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"Financial shocks in Japan : A case for a small open economy"

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Financial shocks in Japan : A case for a small open economy[*]

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Abstract

Following Jermann and Quadrini (2012), we apply the dynamic stochastic general equilibrium modeling method (DSGE) to assess whether financial shocks matter for the Japanese economy. We construct time series of financial shocks and productivity shocks using Japan's quarterly data since 2001 and conduct simultaneous replication on major indicators of aggregate financial flows and real variables. Preliminary results tell us that in a closed economy, financial shocks seem less important than they were in the U.S. economy. However, after extending the original model to a small open economy in which firms can borrow from overseas lenders but may have to pay a default risk premium on interest payments, simulated results show that financial shocks have contributed heavily to the dynamics of aggregate debt and dividend flows. This is consistent with Jermann and Quadrini's (2012) finding on the U.S. economy. By contrast, however, productivity shocks seem to have been dominant in accounting for fluctuations of real variables, such as output, consumption ratio, and investment ratio in Japan.

Keywords: DSGE model, financial friction, small open economy, simulation
JEL classification: E44, E32, F41

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1 Introduction

Recently, there has been an increase in literature focusing on financial constraints and their roles in aggregate economies. Different from many studies that emphasized the propagating effects of financial frictions[1], Benk, Gillman, and Kejak (2005) began to consider credit shocks that originate from bank sectors and suggested that these shocks could be candidates for accounting for the growth of gross domestic product (GDP). Since then, many researchers have begun to focus on the direct effects of financial shocks to macroeconomies. Among recent studies, Jermann and Quadrini (2012) quantitatively show that financial shocks, that is, perturbations that originate directly from financial sectors, have played a key role in accounting for the U.S. economy, not only for business fluctuations, but also for the dynamics of financial flows. After noticing that financial flows have displayed features similar to those in the United States, we applied the model of Jermann and Quadrini (2012) to explore the importance of these financial shocks in the Japanese economy and attempted to conduct simulations on key indicators, such as output, consumption ratio, and investment ratio.

First, we found that aggregate financial flows, that is, aggregate debt flows and dividends flows, in Japan have shown some cyclical features since 2001[2]. Figure 1.1 describes aggregate dividend flows paid to shareholders in Japan and the log value of Japan's GDP. Both data are from the Statistics of Japan and have been seasonally adjusted. Financial data is normalized by GDP. According to this figure, we find that there is a somewhat positive relationship between these two variables. However, Figure 1.2 plots net debt repurchases in nonfinancial corporate business (normalized by GDP) and the log value of GDP. Here net debt repurchases indicate a net reduction in firms' outstanding debt. Outstanding debt includes corporate bonds, bank loans, foreign debt, and financial derivatives, and these data are all from the Bank of Japan. If firms increase their debt issuance, the value of net debt repurchases will become negative. Through this simple but effective indicator, we can easily capture the dynamics of firms' debt-financing activities. Figure 1.2 implies that there is a positive relationship between net debt repurchases and GDP. Especially after 2004, this relationship becomes even more obvious. Therefore, we conjec-

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[1]Such as Kiyotaki and Moore (1997); Bernanke, Gertler, and Gilchrist (1999); Mendoza and Smith (2005); and Mendoza (2010).

[2]The time span we used was selected for three reasons: (1) As we show later, the corporate tax rate is an important parameter in our study. Since there are several adjustments in corporate tax rate before 2000, we chose a long period (after 2000) without tax rate adjustment so as to exclude its possible effect. (2) The Bank of Japan has adopted a new method of statistics (Flow of Funds (1993 SNA)) since 1997Q12; therefore, there would be an inevitable gap in data if we chose data from a period earlier than 1997. (3) Quarterly dividend flows in real value (2005=100) started in 2001. Based on the above reasons, we chose 2001 as the beginning of the period.

ture that the Modigliani-Miller theorem does not hold in Japan, and it is reasonable for us to conjecture that there have been financial frictions in Japan's financial sector since at least 2001.

Enlightened by such a finding, we decided to apply Jermann and Quadrini's (2012) framework to explore the role of financial shocks in the Japanese economy. First, we applied Jermann and Quadrini's (2012) business cycle model and computed parameters to fit the properties of empirical counterparts. This model includes explicit roles for debt and dividend, which is helpful in capturing cyclical properties of financial flows. Additionally, this model includes two central features: (1) the pecking order in a firm's financial decisions, that is, the firm prefers debt to equity financing due to its tax benefit, and (2) the existence of financial rigidity when firms want to change tools of financing and the degree of this rigidity as reflected by the cost of dividend adjustment. Financial shocks in this model are denoted by the disturbances that affect firms' ability to borrow.

Second, we constructed productivity and financial shocks by quarterly time series for Japan. Productivity shocks are computed as the Solow residuals. Financial shocks are computed by a similar method, that is, we constructed this series as residuals of the enforcement constraint in the model. Using the constructed shock series, we not only conducted impulse responses to two kinds of shock but also made simultaneous replications on key indicators of real variables and aggregate financial flows. Preliminary simulation results in a closed economy show that financial shocks seem less important to the Japanese economy than to the U.S. economy. However, after we extend the closed economy model to a small open economy in which firms can borrow from overseas lenders but have to pay a default risk premium on interest payments, we find that financial shocks could play a dominant role in capturing the dynamics of financial flows in Japan. This is consistent with Jermann and Quadrini (2012). By contrast, productivity shocks play an important role in explaining macroeconomic fluctuations whether in closed or open economies. Therefore, we conclude that financial shocks are important in understanding movements in Japanese financial flows, while productivity shocks matter for the real variables. This is in line with the findings of Kaihatsu and Kurozumi (2010), which also show that the main driving force of output fluctuations is the technology shock.

This paper is related to several areas of study. First, it is related to studies about the role of financial sectors in macroeconomies. As we introduced at the beginning of this paper, two views recently dominate: one is the shock-propagating effect of financial sectors, and the other is the direct effect of financial disturbances on aggregate economies. Representative studies about the former view include Kiyotaki and Moore (1997); Bernanke, Gertler, and Gilchrist (1999); Mendoza and Smith (2005); and Mendoza (2010). However, our study is more related to the latter view, which is advocated by Jermann and Quadrini

(2012); that is, we try to explore the possible direct effect of financial disturbances on the aggregate economy. Other literature that starts from this view includes Benk, Gillman, and Kejak (2005); Christiano, Motto, and Rostagno (2008); Kiyotaki and Moore (2008); and Del Negro, Eggertsson, Ferrero, and Kiyotaki (2010). Most of these studies are conducted within a closed economy framework, while we analyze problems within both closed and open economies. Another contribution in this direction is Hirakata, Sudo, and Ueda (2011), but it focuses on shocks to financial intermediaries' net worth.

Another topic related to our paper is the DSGE models within a small open economy. Studies related to this field are Fujiwara and Teranishi (2011) and Christiano, Trabandt, and Walentin (2011). Fujiwara and Teranishi (2011) constructed a new open economy macroeconomic model with staggered loan contracts as a simple form of financial friction. However, the main focus of their study was the effect of financial friction to the real exchange rate dynamics, which is different from our focus in this paper. Christiano, Trabandt, and Walentin (2011) changed the standard new Keynesian model by incorporating financing friction for capital and employment friction for labor and further extending the model into a small open economy setting. They found that financial shock is pivotal for explaining fluctuations in investment and GDP in the Swedish economy.

Our paper is structured as follows: Section 2 reviews the closed model suggested by Jermann and Quadrini (2012), constructs time series of productivity and financial shocks, and applies them to the closed economy. Section 3 proposes a small open economy version by incorporating foreign debt and default risk premium on interest and studies the quantitative properties again. Section 4 concludes.
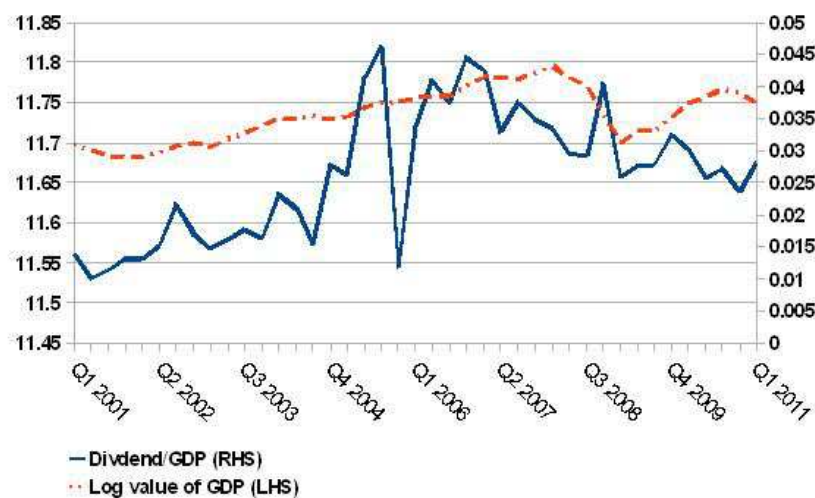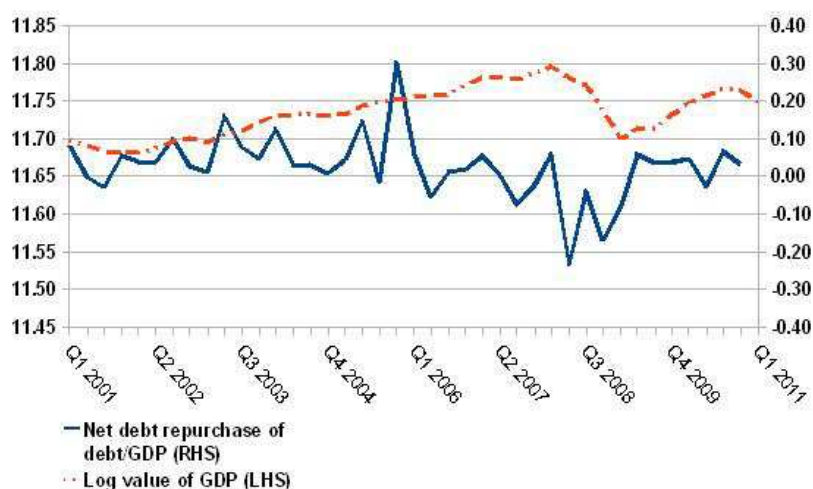
Figure 1.1: Aggregate dividend flows and Japan's GDP

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Figure 1.2: Net debt repurchases and Japan's GDP

2 Case 1: A closed economy with financial frictions

In this section, we start with a brief review of Jermann and Quadrini (2012) and make a quantitative analysis with quarterly data from Japan. A closed economy model contains three sectors: households, firms, and financial sectors. There are four basic assumptions in this environment: (1) Due to tax benefits, firms prefer to use debt financing instead of equity financing. (2) Firms not only face enforcement constraints when conducting debt financing in markets but also incur additional costs when adjusting equity payout. (3) Firms prefer not to change production plans. (4) Financial constraints are binding all the time[3].

2.1 *Model*

2.1.1 Firms

There is a continuum of firms in the [0,1] interval. At the beginning of the period, firms hold capital k_{t-1} and intertemporal liabilities b_{t-1}^H. Here b_{t-1}^H indicates the beginning-of-period value of intertemporal liabilities in period t, and positive value denotes liabilities. Before conducting production activities, firms repay previous debts b_{t-1}^H and choose labor input l_t, investment i_t, equity payout, adjustment cost[4], and next-period debt b_t^H.

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[3]When we conduct simulations on the Lagrangian multipliers of enforcement constraints, we find the fluctuations of their values are less than 100 percent of their steady-state values; therefore, this assumption seems reasonable in our models.

[4]This will be introduced later.

Payments to workers, suppliers of investments, equity holders, and previous debt holders must be made before the realization of revenues, so firms need to take intraperiod loans (no interest occurs) from lenders. Firms will repay these loans after the realization of revenues.

There are two ways for firms to finance their production activities: equity and debt. Debt is preferred to equity due to its tax advantage. Concretely speaking, if r_t represents the interest rate of an intertemporal loan, the effective gross rate for the firm is $1 + r_t(1 - \tau)$, where τ is equal to the tax benefit. Since interest payments on corporate debt are treated as an operational cost, every one unit of debt will save firms τ units of tax payment when compared with equity financing. The problem of firms is maximizing their present equity value, which is equal to the total expected discounted value of equity payout d_t paid to the shareholders. The optimization problem is:

$$E_0 \left[\sum_{t=0}^{\infty} m_t d_t \right]$$

s.t

$$y_t - w_t l_t + \frac{b_t^H}{1 + r_t(1 - \tau)} = b_{t-1}^H + i_t + \varphi(d_t) \tag{1}$$

$$y_t = z_t k_{t-1}^{\theta} l_t^{1-\theta} \tag{2}$$

$$i_t = k_t - (1 - \delta)k_{t-1} \tag{3}$$

$$\varphi(d_t) = d_t + \kappa(d_t - d)^2 \tag{4}$$

$$\xi_t(k_t - \frac{b_t^H}{1 + r_t}) \geq y_t \tag{5}$$

where m_t is the stochastic discount factor decided by shareholders, the value of which is equal to that of the household, and taken as given. Equation (1) represents the budget constraint of the firm. The gross revenue of the firm is y, which is represented by the production function equation (2), where z_t represents total factor productivity in period t. Wage rate and interest rate, w_t and r_t, respectively, are determined in the general equilibrium. Here b_t^H represents intertemporal debt issued in the domestic financial markets, which are only purchased by domestic households. Finally, i_t represents investment in period t, which is equal to equation (3).

As equation (4) shows, $\varphi(d_t)$ is equal to equity payout plus the adjustment cost; d is the long-run dividend target; and $\kappa > 0$ is a parameter to reflect the rigidity that affects the substitution between debt and equity. Jermann and Quadrini (2012) emphasized that this parameter should not be interpreted as a pecuniary cost but should be accepted as a way of modeling how flexibly firms can adjust sources of funds. The larger the value

of κ, the more inflexible the substitution between debt and equity becomes. Jermann and Quadrini (2012) mentioned that κ is the key factor determining the impact of financial shocks.

Firms face enforcement constraints when they borrow intertemporal debt from financial sectors, since they could default on the obligations. Equation (5) represents financial constraints in a linearized form. A simple way to interpret this equation is that the largest amount firms can borrow intraperiod from the public in period t is equal to a fraction ξ_t of the equity value at the end of period, and not more than gross revenues y. Here ξ_t is stochastic and same for all firms, and the financial shocks we indicate are the stochastic innovations of ξ_t. Therefore, financial shocks can be treated as aggregate shocks. Here, we assume that enforcement constraints are binding prior to shocks and that firms prefer not to change production plans.

To understand the effect of ξ_t, Jermann and Quadrini (2012) rewrote the enforcement constraint by assuming $\tau = 0$:

$$\left(\frac{\xi_t}{1-\xi_t}\right)\left[(1-\delta)k_{t-1} - b_{t-1}^H - w_t l_t - \varphi(d_t)\right] \geq F(z_t, k_{t-1}, l_t),$$

Whether financial shocks affect production plans is decided by the rigidity of substitution between debt and equity financing. If adjusting the dividend costs too much, firms would have to change the production plan and, therefore, change labor inputs. For this reason, Jermann and Quadrini (2012) advocate that, supposing constraints are binding all the time, financial shocks could affect the real economy through enforcement constraints.

We define η_t and λ_t^f respectively as the Lagrangian multipliers of enforcement constraints and budget constraints in period t. The first-order conditions of firms are:

$$1 = \lambda_t^f \left[1 + 2\kappa\left(d_t - d\right)\right] \tag{6}$$

$$w_t = \left(1 - \frac{\eta_t}{\lambda_t^f}\right)(1-\theta)\frac{y_t}{l_t} \tag{7}$$

$$1 - \frac{\eta_t}{\lambda_t^f}\xi_t = m_{t+1}\frac{\lambda_{t+1}^f}{\lambda_t^f}\left[1 - \delta + \left(1 - \frac{\eta_{t+1}}{\lambda_{t+1}^f}\right)\theta\frac{y_{t+1}}{k_t}\right] \tag{8}$$

$$\frac{1}{1+r_t(1-\tau)} - \frac{\eta_t}{\lambda_t^f}\xi_t\left[\frac{1}{1+r_t}\right] = m_{t+1}\frac{\lambda_{t+1}^f}{\lambda_t^f} \tag{9}$$

Equation (6) implies that when the amount of equity payout is larger than the long-run target, the marginal utility of the additional unit of dividend becomes smaller than

its marginal cost. By contrast, if equity payout is lower than the steady-state value, the marginal utility of the dividend will become larger than 1. Equation (7) is the key equation in Jermann and Quadrini (2012), since it reveals the main channel through which financial shocks influence the real economy. When enforcement constraints are not binding, the marginal cost of labor is equal to its marginal utility. However, when financial conditions worsen and enforcement constraints become more binding, the Lagrangian multiplier η_t becomes larger than zero, and a labor wedge will lead to efficiency loss. Consequently, the demand for labor would decrease due to a higher wage rate. It should be noted that the labor wedge is related not only to the tightness of the enforcement constraint but also to the rigidity of financing substitution κ. Higher rigidity will induce a higher labor wedge, since the cost of changing the source of funds is higher.

Equation (8) tells us that the conditions of k_{t+1} will be optimal if the marginal cost of capital is equal to its marginal benefit. Compared with the standard real business cycle (RBC) model, the existence of enforcement constraints reduced the marginal cost of capital, since an additional unit of capital increases the collateral value and relaxes constraints. However, the efficiency of capital in the next period is reduced because the increase in capital implies larger intraperiod loans, and the enforcement constraints will tighten in the next period. Equation (9) implies that the marginal benefit of intertemporal debt becomes smaller, since larger liabilities could tighten enforcement constraints and induce extra loss.

2.1.2 Households

There is a continuum of homogeneous households in the [0,1] interval. Households receive wages from firms, trade shares of firms, and hold noncontingent bonds issued by firms in every period. The problem of households is maximizing the lifetime utility as follows:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\ln c_t + \alpha \ln(1 - l_t) \right]$$

s.t

$$w_t l_t + s_t (d_t + p_t) + b_{t-1}^H = \frac{b_t^H}{1 + r_t} + s_t p_t + c_t + T_t \tag{10}$$

where

$$T_t = \frac{B_t^H}{1 + r_t(1 - \tau)} - \frac{B_t^H}{1 + r_t}$$

where c_t is consumption, l_t is labor, and β is the time discount factor. In the utility function, α is a parameter representing the disutility of labor. Equation (10) represents the budget constraint of the household. The one-period bonds issued by firms are represented

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by b_t^H ; s_t and q_t , respectively, are the amount of equity shares and the share price; and T_t is the lump-sum tax that governments collect from households to subsidize firms' debt-financing activities. Then we derive first-order conditions as follows:

$$\frac{w_t}{c_t} = \frac{\alpha}{1 - l_t} \tag{11}$$

$$U_c(c_t, l_t) - \beta(1 + r_t)EU_c(c_{t+1}, l_{t+1}) = 0 \tag{12}$$

$$1 = \beta \frac{\lambda_{t+1}^h}{\lambda_t^h}\left(\frac{d_{t+1} + p_{t+1}}{p_t}\right) \tag{13}$$

where λ_t^h is the Lagrangian multiplier of a household's budget constraint. Equation (11) is the household's decision rule on labor supply, and equation (12) is the key condition to decide the risk-free interest rate. Based on equation (13) and equation (12) , we obtain the stochastic discount factor:

$$m_{t+1} = \beta \frac{\lambda_{t+1}^h}{\lambda_t^h} = \frac{1}{1 + r_t} \tag{14}$$

2.1.3 Market-clearing conditions

When a market clears, we suppose that the total quantity of equity shares is equal to 1 unit. We assume that large characters represent aggregate variables, and small characters indicate variables of individual agents. Therefore,

$$S = 1 \tag{15}$$

Since all the market participants are assumed to be identical and take the same actions, the total resource constraint is:

$$Y_t = I_t + C_t + \kappa(D_t - D)^2 \tag{16}$$

$$Y_t = y_t \quad I_t = i_t \quad C_t = c_t \quad D_t = d_t \quad K_t = k_t \tag{17}$$

$$B_t^H = b_t^H \tag{18}$$

Definition 2.1. (Competitive equilibrium of a closed economy)   A competitive equilibrium is defined as a set of functions for:

- Households' policies c_t, l_t, and b_t^H.

- Firms' policies d_t, l_t, b_t^H, and i_t.

- Aggregate prices w_t, r_t, m_{t+1}, and p_t.

Such that:

- Households' policies satisfy conditions (10)-(13), given w_t, r_t, p_t, and T_t.

- Firms' policies are optimal, given w_t, r_t k_{t-1}, z_t, ξ_t, and m_{t+1}.

- The wage and interest rates clear the labor and bond markets, and $m_{t+1} = \beta \frac{U_c(C_{t+1})}{U_c(C_t)}$.

2.2 *Quantitative analysis*

In this section, we show that in a closed economy model with financial frictions, financial shocks can explain the aggregate dividend flows to a certain extend but cannot capture the aggregate debt flows at all. In comparison, productivity shocks play an important role in replicating the movements of real variables but have little relationship with the movements of financial flows such as debt.

2.2.1 Data and parametrization

In this paper, we apply the seasonally adjusted quarterly data of Japan to a closed economy model. We chose data from 2001 because there was a tax reform in fiscal year 1999. That is, corporate tax (national) was reduced from 34.5 to 30 percent. In order to study effects from financial shocks and productivity shocks, we chose periods without reforms in the basic corporate tax rate. Financial data such as average contracted lending rate, interest rate, and liabilities of nonfinancial corporate businesses[5] are taken from the Bank of Japan, while other data such as dividends of corporate businesses, real gross domestic product, gross capital formation of corporate business, and domestic final consumption expenditure of households are from the Cabinet Office[6] and are taken at the real value (2005=100). Average working hour per week is computed as follows: (average working hour per week in all industries × working population in all industries) ÷ (labor force × 24hours × 7days). Capital stock is calculated as follows: (capital stock of nonfinancial corporate business (end of last period) + gross capital formation of corporate business[7] − consumption of fixed capital). We use the net wealth of nonfinancial corporate businesses at the end of 1980 as the initial value and divide the constructed nominal capital stock by the GDP deflator (2005=100). Other data such as basic corporate tax rate are from the Ministry of Finance, Japan. Average majority prime rate charged by banks in the United

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[5]Liabilities of nonfinancial corporate businesses are constructed by adding corporate bonds, bank loans, foreign debt, and financial derivatives and adjusting by the GDP deflator (2005=100).

[6]Data from the Cabinet Office are obtained from the Office Portal Site of Official Statistics of Japan, developed by Statistics Japan.

[7]This is calculated by subtracting gross fixed capital formation and inventory of government from gross capital formation.

States (the world interest rate) is from the Board of Governors of the Federal Reserve System. All data are seasonally adjusted by Census X12 (except interest rate) and are detrended by the Hodrick-Prescott filters with a default smoothing parameter of 1600. Table 2.1 shows parameters computed by the long-run targets or the second moments of data.

Table 2.1: Parameters set by the long-run targets or the second moments

Parameters set by the steady state value	
Discount factor	0.982
Tax advantage	0.300
Utility parameter	1.799
Production technology	0.362
Depreciation rate	0.049
Enforcement parameter	0.636
Parameters set by the second moments	
Payout cost parameter	3.150

Notes: Long run targets are calculated based on seasonally adjusted quarterly data of Japan.

The discount factor is set to 0.982 because the steady-state value of the average contract interest rate is 1.86 percent. The tax advantage is set to 0.30 because the interest payment is exempt from corporate tax. The disutility parameter is set to 1.799 to make the steady-state value of relative working hours equal to 0.329, which is equal to the relative length of working hours per quarter. The Cobb-Douglas parameter in the production function follows Hayashi (2002). The depreciation rate is set so the output per capital ratio is equal to 0.174. The enforcement parameter is computed by the long-run target of output, capital stock, and domestic liabilities of nonfinancial corporations in Japan. The payout cost parameter κ was chosen to have a standard deviation of dividend output ratio generated by the model equal to the empirical standard deviation 0.0061.

An important procedure in this paper is to construct productivity and financial shocks. Basically, we follow the standard Solow residuals approach, computing productivity shocks from the linearized form of production function as follows:

$$\hat{z}_t = \hat{y}_t - \theta \hat{k}_{t-1} - (1 - \theta)\hat{l}_t,$$

where hat variables imply percentage deviations from deterministic trends, or long-run targets. Using time series data of output, capital stock, and working hours, we obtain the

series of $\hat{z}_t$ and further derive innovations $\epsilon_{z,t}$ of $\hat{z}_t$ by the following equation:

$$\hat{z}_{t+1} = \rho_z \hat{z}_t + \epsilon_{z,t+1}.$$

As to financial shocks, we apply a similar approach to derive innovations of financial variable $\hat{\xi}_t$. An important assumption of this paper is that enforcement constraints are always binding. Therefore, we derive an empirical series of $\hat{\xi}_t$ from the linearized form of the enforcement constraint as follows:

$$\hat{\xi}_t = \hat{y}_t - \frac{\xi K}{Y} \hat{k}_t + \frac{\xi B}{Y} \hat{b}_t^e,$$

where hat variables denote log deviations from long-run targets. Large characters without time scripts denote the steady-state value of aggregate variables [8]. The end-of-period value of debt is represented by $\hat{b}_t^e = \hat{b}_t^H/(1 + r_t)$. The empirical counterparts we use here are the domestic liabilities of nonfinancial corporations collected from the Bank of Japan and adjusted to real terms by GDP deflators (2005=100). The log value is linearly detrended by the Hodrick-Prescott filter. Following the construction of productivity shocks, we derive innovations $\epsilon_{\xi,t}$ by the following equation:

$$\hat{\xi}_{t+1} = \rho_\xi \hat{\xi}_t + \epsilon_{\xi,t+1}.$$

We summarize the properties of constructed series in Table 2.2.

Table 2.2: Parameters calculated by the time series of Japan

Description	
Std of productivity innovations	0.0107
Std of financial innovations	0.0349
Autocorrelation of TFP	0.7416
Autocorrelation of enforcement parameter	0.7378

In the following section, we follow Jermann and Quadrini (2012) to use series of innovations $\epsilon_{z,t}$ and $\epsilon_{\xi,t}$ to replicate the series of z_t and ξ_t. It should be noted that market analysts do not anticipate innovations that occur in every period; they only use the autoregressive function to forecast shocks in the next period. Therefore, by using an innovations series, we can replicate continuous exogenous shocks, simulating real external environments in models.

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[8] We tried two methods of constructing the parameters $\frac{\xi K}{Y}$ and $\frac{\xi B}{Y}$. One is to use a fixed long-run steady-state value of each variable; the other is to use the deterministic tend derived from the Hodrick-Prescott filter. Both ways derive similar series of $\hat{\xi}_t$.

2.2.2 Impulse response

In this section, we will explore the impulse response of productivity shocks and financial shocks, respectively. First, we assume that no unexpected financial shock has occurred, only productivity shocks. According to the following equation,

$$\left(\frac{\xi_t}{1-\xi_t}\right)\{(1-\delta)k_{t-1} - b_{t-1}^H - w_t l_t - [\frac{b_t^H}{1+r_t(1-\tau)} - \frac{b_t^H}{1+r_t}] - \varphi(d_t)\} \geq F(z_t, k_{t-1}, l_t),$$

which is rewritten in light of firms' budget constraints and enforcement constraints, we know that after receiving productivity shocks, firms can adjust their labor input, new intertemporal debt, or equity payout to reach balance again. As Figure 2.1 shows, after receiving a one-time negative productivity shock, enforcement constraints suddenly get looser, and the values of their Lagrangian multiplier η instantly drop. Under this circumstance, because the marginal cost of debt suddenly declines, firms first choose to increase the intertemporal debt position for its low financing cost. As there is change in the value of η, equation (7) implies that if firms want to keep their original production plans, they have to increase their equity payout. However, there is cost in adjusting dividend and firms have to increase working hours. After a short period, enforcement constraints become binding again, and the tightness of enforcement constraints makes firms' debt-financing cost more than the previous period; therefore, firms need to reduce new intertemporal debt as well as other expenditures. Although firms want to keep production plans unchanged, adjustments in the cost of dividends still force them to reduce part of the labor input.

However, if we assume that there are financial shocks but no productivity shocks, responses of aggregate debt and dividend flows show different styles. We show the impulse responses of key variables in Figure 2.2. After receiving a one-time negative financial shock, enforcement constraints suddenly become tighter, and the Lagrangian multiplier of enforcement constraints η_t becomes dramatically larger than its steady-state value. Therefore, debt financing becomes costly, and firms begin to reduce their new borrowing for the next period. Under these circumstances, if firms want to keep their production plans unchanged, they have to reduce their dividend according to equation (7). However, the adjustment costs force firms to reduce labor input to control the total cost. As the firms' debt position becomes smaller, the value of multiplier η_t drops. Since the marginal cost of debt financing becomes cheaper, firms choose to use debt financing again, so debt repurchases drop below the steady-state level.

Figure 2.1: Response to one-time negative productivity shock in a closed economy
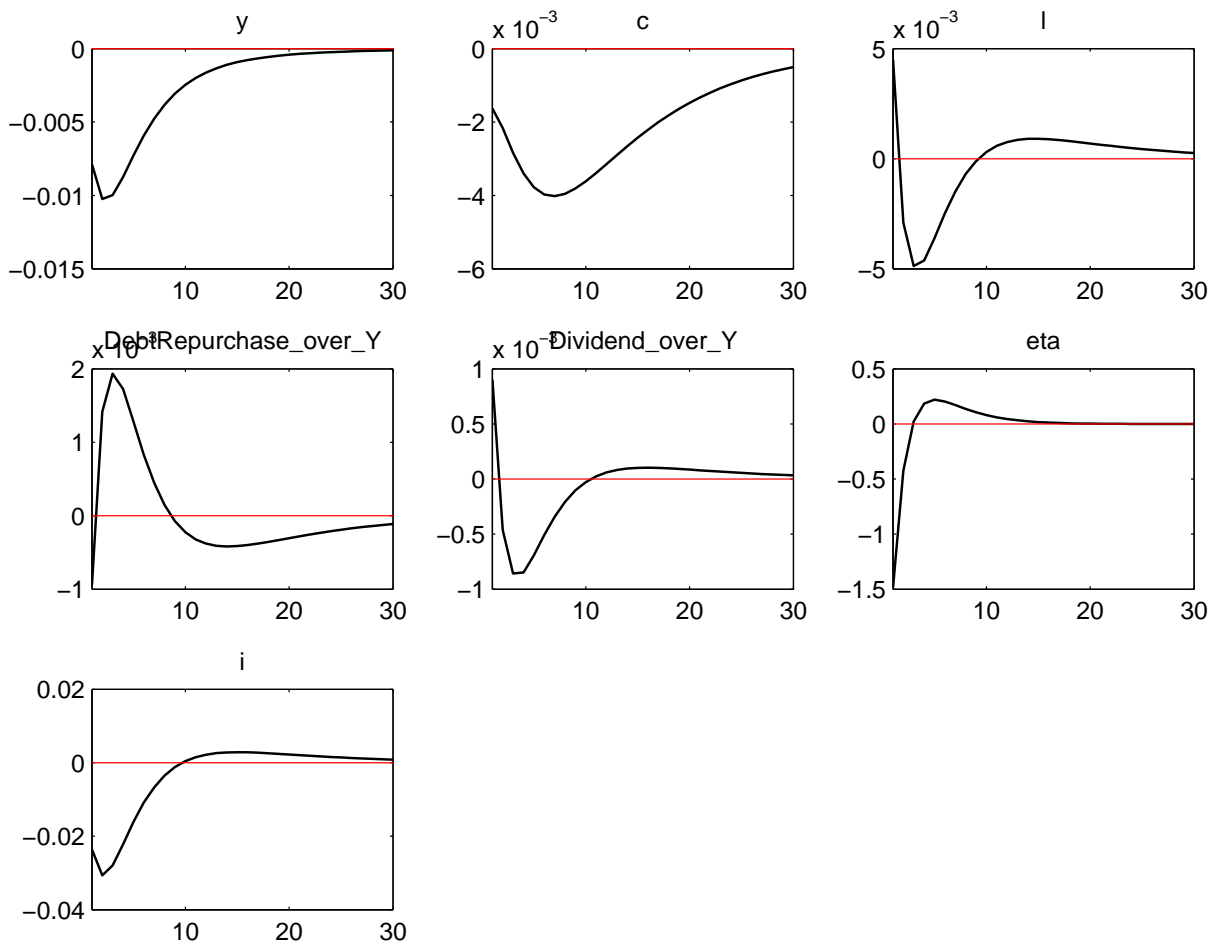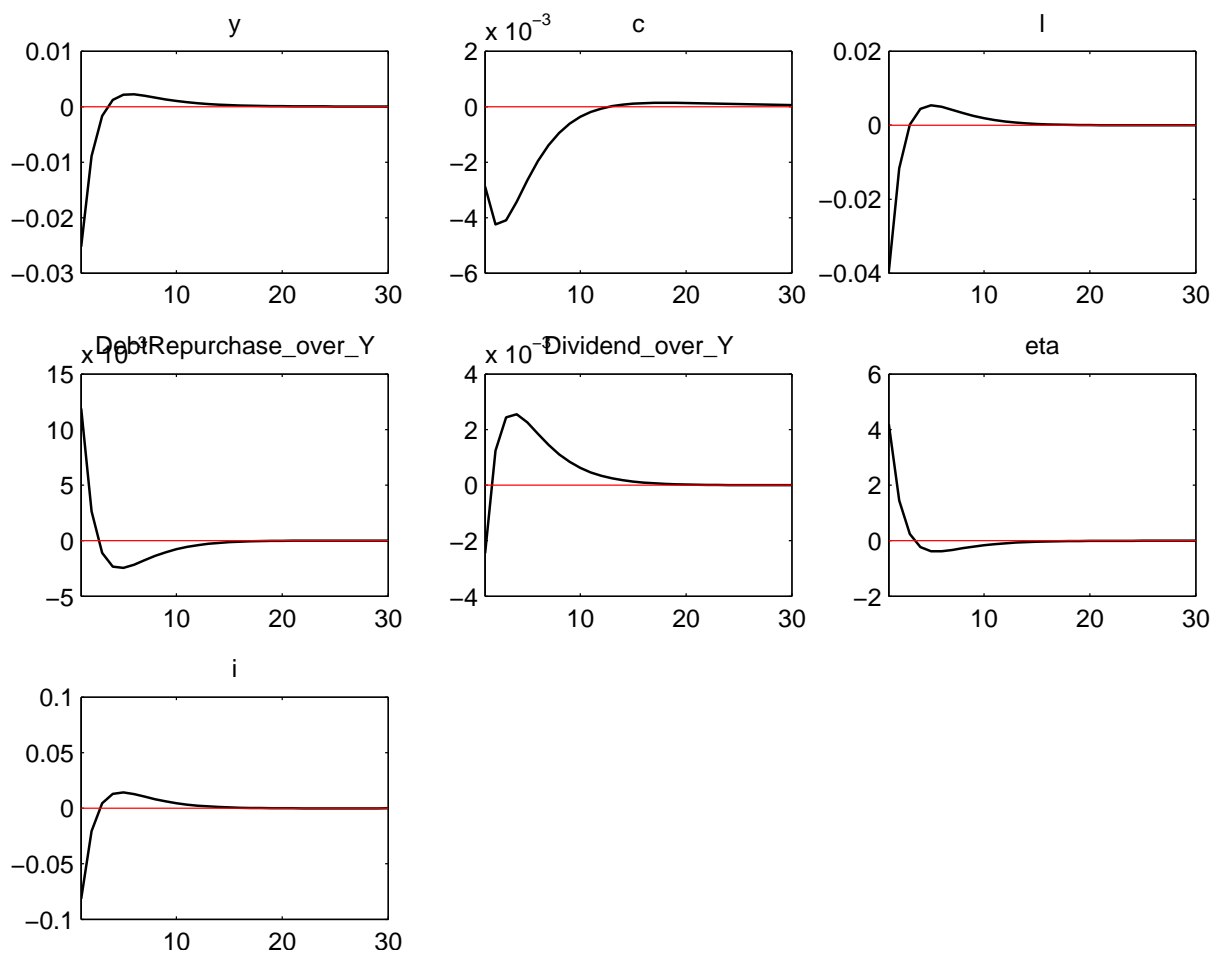
Figure 2.2: Response to one-time negative financial shock in a closed economy

2.2.3 Simulation

In this part, we simulate series in order to check whether financial shocks matter for the movements of aggregate financial flows or real variables. Before showing figures, we first present standard deviations of simulated series and empirical data. According to Table 2.3, we see that simulated volatilities of debt repurchases are far lower than the real value. As to dividends, the standard deviation generated by financial shocks is closer to the data. Yet we can see that in a closed model with only productivity shocks, second moments of simulated macroeconomic variables match the real data quite well, especially for labor and investment. By contrast, standard deviations of real variables generated only by financial shocks are mostly too large.

In order to further confirm the importance of financial shocks, we would like to show the whole process of simulation using figures. Figure 2.3 shows that empirical data of debt repurchases is far more volatile than simulated series generated by two shocks respectively, but dividends generated by financial shocks show a better performance. However, although the rebound of dividends in later 2005 is captured very well, simulated dividends still fail to account for the peak in early 2005. As to real variables, productivity shocks play a significant role in capturing the dynamics of key real variables. Figures 2.4 and 2.5 show that series generated by productivity shocks capture the trends of empirical data quite well, especially for labor and output. However, simulated consumption and investment seem more volatile than the data, especially after 2008. By contrast, as to real variables simulated by financial shocks, they are more volatile than the real level of empirical data. One thing we would like to emphasize is that, although second moments imply that the performances of simulated output and investment ratio are similar, Figures 2.4 and 2.5 show that the performance of output series is actually better than that of investment. Therefore, it reminds us that when we check the performance of the model, besides the second moments, presenting the simulation result by figure is also helpful for drawing conclusions.

2.3 *Summary*

Based on the above work, we can conclude that in the closed model suggested by Jermann and Quadrini (2012), if we assume the credit constraint is binding from 2001Q1 to 2010Q4, and there exists some degree of rigidity in the financial sector in Japan, then:

- Financial shocks can capture the trend of aggregate dividend flows after 2001 but fail to explain the dynamics of aggregate debt flows and macroeconomic variables.

- Productivity shocks could well explain the movements of real variables, especially

Figure 2.3: Simulation in a closed economy (- - -: simulated data ; —: real data ; PS : productivity shocks ; FS : financial shocks)
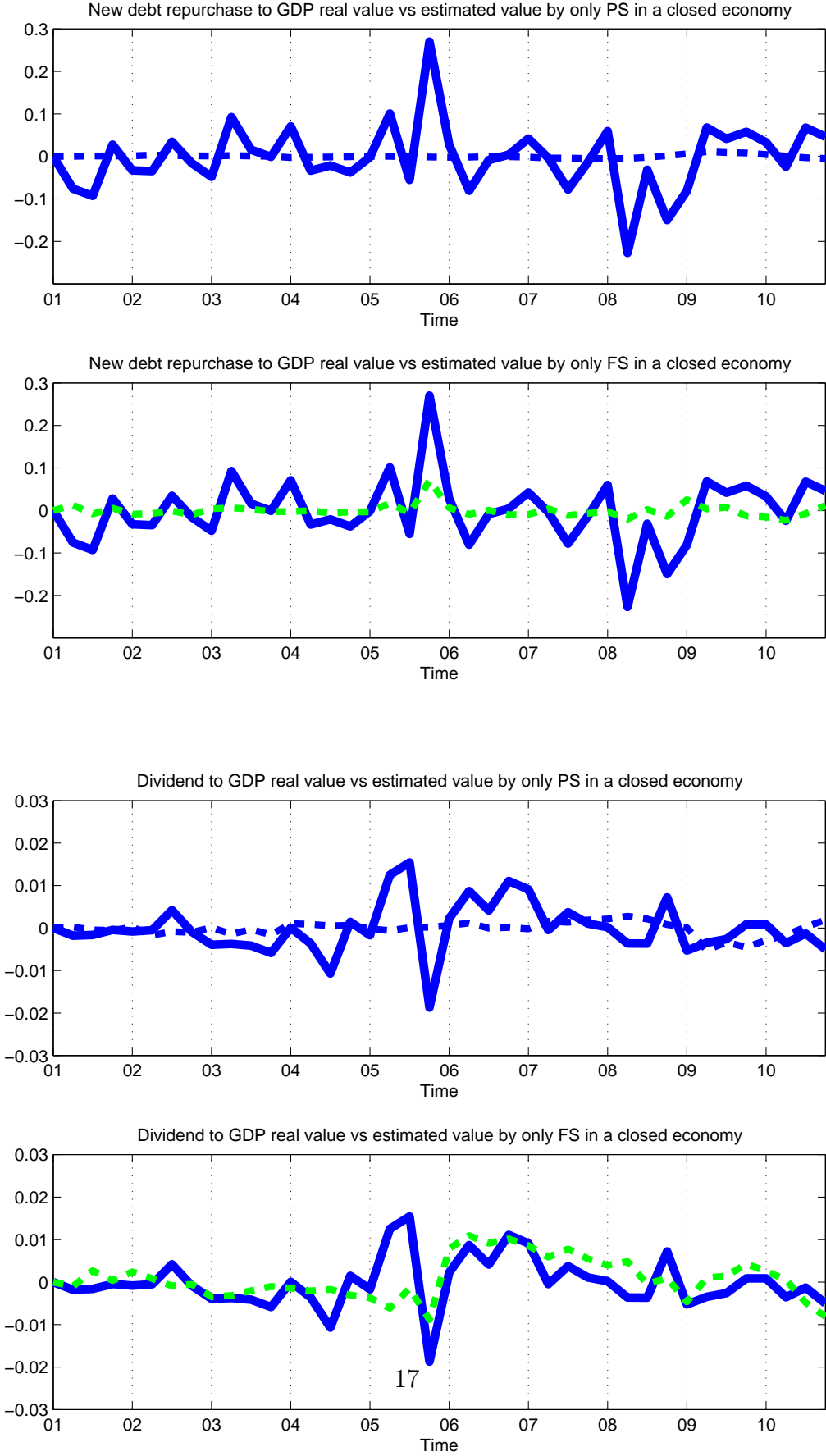
New debt repurchase to GDP real value vs estimated value by only PS in a closed economy

New debt repurchase to GDP real value vs estimated value by only FS in a closed economy

Dividend to GDP real value vs estimated value by only PS in a closed economy

Dividend to GDP real value vs estimated value by only FS in a closed economy

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Figure 2.4: Simulation in a closed economy (- - -: simulated data ; —: real data ; PS : productivity shocks ; FS : financial shocks)
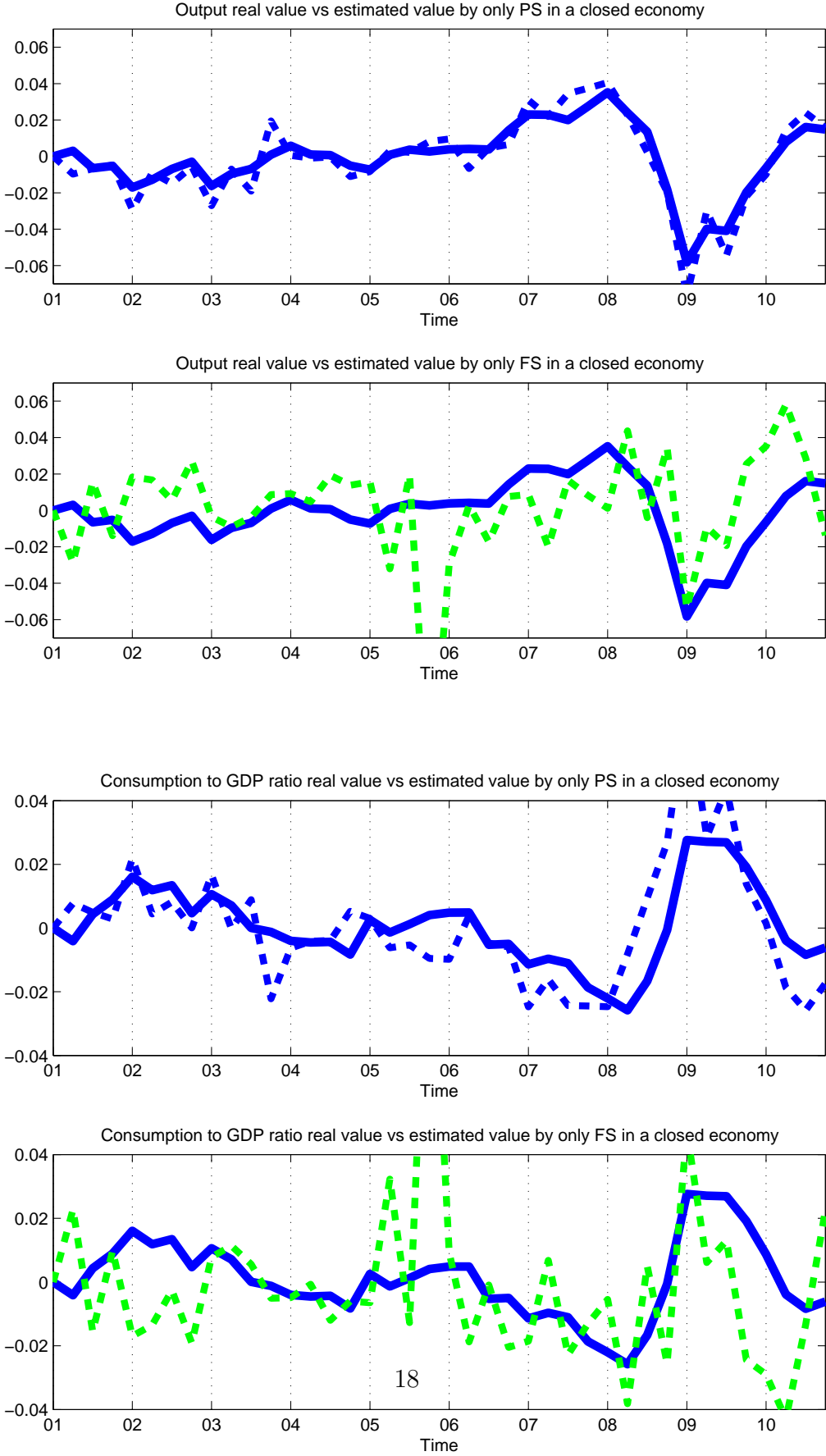
Figure 2.5: Simulation in a closed economy (- - -: simulated data ; —: real data ; PS : productivity shocks ; FS : financial shocks)
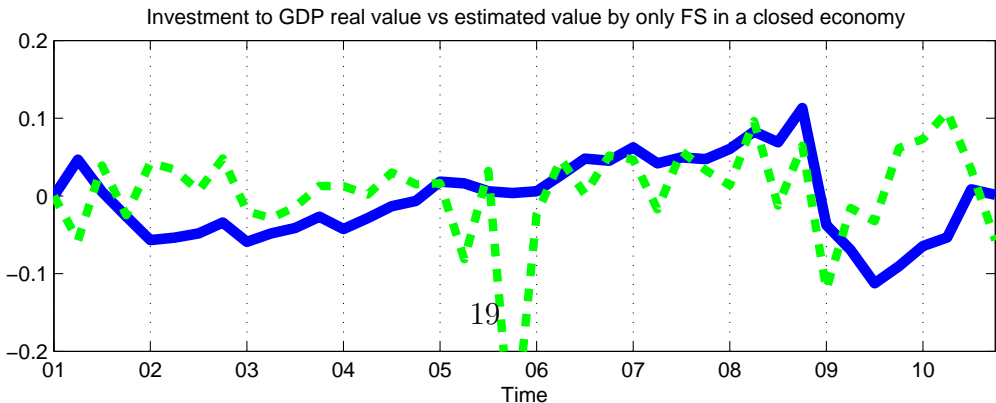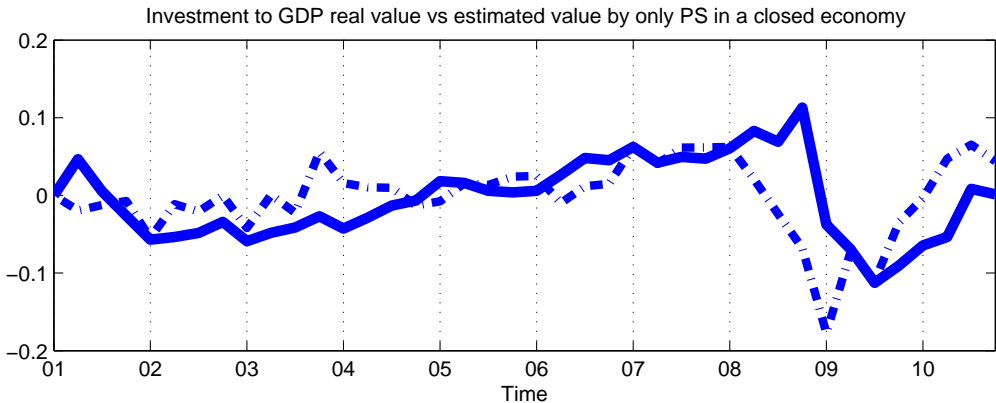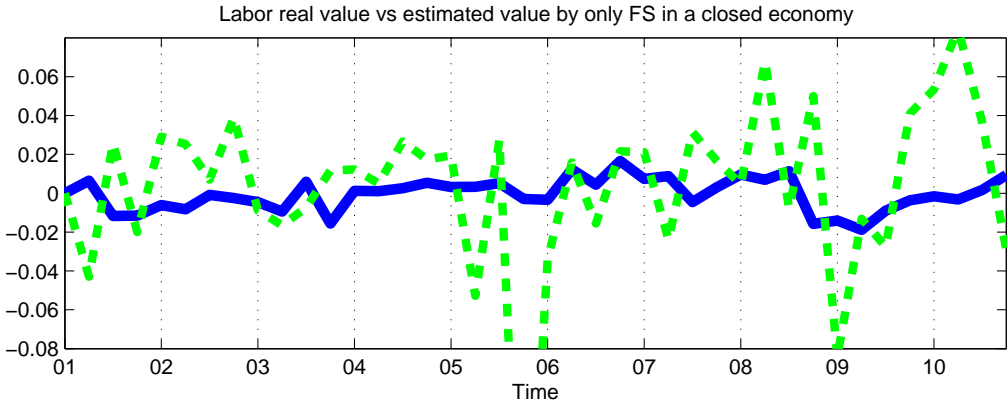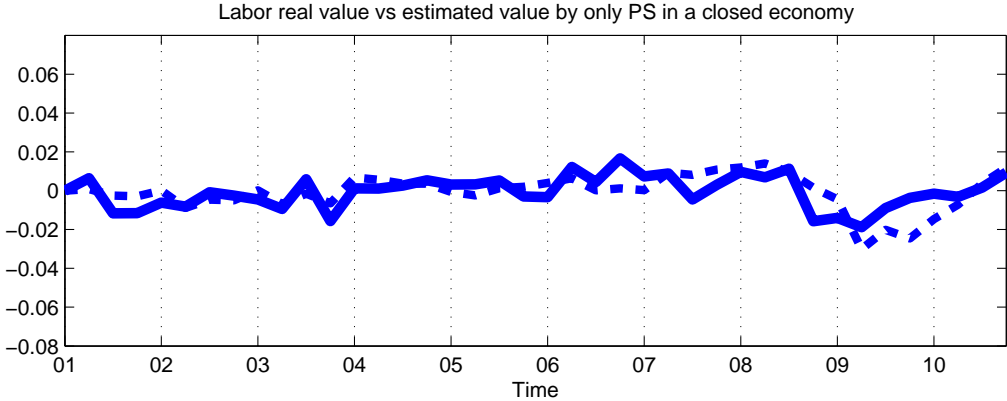
Table 2.3: Estimated business cycle properties in a closed economy : second moments

Variables	Data	Model:only PS	Model:only FS
Financial Variables			
Dividend/GDP	0.0061	0.0017	0.0048
Debt repurchases/GDP	0.0789	0.0037	0.0151
Macroeconomic Variables			
Output	0.0186	0.0233	0.0342
Consumption ratio	0.0124	0.0194	0.0282
Investment ratio	0.0510	0.0489	0.0712
Hours	0.0084	0.0094	0.0517

for output and labor.

Since Japan is often treated as a small open economy in financial literature, we would like to extend a closed economy to a small open economy in the next section to see whether this extension could improve the performance of financial shocks to the dynamics of the Japanese economy.

3 Case 2: A small open economy with financial frictions

In this section, we extend a closed economy to a small open economy to see whether it helps improve the performance of financial shocks in accounting for the Japanese economy. Generally, we extend the original model in two aspects: first, we assume a domestic interest rate subject to the world interest rate and default risk premium. The default risk premium here is determined by the leverage ratio of the economy. Second, we assume firms can borrow from foreign lenders.

3.1 *Model*

3.1.1 Firms

The setup of firm sectors basically follows that in a closed economy except that firms can also accumulate intertemporal debt by borrowing from foreign investors. The amount of foreign debt is denoted by b_t^F, and $b_t^F > 0$ implies that firms hold net liabilities. Each

firm solves the problem as follows:

$$E_0 \left[\sum_{t=0}^{\infty} m_t d_t \right]$$

s.t

$$y_t - w_t l_t + \frac{\left(b_t^H + b_t^F \right)}{1 + r_t(1 - \tau)} = b_{t-1}^H + b_{t-1}^F + i_t + \varphi(d_t) \tag{19}$$

$$\xi_t(k_t - \frac{b_t^H + b_t^F}{1 + r_t}) \geq y_t \tag{20}$$

and using equations (2), (3), and (4). Because we assume that there is no difference between trading domestic and foreign liabilities, first-order conditions of firms in a small open economy are the same as those in a closed economy.

3.1.2 Households

The setup of household sectors is generally the same as that in a closed economy except for lump-sum taxes. Because aggregate amounts of taxes are exogenous to households, first-order conditions of each household are still the same as those in a closed economy.

3.1.3 Interest rate in a small open economy

Different from that in a closed economy, the interest rate in a small open economy model is not determined by the general equilibrium of an economy. We assume that an additional risk premium is required by foreign lenders and is determined by the leverage ratio of a small open economy. We use the following equation to represent this relationship:

$$r_t = r_t^* + \chi \left(\frac{B_t^F}{K_{t-1}} \right) \tag{21}$$

where r_t^* represents the world interest rate. The default risk parameter is denoted by χ and is assumed to be a positive value. This parameter implies that an additional premium is charged to the borrowers, and the amount is determined by their repayment ability. The ratio of net foreign liability to capital stock is interpreted as the leverage ratio in international borrowing market. The lower this ratio becomes, the lower default risk the borrowers are considered to have, and thus less of a premium is required by foreign lenders. Since Japan has kept a positive net financial assets position, its contracted lending rate has been lower than the world interest rate.

3.1.4 Market-clearing conditions

In this part, we want to emphasize two points: First, since capital stock is predetermined, this implies that there is an optimal level of net foreign liability in a small open economy. Second, aggregate revenue is not only used to support domestic expenditure, but it also is needed to cover the interest payments of an external liability as follows:

$$Y_t = I_t + C_t + B_{t-1}^F - \frac{B_t^F}{1 + r_t} + \kappa(D_t - D)^2 \tag{22}$$

The following definition summarizes the equilibrium conditions of a small open economy in our paper,

Definition 3.1. (Competitive equilibrium of a small open economy) A competitive equilibrium is defined as a set of functions for:

- Households' policies c_t, l_t, and b_t^H.

- Firms' policies d_t, l_t, b_t^H, b_t^F and i_t.

- Aggregate prices w_t, r_t, m_{t+1}, and p_t.

Such that:

- Household's policies satisfy conditions (10)-(13), given w_t, r_t, p_t, and T_t.

- Firms' policies are optimal, given w_t, r_t k_{t-1}, z_t, ξ_t, and m_{t+1}.

- The wage clears the labor market, the interest rate is determined by $r_t = r_t^* + \chi\left(\frac{B_t^F}{K_{t-1}}\right)$ and $m_{t+1} = \beta\frac{U_c(C_{t+1})}{U_c(C_t)}$, where r_t^* represents the world interest rate and $\frac{B_t^F}{K_{t-1}}$ represents the aggregate leverage ratio.

3.2 *Quantitative analysis*

In this section, we show that a small open economy model shows a better performance in capturing movements of aggregate financial flows in Japan, especially debt.

3.2.1 Data and parametrization

We use the same data as for a closed economy, but some adjustments have been made to match empirical counterparts, such as the utility parameter and equity payout parameter. Also, the world interest rate, denoted by the U.S. average majority prime rate charged by

banks, is introduced here to estimate the domestic interest rate. Moreover, the parameter of the default risk premium is estimated by the average contracted lending interest rate and the aggregate leverage ratio. This parameter implies that every 1 percent increase in leverage ratio will induce about a 0.01 percent increase in default risk premium. Parameters are listed in Table 3.1.

Table 3.1: Parameters set by the steady-state or second moments

Parameters set by the steady state	
Discount factor	0.982
Tax advantage	0.300
Utility parameter	1.792
Production technology	0.362
Depreciation rate	0.049
Enforcement parameter	0.636
world interest rate	0.055
the parameter of default risk premium	1.036
Parameters set by the second moments	
Payout cost parameter	7.000

3.2.2 Impulse response

In this section, we study responses of key indicators to one-time productivity shocks and financial shocks, respectively. Figure 3.1 shows that, after a one-time productivity shock, enforcement constraints instantly loosen, and the shadow price of enforcement constraint η suddenly goes down. Therefore, firms increase bond issuance to finance production activities. According to equation (7), if firms want to keep production plans unchanged, a downturn in η requires a larger equity payout. However, due to the adjustment cost of dividends, firms have to increase hiring to reduce total cost. Yet sudden debt expansion induces an increase in foreign liabilities, leading to a downturn in the current account. As the debt position becomes larger, enforcement constraints become tighter and gradually become binding again. Under these circumstances, the marginal cost of enforcement constraints becomes larger, and firms start to reduce their debt position to ease binding constraints. At this time, dividends and labor input are forced to decrease. The current account also is rebound due to the decline in foreign liabilities.

Figure 3.2 shows that if the economy receives a one-time financial shock, enforcement constraints suddenly become tighter, and the value of multiplier η surges up and forces

Figure 3.1: Response to one-time negative productivity shock with enforcement constraint in small open economy
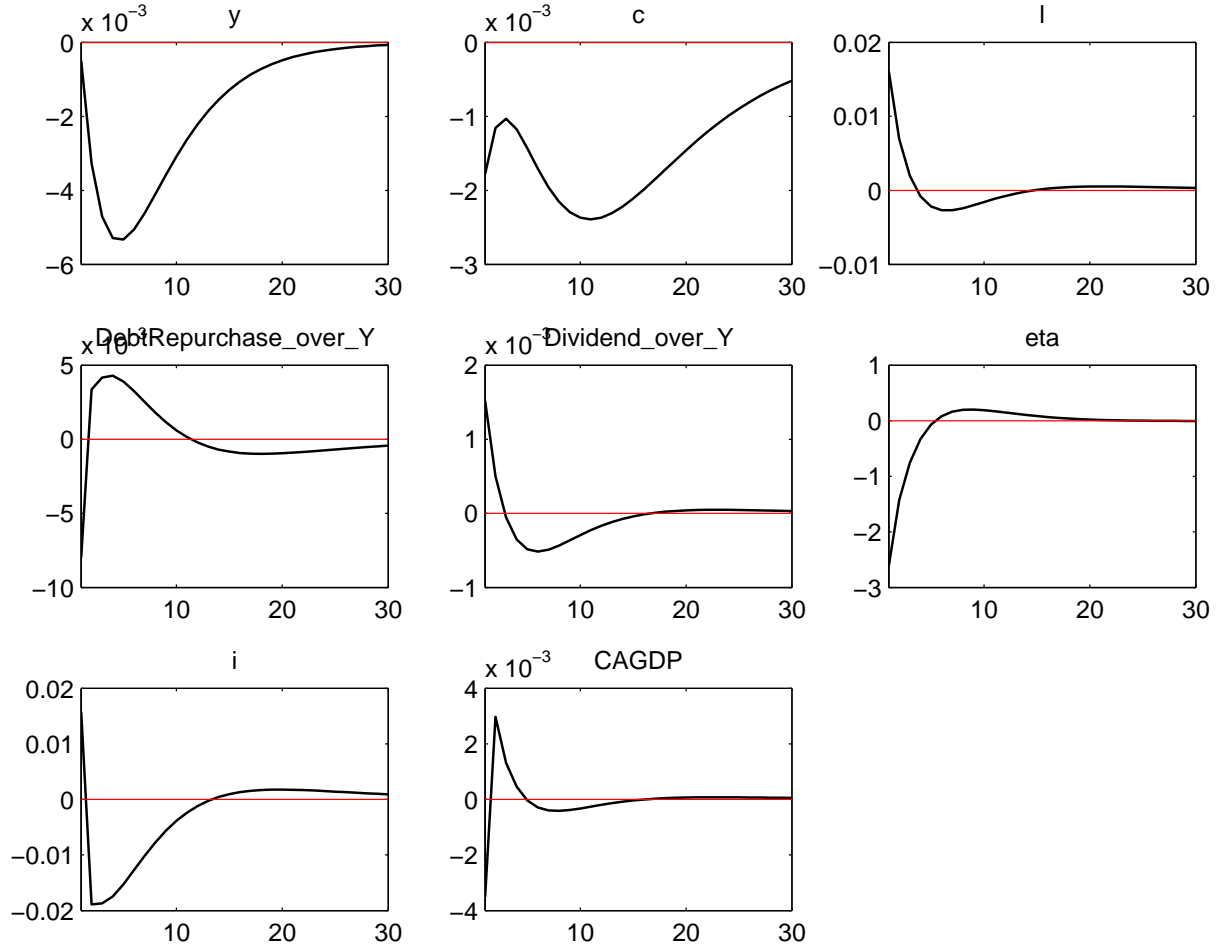
firms to reduce equity payout. Because there is an adjustment cost that accompanies dividend adjustment, labor input is also reduced. The immediate repurchases of debt reduce the external debt position and lead to an increase in the current account. As enforcement constraints are released by debt reduction, constraints are loosened, and firms turn to debt financing again. Therefore, equity payout recovers, and the length of working hours also recovers at the release of constraint tightness. However, because the reduction in investment and the increase in foreign debt position, the interest rate goes up, implying that the cost of debt financing is also increased. Therefore, firms issue more domestic debt instead of borrowing externally, and the current account recovers after a downturn.

Figure 3.2: Response to one-time negative financial shock with enforcement constraint in small open economy
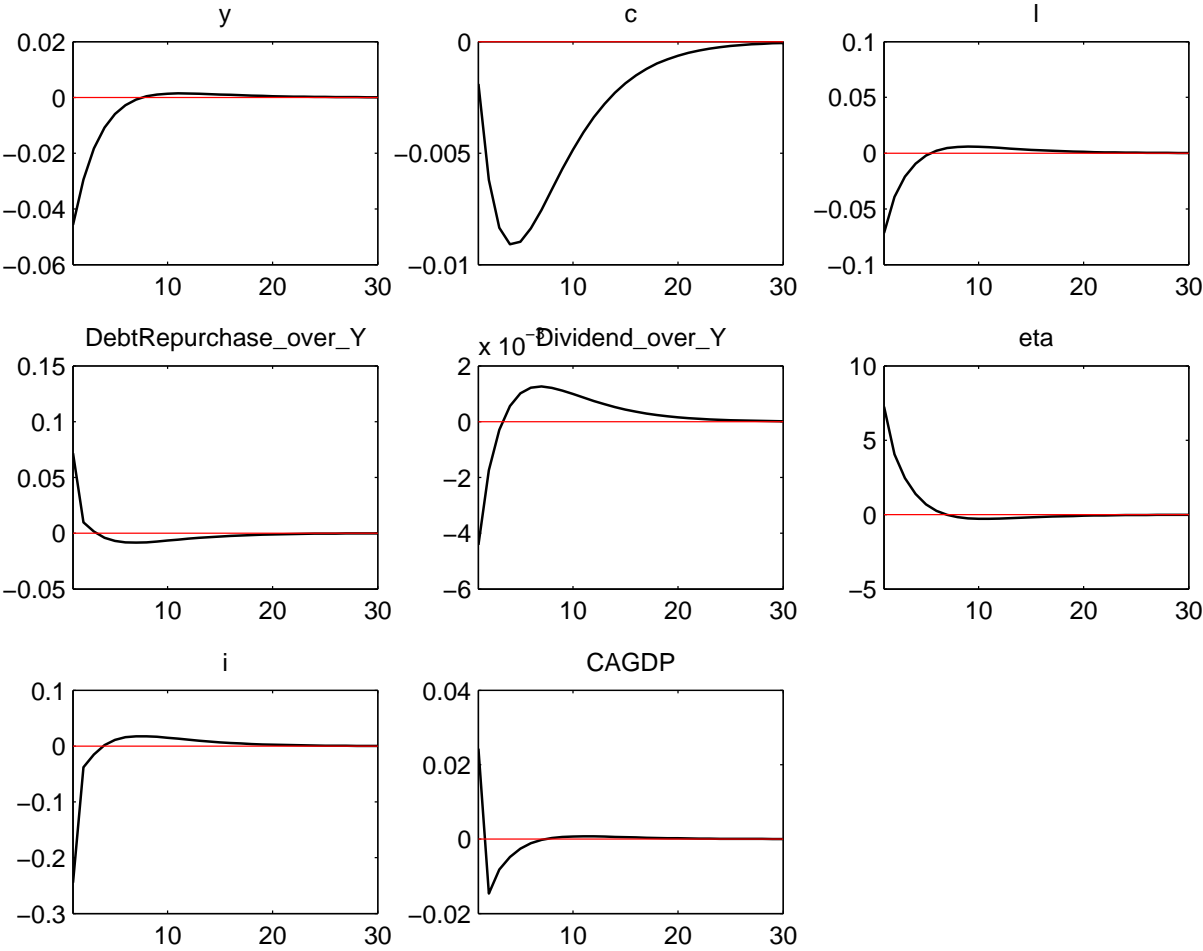
3.2.3 Simulation

In order to see whether a small open economy model can improve the performance of financial shocks, we conducted simulations on some key indicators in which we are interested. Besides variables explored in a closed model, we also paid attention to the current account variable in this section. The biggest surprise we found is that, as shown in Figure 3.3, financial shocks can capture movements of new debt repurchases quite well compared with those in a closed economy. Especially, the second moment of debt repurchase output ratio is improved from 0.0151 to 0.0842, which is quite close to empirical value 0.0789. We conjecture that the main reason is that a higher level of financial rigidity (larger κ) is required in the small open economy to match the empirical value. Therefore, the adjustment cost of dividends in a small open economy is relatively larger than that in a closed one; as a result, labor input displays a higher volatility. Additionally, since capital stock directly influences the interest rate, its volatility has to be depressed by firms. Therefore, the aggregate debt position, especially the domestic debt position, becomes a main channel for adjusting the tightness of enforcement constraints. Consequently, debt repurchases become dramatically more volatile. Also, it shows that the dividend (Figure 3.3) is still well explained by financial shocks in a small open economy, and the second moment of dividend is improved from 0.0048 to 0.0069. However, financial shocks still generally fail in explaining movements of real variables.

As to productivity shocks, according to Table 3.2, we find that they are still dominant in explaining business cycles, although most key indicators are relatively underestimated compared with empirical value, except labor. Moreover, we can see from Figures 3.4 and 3.5 that there is a significant improvement in replication of investment and consumption. In a closed economy, investment ratio is estimated to drop to the bottom in 2009Q1; yet the biggest recession occurred in 2009Q3. In a small open economy, not only has this kind of time mismatching been successfully overcome, but the span of the downturn is also accurately estimated. As to other variables, we are pleased to find that the volatility of consumption is obviously smaller than that in the closed economy, and the second moment of this variable in the open economy also demonstrated this improvement. However, by contrast, we find that the performance of labor becomes worse. As to the current account, Figure 3.6 implies that this model does not capture the trends well.

3.3 *Summary*

Since a closed economy cannot replicate the trends of aggregate financial flows in Japan, we extend it to a small open economy to see whether the performance of financial shocks can be improved. The extension includes two steps: (1) Assume firms can borrow from

Figure 3.3: Simulation with data of Japan (- - -: simulated data ; —: real data ; PS : productivity shocks ; FS : financial shocks)
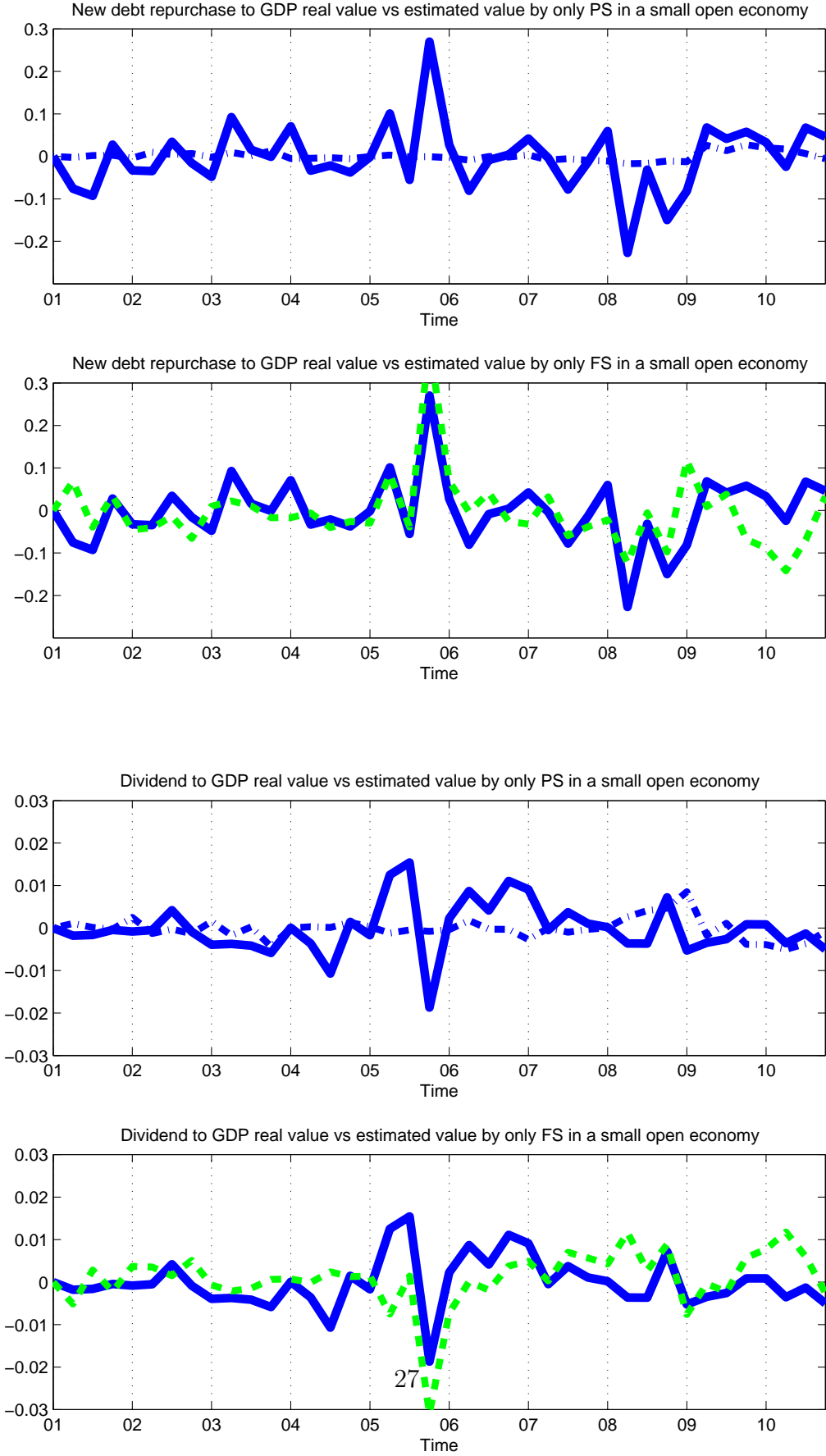

New debt repurchase to GDP real value vs estimated value by only PS in a small open economy

New debt repurchase to GDP real value vs estimated value by only FS in a small open economy

Dividend to GDP real value vs estimated value by only PS in a small open economy

Dividend to GDP real value vs estimated value by only FS in a small open economy

Figure 3.4: Simulation with data of Japan (- - -: simulated data ; —: real data ; PS : productivity shocks ; FS : financial shocks)
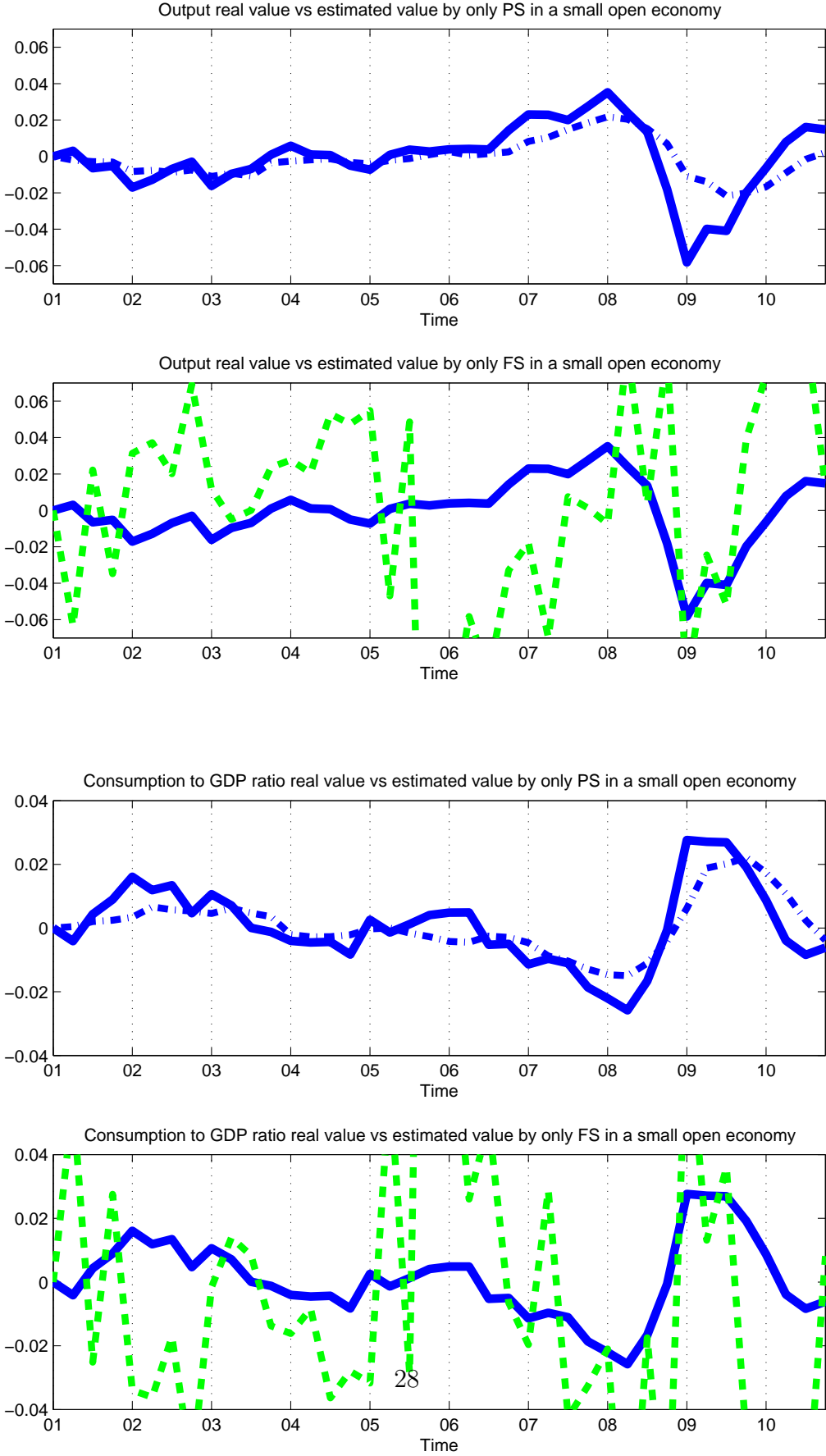
Figure 3.5: Simulation with data of Japan (- - -: simulated data ; —: real data ; PS : productivity shocks ; FS : financial shocks)
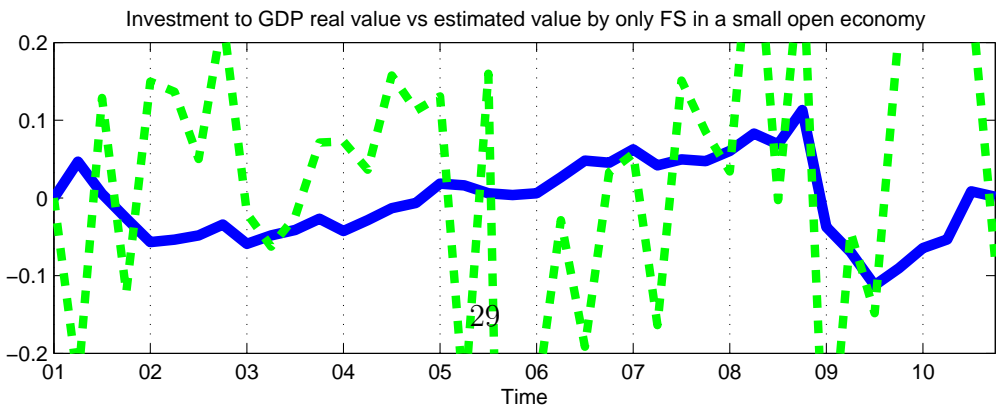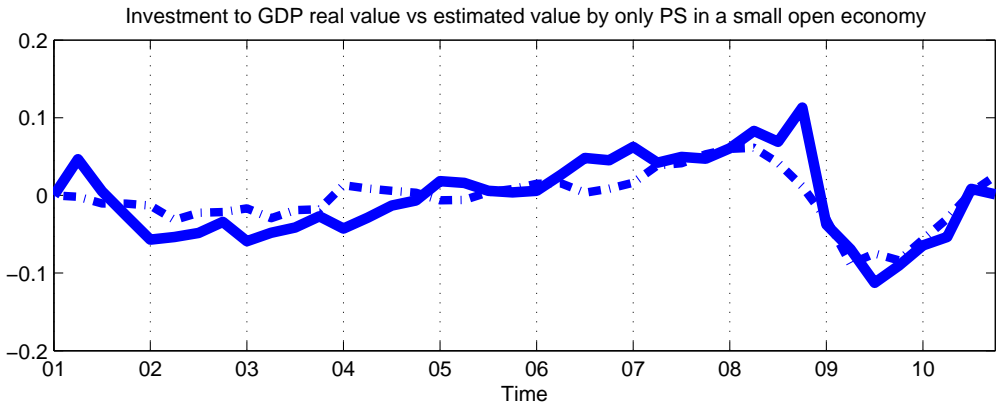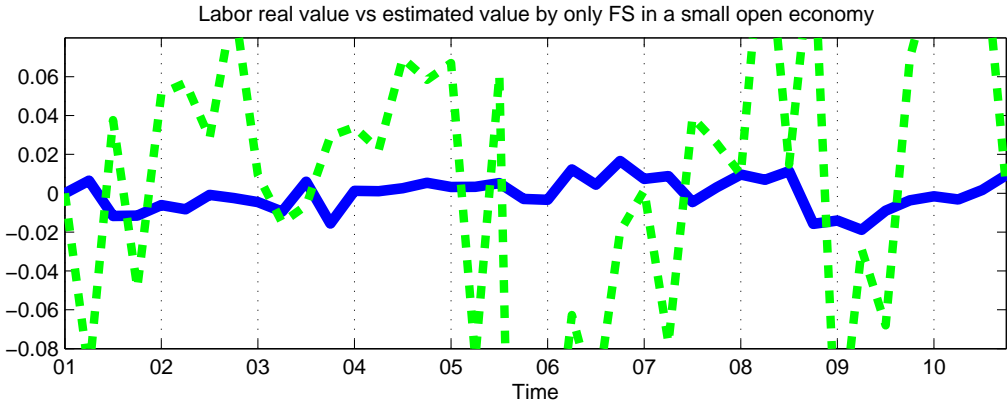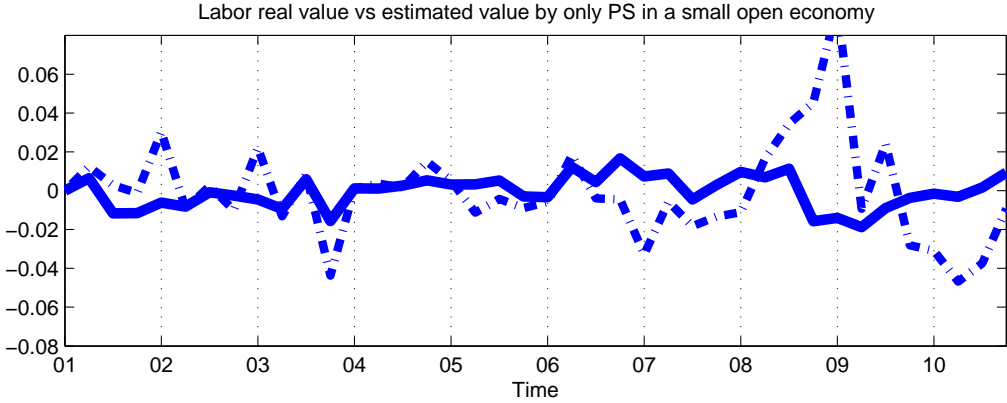
Figure 3.6: Simulation with data of Japan (- - -: simulated data ; —: real data ; PS : productivity shocks ; FS : financial shocks)

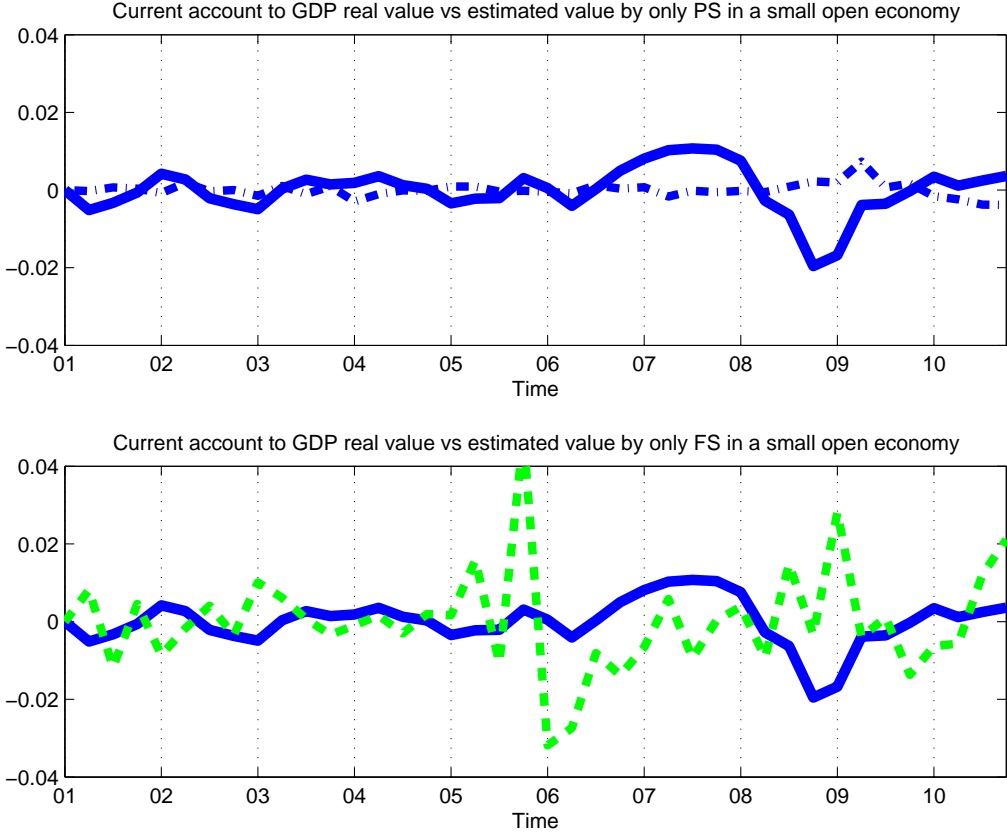Table 3.2: Estimated business cycle properties in small open economy : second moments

Variables	Data	Model:only PS	Model:only FS
Financial Variables			
Dividend/GDP	0.0061	0.0025	0.0069
Debt repurchases/GDP	0.0789	0.0104	0.0842
Macroeconomic Variables			
Output	0.0186	0.0102	0.0788
Consumption ratio	0.0124	0.0087	0.0710
Investment ratio	0.0510	0.0348	0.2795
Hours	0.0084	0.0254	0.1155
Current account/GDP	0.0060	0.0018	0.0137

overseas lenders. (2) Assume that the interest rate requires a default risk premium, and it is now determined by the world interest rate and the aggregate leverage ratio. After we assume enforcement constraints are binding since 2001 and that there exists some degree of rigidity in the financial sector of Japan, we find conclusions as follows:

- Financial shocks play a key role in explaining the aggregate financial flows, especially for equity and debt financing.

- Productivity shocks are significant to real variables in Japan. Specifically, investment and consumption activities are better replicated in a small open economy, but labor and current accounts cannot be explained well by either kind of shock.

4   Conclusion

Have financial shocks been important for the Japanese economy since 2001? This paper suggests that they are dominant factors in the dynamics of Japanese aggregate financial flows, which is consistent with the findings of Jermann and Quadrini (2012). However, they seem less important than productivity shocks for the Japanese real economy, at least for the last decade.

In order to find answers, first we applied the DSGE model of Jermann and Quadrini (2012) to the Japanese economy. In the model, we assume that firms prefer debt issuance to equity financing due to the tax advantage. However, when firms borrow intraperiod debt from the financial sectors, they face identical enforcement constraints that are subjected to their collateral value. In addition, they have to pay an extra cost when adjusting equity payout, and it is regarded as a form of financial rigidity. Second, using

quarterly data from Japan, we constructed time series of financial and productivity shocks as residuals of enforcement constraints and production functions, respectively. Finally, we conducted simulations on key indicators and compared them to empirical series, not only by second moments but also through figures. Preliminary results in a closed economy show that financial shocks do not seem important for the Japanese economy.

Is this a final conclusion? In order to further explore this problem, we extend the closed economy to a small open economy, which has not been widely applied in DSGE studies until recently. The extension includes two steps: (1) Assume firms can borrow from overseas lenders. (2) Assume that the domestic interest rate is subject to the world interest rate and default risk premium and that this premium is positively related to the leverage ratio of the whole economy. By such an extension, we find that, different from those in a closed economy, simulated debt and dividend flows generated by financial shocks track quite closely the empirical series; this also has been proven by comparing second moments. Moreover, this extension proves that productivity shocks seem to have been dominant in accounting for fluctuations of real variables, such as output, consumption ratio, and investment ratio in Japan.

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