Monetary and Financial Policies in Emerging Markets

Kosuke Aoki, Gianluca Benigno and Nobuhiro Kiyotaki*

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Abstract

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1 Introduction

In the past few decades, we have observed a significant process of international financial integration characterized by the rising importance of international financial flows and larger gross external assets and liabilities.[1] To what extent does this international financial integration pose challenges for the conduct of monetary and financial policies in open economies, particularly for emerging market economies? How should government conduct policy during global financial booms and recessions?

Following the extraordinarily expansionary monetary policies of major advanced countries in the aftermath of the Global Financial Crisis from 2007, many emerging market economies experienced a large surge of capital inflow. Emerging market economies adopted a variety of policy tools aimed at curbing credit growth.[2] Later on, in May 2013, the opposite situation materialized: following Bernanke's congressional testimony about the possibility that the Federal Reserve would begin normalizing its highly accommodative monetary policy, many emerging economies experienced sharp capital flow

[1] See for example Lane and Milesi Ferretti (2007), Gourinchas and Jeanne (2013), Alfaro, Kalemli-Ozcan and Volosovych (2014) and Avdjiev, Hardy, Kalemli-Ozcan and Serven (2018).

[2] These measure took different forms in various countries. In October 2009, Brazil adopted a tax of 2% on portfolio flows, covering both equities and fixed income securities. The tax on fixed income securities flows, initially set at 2%, was then raised to 4% and shortly afterwards to 6% in October 2010. Turkey in late 2010 increased reserve requirements to temper loan growth. Moreover, starting in June 2011, the banking regulation agency increased risk weights for new general purpose (consumer) loans and raised provisioning requirements for banks with high levels of consumer loans or non-performing consumer loans. In June 2010, the Central Bank of Indonesia announced several policy measures to tame short-term capital inflows, including a one-month minimum holding period of Sertifikat Bank Indonesia (SBIs) debts. Also the central bank increased the maturity range of its debt instruments by issuing longer maturity SBIs (9-month and 12-month from the original 6-month) to encourage investors to hold their securities for longer periods. In addition, new regulations were introduced on banks' net foreign exchange open positions.

reversals. Brazil, Indonesia, India, South Africa and Turkey – dubbed the Fragile Five - were at the center of an emerging markets turmoil. After the Federal Reserve started gradually raising the policy rate from December 2015, the capital flow reversals intensified and caused significant local currency depreciation in many emerging market economies, including the Fragile five and Argentine in the last couple of years. These sharp retrenchments of capital flows, known as sudden stops, posed a different policy trade-offs for these economies. They create pressure for countries to depreciate their currencies, which can boost inflation. Fighting inflation may require tighter monetary policy, which could lower growth assessment.[3] In addition, currency depreciations reduce the net worth of sectors in home country which have outstanding debts denominated in foreign currencies.

These developments have opened a debate about the role of monetary and macroprudential policies. On one end, Rey (2013) suggests not only that international financial integration exposes emerging market economies to new sources of shocks to the economy (the "global financial cycle") but that "*monetary policies are possible if and only if the capital account is managed, directly or indirectly, regardless of the exchange rate regime.*" Obstfeld (2014) on the other hand, asserts still the ability of emerging market economies to conduct their own monetary policy under the flexible exchange rates,

[3] Brazil and Indonesia did start raising interest rates since the spring of 2013 just before Bernanke's testimony. Facing a depreciating currency, Brazil removed the international financial transaction tax on portfolio flows in June 2013. From May 2013 to January 2014, Brazilian policy rate increased from 8% to above 10%. During approximately the same period, Indonesia policy rate increased from just below 6% to almost 8%. Turkey on the other hand hiked the policy rate only in January 2014 by 5.5% in single policy move to contain the pressure on the Turkish Lira. South Africa also raised rate only in January 2014 by a more modest among of 0.5%. During the same period the Reserve Bank of India increased the repo rate from 7.25% to 8%.

but emphasizes how financial globalization has changed the trade-offs that monetary policies in emerging markets face, asserting "*the monetary trilemma remains, but the difficulty of the trade-offs that alternative choices entails can be worsened by financial globalization.*" Indeed, financial stability considerations can alter the policy trade-offs limiting the ability of monetary policy to pursue the standard macro stability objectives. Exchange rate movements could further exacerbates the tension between monetary and financial stability, complicating the policy problem in emerging market economies. The issue, in Obstfeld's view, is about the effectiveness of monetary policy rather than its independence per se.

The aim of this research is to develop a framework to examine the transmission of shocks in emerging market economies and to provide some guidance for policy. To do so, we propose a model of a small open economy integrated into international financial markets. Building upon a conventional New Keynesian open economy framework, we allow for financial intermediaries which fund capital investment by issuing deposit to home households and borrowing from foreigners. The defining feature of our financial intermediaries (we simply call banks) is the fact that home deposits are denominated in home currency while foreign borrowings are denominated in foreign currency. The latter capture "the original sin"[4] phenomenon that affects emerging market economies.[5]

[4]The original sin hypothesis was first defined by Eichengreen and Hausmann (1999) as a situation "in which the domestic currency cannot be used to borrow abroad or to borrow long term even domestically". Later on they refined this hypothesis by referring only to the international dimension of the problem. (See Eichengreen, Hausmann and Panizza (2007)).

[5]Bruno and Shin (2013) and Shin (2013) note that, in the past years, the transmission channel through foreign currency debt operates via the balance sheets of nonfinancial corporation that borrows issuing debt denominated mainly in dollars at times in offshore markets, and lends in the local currency. This currency mismatch emerges once one considers the consolidated balance sheets of the corporate sector exposing the country to changes in global monetary and financial conditions as we will describe

Because of the Keynesian feature, a decline in the policy rate will increase consumption by the standard intertemporal channel, exports by depreciating the currency and will increase investment by lowering its cost. Monetary authority needs to weigh the trade-offs between inflation and output fluctuations. The banking sector of the model creates an important new mechanism through which shocks propagate into our economy: movements in asset prices, nominal price level and exchange rate can amplify the initial impact of a shock by affecting the balance sheet of the banks. The policy problem now becomes more delicate since macroeconomic stability might come at a cost in terms of financial instability.

We first examine how various shocks affect our economy. As a proxy for the global financial cycle, we consider changes in the interest rate the country borrows from foreigners - due to changes in foreign monetary policy and/or the risk premium foreign lenders ask (see Miranda-Agrippino and Rey, 2014). We consider shocks to foreign demand and domestic productivity as nonfinancial shocks. In our model, foreign interest rate shocks generate more volatility in the economy consistent with the idea that emerging market economies are vulnerable to the global financial cycle. The crucial transmission comes from the exchange rate. An increase in the foreign interest rate, leads to a depreciation of the currency that has an expansionary impact via expenditure switching channel initially, but eventually leads to a recession as the depreciation reduces the net worth and intermediation capacity of banks exposed to foreign currency liabilities. Moreover the ensuing higher inflation associated with exchange rate depreciation requires the monetary authority to raise the nominal interest rates that further worsens the balance sheet

below.

of banks and depresses the economy. Despite of banks having worsening balance sheet, they still have to roll over the foreign debts the country accumulated in the past, which leads to further depreciation of local currency. The combination of depreciated currency, declining asset prices, higher inflation and pressure for tighter monetary policy are consistent with the dynamics observed during the "taper tantrum" in 2013 and the turmoil associated with the US monetary policy tightening in the last couple of years.

We then study the effect of macroprudential policy (bank capital requirements and a tax on foreign currency borrowing) and their interaction with monetary policy. Welfare gains from these permanent prudential policies turns out to be relatively modest in our parametrization, because the gain from more stability is offset by the loss from the smaller gains from trade and intermediations. On the other hand, there is a significant welfare gain from cyclical macroprudential policy (a cyclical tax on foreign borrowing), especially when foreign interest rate shocks are more important and nominal prices are more flexible. Not only the cyclical macroprudential policy helps stabilizing the bank balance sheet, but it allows monetary policy to focus on the more traditional macro stability objective and leads to larger welfare gains. If monetary policy pursues a strict inflation targeting without macroprudential policy, it can reduce the welfare when the prices are relatively flexible and external financial shocks are important.

Our paper is related to different strands of literature. The paper follows Gertler and Karadi (2011) and Gertler and Kiyotaki (2011) for the modelling financial intermediation (banking) sector. It is also related to the conventional New Keynesian open economy framework as in Obstfeld and Rogoff (1995) but departs critically from it by considering the balance sheet channels of banks who face financing constraints.

Secondly, it is related to the literature on open economy financial accelerator model such as Aghion, Bachetta and Banerjee (2001) and Gertler, Gilchrist and Natalucci (2007) for the small open economy case.[6] It is also related to literature on macroprudential policy based on the sudden stop model of Mendoza (2010).[7] Most of the analysis (which include Benigno et al. (2012), Bianchi (2011), Bianchi and Mendoza (2010), Jeanne and Korinek (2010), Korinek (2010)) focus on real models in which there is no scope for monetary policy intervention.[8]

There is an emerging and growing literature that studies the interaction between monetary and macroprudential policy in both closed and open economies. Some early contributions include the works by Angeloni and Faia (2013), Kannan, Rabanal, and Scott (2012), Collard, Dellas, Diba and Oisel (2012), Lambertini, Mendicino and Punzi (2011) who analyze closed economy environments and Unsal (2013), Medina and Roldos (2014), Chang, Cespedes and Velasco (2014, 2017) Chang and Velasco (2017) and Davis and Presno (2016) for open economy.[9]

Perhaps a distinctive feature of our analysis is that we consider a small open economy with financial intermediaries when domestic deposit is denominated by home currency and bank foreign borrowing is denominated in foreign currency. In this way, we can analyze the powerful transmission mechanism of external financial shocks and nonfinancial shocks on the macro economy through the fluctuation of foreign exchange rates,

[6] In the context of the financial accelerator open economy literature, Faia (2007) developed a two-country version this class of models.

[7] See Calvo (1998) for an early discussion of the economics of sudden stops.

[8] An exception within this approach is Benigno, Chen, Otrok, Rebucci and Young (2010) and Fornaro (2015).

[9] See also Angelini, Neri and Panetta (2014) and Beau, Clerc and Mojon (2012).

nominal prices and bank balance sheet, and we can explore the role of monetary and macroprudential policies in emerging market economy. Of course, a deeper question is why agents in emerging markets borrow in foreign currency and do not hedge against the exchange rate risk. We take the allocation of exchange rate risk as given in order to explore the transmission of shocks, leaving these questions for future study.[10]

2 Basic Model

2.1 Producers

Final goods is produced from a variety of differentiated intermediate goods y_{it}, $i \in [0,1]$ under perfect competition according to a constant returns to scale technology as

$$Y_t = \left(\int_0^1 y_{it}^{\frac{\eta-1}{\eta}} di \right)^{\frac{\eta}{\eta-1}} \tag{1}$$

where $\eta > 1$. Each differentiated intermediate goods is produced from capital k'_{it}, imported material m_{it} and labor l_{it} as

$$y_{it} = A_t \left(\frac{k'_{it}}{\alpha_K} \right)^{\alpha_K} \left(\frac{m_{it}}{\alpha_M} \right)^{\alpha_M} \left(\frac{l_{it}}{1 - \alpha_K - \alpha_M} \right)^{1-\alpha_K-\alpha_M}$$

where α_K, α_M and $\alpha_K + \alpha_M \in (0,1)$, and A_t is aggregate productivity shock.

[10] There is also a long tradition of "debt deflation" theory of depression, starting from Fisher (1933). It argues the deflation increases the real burden of debtors, redistributes wealth from the debtors to creditors, and deepens the recession, because the marginal propensity to spending is higher for debtors than creditors. See also Tobin (1982), Auclert (2014) and Kaplan, Moll and Violante (2018). There is also a literature which examines the balance sheet effect of the foreign exchange depreciation when some sectors of home economy has foreign currency denominated debts, including Krugman (1999).

The producer of each differentiated intermediate goods is monopolistically competitive and faces a demand curve for its product (which is consistent with final good production function (1)) as

$$y_{it} = \left(\frac{p_{it}}{P_t}\right)^{-\eta} Y_t,$$

where p_{it} is nominal price of goods i and P_t is aggregate price index as

$$P_t = \left(\int_0^1 {p_{it}}^{1-\eta} di\right)^{\frac{1}{1-\eta}}.$$

Let Z_t, ϵ_t and w_t be rental price of capital, the price of imported material (which equals the real exchange rate), and the wage rate in terms of final goods. The minimized unit cost of production is

$$m_t^C = \frac{1}{A_t} {Z_t}^{\alpha_K} {\epsilon_t}^{\alpha_M} {w_t}^{1-\alpha_K-\alpha_M}. \tag{2}$$

The monopolistic producer i chooses a rule of (p_{it}, y_{it}) to maximize the expected discounted value of profit

$$E_0 \left\{ \sum_{t=0}^{\infty} \Lambda_{0,t} \left[\left(\frac{p_{it}}{P_t} - m_t^C \right) y_{it} - \frac{\kappa}{2} \left(\frac{p_{it}}{p_{it-1}} - 1 \right)^2 Y_t \right] \right\}$$

where the quadratic term is the adjustment cost of the price, and $\Lambda_{0,t}$ is the stochastic discount factor of the representative households given below. From the first order condition with respect to p_{it} evaluated under symmetric equilibrium $p_{it} = P_t$, we have

$$(\pi_t - 1)\pi_t = \frac{1}{\kappa}\left(\eta m_t^C + 1 - \eta\right) + E_t\left[\Lambda_{t,t+1} \frac{Y_{t+1}}{Y_t} \pi_{t+1}(\pi_{t+1} - 1)\right], \tag{3}$$

where $\pi_t = \frac{P_t}{P_{t-1}}$ is one plus the inflation rate of the final goods. Log linearly approximating around the non-inflationary steady state in which $\pi = \frac{\eta}{\eta-1} m^C = 1$, we get a usual New Keynesian Phillips curve as

$$\widehat{\pi}_t = \frac{\eta - 1}{\kappa} \widehat{m^C}_t + \beta E_t \left(\widehat{\pi}_{t+1} \right),$$

where $\widehat{x}_t = \left(x_t - x \right) / x$ is the proportional deviation from the steady state value.[11]

Under the symmetric equilibrium, we also learn

$$Y_t = A_t \left(\frac{K_{t-1}}{\alpha_K} \right)^{\alpha_K} \left(\frac{M_t}{\alpha_M} \right)^{\alpha_M} \left(\frac{L_t}{1 - \alpha_K - \alpha_M} \right)^{1-\alpha_K-\alpha_M}, \tag{4}$$

where K_{t-1}, M_t and L_t are aggregate capital stock, imported materials and labor, where

$$K_{t-1} = \int_0^1 k'_{it} di, \quad M_t = \int_0^1 m_{it} di, \quad L_t = \int_0^1 l_{it} di.$$

Here we consider K_{t-1} as aggregate capital stock accumulated by the end of the last period (and the beginning of this period) which can be used for production of this

[11] In a Calvo style model in which each monopolistic producer can change its price according to a Bernoulli process with arrival rate $1 - \omega$, we get the same expression if we choose

$$\kappa = \frac{(\eta - 1)\omega}{(1 - \omega)(1 - \beta\omega)}.$$

We calibrate κ from a standard choice of ω from this relationship. The monopolistic competition of the intermediate goods sector helps explaining why the nominal prices are sticky and why the producers accommodate the demand.

period. The cost minimization implies

$$\frac{\epsilon_t M_t}{Z_t K_{t-1}} = \frac{\alpha_M}{\alpha_K}, \tag{5}$$

$$\frac{w_t L_t}{Z_t K_{t-1}} = \frac{1-\alpha_K-\alpha_M}{\alpha_K}. \tag{6}$$

Capital stock accumulates through investment as

$$K_t = I_t + \lambda K_{t-1}, \tag{7}$$

where $\lambda \in (0,1)$ is one minus constant depreciation rate. The total investment cost equals $\left[1+\Phi\left(\frac{I_t}{I}\right)\right] I_t$ where $\Phi\left(\frac{I_t}{I}\right)$ is the additional production cost of supplying investment goods that is different from the non-stochastic steady state level I, and $\Phi(1) = \Phi'(1) = 0$ and $\Phi"\left(\frac{I_t}{I}\right) > 0$.[12]

We assume that export demand for final goods by foreigners is a decreasing function of relative price of the export and foreign income as

$$E_{Xt} = \left(\frac{P_t}{e_t P_t^*}\right)^{-\varphi} Y_t^* = \epsilon_t{}^{\varphi} Y_t^*, \tag{8}$$

where e_t and $\epsilon_t \equiv (e_t P_t^*/P_t)$ are the nominal and the real exchange rates, P_t^* is foreign nominal price level, φ is a constant price elasticity of foreign demand, and Y_t^* is an

[12] A particular function we use is

$$\Phi\left(\frac{I_t}{I}\right) = \frac{\kappa_I}{2}\left(\frac{I_t}{I} - 1\right)^2.$$

We choose $\Phi"(1) = \kappa_I$ so that the price elasticity of investment is consistent with instrumental variable estimates in Eberly (1997).

exogenous parameter of foreign demand. We assume there is no inflation in foreign country so that

$$P_t^* = P^* = 1.$$

2.2 Households

We follow Gertler and Karadi (2011) and Gertler and Kiyotaki (2011) to develop an infinite horizon macroeconomic model with banking. The representative household consists of a continuum of bankers and workers with the total population size being normalized to be unity. Each banker member manages a bank (financial intermediary) until he/she retires with probability $1 - \sigma$. The retired bankers transfer its remaining net worth as dividend, to the household and are replaced by the equal number of workers who become new bankers. The new bankers receive ξ fraction of total asset from the household as start-up funds in total.

In order to concentrate the financing constraint on banks, we ignore the financing constraint faced by nonfinancial businesses. In other words, banks can provide fund to nonfinancial businesses without financial friction by buying ownership of capital (equity) to receive the rental income and the resale value of capital as the payoff in the next period.

Workers can also directly buy equity but need extra management cost $\chi^h(K_t^h, K_t) = \frac{\varkappa^h}{2}\left(\frac{K_t^h}{K_t}\right)^2 K_t$ in order to receive the same payoff as the banker. A positive parameter $\varkappa^h$ represents the disadvantage of workers relative to bankers in financing businesses. In addition to direct capital holding, workers can save in bank deposit. We assume the deposit contract is nominal, short term and non-contingent. Those who deposit D_t^n

amount of money (or D_t^n/P_t unit of goods) at date t will receive $(1+i_t)D_t^n$ amount of money at date $t+1$ respectively of the state, where i_t is the nominal interest rate on deposit.

Workers cannot directly hold foreign debt nor borrow from foreigners due to lack of expertise and/or capital control.[13] In addition, foreigners do not directly own capital, nor lend to nonfinancial businesses. Therefore, all the financial transaction between home and foreign agents are through home banks. Moreover, we assume all the foreign financial contract is short term, non-contingent and denominated in foreign currency. Thus the home banks face the exchange rate risk.

The representative households chooses consumption C_t, labor supply L_t, direct capital ownership K_t^h and nominal bank deposit to maximize the expected utility[14]

$$E_0\left[\sum_{t=0}^{\infty}\beta^t \ln\left(C_t - \frac{\zeta_0}{1+\zeta}{L_t}^{1+\zeta}\right)\right]$$

subject to the budget constraint

$$C_t + Q_t K_t^h + \chi^h(K_t^h, K_t) + D_t = w_t L_t + \Pi_t + (Z_t + \lambda Q_t)K_{t-1}^h + R_t D_{t-1}.$$

The variable Q_t is equity price in terms of goods, $D_t = D_t^n/P_t$ is the real value of deposit, and $R_t = \frac{1+i_{t-1}}{\pi_t}$ is the gross real interest rate on home deposit from date $t-1$ to date t. The parameters satisfy $0 < \beta < 1$ and $\zeta, \zeta_0 > 0$. The value of Π_t is distribution of real

[13] We consider that typical home residents do not want to hold foreign bonds, because the real interest rate tends to be lower in foreign country than our emerging market economy (unless the incentive to insure against exchange rate risk is large).

[14] We use Greenwood-Hercowitz-Hoffman style utility function in order to capture the procyclical employment in the formal sector of the emerging economy.

profit from production of differentiated goods and investment goods as well as banking:

$$\Pi_t = \int_0^1 \left[\left(\frac{p_{it}}{P_t} - m_t^C \right) y_{it} - \frac{\kappa}{2} \left(\frac{p_{it}}{p_{it-1}} - 1 \right)^2 Y_t \right] di + \left[Q_t - 1 - \Phi \left(\frac{I_t}{I} \right) \right] I_t$$
$$+(1-\sigma) \left[(Z_t + \lambda Q_t) K_{t-1}^b - R_t D_{t-1} - \epsilon_t R_{t-1}^* D_{t-1}^* \right] - \xi (Z_t + \lambda Q_t) K_{t-1}.$$

The first line is profit from production of differentiated goods and investment goods, and the second line is the dividend from the retiring bankers (described below) minus the start-up fund for the entering bankers. There is no profit from final goods production under perfect competition.

The first order conditions for labor, and saving in equity and deposit and investment goods production imply:

$$w_t = \zeta_0 L_t{}^\zeta \tag{9}$$

$$1 = E_t \left(\Lambda_{t,t+1} \frac{Z_{t+1} + \lambda Q_{t+1}}{Q_t + \varkappa^h \frac{K_t^h}{K_t}} \right), \text{ where } \Lambda_{t,\tau} = \beta^{\tau - t} \frac{C_t - \frac{\zeta_0}{1+\zeta} L_t{}^{1+\zeta}}{C_\tau - \frac{\zeta_0}{1+\zeta} L_\tau{}^{1+\zeta}} \tag{10}$$

$$1 = E_t \left(\Lambda_{t,t+1} R_{t+1} \right) \tag{11}$$

$$Q_t = 1 + \Phi \left(\frac{I_t}{I} \right) + \left(\frac{I_t}{I} \right) \Phi' \left(\frac{I_t}{I} \right). \tag{12}$$

2.3 Banks

Figure 1 describes the flow-of-funds of the aggregate economy. Banks fund capital investment (ownership of capital) by issuing deposits to households, borrowing from foreigners and using own net worth. Each banker member manages a bank until retirement. After then, the bank brings back the net worth as dividend. This retirement limits the possi-

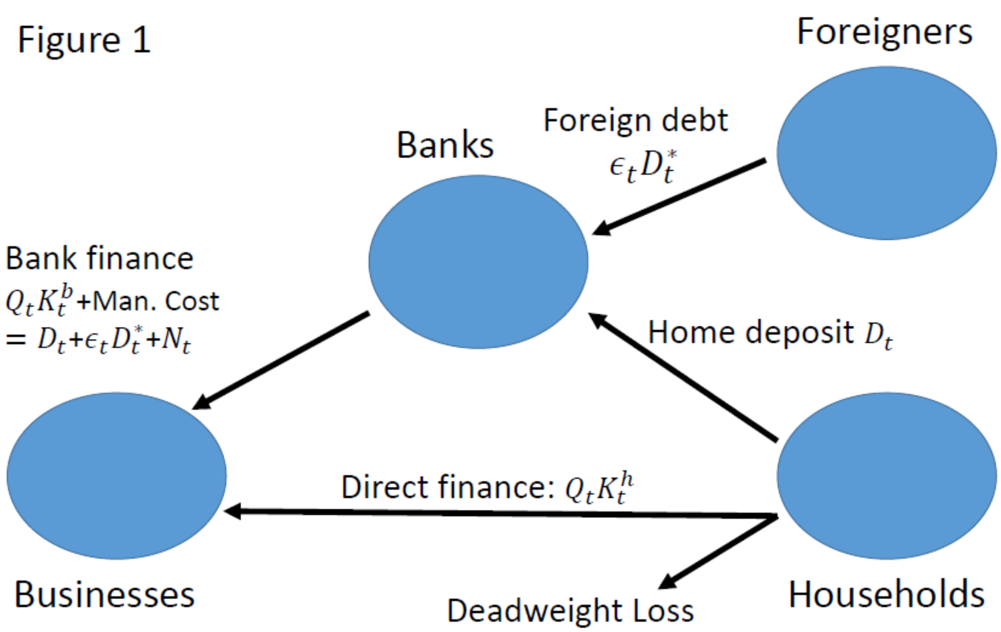

Figure 1: Flow of Funds

bility that banks may save their way out of the financing constraints (described below) by accumulating retained earnings. The objective of the bank is the expected present value of future dividend as

$$V_t = E_t \left[\sum_{j=1}^{\infty} \Lambda_{t,t+j} \sigma^{j-1} (1-\sigma) n_{t+j} \right],$$

where n_{t+j} is net worth (or dividend) of the bank when it retires at date $t+j$ with probability $\sigma^{j-1}(1-\sigma)$ and $\Lambda_{t,t+j}$ is stochastic discount factor of the representative household.

We consider the macroprudential policy as taxes on risky capital holding and foreign borrowing of bankers and subsidy on their net worth. Let τ_t^K and τ_t^{D*} as the tax rate on capital holding and foreign debt, and let τ_t^N be the subsidy rate on net worth.[15] The taxes and subsidy are balanced in the budget in the aggregate.

$$\tau_t^N N_t = \tau_t^K Q_t K_t^b + \tau_t^{D*} \epsilon_t D_t^*, \tag{13}$$

where N_t, K_t^b and D_t^* are aggregate net worth, capital holding and foreign debt of the entire banking sector. The balanced budget makes macroprudential policies similar to flexible bank capital requirement and foreign debt constraints.

The individual bank chooses capital holding, home real deposit and foreign debt, k_t, d_t and d_t^*. To motivate a limit on the bank's ability to raise funds, we introduce the following moral hazard problem: After raising funds and buying assets at the beginning of the period t, but still during the period, the banker decides whether to operate

[15] Gertler, Kiyotaki mand Queralto (2012) consider a smilar policy.

honestly or divert assets for personal use. Operating honestly means holding capital until the payoffs are realized in the next period and then meet the obligations to creditors. To divert means to secretly channel funds away from investment in order to consume personally. We assume banker's ability to divert funds depends upon the sources and the use of funds. Specifically the banker can divert

$$\Theta(x_t) = \theta_0 \exp(-\theta x_t),$$

fraction of assets where $x_t = \frac{\epsilon_t d_t^*}{Q_t k_t}$ is the fraction of assets financed by foreign borrowing and θ_0 and θ are positive parameters. A positive θ implies that the banker can divert a smaller fraction of assets when it raises the foreign funds ($x_t > 0$) and can divert more when saved in abroad ($x_t < 0$). The size of θ measures the degree that foreigner lenders improve the corporate governance of home bankers. Parameter θ_0 represents a severity of the bank moral hazard.

On the other hand, we assume that borrowing from foreigners is costly in terms of resources as

$$\chi^b \left(\epsilon_t d_t^*, Q_t k_t\right) = \frac{\varkappa^b}{2} x_t^2 Q_t k_t, \tag{14}$$

where $\varkappa^b$ is a positive parameter. Thus, even though borrowing from foreigners may be cheaper with relatively low real interest rate and may increase the bank's borrowing capacity, it is increasing costly as the fraction of assets financed by foreign borrowing increases.

Let R_t^* be foreign real gross interest rate from date t to t+1 (which equals the nominal interest rate because we assumed there is no inflation in foreign country). The flow of

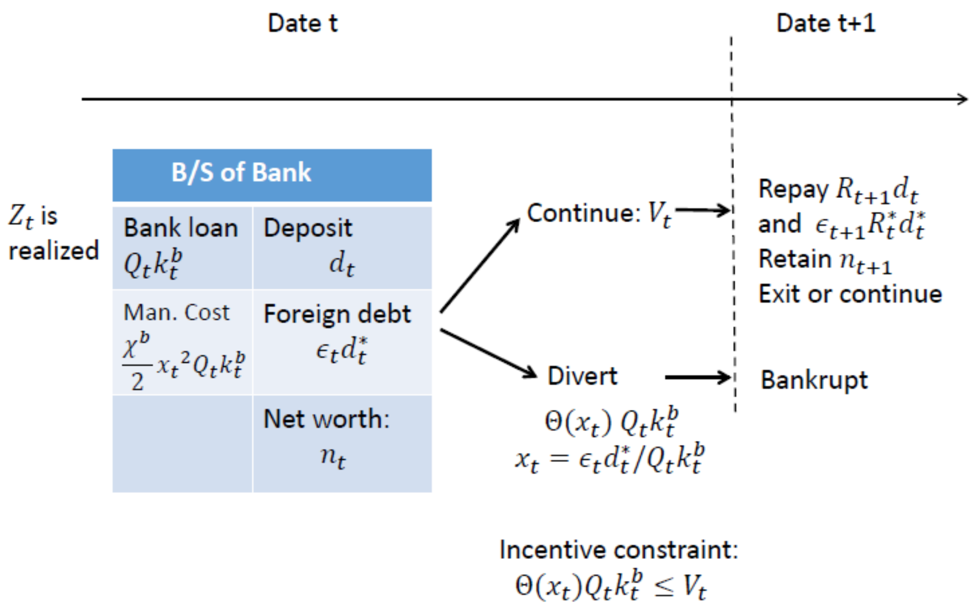

Figure 2: Timing of Banks' Choice

funds constraint of a typical bank is given by:

$$\begin{aligned} \left[1 + \tau_t^K + \frac{\varkappa^b}{2} x_t^2\right] Q_t k_t &= (1 + \tau_t^N) n_t + d_t + (1 - \tau_t^{D*}) \epsilon_t d_t^*, \\ n_t &= (Z_t + \lambda Q_t) k_{t-1} - R_t d_{t-1} - \epsilon_t R_{t-1}^* d_{t-1}^*. \end{aligned} \tag{15}$$

The net worth of a new banker is the initial start-up fund given by the household. Figure 2 describes the timing of the bank's choice.

We assume the process of diverting assets takes time. The banker cannot quickly liquidate a large amount of assets without the transaction being noticed. Thus the banker must decide whether to divert at t prior to the realization of uncertainty at $t+1$. When the banker diverts the asset between dates t and $t+1$, the creditors will force the intermediary into bankruptcy at the beginning of the next period, and banker will loose the franchise completely. The banker's decision boils down to comparing the franchise value of the bank V_t at the end of period t, which measures the present discounted value of future payouts from operating honestly, with the gain from the diverting the funds. In this regard, rational creditors will not supply funds to the banker if he has an incentive to cheat. Any financial arrangement between the bank and its creditors must satisfy the following incentive constraint:

$$V_t \geq \Theta\left(x_t\right) Q_t k_t. \tag{16}$$

Each bank chooses the balance sheet (k_t, d_t, d_t^*) to maximize the franchise value

$$V_t = E_t \left\{\Lambda_{t,t+1}\left[(1-\sigma)n_{t+1} + \sigma V_{t+1}\right]\right\},$$

subject to the balance sheet constraint (15) and the incentive constraint (16).

Because the objective, the balance sheet and the incentive constraint are all constant returns to scale, we can write the value function as

$$\psi_t \equiv \frac{V_t}{n_t} = E_t\left[\Lambda_{t,t+1}(1-\sigma+\sigma\psi_{t+1})\frac{n_{t+1}}{n_t}\right].$$

We can think of ψ_t as Tobin's Q ratio of the bank. Using the balance sheet condition and the definition of the leverage multiple $\phi_t = \frac{Q_t k_t}{n_t}$, we get

$$\frac{n_{t+1}}{n_t} = \frac{Z_{t+1} + \lambda Q_{t+1}}{Q_t}\frac{Q_t k_t}{n_t} - R_{t+1}\frac{d_t}{n_t} - R_t^* \frac{\epsilon_{t+1}}{\epsilon_t}\frac{\epsilon_t d_t^*}{n_t}$$

$$
\begin{aligned}
= & \left[\frac{Z_{t+1}+\lambda Q_{t+1}}{Q_t}-(1+\tau_t^K)R_{t+1}\right]\phi_t+\left[(1-\tau_t^{D*})R_{t+1}-\frac{\epsilon_{t+1}R_t^*}{\epsilon_t}\right]x_t\phi_t \\
& +\left(1+\tau_t^N-\frac{\varkappa^b}{2}x_t^2\phi_t\right)R_{t+1}.
\end{aligned}
$$

Thus the bank chooses (ϕ_t, x_t) to maximize Tobin's Q ratio:

$$
\psi_t = \underset{\phi_t, x_t}{Max}\left[\mu_t\phi_t+\mu_t^*\phi_t x_t+\left(1+\tau_t^N-\frac{\varkappa^b}{2}x_t^2\phi_t\right)\nu_t\right],
$$

subject to the incentive constraint

$$
\psi_t \geq \Theta\left(x_t\right)\phi_t = \theta_0\exp(-\theta x_t)\phi_t,
$$

where

$$
\begin{aligned}
\mu_t &= E_t\left\{\Omega_{t+1}\left[\frac{Z_{t+1}+\lambda Q_{t+1}}{Q_t}-(1+\tau_t^K)R_{t+1}\right]\right\}, && (17)\\
\mu_t^* &= E_t\left\{\Omega_{t+1}\left[(1-\tau_t^{D*})R_{t+1}-\frac{\epsilon_{t+1}}{\epsilon_t}R_{t-1}^*\right]\right\}, && (18)\\
\nu_t &= E_t\left\{\Omega_{t+1}R_{t+1}\right\}, && (19)\\
\Omega_{t+1} &= \Lambda_{t,t+1}(1-\sigma+\sigma\psi_{t+1}).
\end{aligned}
$$

We can regard Ω_{t+1} as the stochastic discount factor of the banker, μ_t as the excess return on capital over home deposit, μ_t^* as the cost advantage of foreign currency debt over home deposit, and ν_t as the marginal cost of deposit. In the following, we restrict our attention to the case in which both μ_t and μ_t^* are strictly positive.

In such case, the incentive constraint is binding and we get

$$\phi_t = \frac{(1+\tau_t^N)\nu_t}{\Theta(x_t) + \frac{\varkappa^b}{2}x_t^2\nu_t - (\mu_t + \mu_t^* x_t)} \quad (20)$$

$$\psi_t = \Theta(x_t)\,\phi_t. \quad (21)$$

$$x_t = \frac{\mu_t^*}{\varkappa^b \nu_t} - \frac{1}{\theta} + \sqrt{\left(\frac{\mu_t^*}{\varkappa^b \nu_t}\right)^2 + \left(\frac{1}{\theta}\right)^2 + 2\frac{\mu_t}{\varkappa^b \nu_t}} = x\left(\frac{\mu_t^*}{\nu_t}, \frac{\mu_t}{\nu_t}\right). \quad (22)$$

We learn the leverage multiple ϕ_t is a decreasing function of a moral hazard parameter θ_0 and an increasing function of $\frac{\mu_t}{\nu_t}$ and $\frac{\mu_t^*}{\nu_t}$. We also know x_t is an increasing function of $\frac{\mu_t}{\nu_t}$ and $\frac{\mu_t^*}{\nu_t}$. (See Appendix A for the detail). Intuitively, if the cost advantage of foreign debt over home deposit and/or the excess return of capital over home deposits large, the bank raises more fund from foreigners

2.4 Market Equilibrium

Output is either consumed, invested, exported, or used to pay the cost of changing prices, managing households's capital and raising funds from foreigners as

$$Y_t = C_t + \left[1 + \Phi\left(\frac{I_t}{I}\right)\right] I_t + E_{Xt} + \frac{\kappa}{2}(\pi_t - 1)^2 Y_t + \chi^h(K_t^h, K_t) + \chi^b(\epsilon_t D_t^*, Q_t K_t^b). \quad (23)$$

GDP equals this output minus the value of import

$$Y_t^{GDP} = Y_t - \epsilon_t M_t.$$

Net output which corresponds to final expenditure is

$$Y_t^{net} = Y_t - \epsilon_t M_t - \frac{\kappa}{2}(\pi_t - 1)^2 Y_t - \chi^h(K_t^h, K_t) - \chi^b(\epsilon_t D_t^*, Q_t K_t^b).$$

Net foreign debt, which equals to the foreign debt of home banks, evolves through net import and the repayment of foreign debt from the previous period as

$$D_t^* = R_{t-1}^* D_{t-1}^* + M_t - \frac{1}{\epsilon_t} E_{Xt}. \tag{24}$$

The aggregate net worth of banks evolves as

$$N_t = \sigma[(Z_t + \lambda Q_t) K_{t-1}^b - R_t D_{t-1} - \epsilon_t R_{t-1}^* D_{t-1}^*] + \xi(Z_t + \lambda Q_t) K_{t-1}. \tag{25}$$

The aggregate balance sheet of the bank is given by

$$Q_t K_t^b \left(1 + \frac{\varkappa^b}{2} x_t^2\right) = \left(1 + \frac{\varkappa^b}{2} x_t^2\right) \phi_t N_t \tag{26}$$

$$= N_t + D_t + \epsilon_t D_t^* \tag{27}$$

$$x_t = \frac{\epsilon_t D_t^*}{Q_t K_t^b}. \tag{28}$$

The market equilibrium for capital ownership (equity) implies

$$K_t = K_t^b + K_t^h. \tag{29}$$

We consider the home nominal interest rate follows a Taylor rule as

$$i_t - i = (1 - \rho_i)\omega_\pi (\pi_t - 1) + \rho_i(i_{t-1} - i) + \xi_t^i. \tag{30}$$

TFP and foreign interest rate and income (A_t, R_t^*, Y_t^*) follow exogenous processes and the policy rule of $\left(\tau_t^{D*}, \tau_t^K\right)$ is specified below. The endogenous state variables are $\left(K_{t-1}, K_{t-1}^b, D_{t-1}, R_{t-1}^* D_{t-1}^*, i_{t-1}\right)$. The recursive competitive equilibrium is given by eight price variables $\left(m_t^C, \pi_t, Z_t, w_t, i_t, \epsilon_t, Q_t, \tau_t^N\right)$, twelve quantity variables (Y_t, M_t, L_t, C_t, I_t, K_t, E_{Xt}, N_t, K_t^b, K_t^h, D_t, D_t^*) and six bank variables $(x_t, \psi_t, \phi_t, \nu_t, \mu_t, \mu_t^*)$ which satisfy twenty six equations $(2 - 13, 17 - 30)$ as functions of the state variables $(K_{t-1}, K_{t-1}^b, D_{t-1},$

$R_{t-1}^* D_{t-1}^*, i_{t-1}, A_t, R_t^*, Y_t^*)$. The household budget constraint is satisfied automatically in equilibrium by Walras' law.

In Appendix, we derive the properties of the competitive equilibrium as well as the non-stochastic steady state (in which there are no stochastic shocks and all variables are constant).

3 Numerical Experiments

Here we describe the baseline calibration without government intervention. We have 16 parameters in the model. Their values are reported in Table 1, while Table 2 shows the non-stochastic steady state values of the equilibrium allocation.

Table 1: Baseline Parameters		
Banks		
θ	elasticity of leverage wrt foreign borrowing	0.1
θ_0	divertable proportion of assets	0.399
σ	survival probability	0.94
ξ	fraction of total assets brought by new banks	0.0046
$\varkappa^b$	management cost for foreign borrowing	0.0219
Households		
β	discount rate	0.985
ζ	inverse of Frisch elasticity of labor supply	0.333
ζ_0	inverse of labor supply capacity	7.883
$\varkappa^h$	cost parameter of direct finance	0.0197
Producers		
α_K	cost share of capital	0.3
α_M	cost share of imported intermediate goods	0.18
λ	one minus depreciation rate	0.98
η	elasticity of demand	9
ω	fraction of non-adjusters $\left(\kappa = \frac{(\eta-1)\omega}{(1-\omega)(1-\beta\omega)}\right)$	0.66
κ_I	cost of adjusting investment goods production	0.67
φ	price elasticity of export demand	1

Table 2: Baseline Steady State (Annual)		
Q	price of capital	1
π	inflation rate	1
R^*	foreign interest rate	1.04
R	deposit interest rate	1.06
R_k	rate of return on capital for bank	1.08
ϕ	bank leverage multiple	4
x	foreign debt-to-bank asset ratio	0.25
$\frac{K}{Y-\epsilon M}$	capital-output ratio	1.98
K^b/K	share of capital financed by banks	0.75
$\frac{\epsilon D^*}{Y-\epsilon M}$	foreign debt-to-GDP ratio	0.372
$Y-\epsilon M$	GDP	10.8
C	consumption	8.15
I	investment	1.6
E_X	export	2.07
ϵM	import	1.92
χ^h	cost of direct finance	0.0123
χ^b	cost of foreign borrowing	0.0103

Most parameters of production and households are relatively standard in macroeconomics models. Parameters of banks are unique to our model. We choose the bank survival rate σ so that the annual dividend payout is $4(1-\sigma) = 24\%$ of net worth.[16] We set $\theta = 0.1$ so that the fraction asset banker can divert decreases by 1% when the fraction of bank asset financed by foreign borrowing increases by 10%. We choose the parameters $(\theta_0, \varkappa^b, \xi)$ to hit the targets in which bank leverage multiple equals 4, the spread between the rate of returns on bank asset and deposit equals 2% annual and the fraction of foreign borrowing is 25% of bank asset in the baseline calibration.[17] We also choose $\varkappa^h$ so that the fraction of capital financed by banks instead of households

[16] This number looks high, but is not high if we include bonus payments to the executives.

[17] We choose a low leverage multiple of banks because we ignore financial friction between banks and non-financial businesses, effectively considering them together.

is 0.75.[18] Of course we keep the same parameters when we change the policy. In the baseline, we choose the mean of foreign real interest rate $R^* = 1.04$ in annual which is lower than home real interest rate of 6% annual.

In the baseline we also choose the coefficient of monetary policy rule as $\omega_\pi = 1.5$ and $\rho_i = 0.8$ (quarterly). The foreign interest rate and log levels of TFP and foreign demand $(R_t^* - 1, \ln A_t, \ln Y_t^*)$ follow independent AR(1) process with serial correlation coefficient of 0.9 (quarterly). In the benchmark example, we choose the standard deviation of innovations of $(R_t^* - 1, i_t)$ to be 1% and 0.5% in annualized rate, that of $(\ln A_t, \ln Y_t^*)$ to be 1.3% and 3% quarterly, and all four shocks are uncorrelated. These numbers are broadly consistent with the literature such as [Mendoza(2010)] and [Avdjiev, Hardy, Kalemli-Ozcan and Serven(2018)]. Given the simplicity of our model, these numerical examples are not precise estimates.

Figure 3 shows the impulse response to the innovation of the foreign interest rate by 1% in annual rate. The impulse response functions are simulated with the first order approximation of the decision rules around the non-stochastic steady state. All the variables are in the log scale so that the changes are in proportion in quarterly, except that home and foreign interest rates and inflation rates are in annual level. The real exchange rates depreciate by 1.8% and export increases by 1.8% - the same magnitude because we set the price elasticity of export to be unity. This mitigates the fall of net output and consumption initially. Because inflation rate rises by 1.2%, the nominal interest rate rises by 0.5% in 2 quarters, leading to a higher real interest rate thereafter.

[18] Given that our capital output ratio of 1.98, the foreign debt to GDP ratio equals 37 percent $(0.25 \times .75 \times 1.98 = 0.37)$.

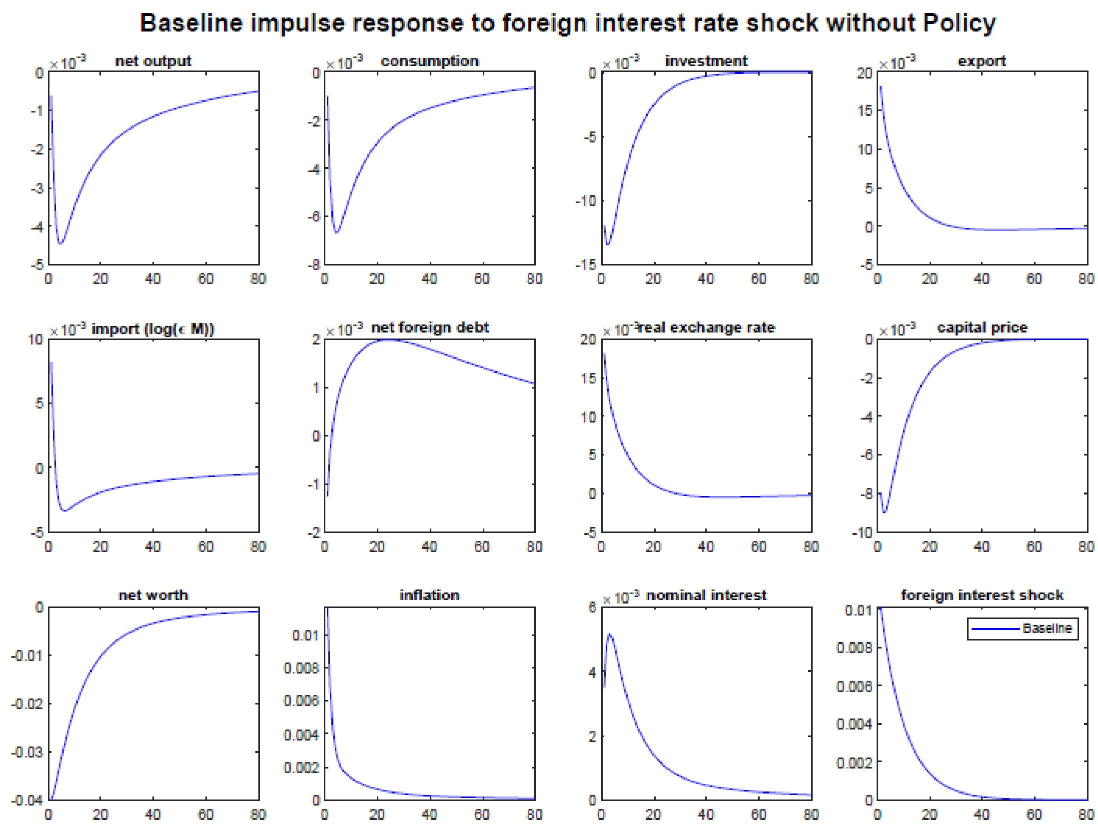

Figure 3: 1% Foreign Interest Rate Shock

Then capital price falls by 0.9% and bank net worth decreases substantially by 4%, due to both the fall of capital price and the exchange rate depreciation with associated ballooning of their foreign debt burden. Because bankers with lower net worth needs to roll over the net foreign debts of the country in equilibrium, currency depreciates further to induce bankers to increase the share of foreign currency debts in the liability. The interaction between the capital price and bank net worth makes the contractionary effect of foreign interest rate hike significant in our economy.[19] Then investment falls by 1.4%. This sends the economy into a persistent recession. At the trough of the recession, net output falls by 0.4% and consumption falls by 0.7%. Concerning the current account adjustment, after the net foreign debt foreign debt initially declines thanks to export expansion, it starts increasing due to higher interest burden before slowing going back to the steady state.

In emerging markets, prices are more flexible than those in developed countries. For example, Gouvea (2007) reports that in Brazil the average duration of prices is between 2.7 and 3.8 months, much shorter than the US estimates.[20] It turns out that the degree of price flexibility has important implications when such emerging economies are hit by foreign interest rate shocks.

Figure 4 presents the impulse response to the foreign interest rate shock of the economy in which the nominal prices are more flexible. The solid line is the flexible

[19] The bank net worth decreases more in proportion as the capital price falls due to the leverage effect of outstanding debts. This further depresses the bank risky asset holding. Because households are less efficient in financing capital, the capital price falls further. See Kiyotaki and Moore (1997) and Gertler and Kiyotaki (2015) for further analysis of financial accelerator through the asset prices.

[20] For example, Nakamura and Steinsson (2007) report the average duration of regular prices is between 8 and 11 months. Also, see Kiley (2000) for cross-country comparison of price flexibility.

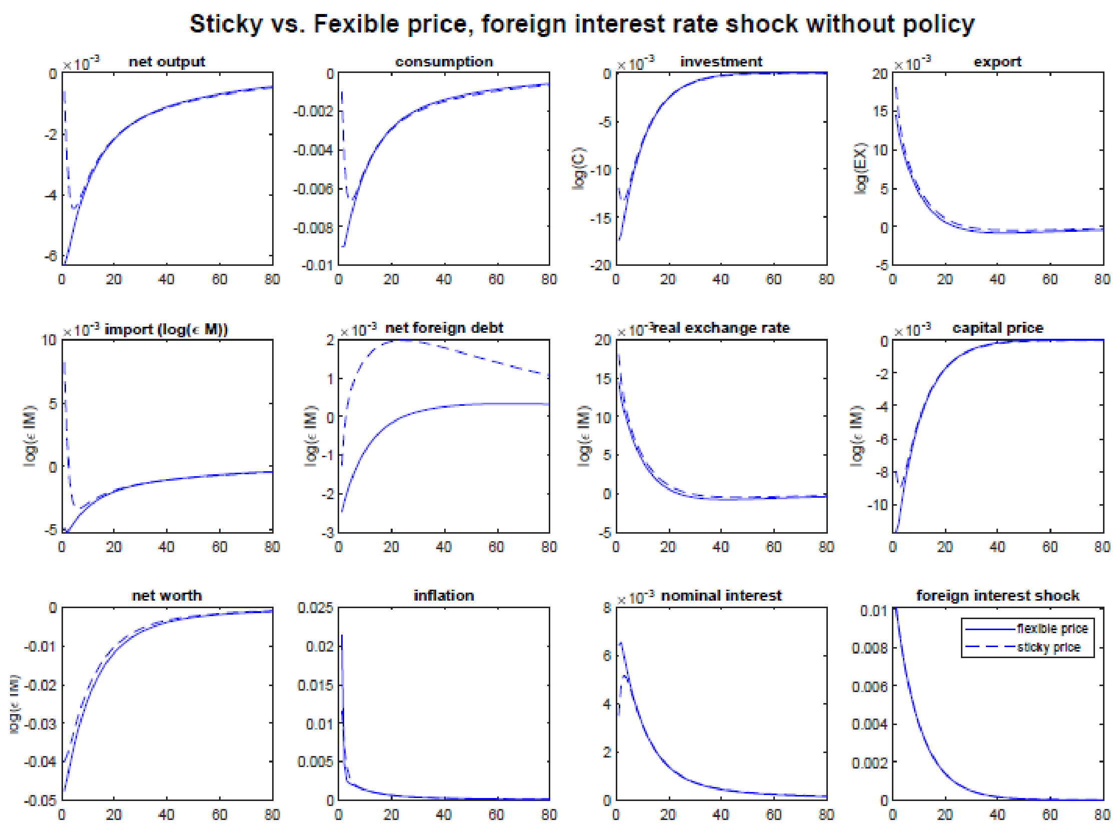

Figure 4: 1% Foreign Interest Rate Shock with more Flexible Prices

price economy where the fraction of monopolistic producers who do not adjust prices within a quarter is only 10% instead of 66% in the baseline (indicated by the dashed line for the comparison). In the more flexible price economy, the foreign interest rate hikes leads to a higher inflation and a sharper rise of the nominal interest rate. Although the real exchange rate depreciation is smaller, capital price falls more, and bank net worth decreases more significantly. As the result, the economy enters into a deeper recession straight away. Here we see the economy with more flexible price suffers more from the foreign interest rate hike (despite of the zero-lower bound of nominal interest rate being not binding), which is different from the lessons of a standard Keynesian literature. The orthodox monetary policy which aims to stabilize the inflation rate tends to worsen the recession triggered by the foreign interest rate hike. The only bright side of the more flexible prices is that the current account tends to improve, mostly due to a sharp import quantity decline.[21]

We discuss the impulse responses to the shocks to the nominal interest rate, TFP and foreign demand as well as the variance decomposition in the Appendix C.

4 Policy Experiments

When the emerging economy is vulnerable to shocks, especially to shocks to the foreign interest rate, it is often argued that we should discourage banks from borrowing in foreign currency. The borrowing in foreign currency is considered as the "original sin."

[21] Import quantity declines by 2%, more than import value (0.5%) due to the exchange rate depreciation.

Another policy recommendation is to discourage banks from holding too much risky assets relative to their net worth by imposing bank capital requirement. In order to analyze the effects of these policies, we consider both permanent and cyclical policies of adjusting taxes on foreign borrowing and risky asset holdings and the subsidy on net worth of banks $\left(\tau_t^{D*}, \tau_t^K, \tau_t^N\right)$.

4.1 Permanent Policy

To examine the effect of policy, we use the second order approximation of the decision rules and the value function around the non-stochastic steady state. The first order approximation is not suitable for policy evaluation because it ignores an important second order issue of risks and because our economy has distortions in the non-stochastic steady state. We consider the standard deviation of shocks to foreign and home interest rates equal 1% and 0.5% in annual rate, and that of log of TFP and foreign demand equal 1.3% and 3%.

In order to examine permanent policy, we assume the economy is at the stochastic steady state without taxes at date t-1.[22] At date t, unanticipatedly, we introduce a policy permanently, and consider how the economy converges to a new stochastic steady state.

Figure 5 shows how the economy converges after government introduces the permanent tax on foreign borrowing of banks by $\tau_t^{D*} = 0.01\%$ at date t in which tax revenue

[22] In a stochastic steady state, individual agents anticipate recurrent arrivals of various shocks and choose the quantities as the function of the state variables; and when aggregate shocks never materialize, the economy settles in the stochastic steady state. There is a bit of contradiction in the stochastic steady state: Even though every agent anticipates aggregate shocks to arrive in future, the shocks never arrive.

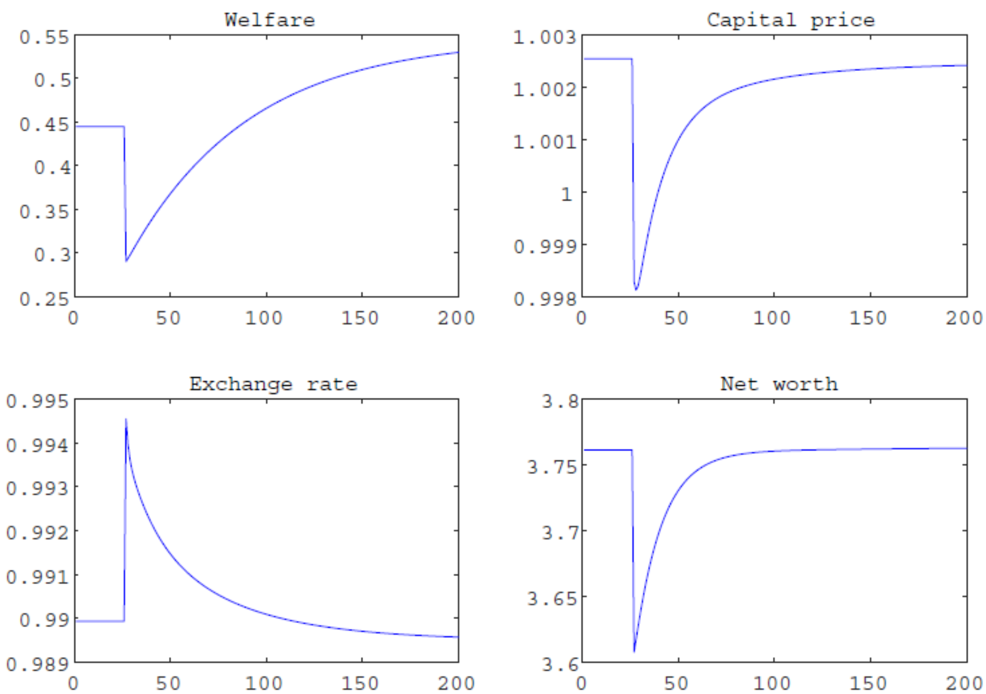

Figure 5: Permanent Tax on Borrowing

is transferred back in proportion to the bank net worth as in (13).[23] The welfare is measured as the expected discounted utility of representative household who have both workers and bankers as its members. In the baseline economy, the welfare decreases with the introduction of the tax on bank foreign borrowing. Even though the allocation improves over time, the initial damage due to mainly the fall in capital price, the real exchange rate depreciation, and associated decrease in bank net worth dominates the future gains in the expected discounted utility calculation.[24] Although the home country becomes less vulnerable to the shocks, it loses the benefit of borrowing cheap from foreigners. Define the consumption equivalence as a percentage change of the initial stochastic steady state consumption (net of disutility of labor) which makes the household indifferent with the economy with introduction of policy at date t. Then the consumption equivalent is -0.0227% in the second order approximation.[25]

Figure 6 shows how the economy converges after government introduces the permanent tax on risky asset holding of banks by $\tau_t^K = 0.01\%$ at date t in which tax revenue is transferred back in proportion to the bank net worth. The representative household looses in welfare with the consumption equivalent of -0.0233% at the time of introduction. Again the welfare loses seem to come from the fall in capital price and exchange rate depreciation and associated decrease in the bank net worth at the time of the in-

[23] We choose the size of tax being small in order to increase the accuracy of the simulation.

[24] The welfare of the new stochastic steady state is higher with a lower foreign debt burden than the old stochastic steady state. But comparing the welfare of two steady states is misleading because people may suffer in the transition. Consider a standard Cass-Koopmans optimal growth model, in which, even if the competitive equilibrium achieves the first best allocation, its steady state welfare and consumption are lower than those in the golden rule steady state.

[25] Although the size of consumption equivalent is small because the size of the tax is small, the elasticity is not so small: If approximation holds for a larger tax change, then 1% permanent increase of the tax on bank foreign borrowing will reduce the welfare by 2.3% in terms of consumption equivalent.

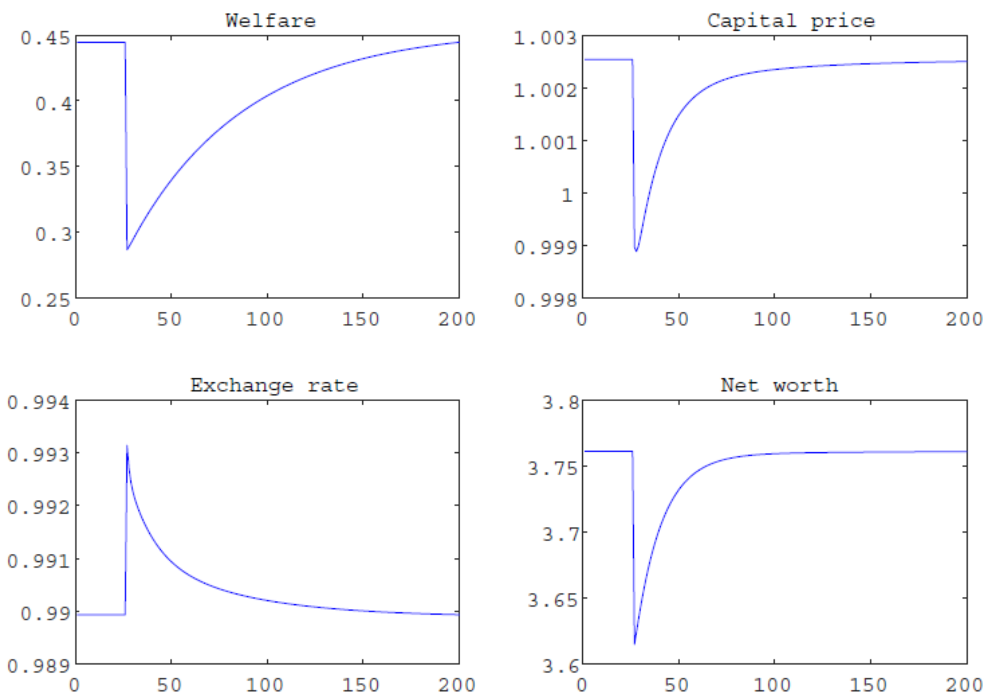

Figure 6: Permanent Tax on Risky Assets

troduction. Eventually economy goes back to very similar but slightly different levels of aggregate quantities and prices.

Although our numerical examples indicate limited scope for welfare improvement by permanent taxes on banks' foreign currency borrowing and risky asset holdings, these results crucially depend upon our setup in which banks can only accumulate their net worth by retained earnings (aside from the modest initial start-up fund) and do not issue new equity.

4.2 Cyclical Policy

From the final goods market equilibrium condition (23) , we observe three distortions: one is the cost of adjusting nominal prices under inflation, $\frac{\kappa}{2}\left(\pi_t - 1\right)^2 Y_t$ (which may be distortion due to the relative price dispersion in Calvo style model), second is the cost of intermediation of households relative to banks, $\chi^h(K_t^h, K_t)$, and the last is the cost for banks to borrow from abroad$\chi^b(\epsilon_t D_t^*, Q_t K_t^b)$. An orthodox policy assignment according to Mundell argues that the monetary policy is responsible to stabilize the inflation rate while the macroprudential policy is responsible to achieve the stable and efficient financial intermediation. In this section, we examine the relative merits of monetary and macroprudential policies in emerging market economy using our framework. For a macroprudential policy we consider government commits to the following cyclical tax (or subsidy) on the foreign debt of the bank:

$$\tau_t^{D*} = \omega_{\tau^{D*}}(\ln K_t^b - \ln K^b). \tag{31}$$

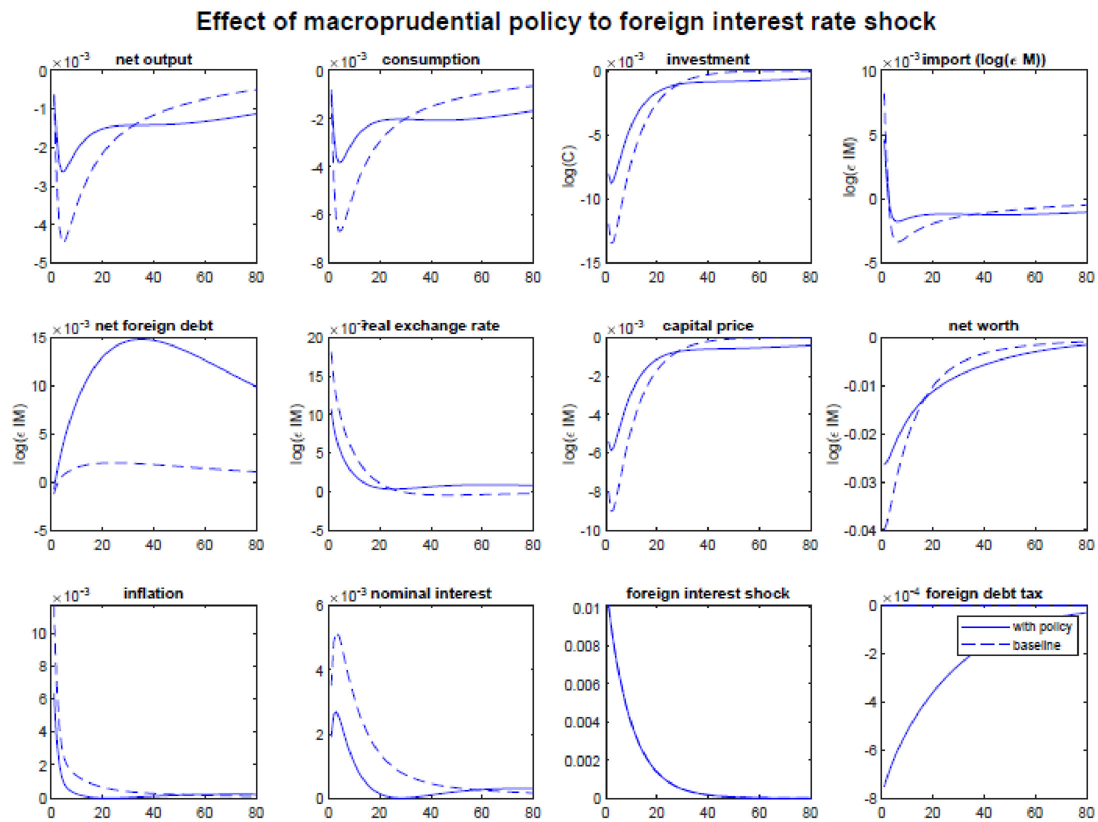

Figure 7: 1% Foreign Interest Rate Shock with Financial Policy

Here, the tax rate on bank foreign debt is an increasing function of the percentage deviation of bank risky asset holding from the non-stochastic steady state. Thus when banks intermediate more to nonfinancial businesses during credit boom, government raises the tax rate on bank foreign debt.

Figure 7 presents the impulse response to a foreign interest rate shock of the economy in which the tax rate on bank foreign debt is adjusted with coefficient of $\omega_{\tau^{D*}} = 0.05$ (the solid line). The dashed line is the baseline economy without such policy. In both economies, monetary policy follows a standard Taylor rule of coefficient of $\omega_\pi = 1.5$.

With an increase in the foreign interest rate, the economy with the macroprudential policy experiences smaller movement in the real exchange rate (1% depreciation instead of 1.8%), inflation rate, nominal interest rate and capital price than the economy without macroprudential policy. As the result, bank net worth and aggregate output and consumption move little, avoiding a deep recession caused by the foreign interest hike in the economy without the macroprudential policy.

Table 3 shows the welfare gains from different combinations of monetary policy and macroprudential policy rule. Each column corresponds alternative macroprudential policy $\omega_{\tau^{D*}} = 0$, 0.005 and 0.01, and each row corresponds alternative Taylor coefficient $\omega_\pi = 1.05, 1.5$ and 2, and the number in the Table is percentage change in welfare in terms of consumption equivalence in the second order approximation relative to the baseline economy of $\omega_{\tau^{D*}} = 0$ and $\omega_\pi = 1.5$.

Table 3: Welfare Effect in Baseline Economy

$\omega_{\tau^{D*}} \diagdown \omega_\pi$	1.25	1.5	2.0
0	-0.310%	0.000%	0.191%
0.01	-0.253	0.060	0.251
0.02	-0.203	0.108	0.294

We observe a relatively modest macroprudential policy of $\omega_{\tau^{D*}} = 0.02$ leads to welfare gains which is equivalent to permanent increase of consumption level by 0.108% when we have a standard monetary policy rule of $\omega_\pi = 1.5$. There are welfare gains from increasing the Taylor coefficient from $\omega_\pi = 1.5$ to 2.0. When the macroprudential policy $\omega_{\tau^{D*}} = 0.02$ is combined with Taylor coefficient of $\omega_\pi = 2$, the welfare gain becomes significant as the consumption equivalent gain equals 0.294%.

Table 4 shows the welfare effect of alternative policy in the economy in which the standard deviation of foreign interest rate shock is twice as large as the baseline economy (while all the other shocks have the same standard deviations).

Table 4: Welfare Effect with Large $var(R_t^*)$

$\omega_{\tau^{D*}} \diagdown \omega_\pi$	1.25	1.5	2.0
0	-0.565%	0.000%	0.299%
0.01	-0.348	0.224	0.532
0.02	-0.144	0.417	0.718

We observe the welfare gains from macroprudential policy is larger than the baseline economy, even though the pattern of welfare effect is similar to the economy. (The gain from having macroprudential policy of $\omega_{\tau^{D*}} = 0.02$ is 0.417% of the steady state net consumption instead of 0.108% in the baseline economy.) The welfare gains from the combination of macroprudential policy and strict inflation targeting ($\omega_{\tau^{D*}} = 0.02$ and $\omega_\pi = 2$) is equivalent to permanent consumption increases by 0.718%.

Table 5 shows the welfare effect of alternative policy in the economy with more flexible price and large shocks to foreign interest rate. The fraction of monopolistic producers who do not adjust prices within a quarter is 0.1 instead of 0.66 in the baseline.

Table 5: Welfare Effect with Flexible Price and Large $var(R_t^*)$

$\omega_{\tau^{D*}} \diagdown \omega_\pi$	1.25	1.5	2.0
0	0.107%	0.000%	-0.120%
0.01	0.227	0.169	0.098
0.02	0.319	0.296	0.257

Under relatively flexible prices, the monetary policy is less effective than the economy under more stick prices. Moreover, the strict inflation targeting tends to reduce the welfare, especially without macroprudential policy. If the monetary authority tries hard to offset the inflationary pressure from the exchange rate depreciation without reducing tax on foreign borrowing of banks, the economy enters into a deeper recession with a foreign interest rate hike. The macroprudential policy mitigates this side effect of monetary policy and improves the welfare. Notice that the welfare gains from introducing macroprudential policy is larger when the Taylor coefficient is larger: The welfare gains from shifting $\omega_{\tau^{D*}}$ from 0 to 0.02 equals $0.257-(-0.120)=0.377\%$ for $\omega_\pi=2$, while it is 0.212% $(=0.319-0.107)$ for $\omega_\pi=1.25$. The above examples show that the macroprudential policy is particularly useful when the external financial shock is large and the nominal price level is relatively flexible.

5 Conclusion

In this paper we propose a framework for studying the interaction between monetary and macroprudential policies for an emerging market economy. Our analysis emphasizes the importance of distinguishing between external financial and nonfinancial shocks. In general external financial shocks generates a volatile response of key macroeconomic variables. From a normative point of view, the combination of external financial shocks with relatively flexible domestic nominal prices creates a scope for a coordination between monetary and cyclical macroprudential policies: a cyclical tax on foreign currency borrowing by banks combined with a relatively strict inflation targeting enhances welfare. Indeed, the same inflation targeting *alone* without macroprudential policy could reduce welfare.

The distinctive feature of our framework is the presence of financial intermediaries (banks) that borrow in foreign currency. We can interpret our "banks" as agents who have access to foreign financial market and can engage in financial intermediation. They could also be interpreted as large nonfinancial corporations that have foreign branches and borrow using offshore accounts (Bruno and Shin (2013)). Under these circumstances the practical implementation of cyclical macroprudential policies might be problematic.

Our framework while capturing some critical features of emerging market economies, abstracts from other relevant aspects. We abstract from a richer specification of international capital flows (home currency denominated debt, currency hedging, equity flows and foreign direct investment) and the role of cross border gross flows that could have a destabilizing role for financial stability. These are topics for future research.

6 Appendix

6.1 Appendix A: Competitive Equilibrium

We first describe the detail of the bank's choice. As described in the text, the bank chooses (ϕ_t, x_t) to maximize Tobin's Q ratio subject to the incentive constraint. Using the Lagrangian

$$\mathcal{L}_t = (1+\lambda_t)\left[\mu_t \phi_t + \mu_t^* x_t \phi_t + \left(1 + \tau_t^N - \frac{\varkappa^b}{2} x_t^2 \phi_t\right) \nu_t\right] - \lambda_t \theta_0 e^{-\theta x_t} \phi_t,$$

the first order conditions with respect to x_t and ϕ_t imply

$$(1+\lambda_t)(\varkappa^b \nu_t x_t - \mu_t^*) = \lambda_t \theta \Theta\left(x_t\right) \tag{32}$$

$$(1+\lambda_t)\left(\mu_t + \mu_t^* x_t - \frac{\varkappa^b}{2} x_t^2 \nu_t\right) = \lambda_t \Theta\left(x_t\right).$$

Combining these, we get

$$F\left(x_t; \frac{\mu_t^*}{\nu_t}, \frac{\mu_t}{\nu_t}\right) = -\theta \frac{\varkappa^b}{2} x_t^2 + \left(\theta \frac{\mu_t^*}{\nu_t} - \varkappa^b\right) x_t + \frac{\mu_t^*}{\nu_t} + \theta \frac{\mu_t}{\nu_t} = 0, \tag{33}$$

where $\mu_t^* \equiv \frac{\mu_{dt}^*}{\mu_t}$. Because $F\left(0; \mu_t^*\right) < 0$, there is a unique $x_t > 0$ which solves this first order condition as

$$x_t = \frac{\mu_t^*}{\varkappa^b \nu_t} - \frac{1}{\theta} + \sqrt{\left(\frac{\mu_t^*}{\varkappa^b \nu_t}\right)^2 + \left(\frac{1}{\theta}\right)^2 + 2\frac{\mu_t}{\varkappa^b \nu_t}} = x\left(\frac{\mu_t^*}{\nu_t}, \frac{\mu_t}{\nu_t}\right).$$

We can check this satisfies the second order condition as we restrict the attention to the case in which $\mu_t^*, \mu_t > 0$. This is condition (22) in the text. We observe $x\left(\frac{\mu_t^*}{\nu_t}, \frac{\mu_t}{\nu_t}\right)$ is an increasing function of $\frac{\mu_t^*}{\nu_t}$ and $\frac{\mu_t}{\nu_t}$ as we argue in the text.

Using the government budget constraint, we find in the equilibrium that

$$\begin{aligned} \psi_t &= E_t\left\{\Omega_{t+1}\left[\left(R_{t+1}^b - R_{t+1}\right)\phi_t + \left(R_{t+1} - \frac{\epsilon_{t+1}}{\epsilon_t} R_t^*\right) x_t \phi_t + \left(1 - \frac{\varkappa^b}{2} x_t^2 \phi_t\right) R_{t+1}\right]\right\} \\ &= \Theta\left(x_t\right)\phi_t, \end{aligned}$$

or

$$\phi_t = \frac{E_t\left(\Omega_{t+1}R_{t+1}\right)}{\Gamma_t\left(x_t\right)}, \text{ where} \tag{34}$$

$$\Gamma_t\left(x_t\right) \equiv \Theta\left(x_t\right) - E_t\left\{\Omega_{t+1}\left[R^b_{t+1} - R_{t+1} + \left(R_{t+1} - \frac{\epsilon_{t+1}}{\epsilon_t}R^*_t\right)x_t - \frac{\varkappa^b}{2}x_t^2 R_{t+1}\right]\right\}.$$

Using (32), we have

$$\begin{aligned}\Gamma'_t\left(x_t\right) &= -\theta\Theta\left(x_t\right) + \varkappa^b\nu_t x_t - \mu^*_t \\ &= \left(1 - \frac{1+\lambda_t}{\lambda_t}\right)\left(\varkappa^b\nu_t x_t - \mu^*_t\right) \\ &< 0,\end{aligned}$$

in the neighborhood of $\tau^K_t = \tau^{D*}_t = 0$. Because we know x_t is an increasing function of $\frac{\mu^*_t}{\nu_t}$ and $\frac{\mu_t}{\nu_t}$, or a decreasing function of τ^K_t and τ^{D*}_t, we learn from (34) that the leverage multiple is a decreasing function of τ^K_t and $\tau^{D*}_t i$ in the neighborhood of$\tau^K_t = \tau^{D*}_t = 0$..

Next we organize a little more of the competitive equilibrium. We can solve (12) with respect to $\widehat{I}_t = \frac{I_t - I}{I}$ as

$$\widehat{I}_t = \widehat{I}(Q_t)$$

For the case of the quadratic adjustment cost $\Phi\left(\frac{I_t}{I}\right) = \frac{\kappa_I}{2}\widehat{I}_t^2$, we can solve (12) explicitly as

$$\frac{1}{\kappa_I}(Q_t - 1) = \frac{1}{2}\widehat{I}_t^2 + \widehat{I}_t\left(\widehat{I}_t + 1\right),$$

or

$$\widehat{I}_t = \widehat{I}(Q_t) = \frac{1}{3}\left[-1 + \sqrt{1 + \frac{6}{\kappa_I}(Q_t - 1)}\right].$$

Then capital accumulation becomes

$$K_t = \lambda K_{t-1} + [\widehat{I}(Q_t) + 1]I. \tag{35}$$

The goods market equilibrium becomes

$$\begin{aligned} & \left[1 - \frac{\kappa}{2}(\pi_t - 1)^2\right] Y_t - \chi^h(K_t^h, K_t) - \chi^b(\epsilon_t D_t^*, Q_t K_t^b) \\ = \;& C_t + [1 + \frac{\kappa_I}{2}\widehat{I}(Q_t)^2][\widehat{I}(Q_t) + 1]I + \epsilon_t^{\varphi} Y_t^* \end{aligned} \tag{36}$$

From $(5, 6, 9)$, we learn

$$\begin{aligned} M_t &= \frac{\alpha_M}{\alpha_K}\frac{Z_t K_{t-1}}{\epsilon_t}, \\ L_t^{1+\zeta} &= \frac{1 - \alpha_K - \alpha_M}{\alpha_K}\frac{Z_t K_{t-1}}{\zeta_0}. \end{aligned}$$

Together with (4), we get

$$Z_t = \left\{ \left(\frac{\epsilon_t^{\alpha_M} Y_t}{A_t}\right)^{1+\zeta} \left(\frac{\alpha_K}{K_{t-1}}\right)^{1+\zeta(\alpha_K+\alpha_M)} \left[(1 - \alpha_K - \alpha_M)^{\zeta}\zeta_0\right]^{1-\alpha_K-\alpha_M} \right\}^{\frac{1}{1-\alpha_K+\zeta\alpha_M}}. \tag{37}$$

Together with $(2, 9)$, we get

$$m_t^C = \left\{ \left[\frac{\epsilon_t^{\alpha_M}}{A_t}\left(\frac{\alpha_K Y_t}{K_{t-1}}\right)^{\alpha_K}\right]^{1+\zeta} [(1 - \alpha_K - \alpha_M)^{\zeta} Y_t^{\zeta}\zeta_0]^{1-\alpha_K-\alpha_M} \right\}^{\frac{1}{1-\alpha_K+\zeta\alpha_M}}. \tag{38}$$

We observe the marginal cost is an increasing function of aggregate output because capital stock is fixed in the short run and because labor supply is not perfectly elastic. The current account balance is modified to

$$D_t^* = R_{t-1}^* D_{t-1}^* + M_t - \epsilon_t^{\varphi-1} Y_t^* \tag{39}$$

where

$$M_t = \alpha_M \left\{ \left[\frac{Y_t}{A_t} \left(\frac{\alpha_K}{K_{t-1}} \right)^{\alpha_K} \right]^{1+\zeta} \left[\frac{(1-\alpha_K-\alpha_M)^{\zeta} \zeta_0}{\epsilon_t} \right]^{1-\alpha_K-\alpha_M} \right\}^{\frac{1}{1-\alpha_K+\zeta\alpha_M}},$$

from $(5, 37)$.

Then the equilibrium is defined as 7 prices $(Q_t, m_t^C, \epsilon_t, i_t, \pi_t, Z_t, \tau_t^N)$ and 8 quantities $(Y_t, C_t, N_t, K_t, K_t^h, K_t^b, D_t, D_t^*)$ and 6 bank variables $(\mu_t, \mu_t^*, \nu_t, \phi_t, \psi_t, x_t)$ as functions of the state variables $(K_{t-1}, K_{t-1}^b, D_{t-1}, R_{t-1}^* D_{t-1}^*, i_{t-1}, A_t, R_t^*, Y_t^*)$ which satisfies 21 equations $(3), (10, 11, 13), (17-22), (25-30)\ (35-39)$.

6.2 Appendix B: Steady State

In the non-stochastic steady state equilibrium, we have

$$\begin{aligned} Q &= 1, \\ R &= \frac{1}{\beta}. \end{aligned}$$

Define the discounted spreads as

$$
\begin{aligned}
s &\equiv \beta(Z+\lambda)-1, \\
s^* &\equiv 1-\beta R^*,
\end{aligned}
$$

where s is endogenous and s^* is exogenous in the steady state. From (10) , we have

$$\frac{K^h}{K}=\frac{s}{\varkappa^h}$$

Because, in the steady state, we have

$$
\begin{aligned}
\frac{\mu^*}{\nu} &= s^*-\tau^{D*} \\
\frac{\mu}{\nu} &= s-\tau^K,
\end{aligned}
$$

we get

$$x=\frac{s^*-\tau^{D*}}{\varkappa^b}-\frac{1}{\theta}+\sqrt{\left(\frac{s^*-\tau^{D*}}{\varkappa^b}\right)^2+\left(\frac{1}{\theta}\right)^2+2\frac{s-\tau^K}{\varkappa^b}}=x(s;s^*,\tau^{D*},\tau^K).$$

Because of the balanced budget condition on taxes and subsidy of government, we learn

$$
\begin{aligned}
G &\equiv \frac{n_{t+1}}{n_t} = [Z + \lambda - R]\phi + [R - R^*]\,\phi x + R \\
&= \frac{1}{\beta}[p(s; s^*, \tau^{D*}, \tau^K)\phi + 1], \text{ where} \\
p(s; s^*, \tau^{D*}, \tau^K) &\equiv s + s^* x - \frac{\varkappa^b}{2} x^2 : \text{ return premium.}
\end{aligned}
$$

From (25) , we get

$$
\begin{aligned}
\beta &= \sigma \beta G + \xi(1+s)\phi \frac{1}{1 - \frac{K^h}{K}} \\
&= \sigma + \left[\sigma p(s; s^*, \tau^{D*}, \tau^K) + \xi \frac{1+s}{1 - \frac{s}{\varkappa^h}}\right]\phi,
\end{aligned}
$$

or

$$
\phi = \frac{\beta - \sigma}{\sigma p(s; s^*, \tau^{D*}, \tau^K) + \xi \frac{1+s}{1 - \frac{s}{\varkappa^h}}}.
$$

We also learn

$$
\begin{aligned}
\psi &= \beta(1 - \sigma + \sigma\psi)G \\
&= \frac{(1-\sigma)[p(s; s^*, \tau^{D*}, \tau^K)\phi + 1]}{1 - \sigma - \sigma p(s; s^*, \tau^{D*}, \tau^K)\phi} \\
&= \Theta(x)\phi.
\end{aligned}
$$

Putting together, we get

$$
\begin{aligned}
0 &= H(s; s^*, \tau^{D*}, \tau^K) \\
&= (1-\sigma)\left[\beta p(s; s^*, \tau^{D*}, \tau^K) + \xi \frac{1+s}{1-\frac{s}{\varkappa^h}}\right]\left[\sigma p(s; s^*, \tau^{D*}, \tau^K) + \xi \frac{1+s}{1-\frac{s}{\varkappa^h}}\right] \\
&\quad -\Theta(x)(\beta-\sigma)\left[\sigma(1-\beta) p(s; s^*, \tau^{D*}, \tau^K) + (1-\sigma)\xi \frac{1+s}{1-\frac{s}{\varkappa^h}}\right].
\end{aligned}
$$

When $\theta, \tau^{D*}, \tau^K \to 0$, we have

$$
p(s; s^*, \tau^{D*}, \tau^K) \to s + \frac{s^{*2}}{2\varkappa^b},
$$

and

$$
\begin{aligned}
H(s; s^*, 0, 0) &= (1-\sigma)\left[\beta\left(s + \frac{s^{*2}}{2\varkappa^b}\right) + \xi \frac{1+s}{1-\frac{s}{\varkappa^h}}\right]\left[\sigma\left(s + \frac{s^{*2}}{2\varkappa^b}\right) + \xi \frac{1+s}{1-\frac{s}{\varkappa^h}}\right] \\
&\quad -\theta_0(\beta-\sigma)\left[\sigma(1-\beta)\left(s + \frac{s^{*2}}{2\varkappa^b}\right) + (1-\sigma)\xi \frac{1+s}{1-\frac{s}{\varkappa^h}}\right].
\end{aligned}
$$

Then as $\xi \to 0$, we have

$$
s + \frac{s^{*2}}{2\varkappa^b} \to \theta_0 \frac{(\beta-\sigma)(1-\beta)}{\beta(1-\sigma)}.
$$

Thus we learn that there exists a unique steady state equilibrium with positive spread $s > 0$ for a small enough (s^*, ξ) and the tax rates. Due to the constant returns to scale property of the bank operation, we learn that bank variables (s, x, ϕ, ψ) depend upon only the parameters of banker $\left(s^*, \tau^{D*}, \tau^K, \theta_0, \theta, \xi, \beta, \sigma\right)$, not the parameters of productions in the steady state.

Once we find the equilibrium value of s, we get

$$Z = \frac{1}{\beta}(1+s) - \lambda.$$

Then we have

$$\frac{K^h}{K} = \frac{s}{\varkappa^h}.$$

Also, from $(2, 4, 5, 6)$, we have

$$m^C = 1 - \frac{1}{\eta} = \frac{Z}{\alpha_K}\frac{K}{Y},$$

or

$$\frac{K}{Y} = \left(1 - \frac{1}{\eta}\right)\frac{\alpha_K}{Z}.$$

Then from (38), we get

$$\left(1 - \frac{1}{\eta}\right)^{1-\alpha_K+\zeta\alpha_M} = \left[\frac{\epsilon^{\alpha_M}}{A}\left(\frac{\alpha_K Y}{K}\right)^{\alpha_K}\right]^{1+\zeta}\left[(1-\alpha_K-\alpha_M)^{\zeta} Y^{\zeta}\zeta_0\right]^{1-\alpha_K-\alpha_M}.$$

Thus we find

$$Y = \frac{1}{(1-\alpha_K-\alpha_M)\zeta_0^{1/\zeta}}\left[\left(1-\frac{1}{\eta}\right)^{1+\zeta(\alpha_M+\alpha_K)}\left(\frac{A}{\epsilon^{\alpha_M}Z^{\alpha_K}}\right)^{1+\zeta}\right]^{\frac{1}{\zeta(1-\alpha_K-\alpha_M)}}.$$

$$\begin{aligned} I &= (1-\lambda)K \\ &= (1-\lambda)\left(1-\frac{1}{\eta}\right)\frac{\alpha_K}{Z}Y. \end{aligned}$$

Then from the current account relationship,

$$\begin{aligned}\frac{\epsilon^{\varphi}Y^{*}}{Y} &= \frac{\epsilon M}{Y}+(R^{*}-1)\,\frac{\epsilon D^{*}}{Y}\\ &= \alpha_{M}\left(1-\frac{1}{\eta}\right)+(R^{*}-1)\,x(s)\left(1-\frac{s}{\varkappa^{h}}\right)\frac{K}{Y}.\end{aligned}$$

Then we have

$$\frac{C}{Y}=1-(1-\lambda)\,\frac{K}{Y}-\frac{\epsilon^{\varphi}Y^{*}}{Y}-\frac{s^{2}}{2\varkappa^{h}}\frac{K}{Y}-\frac{\varkappa^{b}}{2}x(s)^{2}\left(1-\frac{s}{\varkappa^{h}}\right)\frac{K}{Y}.$$

6.3 Appendix C

Figure A1 shows the impulse response to the innovation of nominal interest rate by 1%. Because our economy has relatively flexible nominal price, the inflation rate falls by 1.4%. Because the nominal interest rate reacts to the inflation instantaneously, it rises by 0.6%. Net output fall by 1.1%, consumption falls by 1.5%, investment falls by 1.2% and import value falls by 2.4%. Capital price falls by 0.8%, real exchange rate appreciates by 0.6%, and the bank net worth falls significantly by 3.5%. The interaction between the capital price and bank net worth makes the contractionary effect of monetary policy significant in out economy.

Figure A2 shows the impulse response to the innovation of TFP by 1%.

Net output, consumption and export increase by a little more than 1%, while real exchange rate depreciates by a similar magnitude. Investment rises by 1.6%. Because

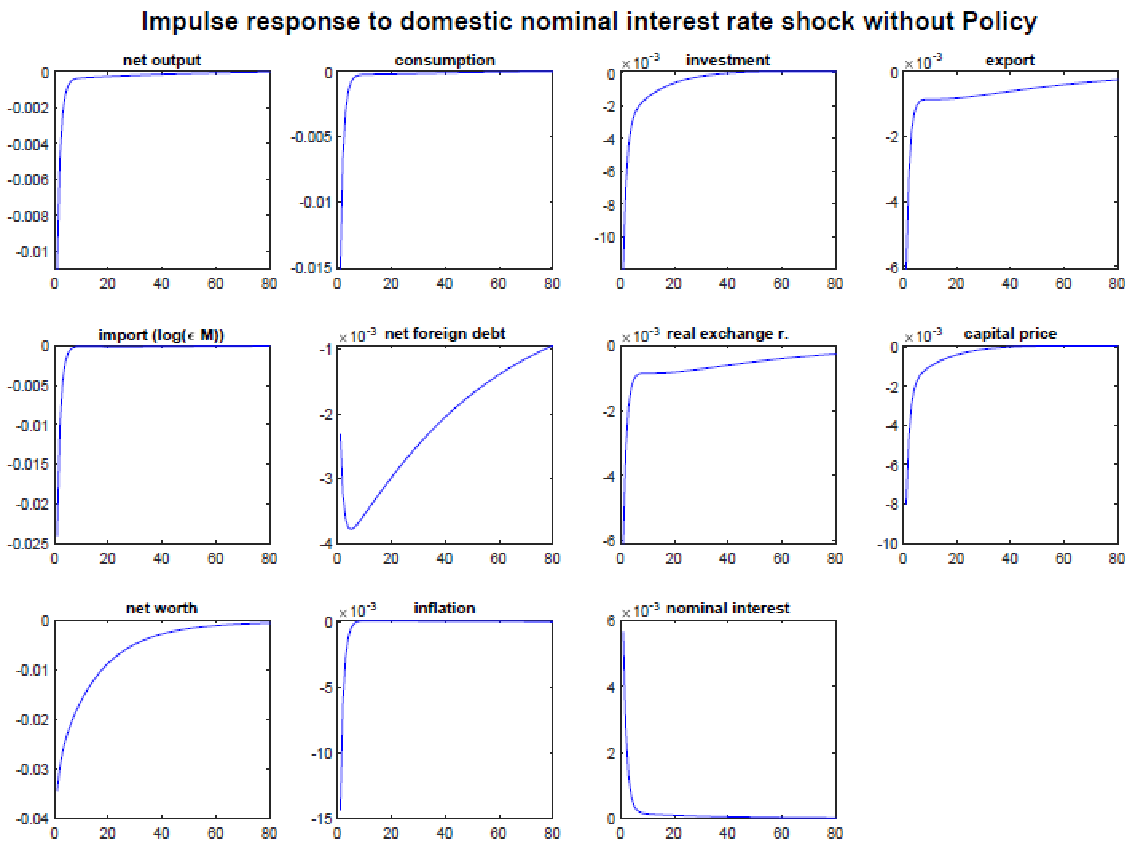

Figure A1: 1% Domestic Nominal Interest Rate Shock

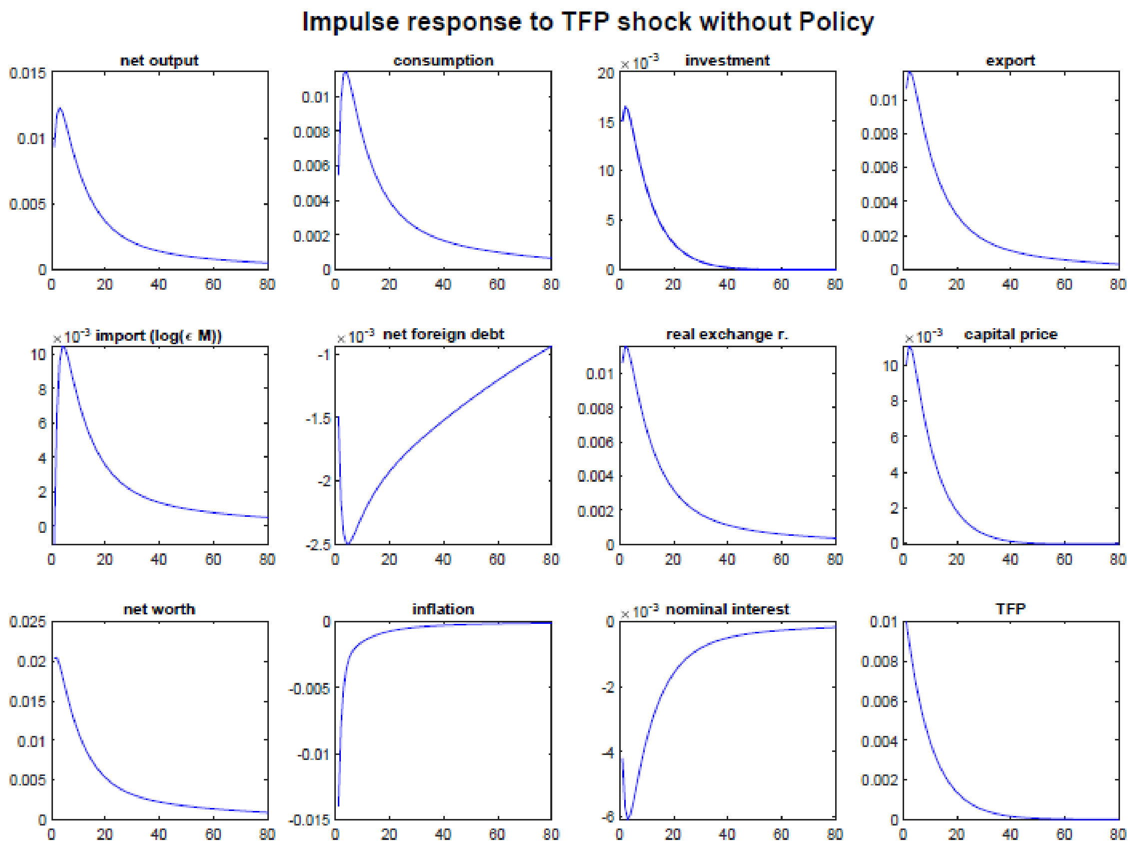

Figure A2: 1% Domestic Productivity Shock

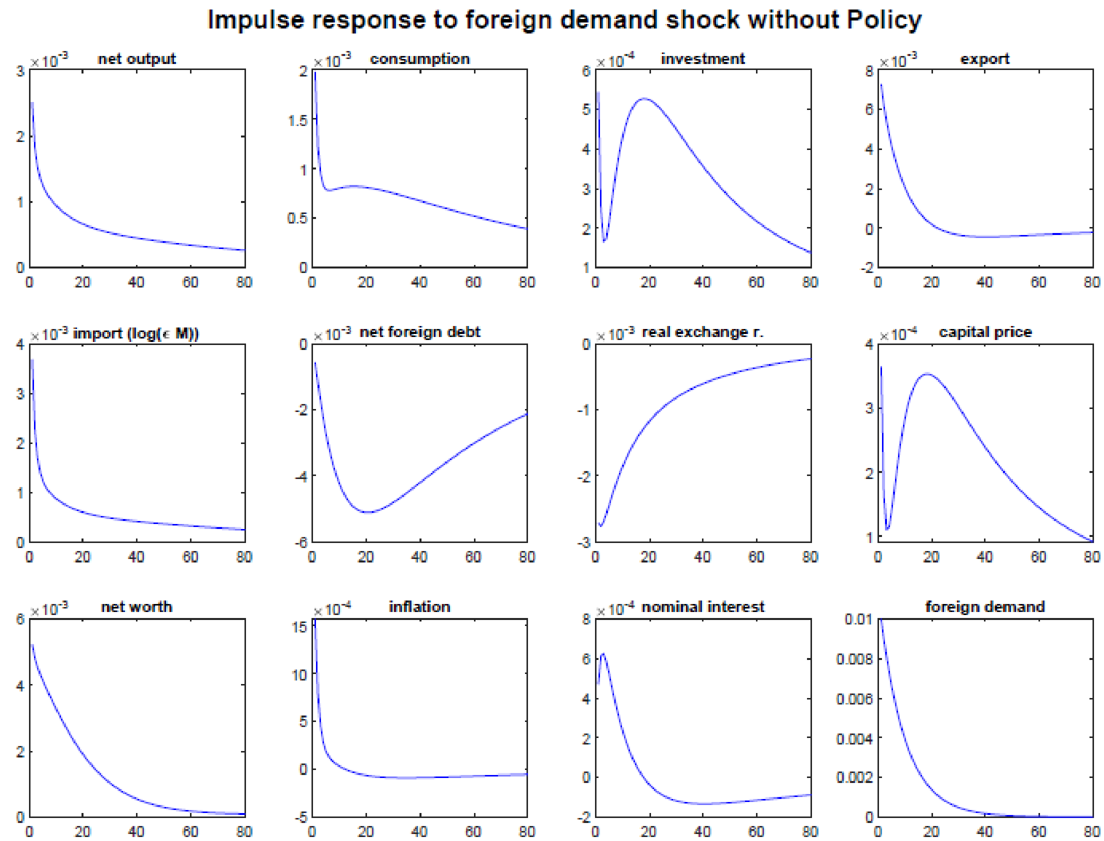

Figure A3: 1% Foreign Demand Shock

TFP shock is a supply shock, inflation falls by 1.4% and nominal interest rate falls by 0.6% in 2 quarter. The capital price rises by 1.1% and bank net worth increase by 2%. The economy enters into a boom driven by the productivity improvement.

Figure A3 shows the impulse response to the innovation of foreign demand by 1%. With the increase of foreign demand, export increases by 0.8% despite of real exchange rate appreciation of 0.3%. With currency appreciation and increasing demand offset each other, inflation rate increases by 0.15% and nominal interest rate falls by 0.06%.

The price of capital increases by 0.03% and investment increase by 0.5%, and bank net worth increases by 0.5%. Net output, consumption and import all increase by about 0.2-0.3%. Because the increase of export exceeds that of import, net foreign debt decreases over time. The economy enters into a boom driven by the export expansion.

If we assume the innovation of shocks to foreign interest rate, home nominal interest rate, TFP and foreign demand are orthogonal, we can compute how much each shock contributes the fluctuation of endogenous variables. Table A1 reports the variance decomposition of the baseline economy in which the standard deviations of innovation of annualized foreign and home interest rates and log levels of TFP and foreign demand are $1\%, 0.5\%, 1.3\%$ and 3% respectively:[26]

Table A1: Variance Decomposition of Baseline Economy

	R_t^*	i_t	A_t	Y_t^*
$\ln Y_t$	8.0	1.7	79.3	11.0
π_t	26.6	7.0	62.5	3.9
$\ln \epsilon_t$	28.4	0.5	49.7	21.4
$\ln Q_t$	28.5	1.3	68.3	1.9
$\ln N_t$	54.9	8.3	26.5	10.3

We observe shocks to TFP make the largest contributions to the fluctuations of gross output, inflation rate, real exchange rate and capital price. Shocks to foreign interest rate is the second largest contributor to these variables, except that it is largest for bank net worth fluctuation. The contributions of foreign demand shock is significant for real

[26] Because the variance decomposition is computed by using the first order approximation of the decision rule, the relative size of the shocks matters rather than the absolute size.

exchange rate, output and bank net worth, while the effect of nominal interest rate are relatively modest in our parametrization.

Table A2 reports the variance decomposition of the flexible price economy in which the only difference from the baseline is the fraction of those who do not adjust the price equals 10% within a quarter instead of 66% in the baseline.

Table A2: Variance Decomposition of Flexible Price Economy				
	R_t^*	i_t	A_t	Y_t^*
$\ln Y_t$	8.9	0.0	84.1	7.0
π_t	23.9	11.7	59.8	4.5
$\ln \epsilon_t$	18.5	0.0	60.0	21.5
$\ln Q_t$	28.8	0.2	69.5	1.5
$\ln N_t$	55.1	3.6	35.5	5.8

Comparing with the baseline, while the contribution of nominal interest rate falls (except for the inflation rate), the contribution of TFP shock increases (except for inflation rate) and that of foreign interest rate shock to the aggregate fluctuations increases. Although these numbers are specific to our formulation, they suggest the economy with banks who issue foreign currency debts is vulnerable to shocks to the foreign interest rate.

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