HONG KONG INSTITUTE FOR MONETARY RESEARCH

STRUCTURAL CHANGE AND COUNTERFACTUAL INFLATION-TARGETING IN HONG KONG

Paul D. McNelis

HKIMR Working Paper No.23/2009

July 2009

Structural Change and Counterfactual Inflation-Targeting in Hong Kong

Paul D. McNelis

Fordham University

Hong Kong Institute for Monetary Research

July 2009

Abstract

This paper evaluates structural change and adjustment in Hong Kong with Bayesian estimation of a small open economy with a fixed exchange rate show little or no change in the structural parameters or volatility estimates of the structural shocks before and after the Asian crisis and the experience of deflation. Terms of trade shocks are the most important sources of volatility for inflation in both periods. A counterfactual simulation shows that the dispersion of consumption and inflation volatility may have slightly decreased with an inflation-targeting regime with no uncertainty, but interest-rate volatility would have increased by factors of 50 to 100 percent.

Keywords: Bayesian Estimation, Structural Change, Inflation Targeting

JEL Classification: E62, F41

---

1. Introduction

Has Hong Kong changed in any significant way, in terms of its macroeconomic structure, since the onset of the Asian crisis, and the experience of recession and deflation? Prolonged periods of deflation, with periods of prolonged recession, often represent regime shifts in the underlying process of price formation. As Yetman (2008) notes, firms are more likely to be less adverse to prices that are too high than to prices which are too low. Thus, we expect prices to be more flexible in periods of inflation than in periods of deflation.

Hong Kong has maintained his currency peg since 1984, with only minor changes so there is not monetary policy regime shift, so there is no obvious break point, matching the Volker/Greespan era from the previous Federal Reserve monetary policy. The question we ask in this paper is the following: did anything happen in Hong Kong since 1998 as a result of the experience of recession and deflation? Evidence from structural model estimation says very little.

Figure 1 pictures quarterly GDP growth and CPI inflation between 1984 and 2008. We see the dramatic drop in GDP growth, concomitant with the deflation, after 1998. From November 1998 till June 2004, the cumulative fall in the CPI was 13.8 percent.

What about developments in the financial sector? Figure 2 pictures the behavior of the Deposit/GDP and Loan/GDP ratios since 1984. We see a sharp fall in the total loan/GDP ratio after 1998, while the Deposit/GDP ratio flattens out, and then starts to increase after 2004. What is noteworthy is that in the in the post 1998 period, the Loan/GDP ratio remains lower than the Deposit/GDP ratio. This phenomenon of course is consistent with an economy in recession, when banks simply cut back their lending to the private sector in spite of large deposits.

By contrast, the index of openness of Hong Kong, defined as the ratio of imports and exports to GDP, and appearing in Figure 3, shows an almost steady upward progress, with a brief flattening out between 1996-2000, over this period.

Likewise, there is little or no obvious change in the pattern of the terms of trade (defined as the unit of exports to the unit price of imported goods) throughout the period, in terms of mean and volatility, as Figure 4 shows.

While much has been written (amid much controversy and debate) about deflation in Japan [see, for example, Krugman (1998), Yoshino and Sakahibara (2002) and McKibbin and Wilcoxen (1998)], Hong Kong is of special interest. First, the usual response of expansionary monetary policy is not an option for Hong Kong, since its currency board arrangement precludes active policy directed at inflation or deflation.

Secondly, Hong Kong is a smaller but much more open economy than Japan, and is thus more susceptible to external factors. Finally, Hong Kong, as a "special administrative region", has been in a process of increasing market integration with mainland China.

However, there are some important similarities. Both Japan and Hong Kong have experienced significant asset-price deflation. Ha and Fan (2002) examined panel data for assessing price convergence between Hong Kong and mainland China. While convergence is far from complete, they showed that the pace has accelerated in recent years. However, comparing price dynamics between Hong Kong and Shenzhen, Schellekens (2003) argued that the role of price equalization as a source of deflation is minor, and contended that deflation is best explained by wealth effects. Genberg and Pauwels (2003) found that both wages and import prices have "significant causal roles", in addition to property rental prices. These three out-perform measures of excess capacity as "forcing variables" for deflation. Razzak (2003) called attention to the role of unit labor costs as well as productivity dynamics for understanding deflation. However, making use of a vector autoregressive model (VAR), Genberg (2003) reported that external factors account for more than fifty percent of "unexpected fluctuations" in the real GDP deflator at horizons of one to two years.

Most of these studies have relied on linear extensions and econometric implementation of the Phillips curve or New Keynesian Phillips curve. In this framework, regime switching models have been widely applied to macroeconomic analysis of business cycles, initially with "linear" regimes switching between periods of recession and recovery [see Hamilton (1989, 1990)]. We follow an alternative approach. Using Bayesian estimation of an open-economy model with data before and after 1998, we examine the structural parameters and volatilities of the underlying structural shocks in a New Keynesian Open Economy model with a fixed exchange rate and capital mobility.

The results show little evidence of any macroeconomic structural shift in Hong Kong. The inflation persistence coefficients were small before the Asian crisis and deflation and they remain so in the period during deflation and afterwards. Similarly largest volatility estimates before the Asian crisis and deflation remained the largest volatility estimates in the period after the crisis. We also show that interest-rate dispersion would have been much larger if Hong Kong had followed an inflation-targeting regime with a fixed exchange rate, but consumption and inflation volatility would not have changed very much.

The next section lays out the model we use for Bayesian estimation as well as the calibration of parameters which affect the steady state. The third section takes up Bayesian estimation of the model, where we look at the priors we impose of the parameters and shocks, the posterior distributions, and the variance decomposition of key variables. Then we engage in a counterfactual simulation: how would consumption, inflation, and interest-rate volatility change if the monetary authority of Hong Kong had adopted a system of inflation-targeting, with perfect certainty. There is only sight evidence that consumption and inflation volatility would have decreased, but overwheming evidence that interest-rate volatility would have increased by factors of 50 to 100 percent.

2. The Model and Calibration

2.1 Household Preferences and Endowments

Households own capital, for rental to home-good producing firms, and supply labor both to these firms and the export-goods producing firms. Capital for rental to the firms depreciates at the rate δ_1. When households accumulate capital or decumulate capital beyond the steady state level, they pay adjustment costs. The following law of motion is specified for capital, while adjustment costs are given by AC_t. The parameter ϕ is the adjustment cost parameter.

$$K_t^h = (1-\delta_1)K_{t-1}^h + I_t^h \tag{1}$$

$$AC_t = \left(\frac{\phi\left(I_t^h - \delta_1 \overline{K}^h\right)^2}{2K_t^h} \right) \tag{2}$$

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

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-γ_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-γ_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 $\prod_t$, with $\prod_t = \prod_t^x + \prod_t^n$. 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):

$$
\begin{aligned}
P_t^{k^h} K_t^h = W_t L_t + \left(1 + R_{t-1}^m\right) M_{t-1} + \prod_t + \\
P_t C_t \left(1 + \tau_c\right) + M_t \\
+ \tau W_t L_t + P_t^f I_t^h \\
+ P_t^f \left(\frac{\phi\left(I_t^h - \delta_1 \overline{K}^h\right)^2}{2K_t^h} \right)
\end{aligned}
\tag{11}
$$

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:

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

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

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

The parameter η is the relative risk aversion coefficient, while γ is the disutility of labor, and ϖ the Frisch labor supply elasticity.

The household chooses the paths of consumption, labor, deposits, investment and capital, to maximize the 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:

$$\underset{\{C_t, L_t, M_t, I_t^h, K_t\}}{Max} \sum_{\iota=0}^{\infty} \beta^{\iota} U\left(\widetilde{C}_{t+\iota} / H_{t+\iota}, L_{t+\iota}\right) \tag{15}$$

where the parameter β represents the constant, exogenous discount factor.

This optimization is subject to the two constraints:

$$\begin{aligned} P_t^{k^h} K_t^h = W_t L_t + \left(1 + R_{t-1}^m\right) M_{t-1} + \prod\nolimits_t + \\ P_t C_t \left(1 + \tau_c\right) + M_t \\ + \tau W_t L_t + P_t^f I_t^h \\ + P_t^f \left(\frac{\phi\left(I_t^h - \delta_1 \overline{K}^h\right)^2}{2K_t^h} \right) \end{aligned} \tag{16}$$

$$K_t^h = \left(1 - \delta_1\right) K_{t-1}^h + I_t^h \tag{17}$$

The variable $P_t^{k^h}$ is the return on productive capital rented to the export firm, while W_t is the nominal wage rate.

The household optimization is represented by the intertemporal Lagrangean:

$$\underset{\{C_t, L_t, M_t, I_t^h, K_t\}}{Max} \mathcal{L} = \sum_{\iota=0}^{\infty} \beta^{\iota} \left\{ \begin{array}{c} U(\widetilde{C}_{t+\iota}/H_{t+\iota}, L_{t+\iota}) \\ -\Lambda_{t+\iota} \left[\begin{array}{c} P_{t+\iota} C_{t+\iota}(1+\tau^C) + M_{t+\iota} \\ -(1+R_{t-1+\iota}^m) M_{t-1+\iota} \\ +P_{t+i}^f I_{t+i}^h + P_{t+i}^f \frac{\phi\left(I_{t+i}^h - \delta_1 \overline{K}^h\right)^2}{2K_{t+i}^h} \\ +(\tau-1) W_{t+\iota} L_{t+\iota} - \Pi_{t+i} - P_{t+i}^k K_{t+i}^h \end{array} \right] \\ -Q_{t+i}^h \left(K_{t+i}^h - I_{t+i}^h - (1-\delta_1) K_{t-1+i}^h\right) \end{array} \right\} \tag{18}$$

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

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

$$\begin{aligned}
\Lambda_t P_t &= \left[\widetilde{C}_t / H_t\right]^{-\eta} \frac{1}{H_t}\left(\widetilde{C}_t\right)^{1-\varkappa} \phi\left(C_t\right)^{-\varkappa-1} && (19)\\
\gamma L_t^{\varpi} &= \Lambda_t (1-\tau^w) W_t && (20)\\
\Lambda_t &= \beta \Lambda_{t+1}(1+R_t^m) && (21)\\
Q_t^h &= \beta \Lambda_{t+1} P_{t+1}^k && (22)\\
&\quad + \beta \Lambda_{t+1} P_{t+1}^f \frac{\left(\phi_1\left[I_{t+1}^h - \delta_1 \overline{K}^h\right]\right)^2}{2\left(K_t^h\right)^2} \\
&\quad + \beta Q_{t+1}^h (1-\delta_1) \\
I_t^h &= \delta_1 \overline{K}^h + \frac{K_t^h}{\phi_1}\left(\frac{Q_t^h}{\Lambda_t} - P_t^f\right) && (23)
\end{aligned}$$

The first equation, 19, 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, 20, states that the marginal disutility of labor is equal to the after take marginal utility of consumption provided by the after-tax wage. The third equation, 21, 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, given by 22, 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, 23, tells us that investment will be equal to the steady state investment, $\delta_1 \overline{K}^h$, when $\frac{Q_t^h}{\Lambda_t} = P_t^f$. Any increase in Tobin's Q_t^h, relative to the marginal utility of income and the price of investment goods, will trigger increases in investment.

3. Production and Technology

3.1 Home-Goods Firms

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

$$Y_t^h = Z_t^h A^h \left[(1-\alpha_1)\left(L_t^h\right)^{-\kappa_1} + \alpha_1\left(K_t^h\right)^{-\kappa_1}\right]^{-\frac{1}{\kappa_1}} \tag{24}$$

The parameters α_1 and $(1-\alpha_1)$ are the shares of capital and labor in the CES production function, while the coefficient κ_1 is the CES aggregator. The technology shock is given by Z_t^h. We assume that this technology shock evolves according to the following stochastic process:

$$\ln(Z_t^h) = \rho_1 \ln(Z_{t-1}^h) + (1-\rho_1)\ln(\overline{Z}^h) + \epsilon_{Z^h,t} \tag{25}$$

$$\epsilon_{Z^h,t} \sim N(0, \sigma^2_{\epsilon_{Z^h}} \quad) \tag{26}$$

where $\overline{Z}^h$ is the steady state value of the shock and ρ_1 is the autoregressive parameter.

The demand for the export good can be both for domestic consumption, as well for government consumption spending:

$$Y_t^h = C_t^h + G_t \tag{27}$$

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:

$$N_t^h = \mu_1 W_t L_t^h \tag{28}$$

$$N_t^h \le \upsilon_1 P_t^{k^h} K_t^h \tag{29}$$

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

$$\prod_t^h = P_t^h Y_t^h - \left(1+\mu_1 R_t^n\right) W_t L_t^h - P_t^k K_t^h \tag{30}$$

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

$$\frac{\partial Y_t^h}{\partial L_t^h} = \left(1 + \mu_1 R_t^n\right) \frac{W_t}{P_t^h} \tag{31}$$

$$\frac{\partial Y_t^h}{\partial K_t^h} = \frac{P_t^k}{P_t^h} \tag{32}$$

In the CES technology, we have the following expressions:

$$\frac{\partial Y_t^h}{\partial L_t^x} = \left(A^h Z_t^h\right)^{\kappa_1} \left(1 - \alpha_1\right) \left(\frac{Y_t^h}{L_t^h}\right)^{1+\kappa_1} \tag{33}$$

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

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

3.2 Export Firms

The firm producing export goods faces a simple production function, with a fixed unitary stock of capital:

$$Y_t^x = Z_t^x \left(L_t^x\right)^{1-\alpha_2} \tag{35}$$

The technology shock to export-good production follows a similar process as the export-technology shock:

$$\ln(Z_t^x) = \rho_3 \ln(Z_{t-1}^x) + (1 - \rho_3) \ln(\overline{Z}^x) + \epsilon_{Z^x,t} \tag{36}$$

$$\epsilon_{Z^x,t} \sim N(0, \sigma^2_{\epsilon_{Z^x}}) \tag{37}$$

We assume that foreign demand responds to the relative price of this export good, in the sense that if the real exchange rate depreciates (relative to steady-state level $\left(\frac{\overline{S}}{\overline{P}}\right)$, foreign demand rises by a factor χ^x.

$$\ln\left(C_t^*\right) = \ln\left(\overline{C^*}\right) + \chi^x \left[\ln\left(\frac{S_{t-1}}{P_{t-1}}\right) - \ln\left(\frac{\overline{S}}{\overline{P}}\right)\right] \tag{38}$$

Under a small open economy setting we 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:

$$\ln(P_t^{x^*}) = \rho_2 \ln(P_{t-1}^{x^*}) + (1-\rho_2)\ln(\overline{P}_t^{x^*}) + \epsilon_{P^{x^*},t} \tag{39}$$

$$\epsilon_{P^{x^*},t} \sim N(0, \sigma^2_{\epsilon_{P^{x^*}}}) \tag{40}$$

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 face a liquidity constraint for meeting their wage bill:

$$N_t^x = \mu_2 W_t L_t^x \tag{41}$$

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

$$\prod_t^x = P_t^x Y_t^x - \left(1 + \mu_2 R_t^n\right) W_t L_t^x \tag{42}$$

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

$$\frac{\partial Y_t^x}{\partial L_t^x} = \left(1 + \mu_2 R_t^n\right)\frac{W_t}{P_t^x} \tag{43}$$

3.3 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:

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

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}. The forward-looking price setting sets the optimal price, P_t^o, so that expected marginal revenue is equal to expected marginal costs.

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

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

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

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

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

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, $\left(\dfrac{P_{t-1}}{P_{t-2}}\right)$ raised to an indexation parameter κ^i, and by the gross inflation target announced by the central bank, $\left(1+\tilde{\pi}_t\right)$, representing monetary policy statements, relative to inflation targets, raised to a parameter κ^π.

3.4 Importing Firms

Imported goods Y^f are used for both consumption C^f and for investment in the export sector I^h:

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

The importing firms do not produce these goods. However, they have to borrow a fraction μ_3 of the cost of these imported goods in order to bring them to the home market for domestic consumers and investors:

$$N_t^f = \mu_3\left(S_t P_t^{f*} Y_t^f\right) \tag{51}$$

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

$$\begin{aligned} P^f &= \left[\mu_3\left(1+R_t^n\right)+\left(1-\mu_3\right)\right]\left(S_t P_t^*\right) \\ &= \left[1+\mu_3 R_t^n\right] S_t P_t^* \end{aligned} \tag{52}$$

4. 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 $\overline{B^f}$:

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

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 fraction of reserves on outstanding deposits, $\phi_4 M_t$. The relevant opportunity cost of holding these reserves is of course the amount the banks can earn by holding risk-free government bonds,

$\phi_4 R_t M_t$. In addition banks are required to set aside a fraction of capital against their outstanding loans, $\phi_5 N_t$. As in the case of the require reserves against deposits, the opportunity cost is given by $\phi_5 R_t N_t$. The gross profit of the banking sector is given by the following balance-sheet identity:

$$\begin{aligned}\prod_t^B = &(1+R_{t-1})B_{t-1}^g + \\ &(1+R_{t-1}^n)N_{t-1} \\ &-(1+R_{t-1}^* + \Phi_{t-1})B_{t-1}^f S_t \\ &-(1+R_{t-1}^m)M_{t-1} \\ &-B_t^g - N_t + S_t B_t^f + M_t \\ &-\phi_4 R_{t-1} M_{t-1} - \phi_5 R_{t-1} N_{t-1}\end{aligned} \tag{55}$$

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

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

This optimization leads to the following set of first-order conditions for financial sector profit maximization:

$$1 = \beta(1+R_t) \tag{56}$$

$$1 = \beta(1+R_t^n) - \beta\phi_5 R_t^n \tag{57}$$

$$1 = \beta(1+R_t^m) + \beta\phi_4 R_t \tag{58}$$

$$S_t = \beta(1+R_t^* + \Phi_t)S_{t+1} + \beta\Phi_t' B_t^f S_{t+1} \tag{59}$$

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

$$R_t = R_t^n - \phi_5 \tag{60}$$

$$R_t = R_t^m + \phi_4 \tag{61}$$

$$(1+R_t)S_t = (1+R_t^* + \Phi_t + \Phi_t' B_t^f)S_{t+1} \tag{62}$$

Under the assumption of a very small band for exchange-rate movement in Hong Kong, we assume that $S_t = S_{t+1}$. Hence,

$$(1+R_t) = (1+R_t^* + \Phi_t + \Phi_t' B_t^f) \tag{63}$$

Note that there are two sources of volatility in the domestic interest rate, R_t. One is due to changes in the foreign interest rate, R_t^*, the other is due to changes in the time-varying risk premium, Φ_t. In this paper we assume that the time-varying risk premium for Hong Kong is very small and changes very little with the level of foreign assets. By contrast, the foreign interest rate evolves according to the following law of motion:

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

Given that the foreign interest rate determines the domestic interest rates, which in turn affect the rates of return on deposits and loans, the change in the reserves of the financial sector evolve according to the following balance-sheet constraint of the financial sector:

$$\begin{aligned} \Delta RES_t = & -N_t - B_t \\ & + (1+R_{t-1}^n - \phi_5 R_{t-1}) N_{t-1} \\ & - (1+R_{t-1}^m + \phi_4 R_{t-1}) M_{t-1} + M_t \\ & + (1+R_{t-1}) B_{t-1} \\ & = (1+R_{t-1}^* + \Phi_{t-1}) B_{t-1}^f S_{t-1} + B_t^f S_t \end{aligned} \tag{64}$$

4.1 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:

$$G_t = (1-\rho_G)\overline{G} + \rho_G G_{t-1} + (1-\rho_G)\rho_{GY}(Y_{t-1} - \overline{Y}) + \epsilon_{G,t} \tag{65}$$

$$\epsilon_{G,t} \tilde{} N(0, \sigma_{\epsilon_G}^2) \tag{66}$$

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

$$TAX_t = \tau W_t L_t + \tau_c P_t C_t \tag{67}$$

$$B_t^g = (1 + R_{t-1}) B_{t-1}^g + P_t^h G_t - TAX_t \tag{68}$$

5. Foreign Debt and Interest Rates

The aggregate foreign borrowing, of course, evolves through the following identity:

$$S_t B_t^f = \left[1 + R_{t-1}^* + \Phi_{t-1}\right] S_t B_{t-1}^f + P_t^f \left(C_t^f + I_t^x\right) - P_t^x \left(C_t^*\right) \tag{69}$$

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. We feel that the incorporation of a time-varying endogenous risk premium is a more intuitive way to close this model.

6. Calibrated Parameters

Before turning to Bayesian estimation, we first calibrate the parameters which determine the steady state. Following Christiano, Motto and Rostagno (2007), we calibrate the values of 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 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, $\theta_1 > \theta_2 \cdot \mu$.

The financial friction parameters μ_i, $i = 1,\ldots 3,$ 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 Hong Kong 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 replicate the shares of capital and labor in the economy. Finally the banking reserve and lending cost parameters $\phi_M, \phi_N,$ are set to replicate observed low spreads in the financial sector.

goods, γ_2, is similarly set at .3. The habit persistence coefficient h is .5. While this value is usually higher for studies in the United States, we assume that consumers in emerging market countries are less habitual. The reason we make this assumption is that Hong Kong has a higher proportion of lower-income households, who would not have scope for habit persistence. The labor supply elasticity, ϖ, is .25, similar to that of other studies, while the disutility of labor is set at 1. We have found that variations of this parameter had little effect on the steady state values.

6.1 Prior Distributions, Means and Standard Errors

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 use eight observables for Bayesian estimation: $\hat{y}, \hat{p}, \hat{c}, \hat{R}, \hat{p}^X, \hat{g}, \hat{c}^*, \hat{m},$ representing output, prices, consumption, foreign interest rates, terms of trade, government spending, exports and deposits. Lower case letters with the circumflex represent the logarithmic transformation of the corresponding variables in the model. In addition, real variables were transformed by the Hodrik-Prescott filter while nominal indices and aggregates were detrended.

Since we have eight observables in the model and only six structural stochastic shocks in the model, we followed Smets and Wouters (2003) by introducing measurement errors for observable output and deposits:

$$\begin{aligned}
\widehat{y}_t^0 &= \widehat{y} + \epsilon_{t,y^o} \\
&\quad \epsilon_{t,y^o} \,\tilde{}\, N(0, \sigma^2_{y^o}) \\
\widehat{m}_t^0 &= \widehat{m} + \epsilon_{t,m^o} \\
&\quad \epsilon_{t,m^o} \,\tilde{}\, N(0, \sigma^2_{m^o})
\end{aligned}$$

For these measurement errors, we impose the same flat prior, with an inverse Gamma distribution, mean of .01 and standard deviation of 2.

7. Bayesian Estimation Results

We first discuss the Bayesian estimates before and after the implementation of the inflation targeting for the parameters and shocks of the model. Then we take up the results of posterior simulations for variance decomposition.

7.1 Parameters and Volatilities

Table 3 shows the results of the Bayesian estimation for the parameters and standard deviations of the stochastic shocks. We list for each parameter its mean, as well as the infimum and supremum for a 95% confidence interval for 500,000 posterior simulations. We show the estimates for the 1984-1997 and the 1998-2008 samples. We see practically no difference in the estimates. The government spending smoothing coefficient has a wide confidence interval, between .3 and .8, so we can say there is some evidence for smoothing.

The countercyclical government spending coefficient, ρ_{GY}, includes zero in the Bayesian 95% interval, so spending can be counter or pro-cyclical.

The volatility estimates show the most important shocks are those to markups on home-goods or non-traded pricing and to the foreign interest rates. Shocks to exports and terms of trade have standard errors in the range of .01, while the other volatility estimates are much lower.

Surprisingly the Calvo pricing parameter is much lower than values reported for industrialized economies. This low Calvo pricing coefficient is consistent with a high degree of price flexibility for Hong Kong.

7.2 Historical Variance Decomposition

Table 4 presents the variance decomposition of $y, p, c,$ and m, for the two samples, for shocks to government spending, markup pricing, the terms of trade, foreign interest, real exports, and domestic consumption.

This table shows, not surprisingly, that the shocks to government spending, exports and terms of trade, and foreign interest matter a great deal for GDP. For the CPI, demand components of exports, government spending and consumption as well as terms of trade account for most of the variation. Consumption is driven by its own shocks as well as spending (due to the utility function specification), while deposit volatility is most closely related to volatility in government spending and foreign interest. We also see that the there is little different between the two periods. Our results suggest that there is little evidence for any structural change-at the macro level-taking place prior to and after 1998. Prices were relatively flexible before and after the experience of deflation.

8. Counterfactual Exchange Rate Regime

What if Hong Kong decides to follow a flexible exchange rate system with inflation targeting, similar to a system adopted by the *Bangko Sentral Ng Pilipinas* in 2002? Dakila (2001) summarizes the reform of the Central Bank of the Philippines and its transformation into the BSP with full independence. We calibrate the model with the steady state parameters and the mean values of the Bayesian estimates for the coefficients and the standard deviations of the structural shocks.

For a counterfactual flexible exchange rate system with inflation targeting, we use the following Taylor rule for the domestic interest rate:

$$R_t = \rho_r R_{t-1} + (1-\rho_r)\left[\overline{R} + \rho_\pi\left({}_t\pi_{t+1} - \tilde{\pi}_t\right)\right], \qquad \rho_\pi > 1 \tag{70}$$

The coefficient ρ_r is the smoothing coefficient while ρ_π is the reaction to deviations of expected inflation, ${}_t\pi_{t+1}$, from the target inflation $\tilde{\pi}_t$, while $\overline{R}$ is the steady-state domestic interest rate. In this system, the exchange rate now follows the following forward-looking adjustment process:

$$(1+R_t)S_t = \left(1 + R_t^* + \Phi_t + \Phi_t' B_t^f\right)S_{t+1} \tag{71}$$

For the counterfactual flexible exchange rate/inflation targeting regime, we set the smoothing coefficient, ρ_r, at .9, the inflation coefficient, ρ_π, at 1.5. Note the absence of a stochastic term: we assume that the alternative inflation-targeting regime is not subject to any form of volatility. The only source of adjustment in the interest rate is inflation deviations from the target rate of inflation.

We simulated the model 1000 times for a sample size of 200, and obtained distribution of the volatility of consumption as well as the volatilities of inflation and interest rate.

Figures 5 and 6 picture consumption and inflation volatility under the currency board and inflation targeting. There is considerable overlap in the distributions, with consumption and inflation volatility slightly higher in the currency board.

However, for interest rate volatility, as pictured in Figure 7, we see practically no overlap in the distributions, with interest-rate volatility capable of being almost twice as high as interest rate volatility under the currency board.

The results show that the price for the possibility of slight reductions in consumption or inflation volatility is a marked increase in interest-rate volatility. This distribution of higher interest-rate volatility, of course, understates the volatility which would be expected, since the counterfactual inflation-targeting regime is totally non-stochastic. Should the alternative regime be implemented, the actual volatility would be much higher, since inflation-targeting can never be free of stochastic components, in the measurement and forecasting of inflation.

References

Christiano, Lawrence, Roberto Motto and Massimo Rostagno (2007), "Financial Factors in Business Cycles," Working Paper, Department of Economics, Northwestern University.

Dakila, Francisco G., Jr. (2001), “Evaluation of Alternative Monetary Policy Rules: A Simulation-Based Study for the Philippines,” Quezon City: University of the Philippines School of Economics, Doctoral Dissertation.

Dincer, N. Negrez and Barry Eichengreen (2007), "Central Bank Transparency: Where, Why and What Effects?" NBER Working Paper No.13003, Cambridge MA: National Bureau of Economic Research.

Genberg, Hans (2003), "Foreign Versus Domestic Factors as Sources of Macroeconomics Fluctuations in Hong Kong," HKIMR Working Paper No.17/2003, Hong Kong Institute for Monetary Research.

Genbeg, Hans and Laurent Pauwels (2003), "Inflation in Hong Kong, SAR.In Search of a Transmission Mechanism," HKIMR Working Paper No.01/2003, Hong Kong Institute for Monetary Research.

Gerlach, Stefan and Wensheng Peng (2003), "Bank Lending and Property Prices in Hong Kong," HKIMR Working Paper No.12/2003, Hong Kong Institute for Monetary Research.

Ha, Jimmy and Kelvin Fan (2002), "Price Convergence between Hong Kong and the Mainland," Hong Kong Monetary Authority Research Memorandum.

Hamilton, James D. (1989), "A New Approach to the Economic Analysis of Nonstationary Time Series Subject to Changes in Regime," *Econometrica*, 57: 357-84.

Hamilton, James D. (1990), "Analysis of Time Series Subject to Changes in Regime," *Journal of Econometrics*, 45: 39-70.

Homan, Boris (2003), "Bank Lending and Property Prices: Some International Evidence," HKIMR Working Paper No.22/2003, Hong Kong Institute for Monetary Research.

Krugman, Paul (1998), "Special Page on Japan: Introduction," Web: web.mit.edu /krugman /www/jpage.html.

Lucas, Robert E., Jr. (1976), "Econometric Policy Evaluation: A Critique," in K. Brunner and A. Meltzer, eds, *The Phillips Curve and Labor Markets*, Amsterdam: North Holland: 19-46.

McKibbin, Warwick and Peter Wilcoxen (1998), "The Theoretical and Empirical Structure of the G-Cubed Model," *Economic Modelling*, 16: 123-48.

Razzak, Weshah A. (2003), "Wage-Price Dynamics, the Labor Market, and Deflation in Hong Kong," HKIMR Working Paper No.24/2003, Hong Kong Institute for Monetary Research.

Schellekens, Philip (2003), "Deflation in Hong Kong SAR," IMF Working Paper No.03/77, Washington D.C.: International Monetary Fund.

Smets, F. and R. Wouters (2003), "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area," *Journal of the European Economic Association*, 1: 1123-75.

Yetman, James (2008), "Hong Kong Prices are Flexible,"

Yoshino, Naoyuki and Eisuke Sakakibara (2002), "The Current State of the Japanese Economy and Remedies," *Asian Economic Papers*, 1(2): 110-26.

Table 1. Calibrated Parameters

Symbol	Definition	Values
β	discount factor	.99
ϱ	habit parameter	.8
δ_1	capital depreciation	.02
ϕ_{K^h}	adjustment cost	.005
γ_1	foreign cons. in total cons. index	.3
γ_2	con of export good in dom.cons. index	.3
η	relative risk aversion parameter	3
ϖ	labor supply elasticity	.5
γ_L	disutility of labor	1
ϕ_C	consumption in CES utility	.95
$\varkappa$	CES utility coefficient	-.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	.1,0.05
μ_1, μ_2, μ_3	financial friction parameters	1,1,1
ζ	substitution elasticity for differentiated goods	
κ	CES substitution parameter in production	-0.1
α_1	capital coefficient in non-traded goods	.3
ϕ_M, ϕ_N	deposit and lending costs for banks	.1, .15

Table 2. Bayesian Priors: Parameters and Distributions

Volatility	Name	Distribution	Mean	Std Dev	Inf	Sup
$\sigma_{\epsilon G}$	Gov. Spending	Inv. Gamma	.01	2	.005	4
$\sigma_{\epsilon Z_P}$	Mark-Ups	Inv. Gamma	.01	2	.005	4
$\sigma_{\epsilon P^{X*}}$	Terms of Trade	Inv. Gamma	.01	2	.005	4
$\sigma_{\epsilon R^*}$	For. Interest	Inv. Gamma	.01	2	.005	4
$\sigma_{\epsilon C^*}$	Exports	Inv. Gamma	.01	2	.005	4
$\sigma_{\epsilon C}$	Consumption	Inv. Gamma	.01	2	.005	4
Coefficient						
ρ_G	Gov. Spending	Beta	.5	.2	.01	.95
ρ_{GY}	Gov. Spending	Normal	0	.1	-.3	.3
$\rho_{P^{X*}}$	Terms of Trade	Beta	.5	.2	.01	.95
ρ_{R^*}	For.Interest	Beta	.5	.2	.01	.95
ρ_{Z_P}	Markup	Beta	.5	.2	.01	.95
ρ_{C^*}	Export	Beta	.5	.2	.01	.95
ρ_{C^*R}	Export-Ex.Rate	Normal	0	.2	.01	1.5
ξ	Calvo Pricing	Beta	.5	.2	.01	.95

Table 3. Volatility and Coefficient Estimates

	1984-1997			1998-2008		
Volatilities	Mean	Inf	Sup	Mean	Inf	Sup
$\sigma_{\epsilon G}$	0.002	0.002	0.002	0.003	0.002	0.003
$\sigma_{\epsilon Z_P}$	0.128	0.103	0.152	0.146	0.112	0.182
$\sigma_{\epsilon P^{X*}}$	0.010	0.009	0.012	0.009	0.008	0.010
$\sigma_{\epsilon R^*}$	0.174	0.148	0.201	0.144	0.118	0.170
$\sigma_{\epsilon C^*}$	0.016	0.014	0.019	0.014	0.011	0.017
$\sigma_{\epsilon C}$	0.018	0.015	0.021	0.018	0.015	0.022
Coefficient						
ρ_G	0.463	0.177	0.743	0.561	0.263	0.878
ρ_{GY}	-0.004	-0.022	0.015	-0.013	-0.057	0.029
$\rho_{P^{X*}}$	0.729	0.592	0.872	0.679	0.485	0.884
ρ_{R^*}	0.838	0.771	0.910	0.883	0.832	0.940
ρ_{Z_P}	0.697	0.627	0.768	0.630	0.519	0.743
ρ_{C^*}	0.595	0.508	0.681	0.615	0.503	0.731
ρ_{C^*R}	-0.049	-0.202	0.107	-0.058	-0.241	0.133
ξ	0.131	0.101	0.160	0.133	0.102	0.164

Table 4. Historical Variance Decomposition

						Shock:
	$\sigma_{\epsilon G}$	$\sigma_{\epsilon Z_P}$	$\sigma_{\epsilon P^{X*}}$	$\sigma_{\epsilon R^*}$	$\sigma_{\epsilon C^*}$	$\sigma_{\epsilon C}$
Variable:	1984-1997					
P	0.415	0.014	0.014	0.014	0.466	0.077
Y	0.305	0.007	0.176	0.281	0.135	0.096
C	0.600	0.012	0.012	0.014	0.167	0.195
M	0.677	0.002	0.002	0.284	0.027	0.007
	1998-2008					
P	0.351	0.007	0.007	0.007	0.577	0.052
Y	0.433	0.002	0.216	0.208	0.105	0.036
C	0.764	0.004	0.003	0.004	0.169	0.057
M	0.654	0.001	0.001	0.318	0.023	0.003

Figure 1. Annual Inflation and GDP Growth

Figure 2. Deposit/GDP and Loan/GDP Ratios

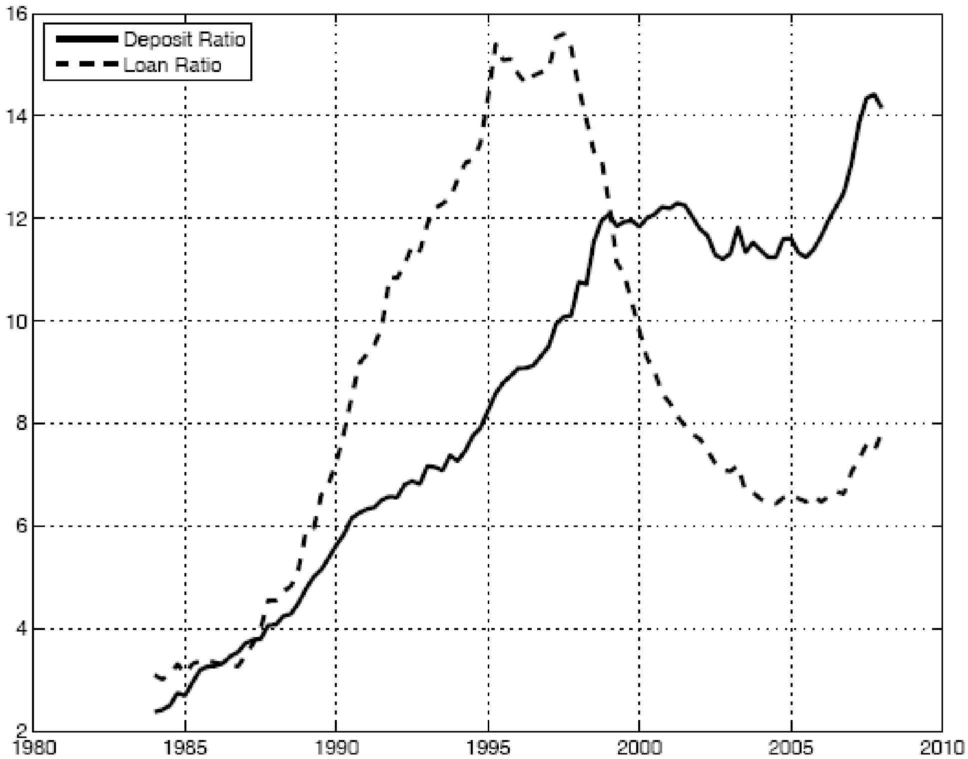

Figure 3. Index of Openness

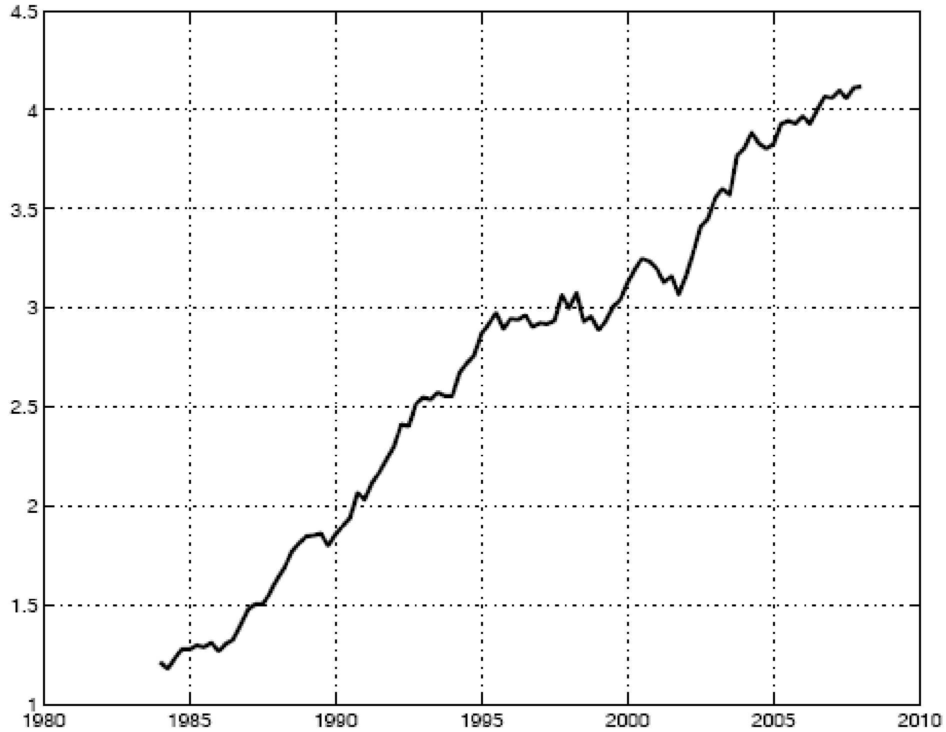

Figure 4. Logarithm of Terms of Trade

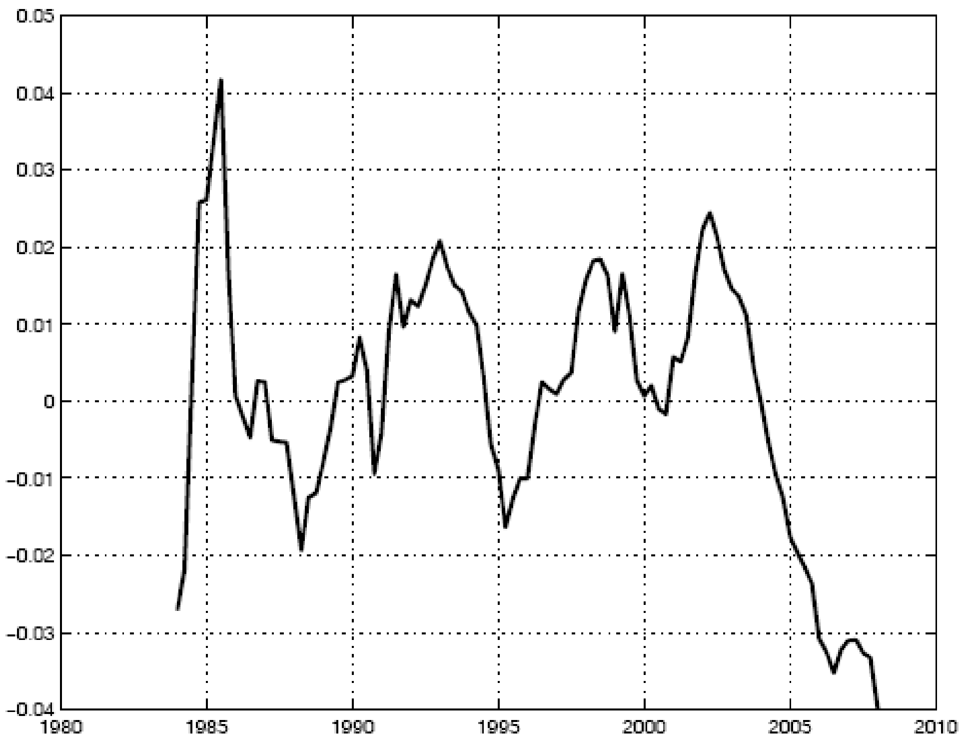

Figure 5. Consumption Volatility under Currency Board and Perfect Inflation Targeting

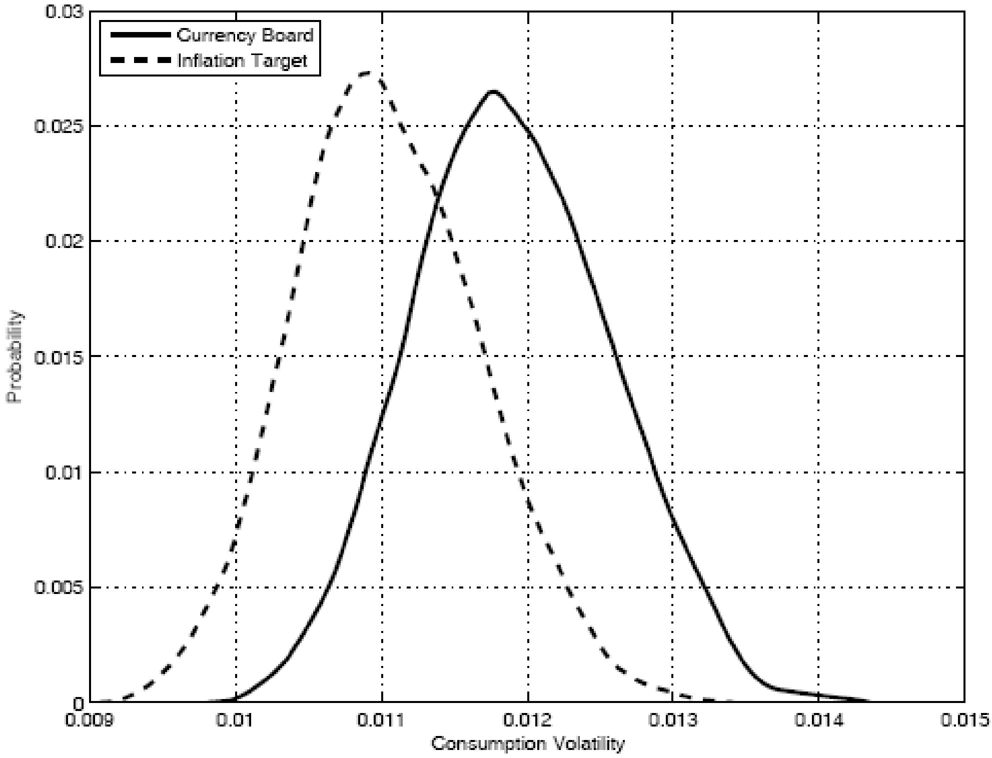

Figure 6. Inflation Volatility

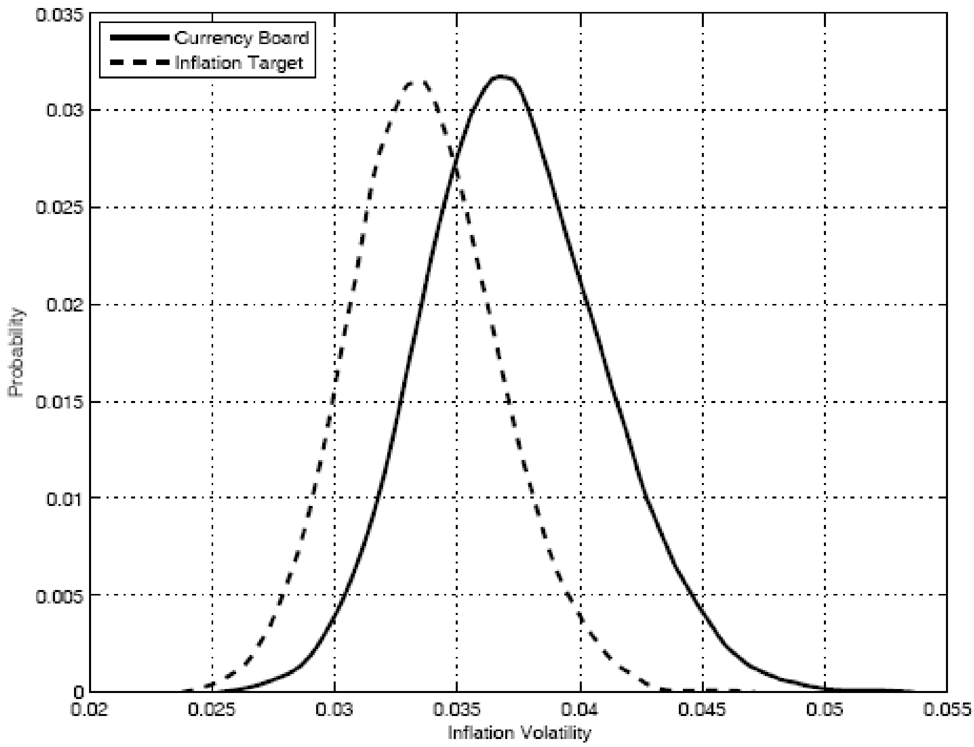

Figure 7. Interest Rate Volatility