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美元本位制下之匯率政策－多國模型下之數量分析
研究成果報告(精簡版)

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計畫參與人員：碩士級-專任助理人員：楊馥菁

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中 文 摘 要 ： 我們利用一個三國（一個大國，兩個週邊國家）的動態隨機一般均衡（DSGE） 模型架構來探討美國的量化寬鬆，特別是在美元扮演了國際貨幣(international currency)的情況下，對於國際社會的影響。此一三國模型使我們可以探討除了美國之外，另兩個區域國家對於量化寬鬆的不同政策反應，會如何改變量化寬鬆對其國內經濟的影響。我們發現，若其中一個國家採取固定匯率制度，另一國則採取彈性匯率，或使其匯率緩
慢調整(一開始對美元升值，再逐漸貶值)，則其產出會下降，但亦可減緩通貨膨脹壓力。

中文關鍵詞： 國際貨幣, 量化寬鬆, 三國 DSGE 模型

英 文 摘 要 ： In this paper, we use a three-country Dynamic Stochastic General Equilibrium (DSGE) model to examine the effects of US' s quantitative easing (QE) on the rest of the world where the US dollar is served as the invoicing currency for most of the trades. The three-country framework permits the examination of the intraregional effects between the periphery countries as China and Japan, or Korea and Taiwan. This is in line with the recent concern of Taiwan about the speed and magnitude of exchange rate adjustment in response to QE, particularly, relative to neighboring countries. This may affect the QE' s effect on Taiwan. Therefore, our analyses emphasize the cases where one Periphey country maintains the fixed exchange rate, while the other implements flexible exchange rate or exchange rate movement. Our result shows that the slower and milder adjustment of exchange rate may result in slower recovery of output, but help reduce domestic inflation.

英文關鍵詞： international currency, quantitative easing, three-country DSGE

Implications of Dollar Standard for Regional Monetary policies - A Multiple-Country DSGE Framework

Yu-Ning Hwang[1]

Department of Economics

National Chengchi University

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Abstract

In this paper, we use a three-country dynamic stochastic general equilibrium (DSGE) model to examine the effects of US's quantitative easing (QE) on the rest of the world where the US dollar is served as the invoicing currency for most of the trades. The three-country framework permits the examination of the intraregional effects between the periphery countries as China and Japan, or Korea and Taiwan. This is in line with the recent concern of Taiwan about the speed and magnitude of exchange rate adjustment in response to QE, particularly, relative to neighboring countries. This may affect the QE's effect on Taiwan. Therefore, our analyses emphasize the asymmetric policy responses of the Periphery countries where one Periphery country implements stronger control on exchange rate, but the other keeps exchange rate flexible. Our numerical results show that, overall, country with less persistent adjustment in interest rate would be more fluctuating. It is shown that one country's control on exchange rate will result in greater fluctuations in both Periphery countries.

[1] Department of Economics at National Chengchi University, 64, Sec. 2, Tz-nan Rd., Wenshan, Taipei 116, Taiwan. Tel.: 886-2-29393091 ext. 51041. Email: yuning@nccu.edu.tw. Fax: 886-2-29390344.

1. Introduction

The objective of this research is to examine the influences of the expansionary monetary policy of the international-currency country, such as the US, on the global economy, and investigate the optimal policy responses of Asian (particularly) countries. Since the outbreak of the subprime crisis in 2008, the US has implemented three rounds of quantitative easing of the US (normally known as the QE1, QE2, and QE3). This policy has raised the reserve by more than US$2.3 trillion to the market, which may continue to rise after the most recent announcement of the QE3.[2,3]

However, the US dollars play a distinct role in international trades as the common invoicing currency.[4] As shown in Table 1, most of the international trades are denominated in the US dollars. Therefore, the exchange rate of the US dollars has been the focus of many central banks. As a result, the announcement of QE2 has brought up global concerns and worries[5], which may greatly affect the imports and

[2] The first round of quantitative easing is called QE1, which was used to help the private credit market recover from the crisis. It is known for the "unconventional monetary policy" that the Fed directly injects liquidity to the private credit markets by buying agency debt and mortgage-backed security (MBS). This has brought qualitative and quantitative examination of the unconventional measures of the Fed. (see Gertler and Karadi, 2009). However, while the QE1 has achieved its goal of stabilizing the credit market, QE2 is implemented to help the real economy recovery. This study is not to examine the unconventional monetary policy as QE1, but focus on how the expansionary monetary policy of the US, as the international-currency country, would influence the global economy.

[3] QE2 was announced on Nov. 3, 2010. The plan of the QE2 is to increase the total of US$600 billion reserve on the market by purchasing US$75 billion of government debts monthly for consecutive 8 months, expected to end in June 2011. In his speech to the European Central Bank (ECB), the Chairman of the Fed, Ben Bernanke, explained the implementation of QE2 can help the economic recovery of the US while the unemployment rate of the US remains at 9.8%, the highest level in 26 years, and the monthly inflation rate is only 0.2%, implying a continuing threat of deflation.

[4] The role of international currency has been discussed extensively in the literature. Please see Devereux, shu, and Xu (2007, 2010), Gertler and Karadi (2009), Goldberg and Tille (2008), Krugman (1984), Li and Matsui (2009), Matsuyama Kiyotaki and Matsui (1993), McKinnon (2001, 2007), Tavlas (1997), and Trejos and Wright (1996) for references.

[5] This may also cause asset bubbles and inflations due to the hot money created by quantitative easing. The prices of major commodities, such as oil and gold, denominated in the US dollars have risen significantly. The prices on the stock markets all over the world have risen greatly as well. However, the major role of the international currency in international capital market is not the focus of this study. We may leave it for the future study. The most recent reference on this issue can be seen in Shi and Xu

exports.[6] However, the problem may not arise from the competition with the US. For example, products from Taiwan and Korea do not closely compete with those made from the US, but closely competing with each other. Thus, the examination of the US dollar depreciation on a small country, as Taiwan, can not neglect its relative effects on its trade partners/competitors, which may depend on the relative responses of monetary policy to the US's policy. Therefore, a multiple-country framework is required for the analyses of US's quantitative easing policy on the rest of the world.

Table 1: International role of the dollar

Year of invoicing observation and trade shares		Share of country exports			Share of country imports		
		Invoiced in dollars (1)	Sold to the US (2)	Sold to the US + "Dollar Bloc" (3)	Invoiced in dollars (4)	Bought from the US (5)	Bought from the US + "Dollar Bloc" (6)
Asia							
Japan	2001	52.8	30.4	51.5	70.0	18.3	51.8
Korea	*2001*	84.9	20.8	49.0	82.2	15.9	45.5
Malaysia	1996	66.0	18.2	31.6	66.0	15.5	22.2
Thailand	1996	83.9	17.8	35.3	83.9	12.3	26.8
Australia	2002	67.9	9.6	29.6	50.1	18.3	36.8
European Union							
Belgium[b]	*2002*	*31.9*	20.1	33.5	33.5	16.4	29.9
France[b]	*2002*	34.2	15.4	27.2	43.3	15.6	29.7
Germany[b]	*2002*	31.6	17.9	28.7	34.5	13.1	25.5
Greece[b]	*2002*	71.1	7.5	18.7	62.0	8.7	28.1
Italy	*2002*	20.5	9.8	17.3	30.8	4.9	12.3
Spain[b]	*2002*	32.8	11.0	19.7	39.5	8.5	24.5
United	2002	26.0	15.5	22.2	37.0	11.9	21.3

(2010).

[6] This may also cause asset bubbles and inflations due to the hot money created by quantitative easing. The prices of major commodities, such as oil and gold, denominated in the US dollars have risen significantly. The prices on the stock markets all over the world have risen greatly as well. However, the major role of the international currency in international capital market is not the focus of this study. We may leave it for the future study.

Kingdom

Source: Goldberg and Tille (2009).

This issue is mostly conducted in a two-country framework. For example, to examine the welfare implications under the dollar standard where the exchange rate pass-through is asymmetric, Devereux, Shi and Xu (2006) construct a two-country dynamic stochastic general equilibrium (DSGE) model where the producers from the US take the producer-currency pricing (PCP) and producers from the rest of the world take the local-currency pricing (LCP). Under PCP, the goods are priced in the producers' currency and thus there is complete pass-through onto the prices of the goods sold in the foreign market. Under LCP, producers price their exports in consumers' currency such that there is no exchange rate pass-through for goods sold in the foreign markets.[7] They find that the absence of exchange rate pass-through will hurt the US, but benefit rest of the world. Their ideas are followed by Hwang and Lai (2010). Their study show that the lack of exchange rate pass-through onto the US prices leads to greater increase in the US output than the foreign from the US's monetary expansion in the short run.

However, the two-country models may tell only part of the story, and have neglected the predominant role of the US dollar in trades not directly with the US. This effect has been well known, as listed in Table 1, but is rarely examined by robust theoretical analyses. To capture the special role of the US dollar, Goldberg and Tille (2009) establish a three-country center-periphery model where the Center country is the international-currency country and there are two periphery countries. They divide the role of the US dollar in international trades into two parts: the direct international role and the global international role. The direct role indicates the US dollars used in

[7] Exchange rate pass-through has been shown crucial in various studies such as Devereux and Engel (2003) and Sutherland (2006).

the transactions that are traded directly with the US denominated in the US dollars, while the global role characterizes the US dollars are used in the intra-periphery trades between two periphery countries. Goldberg and Tille (2009) find that the global role will amplify the impacts of US monetary policy on the global economy. Teo (2009) also use a similar three-country DSGE framework to analyze whether the Asian countries should peg to the regional currency given the US has played a dominant role in intraregional trades. His finding suggests that the Asian countries which peg to a currency basket should lower the share of the US dollar in the basket under the fact most of the intraregional trades are denominated in the US dollars.

Therefore, the primary issues that this research wants to conduct arise. Under the current circumstance that the US dollar serves as the primary denomination currency for most of the international trades, which monetary policy will dampen the impacts of the US policies on the rest of the world? Are the prevention from exchange rate appreciation, which will hurt the export but dampen the domestic inflation pressure, or unilateral exchange rate peg to the dollar beneficial? Would alternative regional monetary arrangements such as using one of the regional currencies or the formation of currency union benefit the regional economy?

Therefore, we will use a three-country center-periphery model, a dynamic version of Goldberg and Tille (2009), which would allow us to take into account the intra-regional trades. In contrast to the study of Goldberg and Tille (2009) which emphasizes the implications of the global role of the international currency for the international economy, this study attempts to examine how different policy responses of small countries to the quantitative easing of the international-currency country may lead to different effects on rest of the world. This may help us understand whether or not a country loses from slower, smaller depreciation than its neighbor when the quantitative easing is conducted.

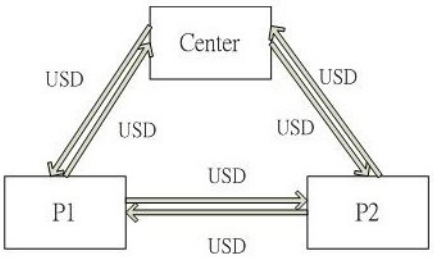

Figure 1: Global trades using international currency

Table 2: Pricing strategies of trades

From \ To	Center	Periphery 1	Periphery 2
Center	N.A.	PCP	PCP
Periphery 1	LCP	N.A.	Dollar standard
Periphery 2	LCP	Dollar standard	N.A.

Rest of the paper is structured as below. Section 2 will outline the model. Section 3 will explain how we conduct calibration. Results are listed and explained in Section 4. Section 5 concludes.

2. Model

In this model, we have three countries, as indicated by Center (Center), Periphery 1 (P1), periphery 2 (P2) countries. Whether the goods are traded with the Center country, all the trades in the world are preset in the currency of the Center country, as the international currency for trade. As a result, the pricing strategies of these three countries is shown by Fig. 1 and are listed in Table 2.

2.1 Goods market

For any country i, $i = cen, P1, P2$, the consumption includes goods from all three countries, with v^i_{cen}, v^i_{p1}, v^i_{p2} as the preference share for each type of goods:

$$C^i = \left[(v^i_{cen})(C^i_{cen})^{\frac{\theta-1}{\theta}} + (v^i_{p1})(C^i_{p1})^{\frac{\theta-1}{\theta}} + (v^i_{p2})(C^i_{p2})^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \quad (1)$$

According to the composite consumption, the aggregate price index, and the associated demand functions can be described as below:

$$P^i = \left[v^i_{cen}(P^i_{cen})^{1-\theta} + v^i_{p1}(P^i_{p1})^{1-\theta} + v^i_{p2}(P^i_{p2})^{1-\theta} \right]^{\frac{1}{1-\theta}}, \quad (2)$$

$$C^i_h = v^i_h \left(\frac{P^i_h}{P^i}\right)^{-\theta} C^i, \quad h = cen, p1, p2. \quad (3)$$

The goods market in each country is monopolistically competitive, composed of a continuum of goods, with the size of n_c, n_{P1}, n_{P2} for the Center, Periphery 1, and Periphery 2 countries respectively. As a result, the consumption and price indexes for goods produced by each country can be characterized as below:

$$C^i_h = \left[\left(\frac{1}{n_h}\right)^{\frac{1}{\varphi}} \int_0^{n_h} \left(C^i_h(z)\right)^{\frac{\varphi-1}{\varphi}} dz \right]^{\frac{\varphi}{\varphi-1}}, \quad P^i_h = \left[\frac{1}{n_h} \int_0^{n_h} \left(P^i_h(z)\right)^{1-\varphi} dz \right]^{\frac{1}{1-\varphi}}, \quad (4)$$

and the corresponding demand function:

$$C^i_h(z) = \frac{1}{n_h} \left(\frac{P^i_h(z)}{P^i_h}\right)^{-\varphi} C^i_h, \quad h = cen, p1, p2 \quad (5)$$

2.2 Households

The household in each country i obtains utility from the consumption, real money

holding, and the labor.

$$E_0 \sum_{t=0}^{\infty} \beta^t U_t^i (C_t^i, \frac{M_t^i}{P_t}, L_t^i) \tag{6}$$

where the utility function follows the form:

$$U_t^i = \frac{\left(C_t^i\right)^{1-\rho}}{1-\rho} + \frac{\chi}{1-\varepsilon}\left(\frac{M_t^i}{P_t^i}\right)^{1-\varepsilon} - \frac{\left(L_t^i\right)^{1+\varphi}}{1+\varphi} \tag{7}$$

M_t^i is the money holding in country *i* and L_t^i is the labor supplied.

Here, we use the money-in-the-utility specification to characterize the role of money in the model. The budget constraint can be written as:

$$B_{t+1}^i + S_t^i + B_{t+1}^{i*} + \sum_{h\in\{cen,p_1\}} \frac{\psi_B}{2} \frac{\left[S_{h,t}^i B_{h,t+1}^i\right]^2}{NY_t^i} = \left(1+i_t^i\right) B_t^i + \left(1+i_t^*\right) B^{*i}{}_t S_t^i + W_t^i L_t^i + \Psi_t^i, \quad i = p1,\ p2 \tag{8}$$

We assume that there is one internationally tradable bond B_t^*, denominated in the center currency. In addition, for the periphery countries, there is also the domestic bonds B_t^* which are not tradable across countries. i_t^i is the interest rate for the home bond, and i_t^* is the interest rate for the tradable bonds. S_t^i is the exchange rate of country in the periphery country relative to the center currency. W_t^i is the nominal wage in country *i*.

The optimization condition of the households can be written as:

$$\frac{W_t^i}{P_t\left(C_t^i\right)^{\rho}} = \left(L_t^i\right)^{\phi}, \tag{9}$$

$$\frac{M_t^i}{P_t} = \frac{\chi^{1/\varepsilon}\left(C_t^i\right)^{\rho/\varepsilon}}{\left(1-d_t^i\right)^{1/\varepsilon}} \tag{10}$$

$$1 = \beta\left(1+i_t^i\right) E\left[\left(\frac{C_{t+1}^i}{C_t^i}\right)^{-\rho}\right] \tag{11}$$

where $d_t^i = 1/\left(1+i_t^i\right)$.

The uncovered interest parity condition also holds:

$$E_t\left[\frac{P_t^i\left(C_t^i\right)^\rho}{P_{t+1}^i\left(C_{t+1}^i\right)^\rho}\times\frac{S_{t+1}^i}{S_t^i}\times\left(1+i_t^*\right)\times\left(1+\frac{\psi_B\left(S_t^i\right)^2 B^{*i}_t}{PY_t^i}\right)^{-1}\right]=E_t\left[\frac{P_t^i\left(C_t^i\right)^\rho}{P_{t+1}^i\left(C_{t+1}^i\right)^\rho}\left(1+i_t^i\right)\right] \quad (12)$$

2.3 Firms

The production function (for any good z) follows the linear form with labor as the only input:

$$Y_t^i(z)=A_t^i L_t^i(z) \quad (13)$$

where A_t^i is the productivity with shocks, which follows the AR(1) process:

$$\ln A_t^i=\rho^F \ln A_{t-1}^i+\varepsilon_t^i \quad (14)$$

The cost minimization of the firm generates the marginal cost:

$$MC_t^i(z)=\frac{W_t^i}{A_t^i} \quad (15)$$

2.3.1 Optimal staggered pricing under PCP and LCP

Firms undertake Calvo's pricing with the probability of γ to change the price γ_t. The PCP prices faced by consumers are

$$P_{i,t+\tau}^h(z)=S_{i,t+\tau}^h\bar{\Pi}^\tau Q_{i,t+\tau}^h(z), \qquad \tau=0,1,2,\ldots,\infty. \quad (16)$$

The firms are solving the profit-maximization problem as stated below:

$$\left[Q_{p_2,t}^{p_2}, Q_{p_2,t}^{cen}, Q_{p_2,t}^{p_1}\right] = \underset{Q_{p2,t}^{p2}, Q_{p2,t}^{cen}, Q_{p2,t}^{p1}}{Arg\ Max} \sum_{\tau=0}^{\infty} \alpha^{\tau} E_t \rho_{t,t+\tau}^{p_2} \pi_{t+\tau}^{p_2}(Q_{p_2}^{p_2}, Q_{p_2}^{cen}, Q_{p_2}^{p_1}) \tag{17}$$

where $\pi_{t+\tau}^{p_2}(Q_{p_2}^{p_2}, Q_{p_2}^{cen}, Q_{p_2}^{p_1}) = \bar{\Pi}^{\tau} Q_{p_2}^{p_2} Y_{p_2,t+\tau}^{p_2}(z) + \bar{\Pi}^{\tau} Q_{p_2}^{cen} Y_{p_2,t+\tau}^{cen}(z) + \bar{\Pi}^{\tau} Q_{p_2}^{p_1} Y_{p_2,t+\tau}^{p_1}(z) - TC_{t+\tau}^{p_2}$.

The optimal pricing of firms can be written as:

$$Q_{p_2,t}^{h} = \frac{\varphi}{\varphi - 1} \frac{E_t \sum_{\tau=0}^{\infty} \gamma^{\tau} \rho_{t,t+\tau}^{p_2} \left[MC_{t+\tau}^{p2}(z) Y_{p_2,t+\tau}^{h}(z)\right]}{E_t \sum_{\tau=0}^{\infty} \gamma^{\tau} \rho_{t,t+\tau}^{p_2} \bar{\Pi}^{\tau} Y_{p_2,t+\tau}^{h}(z)}, \quad h = cen, p_1, \tag{18}$$

The dynamics of the aggregate price is:

$$\left(P_{p_2,t}^{h} / S_{p_2,t}^{h}\right)^{1-\varphi} = \gamma \left(\bar{\Pi}^{\tau} P_{p_2,t-1}^{h} / S_{p_2,t-1}^{h}\right)^{1-\varphi} + (1-\gamma)\left(Q_{p_2,t}^{h}\right)^{1-\varphi}, \quad h = cen, p_1, \tag{19}$$

2.3.2 Optimal staggered pricing under dollar standard

If the firm uses the center currency for denomination, the prices that consumers face are:

$$P_{i,t+\tau}^{h}(z) = S_{t+\tau}^{1} \bar{\Pi}^{\tau} Q_{i,t}^{h}(z), \quad \tau = 0,1,2,\ldots,\infty, \tag{20}$$

The firm solves the profit-maximization problem as above, while the profit becomes:

$$\pi_{t+\tau}^{p_2}(Q_{p_2}^{p_2}, Q_{p_2}^{cen}, Q_{p_2}^{p_1}) = \bar{\Pi}^{\tau} Q_{p_2}^{p_2} Y_{p_2,t+\tau}^{p_2}(z) + S_{cen,t+\tau}^{p_2} \bar{\Pi}^{\tau} Q_{p_2}^{cen} Y_{p_2,t+\tau}^{cen}(z) + S_{cen,t+\tau}^{p_2} \bar{\Pi}^{\tau} Q_{p_2}^{p_1} Y_{p_2,t+\tau}^{p_1}(z) - TC_{t+\tau}^{p_2} \tag{21}$$

The optimal price to the center and periphery countries can be written as:

$$Q_{p_2,t}^{cen} = \frac{\varphi}{\varphi - 1} \frac{E_t \sum_{\tau=0}^{\infty} \gamma^{\tau} \rho_{t,t+\tau}^{p_2} MC_{t+\tau}^{p_2}(z) Y_{p_2,t+\tau}^{cen}(z)}{E_t \sum_{\tau=0}^{\infty} \gamma^{\tau} \rho_{t,t+\tau}^{p_2} \bar{\Pi}^{\tau} S_{cen,t+\tau}^{p_2} Y_{p_2,t+\tau}^{cen}(z)} \tag{22}$$

$$Q_{p_2,t}^{h}=\frac{\varphi}{\varphi-1}\frac{E_t\sum_{\tau=0}^{\infty}\gamma^{\tau}\rho_{t,t+\tau}^{p_2}MC_{t+\tau}^{p_2}(z)Y_{p_2,t+\tau}^{h}(z)}{E_t\sum_{\tau=0}^{\infty}\gamma^{\tau}\rho_{t,t+\tau}^{p_2}\bar{\Pi}^{\tau}S_{cen,t+\tau}^{p_2}Y_{p_2,t+\tau}^{h}(z)},\quad h=p1,\ p2 \tag{23}$$

With staggered pricing, the dynamics of each price follows:

$$(P_{p_2,t}^{cen})^{1-\varphi}=\gamma(\bar{\Pi}P_{p_2,t-1}^{cen})^{1-\varphi}+(1-\gamma)(Q_{p_2,t}^{cen})^{1-\varphi} \tag{24}$$

$$(P_{p_2,t}^{p_1}/S_{cen,t}^{p_1})^{1-\varphi}=\gamma(\bar{\Pi}P_{p_2,t-1}^{p_1}/S_{cen,t-1}^{p_1})^{1-\varphi}+(1-\gamma)(Q_{p_2,t}^{p_1})^{1-\varphi} \tag{25}$$

$$(P_{p_2,t}^{p_2})^{1-\varphi}=\gamma(\bar{\Pi}P_{p_2,t-1}^{p_2})^{1-\varphi}+(1-\gamma)(Q_{p_2,t}^{p_2})^{1-\varphi} \tag{26}$$

2.4 Market clearing conditions

The equilibrium, both goods and asset markets should clear:

$$Y_t^i(z)=\sum_h n_h C_{i,t}^h(z)=\sum_h n_h\frac{1}{n_i}\left(\frac{P_{i,t}^h(z)}{P_{i,t}^h}\right)C_{i,t}^h \tag{27}$$

$$n_{cen}B_{cen,t}^{cen}+n_{p_1}B_{cen,t}^{p_1}+n_{p_2}B_{cen,t}^{p_2}=0, \tag{28}$$

$$n_{cen}B_t^{*cen}+n_{p_1}B_t^{*p_1}+n_{p_2}B_t^{*p_2}=0, \tag{29}$$

$$B_t^i=0,\quad i=p1,\ p2 \tag{30}$$

2.4 Monetary policies

We consider the monetary policies as below:

(a) The Center country: adjust the quantity of money, instead of the growth rate of money:

$$\ln M_{cen,t}=\rho_M M_{cen,t-1}+\varepsilon_{M,t}, \tag{31}$$

(b) The Periphery country: Conduct the Taylor rule, which may respond to the exchange rate movement:

$$\log\left(1+i_t^i\right)=\rho_R\left(1+i_{t-1}^i\right)+\rho_\pi\left(\pi_t^i-\bar{\pi}^i\right)+\rho_y\left(\log(Y_t^i)-\log(\bar{Y}^i)\right)+\rho_S\left(S_t^i-\bar{S}^i\right)+\varepsilon_{R,t}^i, \quad (32)$$

Table 3: Parameter values

Parameter	Description	Value
ρ	Coefficient of risk aversion	2
β	Discount factor	0.99
ψ	Elasticity of labor supply	3
ψ_B	Bond adjustment cost parameter	0.0038
φ	Elasticity of substitution between different brands of goods	7.66
γ	Probability that prices remain unchanged	0.75
$\overline{\Pi}$	Steady state gross inflation rate	1.01
n_{cen}	Size of country center country	0.45
n_1	Size of periphery 1	0.45
n_2	Size of periphery 2	0.1
ρ^A	Autoregressive coefficient on productivity shifter	0.9
ρ_π^i, ρ_y^i	Monetary policy parameters	1.5,0.8
σ_ε^2	Variance of productivity shock	0.01^2
$\rho\left(\varepsilon^i, \varepsilon^h\right)$	Correlation of productivity shock across countries	0
θ	Intratemporal elasticity of substitution	1.5
χ	Parameter in the money utility	0.4718

3. Calibration

We calibrate the model to examine the effects of the center's expansionary monetary policy on other countries. In Table 3, we list the parameter values for calibration. We assume that the Center country is a large country, predominating trades in the world. Thus, we assume that the country sizes of the Center, Periphery 1 and Periphery 2 are 0.5, 0.25 and 0.25 respectively (we can consider them as the US (with the European Union), China and Japan. We may also consider smaller country size for the periphery countries to represent Korea and Taiwan).

To characterize home bias that is prevalent in reality, we follow the specification by Teo (2009) by assuming that the weight of the imported goods in the consumption buddle takes up $\upsilon_h^i = \kappa n_h$, $h = center, P1, P2$, and $\upsilon_i^i = 1 - \upsilon_{cen}^i - \upsilon_{P1}^i$. We assume that $\kappa = 0.5$, thus the home goods will account for the majority of the consumption. The price stickiness is assumed to be 0.75, following conventional settings. Parameters for the responses of Periphery's monetary policies to inflation and output gap are assumed to be 1.5 and 0.8 respectively.

4. Results and Discussions

To characterize the quantitative easing implemented by the Center country, we assume that there is 0.001% shock to its monetary policy, and its AR(1) coefficient is 0.5. The numerical results of three scenarios, flexible exchange rate and exchange rate management with differing persistence ρ_R^i in monetary policy, under this shock are listed in Table 4. We find that, the expected values are about the same for all three cases, but macroeconomic fluctuations vary significantly. The comparison between the first case and second case shows that, to raise the control on the exchange rate (Periphery 1), the country has led to greater fluctuation in the real economy, as well as

Table 4: Numerical results under 0.001% shock to Center country's monetary policy

($\rho_R^1 = 0.9, \rho_R^2 = 0.5$)

	(i) $\rho_S^1 = \rho_S^2 = 0$			(ii) $\rho_S^1 = 1, \rho_S^2 = 0$			(iii) $\rho_S^1 = 0, \rho_S^2 = 1$		
	Center	Peri-1	Peri-2	Center	Peri-1	Peri-2	Center	Peri-1	Peri-2
Mean									
Output	1.1258	1.1477	1.2147	1.1225	1.1472	1.2250	1.1232	1.1474	1.2269
Consumption	0.7937	0.6592	0.9132	0.7978	0.6423	0.9505	0.7974	0.6428	0.9484
Inflation	0	0	0	0	0	0	0	0	0
Standard deviation									
Output	0.0952	0.3392	0.7095	0.1033	0.3658	0.7787	0.1029	0.3690	0.7757
Consumption	0.0193	0.1788	0.4391	0.0207	0.1938	0.4824	0.0206	0.1933	0.4807
Inflation	0.0400	0.0389	0.0197	0.0216	0.0430	0.0415	0.0215	0.0427	0.0414

the nominal fluctuation in inflation. Its action has also significantly raised the fluctuation in its neighbor, Periphery 2, in both real and nominal variables. However, if this action is less persistent, as shown in Case 3, its effect is slightly smaller.

5. Conclusion

With the three-country DSGE model, we examine the quantitative easing of the US on the periphery countries. We emphasize the different policy responses of the Periphery countries to the implementation of QE. When one periphery country maintains stronger control on exchange rate, another periphery country which allows the exchange rate to adjust freely will suffer greater macroeconomic fluctuations.

In the future study, we may further compare the effects under different pricing policies. For instance, both the periphery countries conduct PCP or LCP, to see how

the role of international currency influences the effects of QE on the global economy. We may also examine whether or not the peg to the regional currency would help dampen the direct impacts from the US's quantitative easing.

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國科會補助專題研究計畫項下出席國際學術會議心得報告

日期：101 年 7 月 5 日

計畫編號	NSC 100 － 2410 － H － 004 － 081 －		
計畫名稱	美元本位制下之匯率政策－多國模型下之數量分析		
出國人員 姓名	黃俞寧	服務機構 及職稱	政治大學經濟系助理教授
會議時間	100 年 6 月 29 日至 100 年 7 月 3 日	會議地點	美國舊金山
會議名稱	(中文) (英文) 87th Annual Conference, June 29-July 3, 2012, Hilton San Francisco Union Square		
發表論文 題目	(中文) (英文) Monetary Growth Targeting, the Taylor Rule and Share-Market Stability: The Taiwanese Experience (with Paul McNelis) (英文) The Role of Foreign Direct Investment in Shanghai's Real Estate Price-Culprit or Scapegoat? (with Jr-Tsung Huang and Kuang-Ta Lo)		

一、參加會議經過

本人於當地時間 6 月 28 日晚抵達美國舊金山，29 日與黃智聰教授碰面討論合著文章，並與西雅圖華盛頓大學校友廖珮真副教授、周炳宏助理教授等相聚。30 日時於 WEAI 年會上發表。本次會議本人有兩篇文章發表，"Monetary Growth Targeting, the Taylor Rule and Share-Market Stability: The Taiwanese Experience"一文是與紐約 Fordham University 的 Paul McNelies 教授合著，另一篇"The Role of Foreign Direct Investment in Shanghai's Real Estate Price-Culprit or Scapegoat?"則是與政治大學黃智聰教授與羅光達副教授合著。前者由我報告，後者則由黃智聰教授報告。會議中 Jack Hou 教授、李青教授、黃智聰教授與其他幾位參與者皆對我們的文章提出頗具建設性的建議，有助於我們的文章進行進一步的修改。會後並再與李青教授等人交換貨幣政策與財政政策等相關議題的看法，之後或有合作機會。之後還遇見 University of Washington 的幾位系友，與其交換了許多學術方面的想法。翌日（7 月 1 日）晚間即前往機場，並於 7 月 2 日零晨啟程返回台灣。

二、與會心得

參與此次會議使我獲益良多。參與者多有舊識，除可敘舊之外，更可交換對於國內外學術界、與實務的看法。整體來說，因為此一會議與我的研究有高度相關，參與此一會議，不論是對於目前的學術研究或是未來的研究規劃，包括進一步的貨幣政策、財政政策分析，與目前已在進行的中國大陸研究，皆有相當的助益。目前我所發表的兩篇文章，一篇已經投稿至國際期刊，另一篇亦在持續修改，接近完成階段。而於此次在研討會上所認識的大陸學者與國際學者，我們仍保持密切聯繫，未來當能有更進一步的交流與討論，使在學術研究上有更深更廣的發展。

三、考察參觀活動(無是項活動者略)

四、建議

五、攜回資料名稱及內容

因為所有論文都有電子檔，因此並未攜回書面資料，需要時上網下載即可。

六、其他

Yu-Ning Hwang
Department of Economics
National Chengchi University
, Taipei 116 Taiwan

Saturday, June 30, 2012

[35] 8:15--10:00 a.m.

Allied Organization Session

ECONOMICS IN CHINA AND VIETNAM — (CES-APS)

Organizer: Jack W. Hou, California State University, Long Beach, and Jr-Tsung Huang, Kainan University, and National Chengchi University

Chair: Jack W. Hou, California State University, Long Beach

Papers: Jr-Tsung Huang, Kainan University, and National Chengchi University, and Ching-Wen Yuan, National Chengchi University

The Role of Foreign Direct Investment in Shanghai's Real Estate Price---A Culprit or a Scapegoat?

Qing Li, Renmin University

How China's Individual Income Tax Affects Income Distribution: A Study Based on Data from 2000-2009

Yu-Ning Hwang, National Chengchi University, and Paul D. McNelis, Fordham University

Monetary Growth Targeting, the Taylor Rule and Share-Market Stability: The Taiwanese Experience

Be Thi Ngoc Quyen, National Graduate Institute for Policy Studies, and Minchung Hsu,

Social Security and Demographic Changes in Vietnam

Discussants: Qing Li, Renmin University
Jr-Tsung Huang, Kainan University, and National Chengchi University
Be Thi Ngoc Quyen, National Graduate Institute for Policy Studies
Yu-Ning Hwang, National Chengchi University

Participant Directory

Jack W. Hou
Department of Economics
California State University
1250 Bellflower Boulevard
Long Beach, CA 90840-4607
Day: 562-985-4710
Fax: 562-985-5804
jack.hou@csulb.edu

Jr-Tsung Huang
Department of Public Finance
National Chengchi University
No. 64, Chih-Nan Rd., Sec. 2
Wenshan, Taipei 11623 Taiwan
Day: 886-2-2234-9884
Fax: 886-2-2938-7574
jthuang@nccu.edu.tw

Qing Li
School of Public Administration and
Public Policy
Renmin University of China
No. 59, Zhong Guan Cun Avenue
Beijing, 100872 China
Day: 86-1062511985
Fax:
liqingruc@gmail.com

Yu-Ning Hwang
Department of Economics
National Chengchi University
, Taipei 116 Taiwan
Day: 886-22-939-3091
Fax:
yuning@nccu.edu.tw

Be Thi Ngoc Quyen
2-20-3 Kameari, Katsushika-ku
Tokyo, 124-0002 Japan
Day: 81-8041913586
Fax:
bengocquyen@gmail.com

Monetary Aggregate Targeting and Share Price Volatility: Evidence from Taiwan

Yu-Ning Hwang*and Paul D. McNelis†

June 28, 2012

Abstract

This paper applies counterfactual simulation experiments based on a calibrated model of an open-economy DSGE model for Taiwan. We assess the monetary targeting framework of the Central Bank of the Republic of China realtive to a fixed-rate system practiced in Hong Kong, a Taylor rule used in Korea, and an 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

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. 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. Broad monetary targets remain alive and well in Taiwan, despite the oft quoted phrase of John Crow, former Governor of the Bank of Canada , that we (central bankers) "have not abandoned monetary targets, they abandoned us"[see King (1996), p.4].

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

*Department of Economics, National Chengchi University, Taipei. EMail: yuning@nccu.edu.tw

†Department of Finance, Graduate School of Business Administration, Fordham University, New York 10019.. Email: mcnelis@fordham.edu

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.

The issue of fixed vs. flexible exchane rates, of course, is an old one. A recent contribution, by Lahiri, Singh and Vegh (2007) has drawn attention to the role of asset market segmentation. We know that for real external shocks, and sticky prices, a flexible exchange-rate system dominates a fixed rate system, since exchange-rate flexibility enables relative price adjustment. For monetary shocks, the fixed rate dominates. However, under segmented assets markets, with flexible prices, the opposite result holds. Monetary shocks, due to frictions, imply relative price changes, which require exchange-rate changes, while real shocks, with flexible prices, do not need exchange-rate changes.

Of course most countries, especially emerging markets, have some degree of asset-market segmentation and some degree of price stickiness. Which type of exchange rate system works best?

This paper also draws attention to two types of flexible exchange-regimes, one with broad money targeting and one with inflation targeting.

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. Since headline inflation is readily available to the public, accountability of central bank performance comes to the central of the stage in this framework.

While most of the countries operate interest rate rules, the monetary experiences of Taiwan have demonstrated that monetary targets work well. The macroeconomic fundamentals have remained relatively stable. 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 share price inflation 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, fixed exchange-rate regimes, or exchange-rate management regimes.

Table 1:
Macroeconomic Volatility: Taiwan vs. South Korea

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

To investigate this issue further, this paper investigates the benefit and cost of the monetary targeting relative to a counterfactual inflation-targeting regime, as well as a fixed rate and a managed exchange-rate system, in Taiwan, with a dynamic stochastic general equilibrium models estimated with Bayesian methods. 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. 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. This is the aim of this paper.

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.

In contrast to Scharnagl, Gerberding, and Seitz, we use an open-economy model which includes investment and capital accumulation. We include the financial sector for the liquidity injection by the central bank's monetary aggregate policy with the targeted growth rate of reserve money. On the other hand, the counterfactual experiments focusing on the CPI inflation targeting, away from broad money targeting, neglected the asset price inflation during the period of the Great Moderation. One of the key results we show in this paper is that a monetary targeting framework delivers much lower volatility in Tobin's Q, an indicator or shadow price of assets. Ironically, the focus on inflation targeting, which is more transparent and privdes 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 to the economy.

Thus, the case of Taiwan may have given us a good example of monetary aggregate targeting as an alternative, perhaps "old-fashioned" monetary regime, especially after the widespread financial crisis which has raised questions about the advisability of inflation targeting with interest rate rules. 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 Taiwan would not necesarily be better off if the Central bank followed the policy rules 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

Taiwan is a highly open economy, widely involving in international trades in goods and capital markets. Until the end of 2011, the export is 70% of the GDP and the import is 65% of the GDP, rising from 60% and 55% of export and import shares respectively in 2001. The financial market structure is well structured. In the end of 2011, 78% of the external funds are from the financial intermediary, and 22% is from the direct finance including the stock and bond markets. Thus, a small-open-economy DSGE model with an established financial sector can well characterize Taiwan's 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. The investment variable is a CES aggregate of these two investment goods:

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

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 $\Pi_t = \Pi_t^x + \Pi_t^h$. The household pays taxes on labor income $\tau W_t L_t$ and on consumption $\tau_c C_t$. The following equation gives the household budget constraint (P_t^f is the price of imported goods):

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

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:

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

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 two constraints:

1.

$$W_t L_t + (1 + R_{t-1}^m) M_{t-1} + \Pi_t + R_{t-1}^k K_{t-1} \tag{22}$$

$$= P_t C_t (1+\tau_c) + M_t + \tau W_t L_t + P_t^i I_t + P_t^f \left(\frac{\phi \left(I_t - \delta \overline{K}\right)^2}{2K_t} \right)$$

$$K_t = (1-\delta) K_{t-1} + I_t \tag{23}$$

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 Lagrangean:

$$\underset{\{C_t,L_t,M_t,I_t,K_t\}}{Max}\mathcal{L} = E_t\sum_{\iota=0}^{\infty}\beta^{\iota}\left\{\begin{array}{c} U(\widetilde{C}_{t+\iota}/H_{t+\iota},L_{t+\iota}) \\ -\Lambda_{t+\iota}\left[\begin{array}{c} P_{t+\iota}C_{t+\iota}(1+\tau_c)+M_{t+\iota} \\ -(1+R^m_{t-1+\iota})M_{t-1+\iota} \\ +P^i_{t+i}I^x_{t+i}+ \\ P^i_{t+i}\frac{\phi\left(I_{t+i}-\delta\overline{K}\right)^2}{2K^x_{t+i}} \\ +(\tau-1)W_{t+\iota}L_{t+\iota}-\Pi_{t+i} \\ -R^k_{t+i}K_{t+i} \end{array}\right] \\ -Q_{t+i}\left(K_{t+i}-I_{t+i}-(1-\delta)K_{t-1+i}\right) \end{array}\right\} \tag{24}$$

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:

$$\Lambda_t P_t = \phi_C\left(\widetilde{C}_t\right)^{1-\varkappa-\eta}(H_t)^{\eta-1}(C_t)^{-\varkappa-1}Z^c_t \tag{25}$$

$$\gamma_L L^{\varpi}_t = \Lambda_t(1-\tau)W_t \tag{26}$$

$$\Lambda_t = \beta E_t\Lambda_{t+1}(1+R^m_t) \tag{27}$$

$$Q_t = \beta E_t\left(\Lambda_{t+1}\left(R^k_{t+1}+\beta P^f_{t+1}\frac{\left(\phi\left[I_{t+1}-\delta\overline{K}\right]\right)^2}{2\left(K_t\right)^2}\right)+\beta Q_{t+1}(1-\delta)\right) \tag{28}$$

$$I_t = \delta\overline{K}+\frac{K_t}{\phi}\left(\frac{Q_t}{\Lambda_t}-P^i_t\right) \tag{29}$$

The first equation, Eq. (25), 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. (26), 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

$$Y_t^h = Z_t^h MI_t^{\alpha_h} \left(L_t^h\right)^{1-\alpha_h} \tag{30}$$

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:

$$\begin{aligned} \ln(Z_t^h) &= \rho_{Z^h} \ln(Z_{t-1}^h) + \epsilon_t^h & (31) \\ \epsilon_t^h &\sim N(0, \sigma_h^2 \quad) & (32) \end{aligned}$$

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

$$Y_t^h = C_t^h + G_t \tag{33}$$

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:[1]

$$N_t^h = \mu_h W_t L_t^h, \tag{34}$$

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

$$\Pi_t^h = P_t^h Y_t^h - (1 + \mu_h R_t^n) W_t L_t^h - P_t^{mi} MI_t \tag{35}$$

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:

$$\begin{aligned} \frac{\partial Y_t^h}{\partial L_t^h} &= (1 + \mu_h R_t^n) \frac{W_t}{P_t^h} & (36) \\ \frac{\partial Y_t^h}{\partial MI_t} &= \frac{P_t^{mi}}{P_t^h} & (37) \end{aligned}$$

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

[1] 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.

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

$$MI_t = \left[(1-\gamma_{mi})^{\frac{1}{\theta_{mi}}} \left(MI_t^d\right)^{\frac{\theta_{mi}-1}{\theta_{mi}}} + (\gamma_{mi})^{\frac{1}{\theta_{mi}}} \left(MI_i^f\right)^{\frac{\theta_{mi}-1}{\theta_{mi}}} \right]^{\frac{\theta_{mi}}{\theta_{mi}-1}} \tag{38}$$

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:

$$MI_t^d = (1-\gamma_{mi}) \left(\frac{P_t^x}{P_t^{mi}}\right)^{-\theta_{mi}} MI_t \tag{39}$$

$$MI_t^f = \gamma_{mi} \left(\frac{P_t^f}{P_t^{mi}}\right)^{-\theta_{mi}} MI_t \tag{40}$$

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:

$$P_t^{mi} = \left[(1-\gamma_{mi}) \left(P_t^x\right)^{1-\theta_{mi}} + \gamma_{mi} \left(P_t^f\right)^{1-\theta_{mi}} \right]^{\frac{1}{1-\theta_{mi}}} \tag{41}$$

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:

$$Y_t^x = Z_t^x K_t^{\alpha_x} \left(L_t^x\right)^{1-\alpha_x} \tag{42}$$

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

$$\ln(Z_t^x) = \rho_x \ln(Z_{t-1}^x) + \epsilon_t^x \tag{43}$$

$$\epsilon_t^x \sim N(0, \sigma_x^2) \tag{44}$$

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

$$X_t^* = \rho_{X*} X_{t-1}^* + (1-\rho_{X*})\overline{X^*} + \epsilon_t^* \tag{45}$$

$$\epsilon_t^* \sim N(0, \sigma_{X*}^2) \tag{46}$$

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:

$$\ln(P_t^{x^*}) = \rho_{P^{x*}} \ln(P_{t-1}^{x^*}) + (1 - \rho_{P^{x*}}) \ln(\overline{P}_t^{x^*}) + \epsilon_t^{P^{x^*}} \quad (47)$$

$$\epsilon_t^{P^{x^*}} \sim N(0, \sigma^2_{P^{x*}} \quad) \quad (48)$$

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:

$$N_t^x = \mu_x W_t L_t^x \quad (49)$$

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

$$\Pi_t^x = P_t^x Y_t^x - (1 + \mu_x R_t^n) W_t L_t^x - R_t^k K_t \quad (50)$$

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

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

$$\frac{\partial Y_t^x}{\partial K_t^x} = \frac{R_t^k}{P_t^x} \quad (52)$$

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 :

$$Y_t^f = C_t^f + I_t^f + MI_t^f \quad (53)$$

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:

$$N_t^f = \mu_f(S_t P_t^{f^*} Y_t^f) \tag{54}$$

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:

$$AF_t = \left(1 + \mu_f R_t^n\right) S_t P_t^{f^*} \tag{55}$$

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.[2] This behavior is modelled in a similar manner to the Calvo sticky prices and the model is written in recursive form as:

$$W_t^{num} = (W_t)^{\zeta_w+\zeta_w\varpi}\left(L_t^{1+\varpi}\right) + \xi_w\beta.W_{t+1}^{num} \tag{56}$$

$$W_t^{den} = \left[\phi\left(\widetilde{C}_t\right)^{1-\varkappa-\eta}(H_t)^{\eta-1}(C_t)^{-\varkappa-1}Z_t^c\right](W_t)^{\zeta}L_t + \xi_w\beta.W_{t+1}^{den} \tag{57}$$

$$(W_t^o)^{1+\zeta_w\varpi} = \frac{W_t^{num}}{W_t^{den}} \tag{58}$$

$$W_t = \left[\xi_w(W_{t-1})^{1-\zeta_w} + (1-\xi_w)(W_t^o)^{1-\zeta_w}\right]^{\frac{1}{1-\zeta_w}} \tag{59}$$

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:

$$A_t = \frac{\left(P^{mi}\right)^{\alpha_h}\left[(1+\mu_1 R_t^n)W_t\right]^{1-\alpha_h}}{Z_t^h} \cdot \frac{1}{(\alpha_h)^{\alpha_h}(1-\alpha_h)^{1-\alpha_h}} \tag{60}$$

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}.

[2] 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.

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

$$A_t^{den} = Y_t^h \left(P_t^h\right)^{\zeta} + \beta\xi A_{t+1}^{den} \quad (62)$$

$$P_t^o = \frac{A_t^{num}}{A_t^{den}} + Z_t^P \quad (63)$$

$$\ln(Z_t^P) = \rho_{Z^P} \ln(Z_{t-1}^P) + \epsilon_t^P \quad (64)$$

$$\epsilon_t^P \sim N(0, \sigma_P^2 \quad) \quad (65)$$

$$P_t^{h,b} = P_{t-1}^h \quad (66)$$

$$P_t^h = \left[\xi \left(P_t^{h,b}\right)^{1-\zeta} + (1-\xi)\left(P_t^o\right)^{1-\zeta}\right]^{\frac{1}{1-\zeta}} \quad (67)$$

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 .

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:

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

$$AF_t^{den} = Y_t^f \left(P_t^f\right)^{\zeta} + \beta\xi AF_{t+1}^{den} \quad (69)$$

$$P_t^{f,o} = \frac{AF_t^{num}}{AF_t^{den}} \quad (70)$$

$$P_t^{f,b} = P_{t-1}^f \quad (71)$$

$$P_t^f = \left[\xi_i \left(P_t^{f,b}\right)^{1-\zeta} + (1-\xi_i)\left(P_t^{f,o}\right)^{1-\zeta}\right]^{\frac{1}{1-\zeta}} \quad (72)$$

4 The Financial Sector and Policies

4.1 The Financial Sector

Banks lend to all three types of firms:

$$N_t = N_t^x + N_t^h + N_t^f \quad (73)$$

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 $\overline{B^f}$:

$$\Phi_t = \max\left\{0, \varphi\left[e^{(|B^f_{t-1} - \overline{B^f}|)} - 1\right] B^f_{t-1}\right\} \tag{74}$$

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

In addition to paying deposits the interest rate R^m_t 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.

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

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

$$\begin{aligned} \Pi^B_t &= (1+R_{t-1})B^g_{t-1} + (1+R^n_{t-1})N_{t-1} + S_t B^f_t + M_t \\ & \quad -(1+R^*_{t-1}+\Phi_{t-1})B^f_{t-1}S_t - (1+R^m_{t-1})M_{t-1} \\ & \quad -B^g_t - N_t - \phi_M R_{t-1} M_{t-1} - \phi_N R_{t-1} N_{t-1} \end{aligned} \tag{75}$$

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

$$\underset{\{B^g_t, N_t, M_t, B^f_t\}}{Max} V^B_t = \Pi^B_t + \beta V^B_{t+1}$$

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

$$R_t = R^n_t - \phi_N \tag{76}$$

$$R_t = R^m_t + \phi_M \tag{77}$$

$$(1+R_t)S_t = (1+R^*_t+\Phi_t+\Phi'_t B^f_t)S_{t+1} \tag{78}$$

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.[3]

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

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:

$$
R_t = \rho_r R_{t-1} + (1-\rho_\pi)\rho_\pi \widehat{\pi}_t + (1-\rho_r)\overline{R} \tag{79}
$$

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:

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

$$\begin{aligned}\Delta RES_t &= N_t + B_t + (1 + R_t^* + \Phi_{t-1})B_{t-1}^f S_{t-1} \\ &\quad +(1 + R_t - \phi_M - \phi_M R_t)M_{t-1} - B_t^f S_t \\ &\quad -(1 + R_t + \phi_N - \phi_N R_t)N_{t-1} - M_t - (1 + R_t)B_{t-1} \quad (80)\end{aligned}$$

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:

$$\Delta s_t = \rho_s \Delta s_{t-1} - (1 - \rho_s)\rho_{s\pi}\widehat{\pi}_t + (1 - \rho_r)\overline{\Delta s} \quad (81)$$

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 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:

$$\begin{aligned}G_t &= (1 - \rho_G)\overline{G} + \rho_G G_{t-1} + (1 - \rho_G)\rho_{GY}(Y_{t-1} - \overline{Y}) + \epsilon_{G,t} \quad (82) \\ &\quad \epsilon_{G,t} \tilde{} N(0, \sigma_G^2) \quad (83)\end{aligned}$$

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

$$\begin{aligned}TAX_t &= \tau W_t L_t + \tau_c P_t C_t \quad (84) \\ B_t^g &= (1 + R_{t-1})B_{t-1}^g + P_t^h G_t - TAX_t \quad (85)\end{aligned}$$

4.4 Foreign Assets

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

$$S_t B_t^f = [1 + R_{t-1}^* + \Phi_{t-1}]S_t B_{t-1}^f + P_t^f(C_t^f + I_t^f) - P_t^x(C_t^*) \quad (86)$$

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.[4] $\theta_1 > \theta_2$ 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.

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

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

Table 2: Calibrated Parameters

θ_1Symbol	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
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
ρ_{GY}	Gov. Spending	0
$\rho_{P^{x*}}$	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 productivity shocks to traded and non-traded goods production, then domestic demand shocks to consumption and government spending. 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

				Government Spending			
	Δc	Δp	Δs	r	Δq	Δres	Δm
						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

					Export Demand		
	Δc	Δp	Δs	r	Δq	Δres	Δm
						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, 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 CBC 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.

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 Taylor rule in consumption volatility and greatly reduces share price volatility. For inflation, in this highly open economy, not suprisingly, a fixed rate system works best across a variety of shocks.

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國科會補助計畫衍生研發成果推廣資料表

日期:2012/10/28

國科會補助計畫	計畫名稱: 美元本位制下之匯率政策－多國模型下之數量分析
	計畫主持人: 黃俞寧
	計畫編號: 100-2410-H-004-081- 學門領域: 國際經濟學

無研發成果推廣資料

100 年度專題研究計畫研究成果彙整表

計畫主持人：黃俞寧	計畫編號：100-2410-H-004-081-
計畫名稱：美元本位制下之匯率政策－多國模型下之數量分析	

成果項目			量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
			實際已達成數（被接受或已發表）	預期總達成數(含實際已達成數)	本計畫實際貢獻百分比		
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	1	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	1	0	100%		
國外	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)	無

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

■達成目標

□未達成目標（請說明，以 100 字為限）

□實驗失敗

□因故實驗中斷

□其他原因

說明：

2. 研究成果在學術期刊發表或申請專利等情形：

論文：□已發表 □未發表之文稿 ■撰寫中 □無

專利：□已獲得 □申請中 ■無

技轉：□已技轉 □洽談中 ■無

其他：(以 100 字為限)

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）(以 500 字為限)

本研究是在一個三國（一個大國，兩個週邊國家）的動態隨機一般均衡模型（DSGE）下探討美國的量化寬鬆政策對於其他國家造成的影響。我們引入美元作為國際貨幣的特殊角色，在聯準會施行量化寬鬆之下，探討其他兩國央行採取不同的貨幣政策時，所帶來的不同影響。研究發現，若其中一國採取固定匯率，另一國採取彈性匯率，或是使匯率緩慢調整（一開始會升值，再使其緩慢貶值），則會造成產出下降，但可以減輕通貨膨脹的壓力。此一研究幫助我們瞭解美國量化寬鬆對於台灣的影響；並藉此瞭解我國匯率相較於其他亞洲國家的匯率調整速度與幅度，對於我國經濟的影響。

未來的研究當可持續延伸，作一更為完整的分析，來探討美元作為國際貨幣，其施行量化寬鬆對於國際經濟造成的影響。並可探討處於一有緊密貿易關係的區域經濟之中，台灣當應採取什麼樣的政策來因應來自於大國的量化寬鬆政策。