Monetary Regimes and Share Price Volatility in East Asia

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Abstract

This paper applies counterfactual simulation experiments based on a calibrated DSGE model of a small open-economy. We compare the alternative monetary regimes of East Asia: the monetary targeting framework of the Central Bank of the Republic of China, the fixed-rate system practiced in Hong Kong, the Taylor rule used in Korea, and the exchange-rate management policy used in Singapore. The welfare differences are minimal, but the monetary rule of Taiwan delivers significantly lower share market volatility for a variety of shocks.

JEL Classificaltion: E52, E62,F41

1 Introduction

In the past decade, inflation targeting rule has received wide attention. Amid much debate about the causes of the Great Moderation, for example, Giannone, Lenza, and Reichlin (2008), argue that the underlying cause of the Great Moderation was more than good luck (due to favorable shocks). Rather, it was due to a change in the way the shocks were propagated, through the establishment of a better, more credible monetary policy framework. As noted by King (1996), while broad money targeting can provide credibility, inflation targeting is more direct, since it focuses on the ultimate target, and thus is more transparent. Because headline inflation is readily available to the public, accountability of central bank performance comes to the central of the stage in this framework.

However, since the outbreak of the global financial crisis in 2008, there have been wide debates that the monetary policy (the excessively low interest rate) is one of the causes which exacebates the crisis. Lacking prudent control of the amount of liquidity which particularly pervaded on the financial markets has made the issue whether the interest rate rule can help stablize the asset

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market booms become the main concern. In response to this issue, many studies examine whether interest rate rule which responds to the asset prices or credit growth can help stablize the economy. Christiano, Ilut, Motto and Rostagno (2010) show that the interest rate rule which has narrowly targeted the inflation rate can reinforce the boom-bust cycles of the asset market, while the interest rate rule which responds to credit growth can successfully stablize the asset prices.

The implementation of conventional monetary targeting rule, however, can be in line with the assertion that the control over credit growth helps stablize the asset markets.[1] The broad money aggregate, which consists of money through the multiple deposit creation process, is the primary funds for consumption and investment. The control over the broad money, which is closely related to bank loans, is an even more straightforward measure to control credits.

While most of the countries abandoned the monetary aggregate targeting rule, switching to the interest rate rule by the end of last century, Taiwan can be an unusual case. Since 1992, the Central Bank of the Republic of China (Taiwan) (thereafter CBC) has been officially targeting the growth rate of broad money through base money instruments. According to the "Purpose and Function of the CBC" (CBC, 2006), the CBC generally adopts the framework of monetary targeting and chooses the monetary aggregate, M2, to be the intermediate target. The monetary experiences of Taiwan have demonstrated that monetary targets work well. The macroeconomic fundamentals have remained relatively stable. It appears that the Central Bank of the Republic of China (Taiwan) has thus bucked the trend of inflation targeting or exchange-rate managing among national monetary authorities in East Asia.[2][3] A comparison between Taiwan and Korea (which has implemented inflation targeting rule since 1998), in Table 1, shows that the standard deviations of the GDP growth rate, CPI inflation and

[1] Scharnagl, Gerberding and Seitz (2010) argued that including broad money growth rates in a Taylor rule outperforms pure inflation targeting in a Taylor rule, for the Euro area. These authors make use of an estimated closed economy New Keynesian framework. They base their argument on the reality of measurement error of real-time output used by central bank policy-makers, and thus output-gap uncertainty, in the pure Taylor-rule framework.

[2] Elsewhere in the region, among the "Gang of Four", of South Korea, Hong Kong, and Singapore, there are different monetary regimes in place. The Central Bank of the Republic of Korea has adopted inflation targeting with flexible exchange rates and interest rate instruments after the East Asian crisis. By contrast, the Monetary Authority of Singapore has followed an exchange-rate targeting framework, while the Hong Kong Monetary Authority has maintained its currency board since 1984.

[3] While the official position of the CBC is that its policy comes from a monetary-targeting framework, Hsu (1999) argued that the interest rate has been an important ancillary instrument, while Chen and Wu (2010) found some evidence of switching between interest and monetary-growth rate rules, but they argue that monetary aggregate rules can well characterize the monetary policy of the CBC before 1998. More recently, however, Teo (2009) used Bayesian estimation of a DSGE model to test the hypothesis of a monetary-targeting regime against alternative regimes based on the Taylor rule or exchange-rate targeting. Based on posterior odds ratios, the evidence strongly favored the monetary targeting regime for Taiwan. While Teo's work empirically establishes the use of the monetary targeting regime as the *de facto* policy framework of Taiwan, he did not perform any comparison of the macroeconomic performance of the de facto regime with counterfactual inflation or exchange-rate targeting regimes, which is the aim of this paper.

share price inflation rates are lower in Taiwan than in Korea based during the 1998-2007 period. Based on the experience of these two fast growing economies within the East Asia region, there is no empirical evidence that monetary targeting regimes fare worse than inflation-targeting regimes. While the financial liberalization in the US and European countries may have led to difficulties in the measure of monetary aggregates and thereby the implementatin of monetary targeting, Taiwan can be a successful illustration of monetary targeting.

Table 1:
Macroeconomic Volatility: Taiwan vs. South Korea

	Percentage Growth Rate:			
	GDP	CPI	Share Price Index	
	Standard Deviation:			i
Taiwan	0.0169	0.0035	0.0777	
South Korea	0.0553	0.0664	0.0898	

Recently, in this journal, Kim, Shun and Yun (2013) examined the empirical significance of monetary aggregates for financial stability in Korea. Given that financial stability has become a mandate of central banks, These authors ask if 'monetary aggregates may serve as signals of underlying financial conditions and the potential vulnerability of the financial system to a sharp reversal of permissive financial conditions'[Kim, Shun and Yun (2013): p. 70]. Their central question is simple: do monetary aggregates may play any part if the mission of central banks with respect to their financial stability mandate [Kim, Shun and Yun (2013): p. 70]. Using a VAR framework with sign restrictions, they conclude that by "tracking the procyclical components of monetary aggregates associated with cross-border banking sector liabilities, the central bank may gain valuable insights into the risk attitudes of the intermediary sector and the potential damage that may be done by an abrupt reversal of the permissive financial conditions that have fueled the upswing"[Kim, Shun and Yun (2013): p. 105]

We investigate the question of monetary aggregate targeting and financial stability in a calibrated DSGE small open-economy framework, with a financial sector as well as a traded and non-traded sector. We take as a proxy for financial-sector stability the volatility of Tobin's Q. Since Tobin's Q is the proxy for financial stability, our model includes investment and capital accumulation, in contrast to the model in Scharnagl, Gerberding, and Seitz (2010). We compare four regimes: a monetary-targeting regime, with liquidity injection consistent with the targeted growth rate of reserve money. The counterfactual experiments focus on the CPI inflation targeting (as in Korea) , as well as a fixed exchange rate system (used in Hong Kong), and exchange-rate management (as in Singapore).

One of the key results we show in this paper is that a monetary targeting framework delivers much lower volatility in consumption and Tobin's Q, an indicator or shadow price of assets. The focus on inflation targeting, which is more transparent and provides accountability, is also more limited than broad money targeting in providing stability to the share prices in the economy and financial markets in general. The economy can be stabilized through the conrtol of the growth rate of broad money which is the primary source of liquidity in the economy. In a small open economy as Taiwan, the fixed exchange rate or exchange rate management can help reduce the CPI inflation which composes of a substantial share of import prices.[4]

The next section of the paper presents the model we use for calibration and simulation. We then discuss the numerical specification of parameters, and shock processes. After that, we take up comparative policy simulations, for the base case of monetary targeting and for the counterfactual cases of fixed exchange rate, a Taylor rule, and exchange-rate management. Our results show that switching from a monetary regime would not necesarily be welfare improving relative to the policy regimes of the Hong Kong Monetary Authority, the Central Bank of Korea, or the Monetary Authority of Singapore.

2 The Model

2.1 Household Preferences and Endowments

We calibrate an open economy drawing on estimates used in models for Taiwan. Like many of the fast growing economies in East Asia, whose monetary regimes we compare, Taiwan is a highly open economy, widely involved in international trade in goods and capital markets. Until the end of 2011, the exports account for 70% of the GDP and the imports for 65% of the GDP, rising from ratios of 60% and 55%, respectively, in 2001. The financial market is well structured. In the end of 2011, 78% of the external funds are from financial intermediaries, and 22% from direct finance including the stock and bond markets. Thus, small open economy DSGE model with an established financial sector can well characterize this economy.

Households own capital for rental and supply labor to both these 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, and ϕ is the adjustment cost parameter.

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

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

We assume that investment goods are both domestically produced and imported from abroad, and that the price P^i is the relevant price for these goods.

[4] A previous study by Hou (2005), using data between 1991 and 2003, found that a rule to control the growth rate of the reserve money outperformed the Taylor rule for stabilizing income and prices. Hou's model was based on a relatively simple New Keynesian model and the results were based on parameters estimated by classical methods.

The investment variable is a CES aggregate of these two investment goods:

$$I_t = \left[(1-\gamma_i)^{\frac{1}{\theta_i}} \left(I_t^d\right)^{\frac{\theta_i - 1}{\theta_i}} + (\gamma_i)^{\frac{1}{\theta_i}} \left(I_t^f\right)^{\frac{\theta_i - 1}{\theta_i}} \right]^{\frac{\theta_i}{\theta_i - 1}} \tag{3}$$

The parameters γ_i and $(1-\gamma_i)$ are the relative shares of foreign and domestic goods in the overall investment index, while θ_i is the price elasticity of demand for each investment component. The variable $\overline{K}$ is the steady state level of the capital stock for domestic goods producing firms.

The demand for each investment component is a function of their relative price:

$$I_t^d = (1-\gamma_i) \left(\frac{P_t^x}{P_t^i} \right)^{-\theta_1} I_t \tag{4}$$

$$I_t^f = \gamma_i \left(\frac{P_t^f}{P_t^i} \right)^{-\theta_1} I_t \tag{5}$$

The index P_t^f is the price of imported goods, in domestic currency, while P_t^x is the price of domestic goods-producing forms (which can be exported, or used for domestic consumption and domestic investment). The overall price index for investment goods is given by the following equation:

$$P_t^i = \left[(1-\gamma_i) \left(P_t^x\right)^{1-\theta_1} + \gamma_i \left(P_t^f\right)^{1-\theta_i} \right]^{\frac{1}{1-\theta_i}} \tag{6}$$

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

$$C_t = \left[(1-\gamma_1)^{\frac{1}{\theta_1}} \left(C_t^d\right)^{\frac{\theta_1 - 1}{\theta_1}} + (\gamma_1)^{\frac{1}{\theta_1}} \left(C_t^f\right)^{\frac{\theta_1 - 1}{\theta_1}} \right]^{\frac{\theta_1}{\theta_1 - 1}} \tag{7}$$

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 :

$$C_t^d = (1-\gamma_1) \left(\frac{P^x}{P_t} \right)^{-\theta_1} C_t \tag{8}$$

$$C_t^f = \gamma_1 \left(\frac{P_t^f}{P_t} \right)^{-\theta_1} C_t \tag{9}$$

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 composed of both non-traded services C_t^h and home-produced traded goods C_t^x (some of which are consumed domestically). The following CES aggregator is used for domestically-produced consumption goods:

$$C_t^d = \left[(1-\gamma_2)^{\frac{1}{\theta_2}}\left(C_t^h\right)^{\frac{\theta_2-1}{\theta_2}} + (\gamma_2)^{\frac{1}{\theta_2}}\left(C_t^x\right)^{\frac{\theta_2-1}{\theta_2}}\right]^{\frac{\theta_2}{\theta_2-1}} \tag{10}$$

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

$$C_t^h = (1-\gamma_2)\left(\frac{P_t^h}{P_t^d}\right)^{-\theta_2} C_t^d \tag{11}$$

$$C_t^x = \gamma_2\left(\frac{P_t^x}{P_t^d}\right)^{-\theta_2} C_t^d \tag{12}$$

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:

$$P_t^d = \left[(1-\gamma_2)\left(P_t^h\right)^{1-\theta_2} + \gamma_2\left(P_t^x\right)^{1-\theta_2}\right]^{\frac{1}{1-\theta_2}} \tag{13}$$

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

$$P_t = \left[(1-\gamma_1)\left(P_t^d\right)^{1-\theta_1} + \gamma_1\left(P_t^f\right)^{1-\theta_1}\right]^{\frac{1}{1-\theta_1}} \tag{14}$$

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 $\Pi_t = \Pi_t^x + \Pi_t^h$, and Π_t^B is dividend given by bank. 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:

$$\begin{aligned} & W_t L_t + (1+R_{t-1}^m)M_{t-1} + \Pi_t + \Pi_t^B + R_t^k K_t \\ = \; & P_t C_t(1+\tau_c) + M_t + \tau W_t L_t + P_t^i I_t + P_t^i\left(\frac{\phi\left(I_t - \delta\overline{K}\right)^2}{2K_t}\right) \end{aligned} \tag{15}$$

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 services which enhance household marginal utility (such as law enforcement and communication services):

$$\widetilde{C}_t = \left[\phi_C C_t^{-\varkappa} + (1-\phi_C) G_{t-1}^{-\varkappa}\right]^{-\frac{1}{\varkappa}} \tag{16}$$

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:

$$H_t = \overline{\widetilde{C}}_{t-1}^{\varrho} \tag{17}$$

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

$$U(\widetilde{C}_t/H_t, L_t) = Z_t^c \frac{\left(\widetilde{C}_t/H_t\right)^{1-\eta}}{1-\eta} - \gamma_L \frac{L_t^{1+\varpi}}{1+\varpi} \tag{18}$$

The parameter η is the relative risk aversion coefficient, while γ is the disutility of labor, and ϖ is 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:

$$\ln(Z_t^c) = \rho_c \ln(Z) + \epsilon_t^c \tag{19}$$

$$\epsilon_t^c \sim N(0, \sigma_c^2 \quad) \tag{20}$$

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:

$$\underset{\{C_t, L_t, M_t, I_t, K_t\}}{Max} E_t \sum_{\iota=0}^{\infty} \beta^{\iota} U(\widetilde{C}_{t+\iota}/H_{t+\iota}, L_{t+\iota}) \tag{21}$$

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

This optimization is subject to the budget constraint and the investment equation:

$$K_t = (1-\delta)K_{t-1} + I_t \tag{22}$$

The variable R_t^k is the rental rate for capital to the goods-producing firms , R_t^m is the return on deposits held at banks, while W_t is the nominal wage rate.

The household optimization is represented by the intertemporal Lagrangian:

$$
\underset{\{C_t,L_t,M_t,I_t,K_t\}}{Max}\mathcal{L} \;=\; E_t\sum_{\iota=0}^{\infty}\beta^{\iota}\left\{\begin{array}{c} U(\widetilde{C}_{t+\iota}/H_{t+\iota},L_{t+\iota}) \\ -\Lambda_{t+\iota}\left[\begin{array}{c} P_{t+\iota}C_{t+\iota}(1+\tau_c)+M_{t+\iota} \\ -(1+R^m_{t-1+\iota})M_{t-1+\iota} \\ +P^i_{t+\iota}I^x_{t+\iota}+ \\ P^i_{t+\iota}\frac{\phi\left(I_{t+\iota}-\delta\overline{K}\right)^2}{2K_{t+\iota}} \\ +(\tau-1)W_{t+\iota}L_{t+\iota}-\Pi_{t+\iota} \\ -R^k_{t+\iota}K_{t+\iota} \end{array}\right] \\ -Q_{t+\iota}\left(K_{t+\iota}-I_{t+\iota}-(1-\delta)K_{t-1+\iota}\right) \end{array}\right\} \tag{23}
$$

Note that there are two Lagrange multipliers, one, $\Lambda_{t+\iota}$, is the marginal utility of income, while Q_{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, K_t yields the following set of First-Order Conditions for the representative household:

$$
\Lambda_t P_t = \phi_C\left(\widetilde{C}_t\right)^{1-\varkappa-\eta}(H_t)^{\eta-1}(C_t)^{-\varkappa-1}Z^c_t \tag{24}
$$

$$
\gamma_L L_t^{\varpi} = \Lambda_t(1-\tau)W_t \tag{25}
$$

$$
\Lambda_t = \beta E_t\Lambda_{t+1}(1+R^m_t) \tag{26}
$$

$$
Q_t = \beta E_t\left(\Lambda_{t+1}\left(R^k_{t+1}+P^i_{t+1}\frac{\phi\left(I_{t+1}-\delta\overline{K}\right)^2}{2\left(K_t\right)^2}\right)+Q_{t+1}(1-\delta)\right) \tag{27}
$$

$$
I_t = \delta\overline{K}+\frac{K_t}{\phi}\left(\frac{Q_t}{\Lambda_t}-P^i_t\right) \tag{28}
$$

The first equation, Eq. (24), 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, Eq. (25), states that the marginal disutility of labor is equal to the after tax 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, $\delta\overline{K}$, when $\frac{Q_t}{\Lambda_t} = P^i_t$. Any increase in Tobin's Q_t, relative to the marginal utility of income and the price of investment goods, will trigger increases in investment.

3 Production and Technology

3.1 Nontraded Services

The non-traded services is simply a function of labor L^h, intermediate goods MI and a technology shock Z_t^h

$$Y_t^h = Z_t^h MI_t^{\alpha_h} \left(L_t^h\right)^{1-\alpha_h} \tag{29}$$

We assume intermediate goods MI are both domestically produced and imported from abroad, and that the price P^i is the relevant price for these goods. The investment variable is a CES aggregate of these two investment goods:

$$MI_t = \left[(1-\gamma_{mi})^{\frac{1}{\theta_{mi}}} \left(MI_t^d\right)^{\frac{\theta_{mi}-1}{\theta_{mi}}} + (\gamma_{mi})^{\frac{1}{\theta_{mi}}} \left(MI_i^f\right)^{\frac{\theta_{mi}-1}{\theta_{mi}}}\right]^{\frac{\theta_{mi}}{\theta_{mi}-1}} \tag{30}$$

The parameters γ_{mi} and $(1-\gamma_{mi})$ are the relative shares of foreign and domestic goods in the overall investment index, while θ_{mi} is the price elasticity of demand for each investment component.

The demand for each internediate-good component is a function of its relative price:

$$MI_t^d = (1-\gamma_{mi}) \left(\frac{P_t^x}{P_t^{mi}}\right)^{-\theta_{mi}} MI_t \tag{31}$$

$$MI_t^f = \gamma_{mi} \left(\frac{P_t^f}{P_t^{mi}}\right)^{-\theta_{mi}} MI_t \tag{32}$$

The index P_t^f is the price of imported goods, in domestic currency, while P_t^x is the price of domestic goods-producing forms (which can be exported, or used for domestic consumption and domestic investment). The overall price index for investment goods is given by the following equation:

$$P_t^{mi} = \left[(1-\gamma_{mi}) \left(P_t^x\right)^{1-\theta_{mi}} + \gamma_{mi} \left(P_t^f\right)^{1-\theta_{mi}}\right]^{\frac{1}{1-\theta_{mi}}} \tag{33}$$

The coefficient α_h represents the relative factor shares of intermediate goods, while the technology shock is given by $Z_{t.}^h$ This shock follows the autoregressive process:

$$\ln(Z_t^h) = \rho_{Z^h} \ln(Z_{t-1}^h) + \epsilon_t^h \tag{34}$$

$$\epsilon_t^h \sim N(0, \sigma_h^2) \tag{35}$$

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

$$Y_t^h = C_t^h + G_t \tag{36}$$

We assume that the firm faces a liquidity constraint. It must borrow an amount N_t^h from banks each quarter to pay a fraction μ_h of its wage bill, at the borrowing rate R_t^n:[5]

$$N_t^h = \mu_h W_t L_t^h, \tag{37}$$

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

$$\Pi_t^h = P_t^h Y_t^h - (1 + \mu_h R_t^n) W_t L_t^h - P_t^{mi} MI_t \tag{38}$$

where P^{mi} is the price of intermediate goods. Maximizing profits with respect to the use of labor and intermediate goods, we have the following first-order conditions for the firm:

$$\frac{\partial Y_t^h}{\partial L_t^h} = (1 + \mu_h R_t^n) \frac{W_t}{P_t^h} \tag{39}$$

$$\frac{\partial Y_t^h}{\partial MI_t} = \frac{P_t^{mi}}{P_t^h} \tag{40}$$

3.2 Export Goods

The firm producing export goods, as well as traded goods for domestic consumption as well as domestically-produced investment and intermediate goods, face a Cobb-Douglas technology:

$$Y_t^x = Z_t^x K_t^{\alpha_x} \left(L_t^x\right)^{1-\alpha_x} \tag{41}$$

There is an export demand shock Z^x which follows the autoregressive process:

$$\ln(Z_t^x) = \rho_x \ln(Z_{t-1}^x) + \epsilon_t^x \tag{42}$$

$$\epsilon_t^x \sim N(0, \sigma_x^2 \quad) \tag{43}$$

Foreign export demand X^* is also subject to a stochastic shock, ϵ_t^* at time t.

[5] We assume that all these three sectors, non-traded, export and import, borrow from the domestic financial sector to finance their wage or import spendings. The establishment of the financial sector permits us to examine the financial shock same as the source of the current financial crisis. The occurrence of financial shock leads to the rise in the financing costs of firms and thereby results in production contractions.

$$X_t^* = \rho_{X*} X_{t-1}^* + (1-\rho_{X*})\overline{X^*} + \epsilon_t^* \quad (44)$$
$$\epsilon_t^* \sim N(0, \sigma_{X*}^2 \quad) \quad (45)$$

Under a small 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:

$$\ln(P_t^{x^*}) = \rho_{P^{x*}} \ln(P_{t-1}^{x^*}) + (1-\rho_{P^{x*}}) \ln(\overline{P}_t^{x^*}) + \epsilon_t^{P^{x^*}} \quad (46)$$
$$\epsilon_t^{P^{x^*}} \sim N(0, \sigma_{P^{x*}}^2 \quad) \quad (47)$$

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

$$Y_t^x = C_t^x + X_t^* + I_t^d + MI_t^d$$

These firms face a liquidity constraint for meeting their wage bill:

$$N_t^x = \mu_x W_t L_t^x \quad (48)$$

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

$$\Pi_t^x = P_t^x Y_t^x - (1+\mu_x R_t^n) W_t L_t^x - R_t^k K_t \quad (49)$$

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

$$\frac{\partial Y_t^x}{\partial L_t^x} = (1+\mu_x R_t^n)\frac{W_t}{P_t^x} \quad (50)$$
$$\frac{\partial Y_t^x}{\partial K_t^x} = \frac{R_t^k}{P_t^x} \quad (51)$$

3.3 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:

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

3.4 Importing Firms

Imported goods Y^f are used for both consumption C^f and for investment in the goods-producing firms, I^f as well as intermediate goods MI^f :

$$Y_t^f = C_t^f + I_t^f + MI_t^f \tag{52}$$

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:

$$N_t^f = \mu_f (S_t P_t^{f^*} Y_t^f) \tag{53}$$

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

$$AF_t = \left(1 + \mu_f R_t^n\right) S_t P_t^{f^*} \tag{54}$$

3.5 Calvo Wage and Price Setting

The labor market does not clear, and wages are modelled as staggered contracts with a fraction $(1-\xi_w)$ renegotiated each period. Each household j chooses the optimal wage W_t^o by maximizing the expected discounted utility subject to the demand for its labor $L_t^j = \left(\frac{W_t^o}{W_t}\right)^{-\zeta_w} L_t$ where ζ_w is a parameter governing the degree of substitution.[6] This behavior is modelled in a similar manner to the Calvo sticky prices and the model is written in recursive form as:

$$W_t^{num} = (W_t)^{\zeta_w + \zeta_w \varpi} \left(L_t^{1+\varpi}\right) + \xi_w \beta . E_t W_{t+1}^{num} \tag{55}$$

$$W_t^{den} = \left[\phi \left(\widetilde{C}_t\right)^{1-\varkappa-\eta} (H_t)^{\eta-1} (C_t)^{-\varkappa-1} Z_t^c\right] (W_t)^{\zeta} L_t + \xi_w \beta . E_t W_{t+1}^{den} \tag{56}$$

$$(W_t^o)^{1+\zeta_w \varpi} = \frac{W_t^{num}}{W_t^{den}} \tag{57}$$

$$W_t = \left[\xi_w \left(W_{t-1}\right)^{1-\zeta_w} + (1-\xi_w)(W_t^o)^{1-\zeta_w}\right]^{\frac{1}{1-\zeta_w}} \tag{58}$$

where, W_t^{num} and W_t^{den} are auxiliary variables in the formula.

We assume monopolistically competitive firms in the non-traded services sector. Let the marginal cost at time t be given by the following expression:

$$A_t = \frac{\left(P^{mi}\right)^{\alpha_h} \left[(1 + \mu_1 R_t^n) W_t\right]^{1-\alpha_h}}{Z_t^h} \cdot \frac{1}{(\alpha_h)^{\alpha_h} (1-\alpha_h)^{1-\alpha_h}} \tag{59}$$

[6] By using Bayesian estimation on Taiwan's data, the posterior estimate of ζ_w is 0.469 in Teo (2009). Although it is lower than the estimates of Smets and Wouters (2003) for the European countries, it still shows significant wage stickiness in Taiwan.

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}.

$$A_t^{num} = Y_t^h\left(P_t^h\right)^{\zeta} A_t + \beta\xi E_t A_{t+1}^{num} \tag{60}$$

$$A_t^{den} = Y_t^h\left(P_t^h\right)^{\zeta} + \beta\xi E_t A_{t+1}^{den} \tag{61}$$

$$P_t^o = \frac{A_t^{num}}{A_t^{den}} + Z_t^P \tag{62}$$

$$P_t^{h,b} = P_{t-1}^h \tag{63}$$

$$P_t^h = \left[\xi\left(P_t^{h,b}\right)^{1-\zeta} + (1-\xi)\left(P_t^o\right)^{1-\zeta}\right]^{\frac{1}{1-\zeta}} \tag{64}$$

The stochastic term Z_t^P captures a mark-up pricing shock to the monopolistic price-setting behavior. It follows, in logarithmic form, an autoregressive process with innovations have mean zero and standard deviation σ_P^2 :

$$\ln(Z_t^P) = \rho_{Z^P}\ln(Z_{t-1}^P) + \epsilon_t^P \tag{65}$$

$$\epsilon_t^P \sim N(0, \sigma_P^2) \tag{66}$$

Calvo pricing for imported goods works in a similar way to Cavlo pricing for home goods. Given the marginal cost of imported goods, AF_t, the following recursive setup gives us the price setting behavior for imported goods:

$$AF_t^{num} = Y_t^f\left(P_t^t\right)^{\zeta} AF_t + \beta\xi E_t AF_{t+1}^{num} \tag{67}$$

$$AF_t^{den} = Y_t^f\left(P_t^f\right)^{\zeta} + \beta\xi E_t AF_{t+1}^{den} \tag{68}$$

$$P_t^{f,o} = \frac{AF_t^{num}}{AF_t^{den}} \tag{69}$$

$$P_t^{f,b} = P_{t-1}^f \tag{70}$$

$$P_t^f = \left[\xi_i\left(P_t^{f,b}\right)^{1-\zeta} + (1-\xi_i)\left(P_t^{f,o}\right)^{1-\zeta}\right]^{\frac{1}{1-\zeta}} \tag{71}$$

4 The Financial Sector and Policies

4.1 The Financial Sector

Banks lend to all three types of firms:

$$N_t = N_t^x + N_t^h + N_t^f \tag{72}$$

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 $\overline{B^f}$:

$$\Phi_t = \max\left\{0, \varphi\left[e^{(\left|B_{t-1}^f - \overline{B^f}\right|)} - 1\right] B_{t-1}^f\right\} \tag{73}$$

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, $\phi_{N,t} N_{t.}$. As in the case of the required reserves against deposits, the opportunity cost is given by $\phi_{N,t} R_t N_{t.}$

The parameter $\phi_{N,t}$ is time-varying, and captures a stochastic uncertainty component in the costs of bank lending to all types of firms. The parameter ρ_ϕ is the autoregressive parameter while $\overline{\phi}_N$ is the steady-state capital/asset ratio for banks.

$$\begin{aligned} \phi_{N,t} &= \rho_\phi \phi_{N,t-1} + (1-\rho_\phi)_\phi \overline{\phi}_N + \epsilon_{\phi,t} \\ & \epsilon_{\phi,t}\tilde{\ } N(0, \sigma_\phi^2) \end{aligned}$$

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

$$\begin{aligned} \Pi_t^B &= (1+R_{t-1})B_{t-1}^g + (1+R_{t-1}^n)N_{t-1} + S_t B_t^f + M_t \\ & -(1+R_{t-1}^* + \Phi_{t-1})B_{t-1}^f S_t - (1+R_{t-1}^m)M_{t-1} \\ & -B_t^g - N_t - \phi_M R_{t-1} M_{t-1} - \phi_N R_{t-1} N_{t-1} \end{aligned} \tag{74}$$

The bank maximizes its present discounted value of its profits, given by V_t^B, with respect 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).

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

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

$$
\begin{aligned}
R_t &= R_t^n - \phi_N &(75)\\
R_t &= R_t^m + \phi_M &(76)\\
(1+R_t)S_t &= (1+R_t^* + \Phi_t + \Phi_t' B_t^f)S_{t+1} &(77)
\end{aligned}
$$

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

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

4.2 The Monetary Policy

We assume that the liquidity provision to the banking sector, which causes the change in the reserve of the banking sector ΔRES, adjusts to the target for the rate of growth of deposits in the banking sector.[7]

$$
\begin{aligned}
\Delta RES_t &= \rho_{RES}\Delta RES_{t-1} - (1-\rho_{RES})\rho_M[\Delta M_t - \mu] + \epsilon_{M,t}\\
&\quad \epsilon_{M,t} \tilde{} N(0, \sigma_M^2)
\end{aligned}
$$

where μ is the target rate of deposit growth, ρ_{RES} is the smoothing parameter and ρ_M is the reaction coefficient, with $\rho_M > 1$. There is also a shock to monetary policy, $\epsilon_{M,t}$, normally distributed with variance σ_M^2.

The interest rate adjusts in this case to equilibrate the balance sheet of the financial sector.

$$
R_t = \frac{\begin{array}{c} N_t + B_t + (1+R_t^* + \Phi_{t-1})B_{t-1}^f S_{t-1} + (1-\phi_M)M_{t-1} \\ -\Delta RES_t - M_t - B_t^f S_t - (1-\phi_N)N_{t-1} - B_{t-1} \end{array}}{B_{t-1} + N_{t-1}(1-\phi_N) - M_{t-1}(1-\phi_M)}
$$

Basically this equation states that the flow returns to the system from government bonds and loans to firms, less interest payments on deposits, should be sufficient to finance new loans to firms and the government, as well as payments on foreign debt, net of new deposits and reserve injections by the central bank..

Thus, ceteris paribus, an increase in bond issues or loan demand by firms, or foreign interest rates would increase the domestic interest rate, while an increase in deposits or reserves would decrease the interest rate.

In the counterfactual scenario of an inflation targeting Taylor rule, the interest rate adjusts in the following way:

$$
R_t = \rho_r R_{t-1} + (1-\rho_\pi)\rho_\pi \widehat{\pi}_t + (1-\rho_r)\overline{R} \qquad (78)
$$

[7] In the absence of currency, M_t is equivalent to the measure of broad money in this model.

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. Given that the central bank sets the interest rate, it provides reserves (or takes out reserves) to the banking sector through open market operations to insure a balance-sheet equilibrium:

$$\begin{aligned} \Delta RES_t &= N_t + B_t + (1 + R_t^* + \Phi_{t-1})B_{t-1}^f S_{t-1} \\ &+ (1 + R_t - \phi_M - \phi_M R_t)M_{t-1} - B_t^f S_t \\ &- (1 + R_t + \phi_N - \phi_N R_t)N_{t-1} - M_t - (1 + R_t)B_{t-1} \end{aligned} \tag{79}$$

In the counterfactual cases of the fixed exchange-rate case or exchange-rate mangement, the domestic interest rate follows the foreign interest rate plus the risk premium, while the central bank adjusts reserves to the banking sector to assure balance-sheet equiibrium

For the inflation-targeting exchange-rate rule, the following formula holds:

$$\Delta s_t = \rho_s \Delta s_{t-1} - (1 - \rho_s)\rho_{s\pi}\widehat{\pi}_t + (1 - \rho_r)\overline{\Delta s} \tag{80}$$

This rule shows that the monetary authority adjusts depreciation of the nominal exhange rate relative to the long-run depreciation rate $\overline{\Delta s}$ with a smoothing coefficient ρ_s, with $0 < \rho_s < 1$. When inflation is above its target rate, with $\widehat{\pi}_t > 0$, the monetary authority will allow the nominal rate to appreciate. As in the Taylor rule, we assume $\rho_{s\pi} > 1$.

4.3 Fiscal Policy

The government takes in taxes from the households and engages in spending on non-traded services. . We assume that there is smoothing in government consumption, and there is a stochastic component to spending:

$$G_t = (1 - \rho_G)\overline{G} + \rho_G G_{t-1} + \epsilon_{G,t} \tag{81}$$

$$\epsilon_{G,t} \tilde{\ } N(0, \sigma_G^2) \tag{82}$$

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

$$TAX_t = \tau W_t L_t + \tau_c P_t C_t \tag{83}$$

$$B_t^g = (1 + R_{t-1})B_{t-1}^g + P_t^h G_t - TAX_t \tag{84}$$

4.4 Foreign Assets

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

$$S_t B_t^f = [1 + R_{t-1}^* + \Phi_{t-1}] S_t B_{t-1}^f + P_t^f (C_t^f + I_t^f) - P_t^x (C_t^*) \tag{85}$$

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

5 Calibration

5.1 Calibrated Parameters affecting Steady State

We calibrate the parameters in accordance with the steady state by using the Taiwan's quarterly data from the beginning of 1998 through the end of 2007, before the outbreak of the subprime crisis, for the characterization of the macroeconomic fundamentals in Taiwan.

The discount parameter β follows the value used by most conventional models. The habit persistence parameter ϱ is consistent with most of the empirical estimations.[8] $\theta_1 > \theta_2$ is assumed to indicate 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.

For investment, we assume an equal share of domestic and imported goods, with $\gamma_i = .5$. The elasticity parameter θ_i is set at 2.5, equal to the elasticity parameter for home and foreign goods.

The ratios of consumption of foreign goods in the aggregate consumption, γ_1 and the share of export-goods consumption in the total domestic consumption basket, γ_2, are assumed to be 0.3 and 0.2 respectively, for an approximated characterization of Taiwan's consumption pattern. In this model, the steady-state values are quite sensitive to the tax rates. The income and consumption tax rates τ,τ_C are assumed to be slightly higher than the applicable tax rates in Taiwan, which can be approximately 0.15 on average for the income tax and 0.05 for consumption tax respectively. The parameters are specified to generate the steady-state government expenditure share in GDP to be 0.24 close to 0.2 that the data indicate. We assume a relative high smoothing component for government spending, with ρ_G set at .5.

Since the financial system is well established in Taiwan, thus we assume relatively low financial friction parameters. The parameters μ_i, $i = 1, ..3$,which representing the borrowing needs of the export, home-goods and importing firms, were all set equal at a value of .5. The capital coefficient in the export production function, α_x, is set to to replicate the shares of capital and labor in the

[8] According to Teo (2009), the estimated habit persistence parameter of Taiwan is approximately 0.8.

economy. Finally the banking reserve and lending cost parameters ϕ_M, ϕ_N, are set to replicate observed low spreads in the financial sector.

Table 2: Calibrated Parameters

Symbol	Definition	Values
β	discount factor	0.99
ϱ	habit parameter	0.8
δ	capital depreciation	0.06
ϕ	adjustment cost	0.005
γ_1	foreign cons. in total cons. index	0.3
γ_2	share of export good in dom.cons. index	0.2
γ_i	share. of export good in investment index	0.5
η	relative risk aversion parameter	3.0
ϖ	labor supply elasticity	5
γ_L	disutility of labor	1
ϕ_C	consumption in CES utility	0.9
$\varkappa$	CES utility coefficient	-0.1
θ_1	intratemporal substitution elasticity, total cons	2.5
θ_2	intratemporal substitution elasticity, domestic cons	1.5
θ_i	intratemporal substitution elasticity, investment	2.5
ρ_G	smoothing parameter for government spending	.9
τ, τ_C	tax rates on labor income and consumption	0.2, 0.2
μ_h, μ_x, μ_f	financial friction parameters	0.5
ζ, ζ_w	substitution elasticity for differentiated goods and labor	6
α_x	capital coefficient in traded goods	0.33
α_h	intermediate coefficient in non-traded production	0.33
ϕ_M, ϕ_N	deposit and lending costs for banks	0.1, 0.2

5.2 Calibrated Parameters for Dynamics and Volatilites

Table 2 shows the calibrated values for the volatilities and the dynamic adjustment parameters for the shock processes and the Calvo pricing. Since this is a a simulation, we specify the shocks volatilities at .01 for separate simulations. We make use of Bayesian estimation resutls by Teo for most of the parameters governing the dynamics of the shocks and the Calvo pricing.

Table 3:
Parameters and Std Deviations for Dynamic Processes

Volatility	Name	Values
σ_G	Gov. Spending	.01
σ_{Z^x}	Export Prod.	.01
$\sigma_{P^{x*}}$	Terms of Trade	.01
σ_{R^*}	For. Interest	.01
σ_{X^*}	Export Demand	.01
σ_C	Consumption	.01
σ_ϕ	Lending Cost	.01
σ_{Z^h}	Home Goods Prod	.01
σ_P	Mark-Up Pricing	
Coefficient		
ρ_{RES}	Money Lag	.5
ρ_ϕ	Money Target Coeff.	.5
ρ_G	Gov. Spending	.5
$\rho_{P^{x*}}$	Terms of Trade	.5
ρ_{R^*}	For.Interest	.5
ρ_{C^*}	Export	.5
ρ_{Z^h}	Home Goods Prod.	.5
ρ_{Z^x}	Traded Goods Prod	.5
ξ	Calvo Pricing-Home Goods	.5
ξ_w	Calvo Wage Setting	.5
ξ_I	Calvo Pricing-Imported Goods	.5

6 Simulation Results

We are interested in the response of consumption, inflation, the exchange rate, the interest rate, Tobin's Q, as well as liquidity and deposit volatility (representing narrow and broad money aggregates) to the underlying shocks, for four altneraive monetary regimes. We compore the base regime, with broad money base targeting, with the fixed exchange rate regime, the Taylor-rule regime and the exchange rate management regime. Then we examine the volatility results for recurring shocks to the stochastic variables, based on 1000 realizations of simulations with sample size 500. We calculate the median as well as the lower and upper values of the volatilities based on a 95% confidence level.

We first take up domestic demand shocks to consumption and government spending, then productivity shocks to traded and non-traded goods production, followed by . After that, we examine the nominal domestic shocks to the loan cost provision and mark-up pricing, followed by foreign shocks to export demand, terms of trade and the LIBOR interest rate.

6.1 Domestic Demand Shocks

Table 4 and 5 contain the volatility results of consumption, the asset prices and returns and the monetary aggregates for the shocks to consumption demand and government spending. We see, overall, that the money-targeting delivers lower volatility to consumption while the fixed rate system delivers lower inflation volatility under the consumption demand shocks. As expected, the money targeting rule delives lower broad-money volatility for the consumption demand shocks. For government spending shocks, we see that the fixed-rate delivers lower consumption volatility and inflation volatility. However, for Tobin's q, we see that the broad money targeting outperforms all of the other regimes for recurring consumpton demand shocks and does as well as the fixed exchange rate regime for the government spending shocks. The results indicate that for the recurring consumption demand shocks, the money-targeting regime dominates, while for the recurring government spending shocks (which are for demand for non-traded goods and services), the fixed-rate system dominates.

Table 4: Domestic Demand Shocks: Consumption Demand

							Consumption Demand
	Δc	Δp	Δs	r	Δq	Δres	Δm
							Money-Targeting
Median	0.005	0.009	0.019	0.006	0.007	0.004	0.093
Lower	0.005	0.009	0.018	0.005	0.006	0.003	0.089
Upper	0.005	0.010	0.020	0.006	0.007	0.004	0.097
							Fixed-Rate System
Median	0.007	0.003	0.000	0.000	0.015	0.005	0.149
Lower	0.006	0.003	0.000	0.000	0.014	0.005	0.143
Upper	0.007	0.004	0.000	0.000	0.016	0.005	0.156
							Taylor Rule
Median	0.010	0.012	0.013	0.011	0.024	0.048	0.449
Lower	0.010	0.011	0.012	0.010	0.023	0.046	0.430
Upper	0.011	0.013	0.014	0.011	0.025	0.050	0.468
							Ex Rate Rule
Median	0.009	0.009	0.002	0.002	0.018	0.007	0.219
Lower	0.009	0.008	0.001	0.001	0.017	0.006	0.209
Upper	0.010	0.009	0.002	0.002	0.019	0.007	0.230

Table 5: Domestic Demand Shock: Government Spending

	Δc	Δp	Δs	r	Δq	Δres	Δm
							Government Spending
							Money-Targeting
Median	0.010	0.022	0.030	0.015	0.015	0.008	0.167
Lower	0.009	0.021	0.029	0.014	0.014	0.007	0.160
Upper	0.010	0.024	0.032	0.016	0.015	0.009	0.174
							Fixed-Rate System
Median	0.006	0.003	0.000	0.000	0.015	0.005	0.150
Lower	0.006	0.003	0.000	0.000	0.014	0.005	0.144
Upper	0.006	0.004	0.000	0.000	0.015	0.005	0.157
							Taylor Rule
Median	0.067	0.122	0.112	0.104	0.140	0.687	4.984
Lower	0.063	0.114	0.104	0.097	0.134	0.656	4.766
Upper	0.072	0.131	0.122	0.111	0.146	0.719	5.210
							Ex Rate Rule
Median	0.012	0.009	0.002	0.002	0.019	0.007	0.223
Lower	0.012	0.008	0.001	0.001	0.018	0.007	0.213
Upper	0.013	0.010	0.002	0.002	0.019	0.008	0.234

6.2 Productivity Shocks

Table 6 and 7 contain the volatility results for productivity shocks. Again we see that the volatility to Tobin's q is lowest under the monetary targeting regime, followed by the fixed exchange-rate system. For inflation, the fixed rate system delivers the lower volatilities while for consumption, the monetary-targeting regime does best. Not surprisingly, the exchange rate volatility is lowest, after the fixed system, for the exchange-rate rule, while the interest-rate volatility is slightly higher under the Taylor rule than under the monetary-targeting rule.

Table 6: Productivity Shocks: Non-Traded Production

	Non-Traded Production						
	Δc	Δp	Δs	r	Δq	Δres	Δm
							Money-Targeting
Median	0.005	0.011	0.020	0.006	0.007	0.004	0.094
Lower	0.005	0.010	0.019	0.006	0.006	0.003	0.090
Upper	0.005	0.011	0.020	0.007	0.007	0.004	0.098
							Fixed-Rate System
Median	0.006	0.006	0.000	0.000	0.015	0.007	0.150
Lower	0.005	0.006	0.000	0.000	0.014	0.006	0.144
Upper	0.006	0.007	0.000	0.000	0.016	0.007	0.157
							Taylor Rule
Median	0.025	0.038	0.037	0.035	0.054	0.203	1.584
Lower	0.023	0.035	0.034	0.032	0.051	0.194	1.518
Upper	0.027	0.041	0.040	0.037	0.057	0.212	1.658
							Ex Rate Rule
Median	0.010	0.010	0.002	0.002	0.019	0.007	0.224
Lower	0.009	0.009	0.001	0.001	0.018	0.007	0.214
Upper	0.010	0.010	0.002	0.002	0.020	0.007	0.235

Table 7: Productivity Shock: Traded Production

	Traded Production						
	Δc	Δp	Δs	r	Δq	Δres	Δm
							Money-Targeting
Median	0.005	0.009	0.019	0.006	0.007	0.004	0.093
Lower	0.005	0.009	0.018	0.005	0.006	0.003	0.089
Upper	0.005	0.010	0.020	0.006	0.007	0.004	0.097
							Fixed-Rate System
Median	0.006	0.003	0.000	0.000	0.015	0.005	0.149
Lower	0.005	0.003	0.000	0.000	0.014	0.005	0.142
Upper	0.006	0.004	0.000	0.000	0.015	0.005	0.155
							Taylor Rule
Median	0.009	0.009	0.011	0.008	0.022	0.010	0.292
Lower	0.009	0.008	0.010	0.007	0.021	0.010	0.279
Upper	0.010	0.009	0.011	0.008	0.023	0.011	0.305
							Ex Rate Rule
Median	0.009	0.009	0.002	0.001	0.018	0.007	0.219
Lower	0.009	0.008	0.001	0.001	0.017	0.006	0.209
Upper	0.010	0.009	0.002	0.002	0.019	0.007	0.229

6.3 Nominal Shocks

Table 8 and 9 contain the volatility results for nominal shocks, for non-traded goods mark-up pricing and for bank lending costs. Again we see that the volatility to Tobin's q is lowest under the monetary targeting regime, followed by the fixed exchange-rate system and then the exchange-rate rule. For consumption, the monetary-targeting regime outperforms the fixed rate system.

Table 8: Nominal Shocks: Mark-Up Pricing

							Mark-Up Pricing
	Δc	Δp	Δs	r	Δq	Δres	Δm
							Money-Targeting
Median	0.005	0.009	0.019	0.006	0.007	0.004	0.093
Lower	0.004	0.009	0.018	0.005	0.006	0.003	0.089
Upper	0.005	0.010	0.020	0.006	0.007	0.004	0.097
							Fixed-Rate System
Median	0.006	0.003	0.000	0.000	0.015	0.005	0.149
Lower	0.005	0.003	0.000	0.000	0.014	0.005	0.142
Upper	0.006	0.004	0.000	0.000	0.015	0.005	0.156
							Taylor Rule
Median	0.021	0.036	0.034	0.031	0.045	0.199	1.474
Lower	0.020	0.033	0.031	0.029	0.043	0.190	1.409
Upper	0.023	0.038	0.036	0.033	0.047	0.208	1.541
							Ex Rate Rule
Median	0.009	0.009	0.002	0.002	0.018	0.007	0.222
Lower	0.009	0.008	0.001	0.001	0.018	0.006	0.211
Upper	0.010	0.009	0.002	0.002	0.019	0.007	0.232

Table 9: Nominal Shock: Bank Lending Costs

							Bank Lending Costs
	Δc	Δp	Δs	r	Δq	Δres	Δm
							Money-Targeting
Median	0.005	0.009	0.019	0.006	0.007	0.004	0.093
Lower	0.004	0.009	0.018	0.005	0.006	0.003	0.089
Upper	0.005	0.010	0.020	0.006	0.007	0.004	0.097
							Fixed-Rate System
Median	0.006	0.003	0.000	0.000	0.015	0.005	0.149
Lower	0.005	0.003	0.000	0.000	0.014	0.005	0.142
Upper	0.006	0.004	0.000	0.000	0.015	0.005	0.156
							Taylor Rule
Median	0.017	0.027	0.026	0.023	0.037	0.146	1.099
Lower	0.016	0.025	0.024	0.022	0.035	0.139	1.050
Upper	0.018	0.029	0.028	0.025	0.038	0.153	1.147
							Ex Rate Rule
Median	0.009	0.009	0.002	0.002	0.018	0.007	0.219
Lower	0.009	0.008	0.001	0.001	0.017	0.006	0.209
Upper	0.010	0.009	0.002	0.002	0.019	0.007	0.230

6.4 Terms of Trade and Foreign Demand Shocks

Table 10 and 11 contain the volatility under terms of trade and export demand shocks. Again we see that the volatility to Tobin's q is lowest under the monetary targeting regime, followed by the fixed exchange-rate system for terms of trade shocks, but followed by the Taylor rule for the export-demand shocks. For consumption volatility, the monetary rule performs best for the terms of trade shocks, but the Taylor rule works best for the export demand shocks. For inflation, the fixed exchange rate system works best for both sets of shocks. .

Table 10: Foreign Shock: Terms of Trade

							Terms of Trade
	Δc	Δp	Δs	r	Δq	Δres	Δm
							Money-Targeting
Median	0.005	0.009	0.023	0.008	0.007	0.004	0.095
Lower	0.005	0.009	0.022	0.007	0.007	0.003	0.091
Upper	0.005	0.010	0.024	0.009	0.007	0.004	0.099
							Fixed-Rate System
Median	0.008	0.005	0.000	0.000	0.018	0.009	0.179
Lower	0.007	0.005	0.000	0.000	0.017	0.008	0.171
Upper	0.008	0.005	0.000	0.000	0.019	0.009	0.188
							Taylor Rule
Median	0.028	0.035	0.035	0.031	0.059	0.134	1.312
Lower	0.026	0.032	0.032	0.029	0.056	0.128	1.256
Upper	0.030	0.037	0.038	0.033	0.061	0.140	1.370
							Ex Rate Rule
Median	0.011	0.011	0.002	0.002	0.022	0.010	0.263
Lower	0.010	0.010	0.002	0.002	0.021	0.010	0.251
Upper	0.012	0.012	0.002	0.002	0.023	0.011	0.276

Table 11: Foreign Shock: Export Demand

	Δc	Δp	Δs	r	Δq	Δres	Δm
							Export Demand
							Money-Targeting
Median	0.013	0.040	0.057	0.023	0.021	0.015	0.288
Lower	0.013	0.037	0.055	0.021	0.020	0.013	0.275
Upper	0.014	0.043	0.060	0.025	0.022	0.016	0.301
							Fixed-Rate System
Median	0.017	0.006	0.000	0.000	0.043	0.007	0.464
Lower	0.016	0.006	0.000	0.000	0.041	0.007	0.444
Upper	0.018	0.007	0.000	0.000	0.045	0.007	0.485
							Taylor Rule
Median	0.010	0.018	0.018	0.016	0.026	0.159	0.764
Lower	0.009	0.017	0.016	0.015	0.025	0.152	0.731
Upper	0.011	0.019	0.019	0.017	0.027	0.167	0.798
							Ex Rate Rule
Median	0.045	0.030	0.005	0.005	0.089	0.016	1.040
Lower	0.042	0.028	0.005	0.005	0.085	0.016	0.993
Upper	0.048	0.032	0.006	0.006	0.094	0.017	1.089

6.5 Foreign Inerest Rate Shocks

Table 12 contains the volatility results due to foreign interest-rate shocks. , Again we see that the volatility to Tobin's q is lowest under the monetary targeting regime, followed by the fixed exchange-rate system . For consumption volatility, the monetary rule performs best, while for inflation, the fixed-rate rule works best.

In sum, for most of the shocks, monetary targeting rule can successfully stablize the consumption and Tobin's q, while the fixed rate rule can lead to lowest inflation volatility. The result is quite intuitive. By controlling the liquidity for consumption and investment, the consumption and the capital price can be well stablized. While the over expansionary liquidity on the capital market has been considered as the primary factor accounting for the recent financial crisis. Our result demonstrates how the control over the liquidity circulating in the economy can help stablize the key macroeconomic variables with no significant welfare loss. On the other hand, since the import of foreign goods takes up a significant share in the overall consumption, the fixed exchange rate helps lower inflation volatility by reducing exchange rate fluctuations.

Table 12: Foreign Interst Rate Shocks

	Δc	Δp	Δs	r	Δq	Δres	Δm
							Money-Targeting
Median	0.005	0.009	0.019	0.006	0.007	0.004	0.093
Lower	0.004	0.009	0.018	0.005	0.006	0.003	0.089
Upper	0.005	0.010	0.020	0.006	0.007	0.004	0.097
							Fixed-Rate System
Median	0.006	0.003	0.000	0.0001	0.015	0.005	0.149
Lower	0.005	0.003	0.000	0.0001	0.014	0.005	0.142
Upper	0.006	0.004	0.000	0.0001	0.015	0.005	0.156
							Taylor Rule
Median	0.009	0.009	0.011	0.008	0.022	0.010	0.292
Lower	0.009	0.008	0.010	0.007	0.021	0.010	0.280
Upper	0.010	0.009	0.011	0.008	0.023	0.011	0.306
							Ex Rate Rule
Median	0.009	0.009	0.002	0.002	0.018	0.007	0.219
Lower	0.009	0.008	0.001	0.001	0.017	0.006	0.209
Upper	0.010	0.009	0.002	0.002	0.019	0.007	0.230

7 Conclusion

Our counterfactual simulation experiments, based on calibrated parameters for Taiwan, but representing a model for a small highly-open economy, suggest that there would be little to gain or lose, by abandoning monetary targets in favor of a Taylor type inflation targeting regime. Our result may suggest that the central bank should reinforce its regulation on exchange rate volatility. The only exception would be if foreign export-demand shocks dominated. Then the Taylor rule delivers lowest consumption volatility (though not as low inflation volatility as in a fixed rate system), with Q-volatility only slightly higher than in the case of monetary targets. But across all shocks, for delivering lowest Q-volatility, monetary targeting domintes the alternative policy regimes, with the exception of government spending shocks, when a fixed-rate regimes does as well.

Our Taylor rule was a simple Taylor rule for inflation targeting alone. We did not take into account a hybrid Taylor rule could be amended to include Q-targeting. Clearly a Taylor-type inflation targeting program can be modified to include expanded sets of price indices. But if the standard argument for the Taylor rule is its transparency and simplicity, then such a modification would make this rule less attractive. The key result of this paper is that a simple monetary targeting framework does as well as a simple transparent Taylor rule for reducing the consumption and share price volatility. For inflation, in this highly open economy, not suprisingly, a fixed rate system works best across a variety of shocks. But for overall financial stability, proxied by the volatility of Tobin's Q, the results strong suggest the monetary aggregate targets should play a major role.

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