2,0.1
μ_x, μ_h, μ_f	financial friction parameters	1,1,1
ζ	substitution elasticity for differentiated goods	6
κ	CES substitution parameter in production	-0.1
α_1	capital coefficient in non-traded goods	0.3
α_2	capital coefficient in export goods	0.4
ϕ_M, ϕ_N	deposit and lending costs for banks	0.1, 0.15
ϕ_B	risk coefficient for government bonds	0, 0.3

Table 2 shows the prior distributions with the means and standard errors as well as values for the infima and suprema of the distributions. We make use of relatively flat priors for the standard deviations for the volatilities of the shocks in the model. The coefficients we estimate relate to stochastic process for government spending, and the persistence coefficient for exports, export prices, mark-up pricing shocks. We allow the government spending coefficient with respect to output to be positive or negative, thus allowing the data to determine if spending is pro or counter-cyclical. We make a similar assumption for the coefficient of exports with respect to the real exchange rate. The coefficients for the Tayor rule are standard.

Table 2:
Bayesian Priors: Parameters and Distributions

		Distribution	Mean	Std Dev	Inf	Sup
Volatility	Name					
σ_G	Gov. Spending	Inv. Gamma	.001	2	.005	.5
σ_{Z^x}	Export Prod.	Inv. Gamma	.001	2	.005	.5
σ_{PX^*}	Terms of Trade	Inv. Gamma	.001	2	.005	.5
σ_{R^*}	For. Interest	Inv. Gamma	.001	2	.005	.5
σ_{C^*}	Exports	Inv. Gamma	.001	2	.005	.5
σ_C	Consumption	Inv. Gamma	.001	2	.005	.5
σ_M	Monetary Rule	Inv. Gamma	.001	2	.005	.5
σ_{Z^h}	Home Goods Prod	Inv. Gamma	.001	2	.005	.5
Coefficient						
λ	DSGE Weight	Uniform	–	–	0	2
ρ_R	Taylor Lag	Beta	.5	.2	.1	.9
ρ_π	Taylor Inflation	Normal	1.5	.2	1.1	2
ρ_y	Taylor Output	Beta	.5	.5	.01	.95
ρ_G	Gov. Spending	Beta	.5	.5	.01	.95
ρ_{GY}	Gov. Spending	Normal	0.	.1	-.3	.3
ρ_{PX^*}	Terms of Trade	Beta	.5	.2	.01	.95
ρ_{R^*}	For.Interest	Beta	.5	.2	.01	.95
ρ_{C^*}	Export	Beta	.5	.2	.01	.95
ρ_{C^*S}	Export Ex. Rate	Beta	.25	.2	.01	.95
ρ_{Z^h}	Home Goods	Beta	.5	.2	.01	.95
ξ	Calvo Pricing	Beta	.5	.2	.01	.95

3.1 Parameter and Volatility Estimates

We estimated the models for the period 1988-2007 for the following observables: consumption, government, exports, terms of trade, foreign interest rate, inflation, the exchange rate. Except for the foreign interest rate, the data are log first differenced.

We estimate the model for a DSGE framework and a DSGE/VAR framework. The combined DSGE/VAR framework starts with the premise that the DSGE framework is misspecified and needs to be supplemented with a VAR, in our case with four lags. The question is, what is the relative weight for the VAR and DSGE for the best fit? In a Bayesian context, the relative weight for the VAR is the value $1/(1+\lambda)$. For the pure DSGE model, with no weight given to the VAR, $\lambda = \infty$ while for a pure VAR model, $\lambda = 0$.

We estimated the DSGE model under the restriction $\lambda = \infty$ and for the optimal λ within an interval $[0, 2]$. The best fit gives $\lambda = .1.406$ by both the Laplace and Harmonic Mean measurements of the Marginal Likelihood.

Table 3:
Fit of DSGE Models

		Marginal Likelihood	
Specification	λ	Laplace	Harmonic Mean
DSGE	Inf	815.589	882.359
DSGE/VAR	1.406	817.623	893.453

3.2 Volatility and Parameter Estimates

Table 4 pictures the results for Japan under the pure DSGE and the DSGE/VAR framework for the mean $\lambda = .1.406$, The table contains the mean of the Bayesian estimates for 200,000 simulations in four blocks. We also show the infimum and supremum of each estimate for a 95% confidence interval.

We see that the highest persistence is in the markup pricing behavior under both methods. The major difference in the estimates given by the two methods is in the persistence coefficient for the shock to adjustment costs, ρ_A. The pure DSGE method gives a relatively low value while the DSGE/VAR a relatively high one. Under both methods, government spending can be either counter or procyclical. The effect of the real exchange rate on exports, given by ρ_{C^*S}, is relatively small but positive in both the DSGE and DSGE/VAR method. The Calvo price stickiness coefficient, ξ, is also small, relative to commonly accepted specifications of .75 or .8, under both methods. The estimated volatilities are all relatively small, but somewhat larger in the pure DSGE than in the DSGE/VAR, with the shock to non-traded goods production and consumption demand having the largest values in both frameworks.

Table 4: Parameter and Volatility Estimates, DSGE and DSGE/VAR Models

	DSGE			DSGE/VAR		
Coefficient	Mean	Inf	Sup	Mean	Inf	Sup
λ	∞	–	–	1.406	1.134	1.576
ρ_R	0.046	0.016	0.079	0.131	0.108	0.185
ρ_π	1.504	1.501	1.506	1.490	1.488	1.491
ρ_y	0.333	0.236	0.415	0.146	0.063	0.204
ρ_C	0.609	0.547	0.648	0.151	0.108	0.197
ρ_G	0.933	0.918	0.949	0.573	0.542	0.598
ρ_{GY}	0.094	0.081	0.111	0.151	0.132	0.170
$\rho_{P^{X^*}}$	0.834	0.810	0.854	0.411	0.323	0.468
ρ_{R^*}	0.942	0.935	0.949	0.915	0.889	0.948
ρ_{Z^x}	0.130	0.104	0.154	0.170	0.138	0.205
ρ_{C^*}	0.878	0.848	0.910	0.574	0.557	0.592
ρ_{C^*S}	0.094	0.067	0.139	0.032	0.018	0.047
ξ	0.592	0.505	0.637	0.523	0.480	0.576
Volatility	Mean	Inf	Sup	Mean	Inf	Sup
σ_G	0.010	0.009	0.011	0.009	0.007	0.010
σ_M	0.072	0.045	0.089	0.020	0.014	0.026
σ_{Z^h}	0.140	0.118	0.156	0.036	0.026	0.047
$\sigma_{P^{X^*}}$	0.045	0.040	0.051	0.018	0.014	0.022
σ_{R^*}	0.042	0.036	0.048	0.023	0.017	0.027
σ_{C^*}	0.009	0.008	0.010	0.008	0.007	0.009
σ_C	0.100	0.085	0.114	0.044	0.035	0.054

3.3 Variance Decomposition

Of course, these estimates tell us nothing about the relative importance of each of the exogenous shocks for key endogenous variables of the model. Table 5 gives the mean variance decomposition of the Bayesian estimation under both the DSGE and DSGE/VAR frameworks.

We see a number of expected results, for example, that the shock to consumption explains more than 20 percent of the variance in consumption, the shock to terms of trade and production are important for the exchange rate, and the shock to export demand accounts more than 30 percent of consumption in the DSGE/VAR model. The shock to the Taylor rule accounts for more than 50 percent of the variance of inflation in the DSGE and 36 percent in the DSGE/VAR approaches.

Table 5: Variance Decomposition

DSGE							Volatility:
Variable	σ_G	σ_{R^*}	σ_M	σ_{z^h}	σ_{PX^*}	σ_{C^*}	σ_C
$\widehat{\pi}$	0.018	0.001	0.504	0.042	0.325	0.096	0.014
$\widehat{c}$	0.019	0.001	0.436	0.048	0.323	0.087	0.085
$\widehat{s}$	0.004	0.000	0.195	0.457	0.265	0.076	0.003
DSGE/VAR							
$\widehat{\pi}$	0.040	0.003	0.364	0.028	0.127	0.434	0.005
$\widehat{c}$	0.047	0.002	0.256	0.032	0.119	0.324	0.221
$\widehat{s}$	0.007	0.001	0.087	0.230	0.269	0.405	0.001

4 Counterfactual Simulations

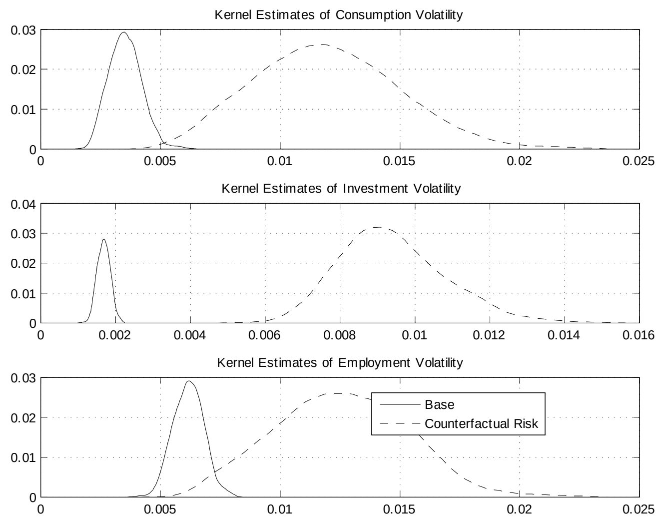
The results come from 500 simulation experiences for a sample size of 100. The model is solved with a second-order perturbation method. At each simulation, we calculate the volatility of key variables and then use the Epanechnikov kernel for evaluating the distribution of these volatilities for alternative seeds for the random shocks to government spending, with $\sigma_G = .01$. All other shocks are set to zero.

We first compare the behavior of key variables under the base "no risk" and counterfactual risk scenario. Then, under the high risk assumption, we evaluate the gains or losses from switching to an exchange rate rule for monetary policy.

4.1 No Risk vs. High Risk Scenario

Figure 3 pictures the kernel estimates of the volatility measures of consumption, investment, and employment under the base scenario no risk on government bonds, and a counterfactual risk premium on government bonds. This figures shows that the risk premium on bonds leads to a jump in volatility of all three variables by more than a factor of three.

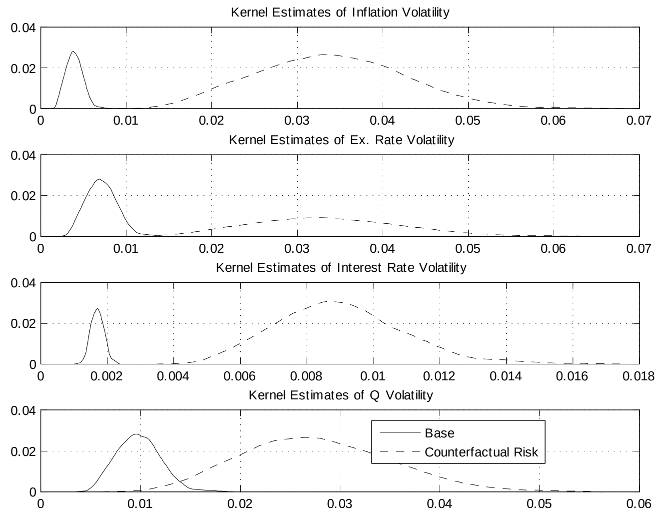
Figure 3



Consumption, Investment and Employment Volatility
under Base and Counterfactual Risk on Bonds

Figure 4 pictures the volatility distributions for inflation, the exchange rate, the interest rate and Tobin's Q under the base and counterfactual risk scenario. Again, there is a jump in volatility by factors of three or more when the risk premium on bonds comes into play.

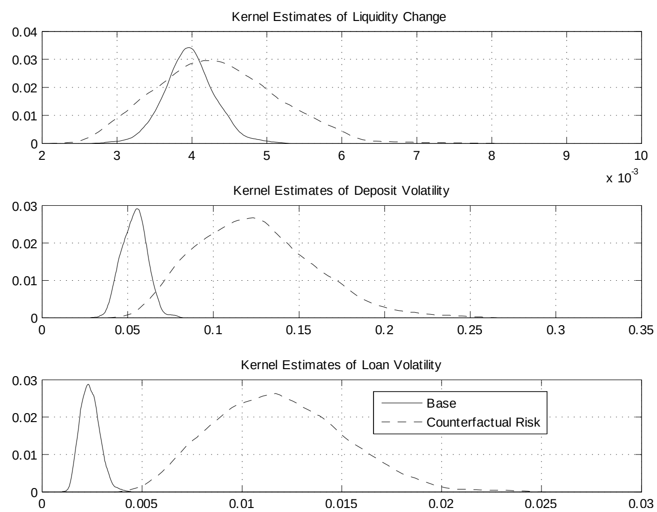
Figure 4



Inflation, Exchange Rate, Interest Rate and Q Volatility
under Base and Counterfactual Risk on Bonds

Figure 5 pictures the distributions of liquidity provision by the central bank, as well as deposit and loan volatility in the financial sector. The distribution of liquidity provision by the central bank is slightly more disperse in the counterfactual simulation. However, volatility in deposits and loans increase by factors of two more more.

Figure 5



Liquidity, Deposit and Loan Volatility under Base and Counterfactual Risk on Bonds

While we have discussed volatilities, what does this mean for welfare? One way to evaluate welfare gains or losses between two scenarios is to calculate the percent compensation one would need to equalize welfare in the two scenarios.

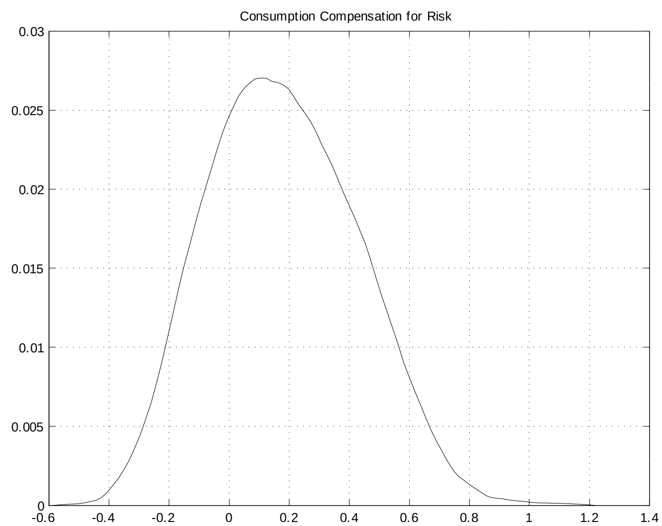
Figure 6 pictures the distribution of the implied percentage consumption compensation needed to make the representative household indifferent between the high risk and no risk premium on government bonds. This compensation factor, Δ_C, takes the following functional form for each simulation experiment:

$$\begin{aligned}
\Delta_C &= 100\left[1-\left(\frac{V^{Counter}-V^{Base}}{V_C^{Base}}+1\right)^{\frac{1}{1-\eta}}\right] \\
V^{Basse} &= \sum_{\iota=0}^{T}\beta^{\iota}U(\widetilde{C}_{t+\iota}^{Base}/H_{t+\iota}^{Base},L_{t+\iota}^{Base}) \\
V^{Counter} &= \sum_{\iota=0}^{T}\beta^{\iota}U(\widetilde{C}_{t+\iota}^{Counter}/H_{t+\iota}^{Counter},L_{t+\iota}^{Counter}) \\
V_C^{Base} &= \sum_{\iota=0}^{T}\beta^{\iota}U(\widetilde{C}_{t+\iota}^{Base}/H_{t+\iota}^{Base})
\end{aligned}$$

where V^{Base} and $V^{Counter}$ are the welfare measures for the base and counterfactual cases, and V_C^{Base} is the component of welfare explained by consumption alone. A positive value implies that the household in the counterfactual scenario is worse off and needs a positive consumption compensation to have the same welfare as households in the base scenario. A negative value means that the household is better off in the counterfactual scenario, and would have to have consumption reduced to be equal to the welfare realized in the base scenario.

Figure 6 shows that the distribution is skewed: 75% of the time the compensation would be positive, with a mean value of .31%, entailing expectation of continuing welfare losses.

Figure 6



Percentage of Consumption Compensation for Equalizing Welfare between Base and Counterfactual Bond Risk

4.2 Interest Rate vs. Exchange Rate Rule for Monetary Policy

Given the large welfare losses entailed by an risk premium on domestic debt, would a change in the monetary policy regime make any difference? Specifically, if the increased risk premium under inflation targeting framework leads to higher real exchange rate volatility, would a switch to an exchange-rate targeting framework reduce overall macro volatility and improve welfare, relative to staying with the base Taylor rule inflation targeting framework?

Dropping the Taylor rule, we assume that the Bank of Japan follows a rule similar to that used by the Monetary Authority of Singapore [see McCallum (2006)]:

$$
\begin{aligned}
[\ln(S_{t+1}) - \ln(S_t)] &= \rho_S[\ln(S_t) - \ln(S_{t-1})] \\
&+(1-\rho_s)[\ln(P_{t+1}) - \ln(P_t)] \\
&-(1-\rho_s)\rho_\pi[\ln(P_{t+1}) - \ln(P_t) - \widetilde{\pi}]]
\end{aligned} \tag{68}
$$

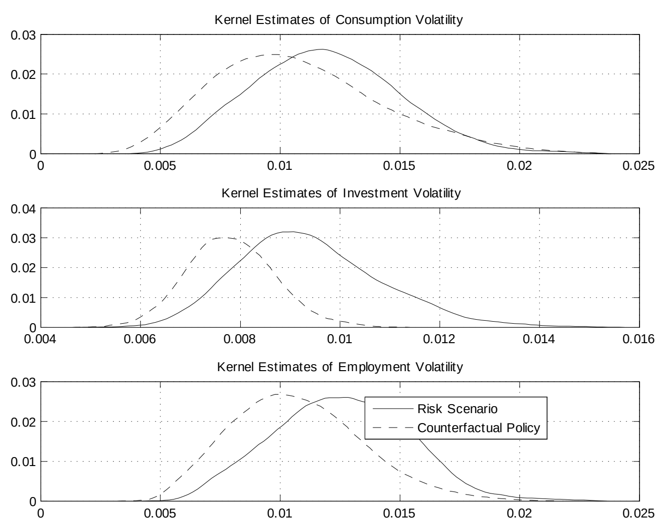
where $\widetilde{\pi}$ is the target rate of inflation, ρ_S is the depreciation persistence parameter and ρ_π is the inflation coefficient. This rule implies that in the absence of deviations of inflation from the target rate, the monetary authority will follow a purchasing power parity approach to exchange rate depreciation or appreciation. However if inflation exceeds its target, there will real appreciation.

We do not estimate the parameters of this rule since Japan followed a Taylor rule. Instead we specify the same persistence parameters and inflation target parameters to this rule which were obtained from the estimated Taylor rule under the more accurate DSGE/VAR framework Hence, $\rho_S = .131$ and $\rho_\pi = 1.49$.

We simulate the model with the Taylor rule and high risk premium as the base, and the high risk premium with the exchange-rate rule as the counterfactual, again for the same set of recurrent government spending shocks.

Figure 7 pictures the distribution of consumption, investment and employment volatility in the two scenarios. We see that the adoption of an exchange rate rule reduces the volatilities of all three variables by factors of two or more.

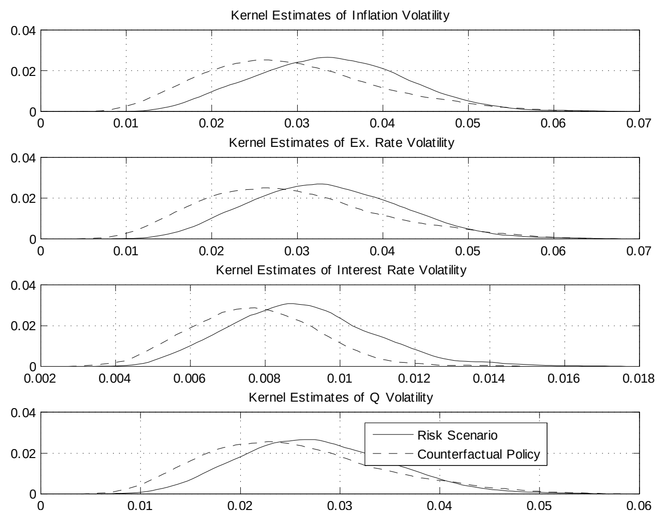
Figure 7



Consumption, Investment and Employment Volatility
under Risk and Counterfactual Exchange-Rate Policy

Figure 8 shows that a similar pattern emerges for the distribution of the volatility of inflation, the exchange rate, the interest rate and Tobin's Q.

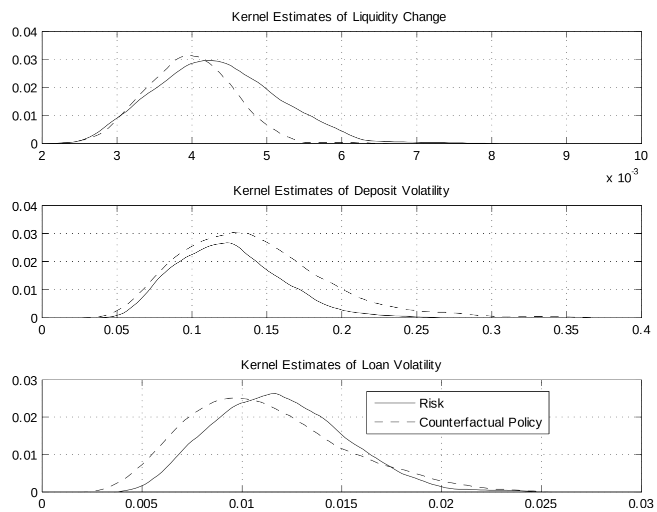
Figure 8



Inflation, Exchange Rate, Interest Rate and Q Volatility under Risk and Counterfactual Exchange-Rate Policy

Figure 9 pictures the distributions of the volatility of liquidity provision to banks, deposits and loans. There is little change in the volatility of liquidity provision by the central bank, but there is a reduction by more than a factor of two for deposits and loans.

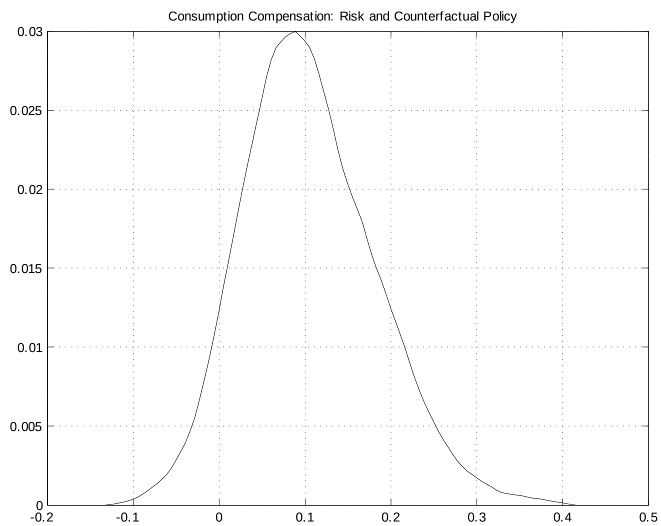
Figure 9



Liquidity, Deposit and Loan Volatility Under Risk and Counterfactual Exchange-Rate Policy

Figure 10 pictures the distribution of the consumption compensation to equalize welfare between the two scenarios. Not surprisingly, the distribution is more likely to be negative, meaning that the welfare of the household in the counterfactual exchange-rate targeting regime is 66% more likely to be better off than in the base high-risk inflation targeting regime. The mean consumption differential would be .4% .

Figure 10



Percentage of Consumption Compensation for Equalizing Welfare between RIsk and Counterfactual Exchange-Rate Policy

4.3 Taylor Rule with Exchange-Rate Targeting

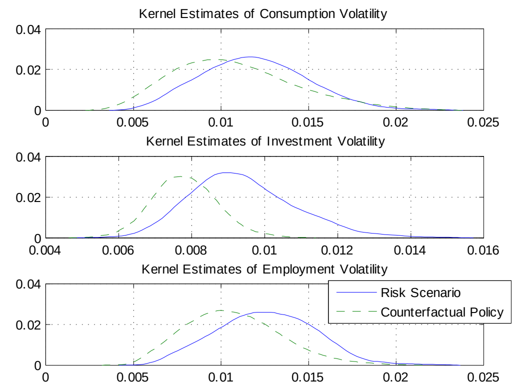
What if Japan adopts an expanded Taylor rule with an exchange rate depreciation target as well as inflation and output growth targets? In this case we substitute use the following policy rule:

$$
\begin{aligned}
R_t^{ff} &= \rho_r R_{t-1}^{ff} + (1-\rho_r)\rho_\pi \widehat{\pi}_t + (1-\rho_r)\rho_y \widehat{y}_t (1-\rho_r)\overline{R}^{ff} \qquad (69) \\
&\quad +(1-\rho_r)\rho_s \widehat{s}_t \\
\widehat{s}_t &= \ln(S_t) - \ln(S_{t-1}) \qquad (70)
\end{aligned}
$$

We use the estimated values for ρ_r, ρ_π, and ρ_y. We calibrate a high value, with $\rho_s = .75$, relative to the weight on inflation, in order to indicate that the exchange rate plays almost as high a role in the monetary decision. As in the previous experiment, we simulate the model with recurring shocks to government spending only, under the high risk scenario for government debt.

We see that adopting an expanded Taylor rule, with a relatively high weight on depreciation, slightly reduces consumption, investment and employment volatility, as Figure 11 shows.

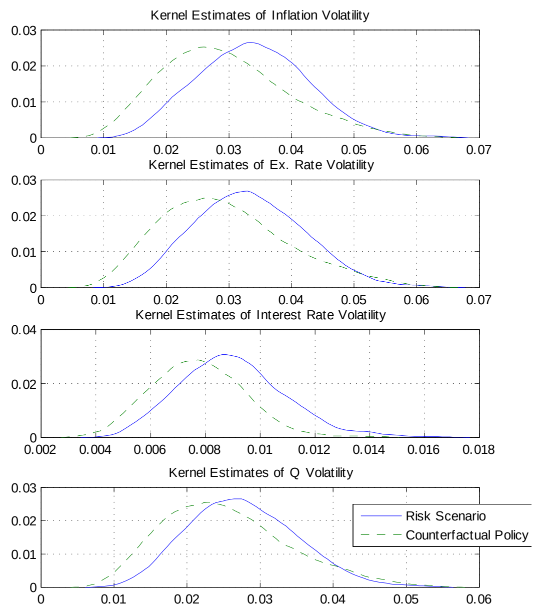
Figure 11



Distribution of Consumption, Investment, and Employment Volatility under Taylor Rule and Counterfactural Extended Taylor Rule

Figure 12 shows the corresponding volatility distributions for inflation, the exchange rate, the interest rate and Tobin's Q. Again, using the expanded Taylor rule shifts the distribution to the left.

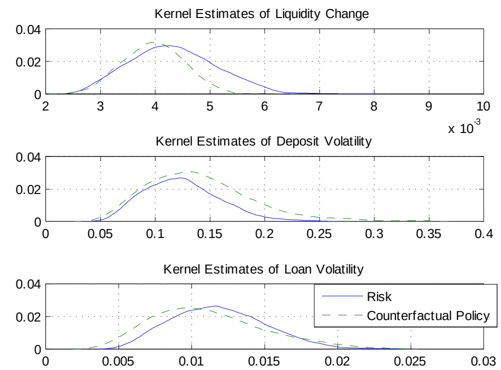
Figure 12



Inflation, Exchange Rate, Interest and Q Volatility Under Taylor Rule and Counterfactual Taylor Rule

Figure 13 pictures the volatility distributions of liquidity provision by the central bank, as well as deposit and loan volatility in the financial sector. We see that there is little or no difference in these distributions.

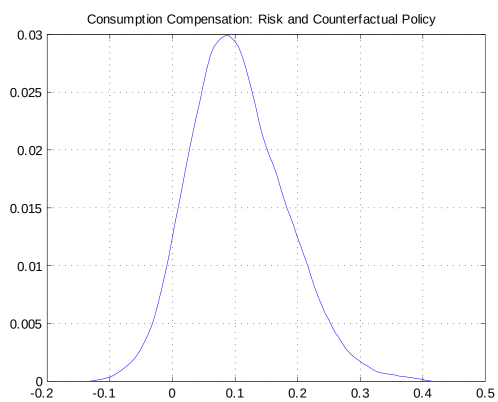
Figure 13



Distribution of Liquidity, Deposits and Loans
under Taylor Rule and Expanded Taylor Rule

Figure 14 pictures the distribution of the consumption compensation needed to equalize welfare in the two regimes. We see that the distribution of this compensation is similar to Figure 10, implying that there is an expected positive compensation for households in the base scenario, to equailize welfare under the expanded Taylor rule.

Figure 14



Consumption Compensation for Equalizing
Welfare under Taylor Rule and Counterfactual
Amended Taylor Rule

The results of this sector show that adding the exchange rate depreciation in the Taylor rule can achieve similar effects on volatility distributions and welfare as targeting the exchange rate itself, as a function of inflation. The only drawback to the use of the Taylor rule is the zero lower band on the interest rate. The results indicate that the exchange rate depreciation weight in the Taylor rule has to be relatively strong for the Taylor rule to work as effectively as a direct exchange-rate instrument.

5 Conclusion

Our Bayesian analysis for Japan suggests reasons for abandoning the traditional Taylor rule framework in favor of an exchange rate targeting framework used by the Monetary Authority of Singapore, or an expanded Taylor rule which includes the exchange rate. Of course, the direct use of an exchange-rate instrument, in place of a Taylor rule with an exchange rate argument, opens the monetary authority of a large country like Japan, much more than Singapore, to criticism of currency maniuplation by major trading partners. While the Taylor rule suffers from the drawback of a zero lower bound, the exchange-rate alternative suffers from the threat of political backlash.

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