How Does the Market-Based Intermediary Sector Affect the Business Cycle? — An Empirical Analysis Based on a DSGE Framework

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Abstract

Sudo [2011] developed a new-Keynesian DSGE model in which market-based intermediaries or active investors have an interactive relationship with the ultimate borrowers and lenders, and derived the following important propositions from the theoretical analysis. First, the greater the active investor's asset size, the higher will be the expected net profits. Second, the steeper the yield curve, the greater is the asset size. These propositions together suggest that steeper yield curves will yield higher net profits to active investors. Third, the term structure of interest rates is endogenously shifted by the modified relative amounts of money and each bond that is outstanding.

Using the developed model in Sudo [2011] and the U.S. quarterly data for 1990:Q1-2010:Q3, this study performs empirical analyses and thereby empirically proves the abovementioned propositions in the model. Furthermore, the analyses indicate that the active investor sector is not only a source of the business cycle but also a fluctuation amplifier, that active investors might impede the propagation of monetary policy effects, and that although rigorous financial regulation could forestall asset price bubbles, it might not necessarily lead to economic stability.

The results of the empirical analysis indicate that the active investor sector has significant effects on the business cycle, thus supporting the view of Adrian, Moench and Shin [2010b].

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Contents

I Introduction

It appears that since 2000, market-based intermediaries have played a crucial role in business cycles, especially boom-bust cycles, because nonbank financial intermediaries have become increasingly important sources of credit, particularly due to the growing popularity of securitization, as pointed out by many studies such as Adrian and Shin [2010a, 2011a] and Woodford [2010]. In that case, is it possible that the market-based intermediaries substantially impact business cycles? How would they do so? The research conducted on this issue so far has mainly focused on the behaviour of these intermediaries[1].

We have two objectives: first, to present a new-Keynesian DSGE model which will provide a microeconomic foundation to the interconnections among the ultimate borrowers, ultimate lenders and market-based financial intermediaries; second, to perform empirical analyses, using the U.S. data, and to assess the influences of the market-based intermediary sector on business cycles. The first objective was attained by Sudo [2011]. Hence, that study developed a new-Keynesian DSGE model in which market-based intermediaries or active investors have an interactive relationship with the ultimate borrowers and lenders, and derived the following four propositions from the theoretical analysis.

First, the collateral constraint on end-user borrowers is likely to push down housing stock in a steady state. This implies that the constraint controls residential investment. The second proposition is that, under a probable condition on active investors' investment, the marginal increases in capital would raise the expected net profits. This proposition indicates that, when an increase in the active investor's asset size induces a rise in capital, it pushes up the expected net profits. The third proposition states that the active investor's holdings of risky assets are affected by the slope of the yield curve; hence, the steeper the yield curve, the larger is its asset size. This proposition, together with the second one, suggests that a steeper yield curve is likely to yield larger net profits for active investors, which theoretically supports the views of Adrian, Moench and Shin [2010b], Cúrdia and Woodford [2010] and Woodford [2010]. Finally, the fourth proposition posits that the term structure of interest rates is endogenously shifted by the modified relative amounts of money and each bond that is outstanding. This proposition is consistent with Tobin's [1969] view.

The aim of this study is to achieve the second objective, based on the developed model in Sudo [2011] and the U.S. data: to empirically examine the abovementioned second to fourth propositions, and to assess effects of the presence of the market-based intermediary sector on the business cycle.

II Model specification

As mentioned above, this study follows a model developed in Sudo [2011]. Appendix A illustrates the whole picture of the model. In order to explore the model, let us log-linearize the equations describing the model around the steady state. However, the entire model is so complicated that it is not easy to fulfil the Blanchard and Kahn [1980] condition, that is, to carry out the empirical analysis of the model. Hence, let us incorporate some additional assumptions to simplify the model.

First, we assume that $\frac{C_{1,t}}{C_t}=\frac{N^s_{1,t}}{N^s_t}=\tau_1$, where $\tau_1 \in (0, 1)$ is constant. Second, the lump sum transfer, T_t, is ignored in the case of passive investors. Third, since ξ_t is the dummy variable in equation (A.24), let us ignore the term multiplied by ξ_t for the sake of simplicity.

The final assumption is that active investors always choose a constant ratio of accepted deposits as reserves. This implies that in the active investor's first-order conditions, $B_{r,t}$ is replaced by $\tau_2 M_t$, where $\tau_2 \in (0, 1)$ denotes the constant ratio. Although this assumption imposes a strong restriction on the active investor's behaviour, it can be supported by two points: first, the fact that banks actually behave thus, and second, the fact that it helps maintain the second and third propositions stayed above.

III Estimation

1. Preliminary setting

In this study, we have used the U.S. quarterly data for the period extending from 1990:Q1 to 2010:Q3. The data pertain to the following: real consumption, hours in business sector, compensation per hour in business sector, house prices, housing stock, real residential investment, consumer prices, money supply, interest rates (one-period and long-term), bond outstandings (short- and long-term), reserves and central bank loans to financial institutions. The data series and their sources are listed in Appendix B. The trends have been removed from the variables by

Table 1. Calibrated parameters

Parameter	Value	Parameter	Value
σ_1, σ_2	2	ω	0.6
β_1	0.97	η	0.85
h_1, h_2	0.9	Θ	0.2
$\varphi_1, \varphi_2, \varphi$	1	ρ_r	0.8
χ	1	ρ_π	1.5
k_h	0.925	ρ_y	0.3
k_{bs}	0.3	ι_h	0.016
β_2	0.99	τ_1	0.35
α	0.36	τ_2	0.037
β	0.983	$\overline{X}$	0.2

using the Hodrick-Prescott filter. In the study, we have defined active investors as comprising commercial banking, securities dealer-brokers, asset-backed security (ABS) issuers, finance companies, funding corporations, and agency- and government-sponsored enterprises (GSE) -backed mortgage pools in the *Flow of Funds Accounts of the United States*[2).

We have not estimated all the parameters considered in the model; the values of some of these parameters have been set on the basis of previous studies. These parameters and their values are given in Table 1.

Since the present study's end-user borrowers and passive investors correspond to the impatient and patient households, respectively, in Gerali et al. [2010] and Iacoviello and Neri [2010], some parameters associated with these agents are set based on these studies, that is, β_1=0.97, k_h=0.925, χ=1 and $\varphi_1=\varphi_2=\varphi=1$[3). Moreover, τ_1 is set as 0.35. Iacoviello and Neri [2010] estimate the labour income share of collateral constrained agents to be 21%. While both collateral constrained (borrowers) and unconstrained (lenders) households invest in residential assets in their model, the former invest in residential assets and the latter possess financial assets in our model. Therefore, we regard the income share of the former as not much lower than that of the latter and retain its prior mean of 35%, sourced from the estimation by Iacoviello [2005].

This study has formulated the utility on real consumption in a manner different from Gerali et al. [2010] and Iacoviello and Neri [2010] but identical to Andrés, López-Salido and Nelson [2004a, b], wherein households correspond to passive investors (i.e. patient households) in our model. Consequently, based on Andrés, López-Salido and Nelson [2004a], we have set $\sigma_1=\sigma_2=2$ and $h_1=h_2=0.9$. Moreover, β_2 is set as 0.99 based on $\frac{1}{H_l}$, and ι_h is set as 0.016 based on the definition of depreciation $\iota_h \equiv \frac{\bar{I}_h}{\bar{Q}'_h \bar{S}_h}$, where $\bar{I}_h$ represents a steady state value on real residential investment.

With regard to the active investor part, τ_2 and k_{bs} are set based on $\frac{\bar{B}_r}{\bar{M}}$ and $\frac{\overline{RB}_s^s}{\bar{H}_l \bar{B}_{1,l}}$, respectively, as τ_2=0.037 and k_{bs}=0.3. The setting of k_{bs} should be noted. In the repo market, a haircut of 2% is traditionally applied to AAA through AA grade bonds. In practice, however, not all short-term bonds are secured by collateral, so we can calibrate k_{bs} as above, based on equation (A.16).

The setup of the firm is the same as described in Sudo [2010]. Therefore, the related parameters are set on the basis of his study: α=0.36, ω=0.6, η=0.85 and Θ=0.2. Furthermore, based on equation (A.28), β is calculated as 0.983.

The interest rate rule is similar to that in Iacoviello and Neri [2010], except for the inclusion of the term $\rho_\mu \ln\left(\frac{\Phi_t}{\bar{\Phi}}\right)$ in equation (A.31). Consequently, the related parameters are set based on the above study; ρ_r=0.8, ρ_π=1.5 and ρ_y=0.3. ρ_μ will be estimated in this study.

Finally, we set $\bar{X}$= 0.2, because in the period between 1990 and 2010, we will assume that the end-user borrowers have started facing financial distress after 2007.

2. Parameters estimation

The remaining parameters—γ, $v_{1,l}$, $v_{2,s}$, $v_{2,l}$, ρ_μ, ρ_{qh1}, ρ_{qh2}, ρ_x, ρ_h, ρ_a, ρ_R and the standard deviation on disturbances—still need to be estimated. To estimate unknown parameters, we will perform Bayesian inference using the Markov Chain Monte Carlo (MCMC) method, which is now a standard technique for estimating the DSGE model[4]. The observable data used to estimate the unknown parameters include real balances, federal funds rates, real house prices and inflation rates; the estimation results are presented in Table 2. For all parameters except for the standard deviation on disturbances, the estimated values fulfil relevant conditions[5].

All shocks are highly persistent. Real house prices are also highly persistent, while the elasticity of real house prices with respect to housing stock is very low.

$v_{1,l}$ indicates the degree of self-imposed liquidity requirement when active investors invest in risky assets. The larger the value of $v_{1,l}$, the higher is the liquidity requirement imposed by active investors. Although the $v_{1,l}$ estimate fulfils the condition of $0 < v_{1,l} < 6$ stated in Sudo [2011, p.25], its value may not be high. Moreover, defining the term premia between one-period holding returns on long- or short-term bonds and one-period interest rates as term premia on long-term and short-term returns, respectively, we can calculate the semi-elasticity of the real risky asset holding by active investors with respect to the term premia according to equation (45) in Sudo [2011, p.26]. As a result, if the term premia on long-term returns increase by 1% , the real risky asset holdings (i.e. active investors' assets) would correspondingly increase by 2.15%, on average. On the other hand, a 1% increase in the term premia on short-term returns would depress the real risky asset holdings by 0.52%.

Table 2. Prior and posterior distribution of the structural parameters

Parameter	Prior distribution			Posterior distribution		
	distribution	Mean	Std. dev.	Mean	2.5%	97.5%
γ	Beta	0.5	0.01	0.4951	0.4802	0.5110
$v_{1,l}$	Gamma	0.5	0.01	0.5008	0.4845	0.5171
$v_{2,s}$	Gamma	0.2	0.01	0.2006	0.1840	0.2170
$v_{2,l}$	Gamma	0.2	0.01	0.1987	0.1826	0.2128
ρ_{μ}	Gamma	0.3	0.1	0.1466	0.1033	0.1933
ρ_{qh1}	Beta	0.8	0.1	0.9070	0.8533	0.9602
ρ_{qh2}	Beta	0.03	0.01	0.0174	0.0088	0.0265
ρ_{x}	Gamma	0.5	0.1	0.7130	0.5647	0.8526
ρ_{h}	Beta	0.8	0.1	0.9596	0.9245	0.9969
ρ_{a}	Beta	0.8	0.1	0.9959	0.9930	0.9989
ρ_{R}	Beta	0.8	0.1	0.8569	0.7716	0.9521
σ_{h}	Inv. gamma	0.05	0.05	0.2762	0.2289	0.3212
σ_{qh}	Inv. gamma	0.05	0.05	0.0106	0.0093	0.0120
σ_{a}	Inv. gamma	0.05	0.05	0.0330	0.0277	0.0379
σ_{R}	Inv. gamma	0.05	0.05	0.0083	0.0078	0.0088

Since $v_{2,s}$ and $v_{2,l}$ are estimated as positive, they have the following implications. First, changes in the real demand for short- and long-term bonds influence the real balance. Second, the relative weight of the real balance, in terms of real holdings of short- or long-term bonds by passive investors, affects not only the one-period holding returns on the corresponding bond but also the other bonds.

ρ_{μ} indicates the effect of changes in the money multiplier on the policy rate setting. The estimate of ρ_{μ} shows that changes in the money multiplier have a very small impact on the policy rate decision, as compared to changes in the output and the inflation rate.

Ⅳ Analysis

In this section, we will discuss the dynamics of the linearized model using impulse responses, while focusing on the active investor sector. Our aim is to empirically examine the second to the fourth propositions and to assess the effects of the presence of the active investor sector on the business cycle.

Before proceeding to the main results, let us have an overview of the role of each shock in

Table 3. Forecast error variance decomposition

(%)

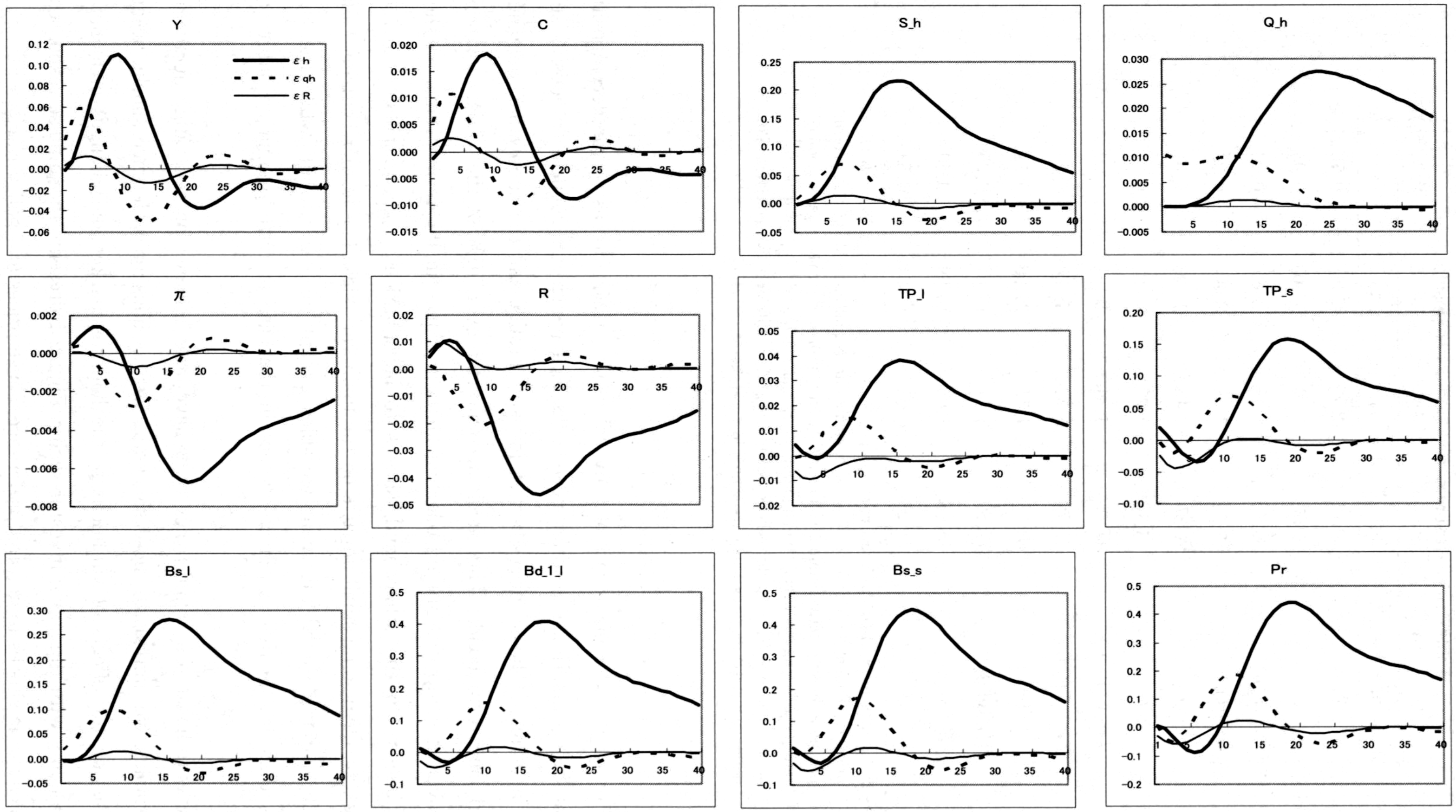
Main variables	ε_h	ε_{qh}	ε_a	ε_R
Y	39.01	12.81	47.48	0.70
C	3.57	1.30	95.05	0.08
S_h (S_h)	86.45	4.47	8.86	0.22
Q_h (Q_h)	87.71	7.38	4.84	0.08
π	2.37	0.18	97.43	0.01
R	25.18	2.25	72.23	0.34
TP_l (TP_l)	47.05	3.34	48.61	1.00
TP_s (TP_s)	57.79	5.32	35.30	1.58
B_l^s (Bs_l)	80.36	4.56	14.96	0.11
$B_{1,l}^d$ (Bd_1_l)	77.89	5.11	16.64	0.35
B_s^s (Bs_s)	75.66	4.95	18.99	0.40
Pr	77.91	6.62	14.94	0.53

Note: Y stands for real GDP; C, real consumption; S_h, real housing stock; Q_h, real house price; π, nominal inflation rate; R, gross nominal one-period interest rate; TP_l, term premium on long-term nominal returns; TP_s, term premium on short-term nominal returns; B_l^s, long-term bond outstanding; $B_{1,l}^d$, real holding of long-term bonds by active investors; B_s^s, short-term bond outstanding; Pr, profits of active investors. The notations used in Figures 1 to 4 are shown in parentheses.

generating fluctuations in the main variables by calculating their forecast error decomposition. Table 3 presents the results. Housing preference shocks, ε_h, have large influences on housing stock (i.e. residential investment), house prices, active investor profits, and the supply and demand of both short- and long-term bonds. The shock accounts for over 70% of the variance in these variables; moreover, it comprises around one-half of the variance in the term premia on short- and long-term bonds. On the other hand, shocks to house prices, ε_{qh}, and policy rates (i.e. monetary policy), ε_R, have some small impacts on the main variables. The former contributes less than 10% to the variance in all the main variables except for real output, while the latter contributes less than 1% to their variance, except in the case of term premia on short- and long-term bonds.

Although shocks to house prices and policy rates have little influence on generating fluctuations in the main variables, we emphasize these shocks as well as housing preference shocks because this study focuses on the effects of variations in the housing market and changes in monetary policy on the economy with the active investor sector. Figure 1 presents the impulse responses of the main variables to the shocks to housing preference, house prices and policy rates.

Figure 1. Impulse responses of main variables in the model with the active investor sector



Note: The unit of horizontal axes is a quarter. Thick solid lines show impulse responses to housing preference shocks; dotted lines, to house price shocks; and thin solid lines, to policy rate shocks.

1. Properties of the model and empirical examination of the propositions

(1) Positive shocks to housing preference

Positive housing preference shocks raise house prices and housing stock (i.e. residential investment), which increase both real output and inflation rates, thus inducing rises in the policy rates. Meanwhile, increases in the housing stock lead to greater issuances of long-term bonds, which push up long yields, that is, one-period holding returns on the long-term bonds. Although this induces the long-term premia to decrease, initially, because one-period holding returns rise to a lesser extent than policy rates, they increase soon enough. Increases in the long-term premia (i.e. a steeping yield curve) apply downward pressure on the main variables mentioned above, which finally causes the premia to decrease.

With respect to the active investor sector, its profits and demand for long-term bonds change in accordance with the long-term premia. This empirically proves propositions 2 and 3. In addition, the increasing demand for long-term bonds stimulates the issuing of short-term bonds, which in turn increases the short-term premia through increases in the one-period holding returns on short-term bonds. Therefore, if we combine this fact with the explanation given in the previous paragraph, we can say that there exists a bi-directional feedback system between the yield curve and the economy; this empirically proves proposition 4.

(2) Positive shocks to house prices

The shape of the impulse responses of the main variables is similar to those in the positive housing preference shocks. Accordingly, in this case, we can say that the second to the fourth propositions have been empirically proved as well.

However, the period of impulse responses is much shorter than that of positive housing preference shocks. Although the reason for this is not clear, we can infer it as follows. Although the house prices initially rise due to the shocks, they gradually fall to reach equilibrium soon afterward. Consequently, while the initial impact has the continuous effect of expanding the economy, the subsequent price reductions counteract this effect. This interaction is likely to shorten the period of impulse responses.

(3) Positive shocks to policy rates (tightening monetary policy)

The impulse responses of the main variables in this study are different from the standard results in previous studies. In particular, the real output, real consumption, housing stock and house prices are initially found to move upwards in spite of increasing policy rates. We infer the reason as follows. First, let us consider the reason for the initial increases in housing stock and house prices.

On the one hand, a rise in policy rates induces corresponding increases in the one-period holding returns on long-term bonds or long yields, thereby decreasing the issuance of long-term bonds. On the other hand, passive investors increase their long-term bond holdings or investment in long-term bonds because of improving holding returns, while active investors reduce such investment because their assets are almost entirely composed of long-term bonds and rising long yields leads to deteriorations in their balance sheet. Due to the changing supply and demand of long-term bonds, their holding returns initially increase, but take a rapid downturn soon afterward[6]. Consequently, the real returns decrease, which accordingly pushes up the housing stock as well as house prices.

Second, let us consider the reason for the initial increases in real consumption. As stated above, the rise in policy rates causes active investors to cut down on their long-term bond investment, thus reducing the issuing of short-term bonds accordingly. This induces the passive investors to reduce their short-term bond purchases and consequently push up real consumption.

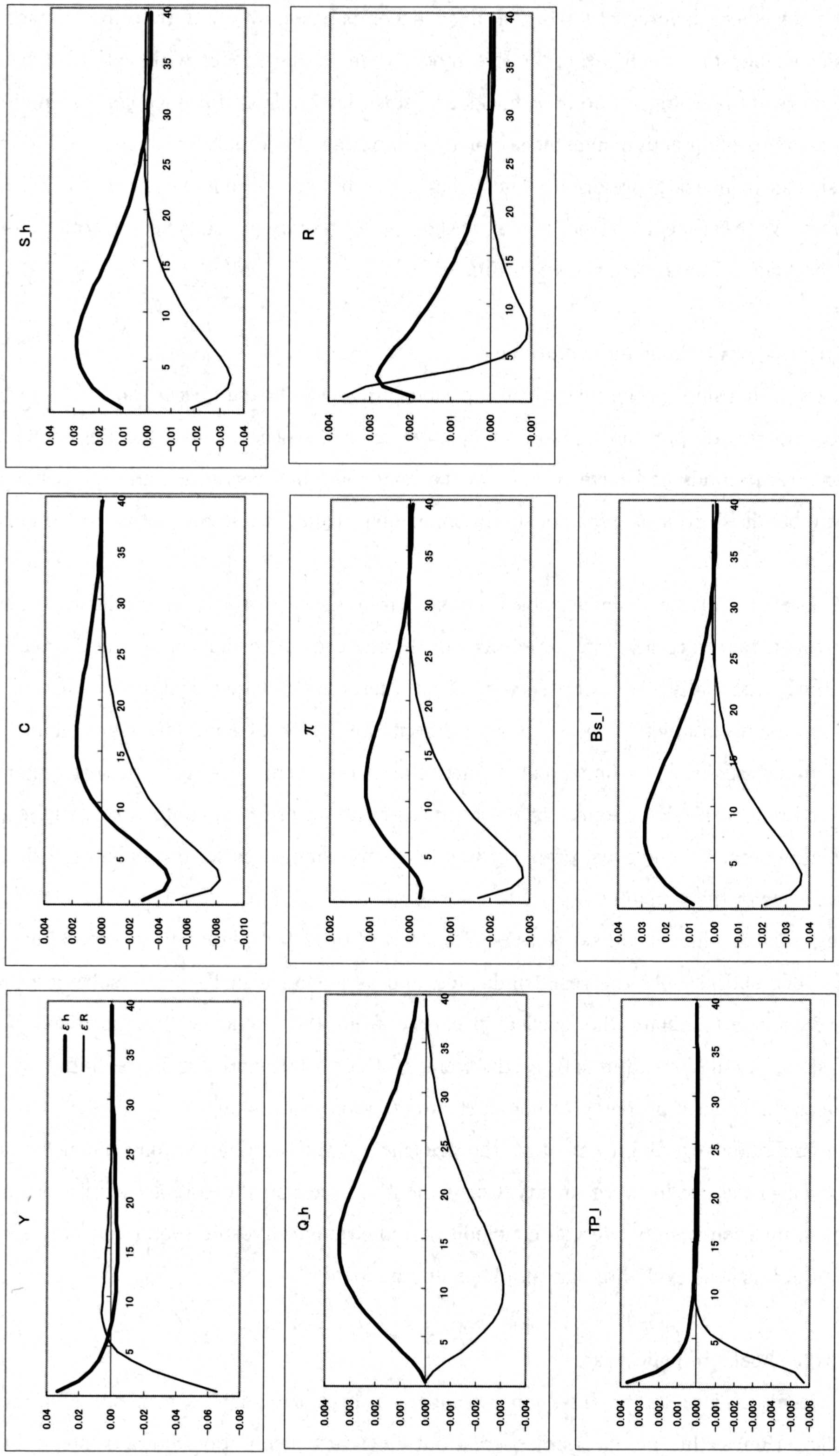
After its initial expansion, the economy goes through a downturn through the following process. Increases in housing stock lead to increases in the supply of long-term bonds, which cause the real holding returns on the bond (i.e. real long yields) and term premia on the bond to go up, thereby pushing down residential investment or housing stock. On the other hand, increases in term premia stimulate long-term bond investment and short-term bond issues by active investors, and the rise in short-term bond issuances leads to greater short-term bond investment by passive investors and accordingly pushes down real consumption. Furthermore, falls in housing stock affect both long- and short-term bond markets and consequently the term premia through the holding returns on these bonds.

The process described above conveys the very important implication that it takes some time for a monetary policy to penetrate through an economy. In addition, it indicates the existence of a bi-directional relationship between the yield curve and the economy; that is, it confirms the validity of proposition 4. Finally, Figure 1 suggests that propositions 2 and 3 are also empirically relevant.

2. Effects of the presence of an active investor sector

In order to investigate the effects of the presence of an active investor sector on the economy, we will introduce another model. In this model, there are no active investors, and instead, we implicitly assume a financial institution that raises funds from passive investors in the form of deposits, M_t, and short-term bond issues, $B_{s,t}$, in period t[7]. Following this, the institution transfers these funds to the central bank as reserves to yield interest and repays the funds with their interest, $R_t M_t$ and $R_t B_{s,t}$, respectively, to passive investors in period $t+1$[8].

Figure 2. Impulse responses of main variables in the model without the active investor sector



Note: The unit of horizontal axes is a quarter. Thick solid lines show impulse responses to housing preference shocks, and thin solid lines, to policy rate shocks.

Computing each shock's forecast error variance decomposition, we find that the impacts of policy rate shocks become much larger in this model than in the model with active investors, while the influences of housing preference shocks are much lower. Therefore, we can examine the effect of the existence of an active investor sector by comparing the impulse responses of the main variables to shocks to housing preference and policy rates between economies with and without active investors. With respect to the model without the active investor sector, the impulse responses of the main variables are shown in Figure 2.

(1) Positive shocks to housing preference

Positive shocks to housing preference push up housing stock, house prices and real output, thereby increasing the supply and demand of long-term bonds, policy rates, one-period holding returns on long-term bonds and term premia on the bond. The increasing demand for residences and long-term bonds decreases real consumption, which results in slight initial reductions in inflation rates.

The initial responses of the main variables are similar to those in the base model with active investors. However, there are material differences in the features of responses between economies with and without the active investor sector. First, there are few cyclical properties in the responses of the main variables in the economy without the sector. Second, for this economy, the responses are much smaller. The first point is particularly important because it suggests that the behaviour of active investors is a source of the business cycle. In order to confirm this suggestion, we will examine whether the cyclical property is due to any changes in the probability of default, that is, the presence of the variable X_t.

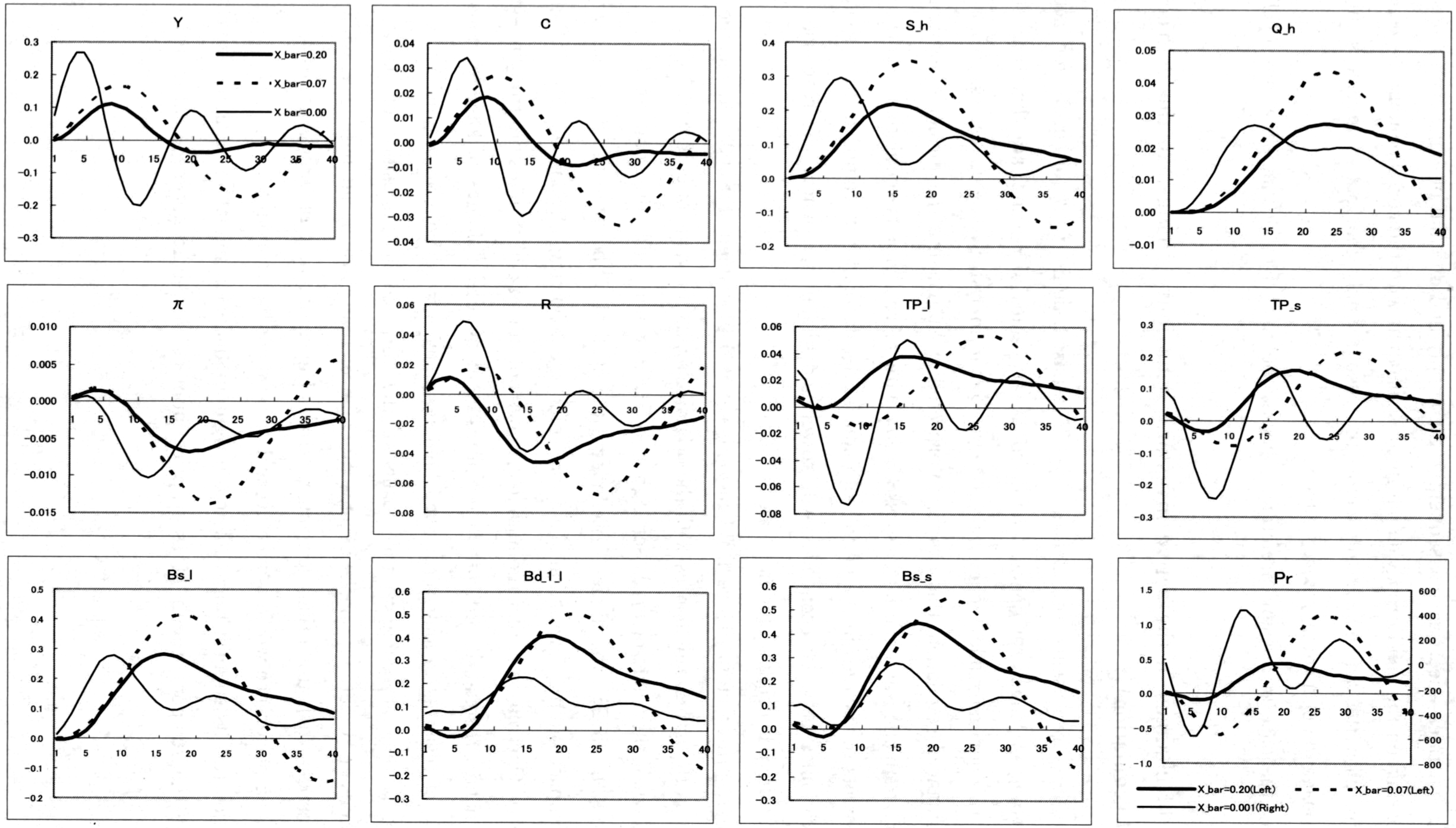
Hence, using our base model, we set $\overline{X}$ as 0.07 instead of 0.20 and perform the simulation with housing preference shocks[9]. As the result indicates, and as is shown in Figure 3, setting a lower value for $\overline{X}$ does not eliminate the cyclical property from the economy. Furthermore, if we perform the same simulation after setting the values of $\overline{X}$=0.001 and ρ_x=5, we find that this setting enhances the cyclical property, although the fluctuation is attenuated[10].

The above simulation results indicate that the presence of the variable X_t may not necessarily produce the cyclical feature in the economy. Consequently, based on the comparison of responses as well as the simulation results, we can conclude that the active investor sector not only serves as a source of the business cycle but also amplifies fluctuations[11].

(2) Positive shocks to policy rates

Without the active investor sector, the economy indicates typical responses to positive shocks to monetary policy. Hence, the main variables—real output, real consumption, housing stock, house

Figure 3. Impulse responses of main variables in the model with very low probability of default



Note: The unit of horizontal axes is a quarter. Responses are to housing preference shocks. The model includes the active investor sector. Thick solid lines show impulse responses in the case of $\overline{X}$= 0.20 and ρ_x = 0.7130 (base); dotted lines, in the case of $\overline{X}$= 0.07 and ρ_x = 0.7130; and thin solid lines, in the case of $\overline{X}$= 0.001 and ρ_x = 5.

prices and inflation rates—decrease; consequently, the supply and demand of long-term bonds as well as term premia on the bond drop. Comparing this situation with the corresponding responses in the economy with the active investor sector, the results imply that active investors might impede the propagation of monetary policy effects.

Finally, as in the case of housing preference shocks, the responses do not show any cyclical property.

3. Effects of changes in the active investors' behaviour (changes in the degree of financial regulation)

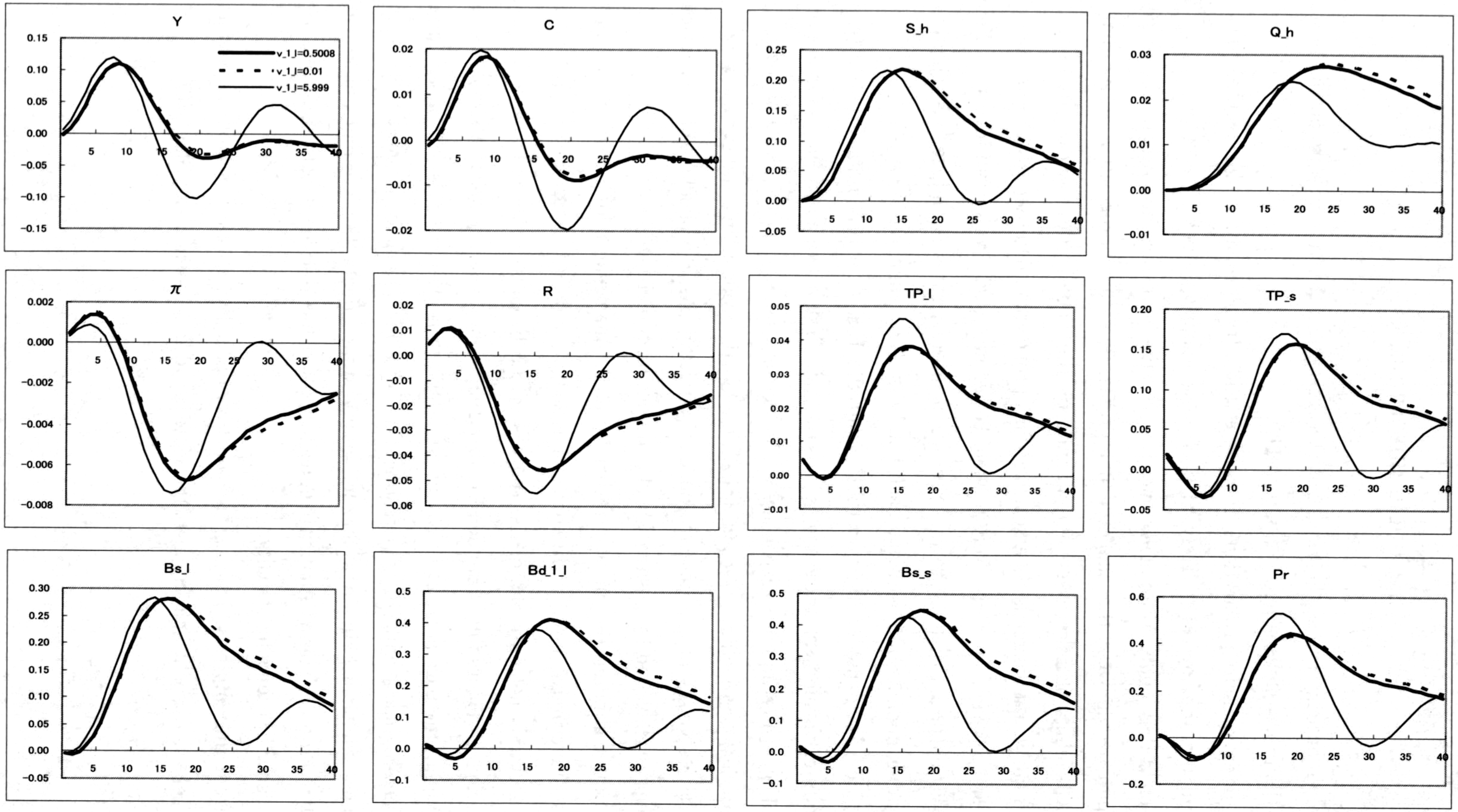
The parameter $v_{1,t}$ represents the degree of self-imposed liquidity requirement for active investors investing in long-term bonds. Therefore, lower values of $v_{1,t}$ indicate that the active investors are risk lovers, while higher values of $v_{1,t}$ point to risk-averse investors. From the viewpoint of financial regulation, this can be interpreted as suggesting the former's association with less strict regulation and the latter's association with more rigorous regulation. In order to examine the effects of changes in the degree of financial regulation, let us compare the responses of the main variables between economies with lower and higher $v_{1,t}$, where the responses are derived from positive housing preference shocks.

The results are presented in Figure 4. When $v_{1,t}$ is set as 0.01 instead of 0.5008, the change has little influence on the impulse responses with the original parameter value of 0.5008[12].

In contrast, when the value of $v_{1,t}$ is set higher at 5.999, which fulfils the condition $0 < v_{1,t} < 6$ stated in Sudo [2011, p.25], the higher $v_{1,t}$ enhances the cyclical property of the responses, while having little impact on the fluctuations. We can infer the following reasons for the enhanced cyclical property. One reason is that the higher $v_{1,t}$ does not inhibit active investors from investing in long-term bonds. Instead, it prompts faster adjustment of their holdings of long-term bonds when the ratio of reserves to long-term bond holdings moves away from an optimal value. The second reason is that, according to the results of the variance decomposition of shocks, the influences of housing preference shocks become much lower than those in our base case, while the influences of shocks to house prices are much larger. Hence, impacts on house prices through shocks to housing preference would induce cyclical variation of the economy.

The simulation results suggest that while more rigorous financial regulation for active investors could prevent the further growth of asset price bubbles, it might not necessarily usher in economic stability.

Figure 4. Impulse responses of main variables in the model with various degree of financial regulation



Note: The unit of horizontal axes is a quarter. Responses are to housing preference shocks. The model includes the active investor sector. Thick solid lines show impulse responses in the case of $v_{1,l}$ = 0.5008 (base); dotted lines, in the case of $v_{1,l}$ = 0.01; and thin solid lines, in the case of $v_{1,l}$ = 5.999.

V Concluding remarks

In this study, we empirically assess the effects of the presence of active investors on the business cycle as well as the propositions stated in Sudo [2011].

Sudo [2011] derived four propositions from the theoretical analysis. First, the collateral constraint on end-user borrowers is likely to push down housing stock in a steady state. The second proposition is that, under a probable condition on active investors' investment, the marginal increases in capital would raise the expected net profits. The third proposition states that the active investor's holdings of risky assets are affected by the slope of the yield curve; hence, the steeper the yield curve, the larger is its asset size. This proposition, together with the second one, suggests that a steeper yield curve is likely to yield larger net profits for active investors. Finally, the fourth proposition posits that the term structure of interest rates is endogenously shifted by the modified relative amounts of money and each bond that is outstanding.

Based on the developed model in Sudo [2011] and the U.S. quarterly data from 1990:Q1 to 2010:Q3, this study performed empirical analyses as follows. First, it examined the dynamics of the linearized model by using impulse responses, while focusing on the active investor sector. The examination empirically proved the second, third and fourth propositions and revealed that the period of impulse responses of the main variables elicited by positive shocks to house prices is much shorter than that elicited by positive shocks to housing preference.

Second, the study compared the impulse responses of the main variables between models with and without the active investor sector. In consequence, two points were brought to light: one, the active investor sector is not only one of the sources of the business cycle but also a fluctuation amplifier; two, active investors might impede the propagation of monetary policy effects.

Third, by changing the parameter of active investors, which represents a degree of self-imposed liquidity requirement along with their investment in long-term bonds, the study investigated whether and how financial regulation for active investors affects the economy. The results revealed that while more rigorous financial regulation could forestall asset price bubbles, it may not necessarily usher in economic stability.

The results from the empirical analysis indicate that the active investor sector has significant effects on the business cycle, which supports the view of Adrian, Moench and Shin [2010b].

Appendix A: Based model

The following model is rewritten from Sudo [2011]. In what follows, for any variable Z_t, $\overline{Z}$ stands for a steady state of the sequence $\{Z_t\}$ and Z_t' represents a real variable in terms of consumer price, that is, $Z_t' \equiv Z_t/P_t$. For detail, see Sudo [2011].

1. End-user borrowers

<Variables and parameters>

[Variables]

$C_{1,t}$: real consumption of the borrower, $S_{h,t}$: housing stock holdings, $N_{1,t}^s$: number of hours worked by the borrower, P_t: price of the consumption goods, W_t: nominal wage, $B_{l,t}^s$: long-term bond outstandings, $Q_{h,t}$: house prices, $H_{l,t}$: gross one-period nominal costs of issuing the long-term zero-coupon bond, R_t: gross nominal one-period interest rate, $\Pi_t \equiv P_t/P_{t-1}$, X_t: probability with which borrowers are faced with financial distress, $e_{h,t}$: shocks to the borrower's demand for housing, $\Lambda_{1,t}$: Lagrange multipliers for the budget constraint, $\Lambda_{2,t}$: Lagrange multipliers for t the collateral constraint

[Parameters]

σ_1: inverse of the elasticity of inter-temporal substitution, χ: inverse of the interest elasticity of the demand for housing, φ_1: inverse of the Frisch labour supply elasticity, h_1: habit persistence parameter indicating the extent of habit formation, ι_h: depreciation rate on housing stock, k_h: parameter measuring the collateral value of houses owned by the borrower, β_1: discount factor, γ: rate at which borrowers can redeem long-term bonds by disposing of their own houses

<Behaviour>

$$\max_{\{C_{1,t}, N_{1,t}^s, S_{h,t}, B_{l,t}^s\}} E_t \sum_{i=0}^{\infty} \beta_1^{t+i} \{(1-X_{t+i}) U_{1,p}(C_{1,t+i}, C_{1,t+i-1}, N_{1,t+i}^s, S_{h,t+i}, e_{h,t+i}) + X_{t+i} U_{1,d}(C_{1,t+i}, C_{1,t+i-1}, N_{1,t+i}^s)\},$$

$$\text{s.t.} \quad \left(\frac{1}{P_{t+i}}\right)[W_{t+i}N_{1,t+i}^s + (1-X_{t+i})\{B_{l,t+i}^s + (1-\iota_h) Q_{h,t+i} S_{h,t+i-1}\}] - C_{1,t+i} - \left(\frac{1}{P_{t+i}}\right)(1-X_{t+i})(H_{l,t+i-1}B_{l,t+i-1}^s + Q_{h,t+i}S_{h,t+i}) = 0 \tag{A.1}$$

and

$$\left(\frac{1}{P_{t+i}}\right)(1-X_{t+i})(k_h Q_{h,t+i} S_{h,t+i} - R_{t+i} B_{l,t+i}^s) \geq 0. \tag{A.2}$$

<Optimality conditions and assumptions>

$$\Lambda_{1,t}=\frac{C_{1,t}^{-\sigma_1}}{C_{1,t-1}^{h_1(1-\sigma_1)}}-\beta_1 h_1 E_t\left[\frac{C_{1,t+1}^{1-\sigma_1}}{C_{1,t}^{h_1(1-\sigma_1)+1}}\right], \tag{A.3}$$

$$(N_{1,t}^{s})^{\varphi_1}=\Lambda_{1,t}W_t', \tag{A.4}$$

$$S_{h,t}^{-\chi}e_{h,t}=(\Lambda_{1,t}-k_h\Lambda_{2,t})Q_{h,t}'-\beta_1(1-\iota_h)E_t\left[\Lambda_{1,t+1}Q_{h,t+1}'\left(\frac{1-X_{t+1}}{1-X_t}\right)\right], \tag{A.5}$$

$$\Lambda_{1,t}-\Lambda_{2,t}R_t=\beta_1 E_t\left[\Lambda_{1,t+1}H_{l,t}\left(\frac{1}{\Pi_{t+1}}\right)\left(\frac{1-X_{t+1}}{1-X_t}\right)\right], \tag{A.6}$$

$$C_{1,t}=W_t'N_{1,t}^{s}+(1-X_t)\left\{B_{l,t}^{s'}+(1-\iota_h)Q_{h,t}'S_{h,t-1}-H_{l,t-1}\frac{B_{l,t-1}^{s'}}{\Pi_t}-Q_{h,t}'S_{h,t}\right\}, \tag{A.7}$$

$$B_{l,t}^{s'}=k_h\left(\frac{Q_{h,t}'}{R_t}\right)S_{h,t}, \tag{A.8}$$

$$e_{h,t}'=\rho_h e_{h,t-1}'+\varepsilon_{h,t}, \tag{A.9}$$

where $e_{h,t}'\equiv\ln(e_{h,t})$, $\rho_h\in(0,1)$ and $\varepsilon_{h,t}\sim i.i.d.(0,\sigma_h^2)$.

2. Active investors

<Variables and parameters>

[Variables]

$B_{r,t}$: reserve outstandings, $B_{1,l,t}^{d}$: holdings of long-term bonds, $B_{s,t}^{s}$: short-term bond outstandings, M_t: deposits accepted from passive investors (demand for money), $H_{s,t}$: gross one-period nominal cost of issuing short-term bonds, E_m: minimum capital (capital adequacy) requirement, L_t: capital injections through the central bank to maintain the minimum capital requirement, $AC_{l,t}$: cost function for investing in long-term bonds, specified as

$$AC_{l,t}\equiv\frac{v_{1,l}}{2}\left(\frac{B_{r,t}}{B_{1,l,t}^{d}}\kappa_{1,l}-1\right)^2 \text{ (where } v_{1,l} \text{ and } \kappa_{1,l}\equiv\frac{\overline{B}_{1,l}^{d}}{\overline{B}_r} \text{ are parameters),}$$

$\Lambda_{3,t}$: Lagrange multipliers for the budget constraint, $\Lambda_{4,t}$: Lagrange multipliers for the collateral constraint

[Parameter]

k_{bs}: parameter measuring the collateral value of the long-term bond holdings

<Behaviour>

$$\max_{\{B_{r,t},B^{d}_{1,l,t},B^{s}_{s,t}\}} (1-X_t)F_p(B_{r,t},\ B^{d}_{1,l,t},\ B^{s}_{s,t})+X_tF_d(B_{r,t},\ B^{d}_{1,l,t},\ B^{s}_{s,t})$$

$$\text{s.t.}\quad \begin{aligned} &R_tB_{r,t}(1+AC_{l,t})-R_tM_t+(1-X_t)\ (H_{l,t}B^{d}_{1,l,t}-H_{s,t}B^{s}_{s,t})\\ &\qquad +X_t\{\gamma(1-k_{bs})H_{l,t}B^{d}_{1,l,t}+L_t\}=E_m \end{aligned} \tag{A.10}$$

and

$$(1-X_t)\ (k_{bs}H_{l,t}B^{d}_{1,l,t}-R_tB^{s}_{s,t})\geq 0. \tag{A.11}$$

<Optimality conditions and assumptions>

$$\begin{aligned} &-\Lambda_{3,t}R_t\left\{1+\frac{\upsilon_{1,l}}{2}\left(\frac{B'_{r,t}}{B^{d'}_{1,l,t}}\kappa_{1,l}-1\right)^2+\upsilon_{1,l}\kappa_{1,l}\left(\frac{B'_{r,t}}{B^{d'}_{1,l,t}}\kappa_{1,l}-1\right)\left(\frac{B'_{r,t}}{B^{d'}_{1,l,t}}\right)\right\}\\ &\quad =R_t-1, \end{aligned} \tag{A.12}$$

$$(1-X_t)\Lambda_{4,t}R_t=1-(1-X_t)\ (1+\Lambda_{3,t})H_{s,t}, \tag{A.13}$$

$$\begin{aligned} &-\upsilon_{1,l}\kappa_{1,l}\Lambda_{3,t}R_t\left(\frac{B'_{r,t}}{B^{d'}_{1,l,t}}\kappa_{1,l}-1\right)\left(\frac{B'_{r,t}}{B^{d'}_{1,l,t}}\right)^2\\ &\quad =1-\{(1-X_t)\ (1+\Lambda_{3,t}+k_{bs}\Lambda_{4,t})+\gamma(1-k_{bs})X_t(1+\Lambda_{3,t})\}H_{l,t}, \end{aligned} \tag{A.14}$$

$$\begin{aligned} &R_tB'_{r,t}\left\{1+\frac{\upsilon_{1,l}}{2}\left(\frac{B'_{r,t}}{B^{d'}_{1,l,t}}\kappa_{1,l}-1\right)^2\right\}\\ &\quad =E'_m+R_tM'_t+(1-X_t)\ (H_{s,t}B^{s'}_{s,t}-H_{l,t}B^{d'}_{1,l,t})\\ &\qquad\quad -\gamma(1-k_{bs})X_tB^{d'}_{1,l,t}-X_tL'_t, \end{aligned} \tag{A.15}$$

$$B^{s'}_{s,t}=k_{bs}\left(\frac{H_{l,t}}{R_t}\right)B^{d'}_{1,l,t}, \tag{A.16}$$

$$R_tB'_{r,t}(1+AC_{l,t})+\gamma H_{l,t}B^{d'}_{1,l,t}-R_tM'_t-k_{bs}\gamma H_{l,t}B^{d'}_{1,l,t}+L'_t=E'_m. \tag{A.17}$$

3. Passive investors

<Variables and parameters>

[Variables]

$C_{2,t}$: real consumption of the investor, $N^{s}_{2,t}$: number of hours worked by the investor, $B^{d}_{2,l,t}$: holdings of long-term bonds, $B^{d}_{s,t}$: holdings of short-term bonds, T_t: lump sum transfers (which include dividends from firms and active investors of which the passive investors are the only owners), $\Lambda_{5,t}$: Lagrange multiplier for the budget constraint, ξ_t: dummy variable, $AC_{m,t}$: cost function for investing in short- and long-term bonds, specified as

$AC_{m,t} \equiv \frac{v_{2,s}}{2}\left(\frac{M_t}{B^d_{s,t}}\kappa_{2,s}-1\right)^2+\frac{v_{2,l}}{2}\left(\frac{M_t}{B^d_{2,l,t}}\kappa_{2,l}-1\right)^2$ ($v_{2,s}$, $v_{2,s}$, $\kappa_{2,s} \equiv \overline{B}^d_s/\overline{M}$ and $\kappa_{2,l} \equiv \overline{B}^d_{2,l,t}/\overline{M}$ are parameters)

[Parameters]

σ_2: inverse of the elasticity of inter-temporal substitution, φ_2: inverse of the Frisch labour supply elasticity, h_2: habit persistence parameter, β_2: discount factor (we suppose $\beta_2 > \beta_1$)

<Behaviour>

$$\max_{(C_{2,t}, N^s_{2,t}, B^d_{s,t}, B^d_{2,l,t}, M_t)} E_t \sum_{i=0}^{\infty} \beta_2^{t+i}\{(1-X_{t+i})U_{2,p}(C_{2,t+i}, C_{2,t+i-1}, N^s_{2,t+i}) + X_{t+i}U_{2,d}(C_{2,t+i}, C_{2,t+i-1}, N^s_{2,t+i})\}$$

$$\text{s.t.} \quad \left(\frac{1}{P_{t+i}}\right)\{W_{t+i}N^s_{2,t+i}+T_{t+i}+(1-X_{t+i})(H_{s,t+i-1}B^d_{s,t+i-1}+H_{l,t+i-1}B^d_{2,l,t+i-1}) + \xi_{t+i}X_{t+i}\gamma H_{l,t+i-1}(k_{bs}B^d_{1,l,t+i-1}+B^d_{2,l,t+i-1})+R_{t+i-1}M_{t+i-1}\} - C_{2,t+i}-\left(\frac{1}{P_{t+i}}\right)\{M_{t+i}+(1-X_{t+i})(B^d_{s,t+i}+B^d_{2,l,t+i}+M_{t+i}AC_{m,t+i})\}=0. \tag{A.18}$$

<Optimality conditions and assumptions>

$$\Lambda_{5,t}=\frac{C_{2,t}^{-\sigma_2}}{C_{2,t-1}^{h_2(1-\sigma_2)}}-\beta_2 h_2 E_t\left[\frac{C_{2,t+1}^{1-\sigma_2}}{C_{2,t}^{h_2(1-\sigma_2)+1}}\right], \tag{A.19}$$

$$(N^s_{2,t})^{\varphi_2}=\Lambda_{5,t}W'_t, \tag{A.20}$$

$$\Lambda_{5,t}-\beta_2 E_t\left[\Lambda_{5,t+1}H_{s,t}\left(\frac{1}{\Pi_{t+1}}\right)\left(\frac{1-X_{t+1}}{1-X_t}\right)\right] =\Lambda_{5,t}\left\{v_{2,s}\kappa_{2,s}\left(\frac{M'_t}{B^{d'}_{s,t}}\kappa_{2,s}-1\right)\left(\frac{M'_t}{B^{d'}_{s,t}}\right)^2\right\}, \tag{A.21}$$

$$\Lambda_{5,t}-\beta_2 E_t\left[\Lambda_{5,t+1}H_{l,t}\left(\frac{1}{\Pi_{t+1}}\right)\left(\frac{1-X_{t+1}}{1-X_t}\right)\right] =\Lambda_{5,t}\left\{v_{2,l}\kappa_{2,l}\left(\frac{M'_t}{B^{d'}_{2,l,t}}\kappa_{2,l}-1\right)\left(\frac{M'_t}{B^{d'}_{2,l,t}}\right)^2\right\}, \tag{A.22}$$

$$\Lambda_{5,t}-\beta_2 R_t E_t\left[\Lambda_{5,t+1}\left(\frac{1}{\Pi_{t+1}}\right)\right] =-\Lambda_{5,t}(1-X_t)\left\{\frac{v_{2,s}}{2}\left(\frac{M'_t}{B^{d'}_{s,t}}\kappa_{2,s}-1\right)^2+\frac{v_{2,l}}{2}\left(\frac{M'_t}{B^{d'}_{2,l,t}}\kappa_{2,l}-1\right)^2 + v_{2,s}\kappa_{2,s}\left(\frac{M'_t}{B^{d'}_{s,t}}\kappa_{2,s}-1\right)\left(\frac{M'_t}{B^{d'}_{s,t}}\right)+v_{2,l}\kappa_{2,l}\left(\frac{M'_t}{B^{d'}_{2,l,t}}\kappa_{2,l}-1\right)\left(\frac{M'_t}{B^{d'}_{2,l,t}}\right)\right\}, \tag{A.23}$$

$$C_{2,t}=\Big[W'_tN^s_{2,t}+T'_t+(1-X_t)\Big(H_{s,t-1}\frac{B^{d'}_{s,t-1}}{\Pi_t}+H_{l,t-1}\frac{B^{d'}_{2,l,t-1}}{\Pi_t}\Big)$$

$$+\gamma X_t\xi_tH_{l,t}\Big(k_{bs}\frac{B^{d'}_{1,l,t-1}}{\Pi_t}+\frac{B^{d'}_{2,l,t-1}}{\Pi_t}\Big)+R_{t-1}\frac{M'_{t-1}}{\Pi_t}-M'_t \qquad \text{(A.24)}$$

$$-(1-X_t)\Big\{B^{d'}_{s,t}+B^{d'}_{2,l,t}+M_t\Big\{\frac{v_{2,s}}{2}\Big(\frac{M'_t}{B^{d'}_{s,t}}\kappa_{2,s}-1\Big)^2+\frac{v_{2,l}}{2}\Big(\frac{M'_t}{B^{d'}_{2,l,t}}\kappa_{2,l}-1\Big)^2\Big\}\Big\}\Big],$$

$$t_t=\rho_tt_{t-1}+\varepsilon_{t,t}, \qquad \text{(A.25)}$$

where $t_t\equiv\ln(T_t)$, $\rho_t\in(0,1)$ and $\varepsilon_{t,t}\sim i.i.d.(0,\sigma_t^2)$.

4. Firms (NKPC)

<Variables and parameters>

[Variables]

A_t: level of technology, $\hat{\pi}_t$, $\hat{\lambda}_{k,t}$ (k =1, 5) and $\hat{a}_t$: log-linear approximation to Π_t, $\Lambda_{k,t}$ (k =1, 5) and A_t respectively, $\hat{\lambda}_{6,t}$: variable calculated by equation (A.30)

[Parameters]

ω: parameter measuring the degree of indexation, α: share of capital in production, ε: constant price elasticity, $1-\eta$: probability with which a firm has an opportunity to reoptimize its price in period t, β: discount factor calculated by equation (A.28), φ: inverse of the Frisch labour supply elasticity calculated by equation (A.29)

<Behaviour>

$$\hat{\pi}_t=\frac{\omega}{1+\omega\beta}\hat{\pi}_{t-1}+\frac{\beta}{1+\omega\beta}E_t\hat{\pi}_{t+1}+\frac{(1-\eta)(1-\beta\eta)}{\eta(1+\omega\beta)}\Theta\hat{mc}_t, \qquad \text{(A.26)}$$

where $\Theta\equiv\dfrac{1-\alpha}{1-\alpha+\alpha\varepsilon}\leq1$,

$$\hat{mc}_t=-\hat{\lambda}_{6,t}+\frac{\varphi+\alpha}{1-\alpha}\hat{c}_t-\frac{1+\varphi}{1-\alpha}\hat{a}_t. \qquad \text{(A.27)}$$

<Assumptions>

$$\beta\approx\frac{\overline{C}_1}{\overline{C}}\beta_1+\frac{\overline{C}_2}{\overline{C}}\beta_2, \qquad \text{(A.28)}$$

$$\varphi=\Big(\frac{\overline{N}^s}{\overline{N}^s_1}\Big)\Big(\frac{\overline{C}_1}{\overline{C}}\Big)\varphi_1\Big(=\Big(\frac{\overline{N}^s}{\overline{N}^s_2}\Big)\Big(\frac{\overline{C}_2}{\overline{C}}\Big)\varphi_2\Big), \qquad \text{(A.29)}$$

$$\hat{\lambda}_{6,t}\approx\frac{\overline{C}_1}{\overline{C}}\hat{\lambda}_{1,t}+\frac{\overline{C}_2}{\overline{C}}\hat{\lambda}_{5,t}, \qquad \text{(A.30)}$$

where $\overline{C}=\overline{C}_1+\overline{C}_2$ and $\overline{N}^s=\overline{N}^s_1+\overline{N}^s_2$.

5. The central bank

<Variables and parameters>

[Variables]

Y_t: real GDP, $e_{R,t}$: shock to monetary policy

[Parameters]

ρ_r, ρ_π, ρ_y and ρ_μ: parameters on Taylor-type interest rate rule (see equation (A.31))

<Behaviour>

$$\ln\left(\frac{R_t}{\overline{R}}\right)=\rho_r\ln\left(\frac{R_{t-1}}{\overline{R}}\right)+(1-\rho_r)\left\{\rho_\pi\ln\left(\frac{\Pi_t}{\overline{\Pi}}\right)+\rho_y\ln\left(\frac{Y_t}{\overline{Y}}\right)+\rho_\mu\ln\left(\frac{\Phi_t}{\overline{\Phi}}\right)\right\}+e_{R,t}, \tag{A.31}$$

where $\Phi_t\equiv\frac{M'_t}{B'_{r,t}+X_tL'_t}$ and L'_t is derived from equation (A.17).

<Assumptions>

$$Y_t=C_{1,t}+C_{2,t}+(1-X_t)\{S_{h,t}-(1-\iota_h)S_{h,t-1}\}Q'_{h,t}, \tag{A.32}$$

$$e_{R,t}=\rho_R e_{R,t-1}+\varepsilon_{R,t}, \tag{A.33}$$

where $\rho_R\in(0,1)$ and $\varepsilon_{R,t}\sim i.i.d.(0,\sigma_R^2)$.

6. Complete model

<Variables and parameters>

[Variables]

N_t^d: number of work-hours hired from end-user borrowers and passive investors,

$e_{qh,t}$: shock to the real house prices

[Parameters]

$G>0$, ρ_{qh1}, and ρ_{qh2}: parameters on determining of real house prices, ρ_x: parameter on determining of probability X_t

<market-clearing conditions>

$$C_t=C_{1,t}+C_{2,t}, \tag{A.34}$$

$$N_t^d=N_{1,t}^s+N_{2,t}^s, \tag{A.35}$$

$$B_{s,t}^{s'}=B_{s,t}^{d'}, \tag{A.36}$$

$$B_{l,t}^{s'}=B_{1,l,t}^{d'}+B_{2,l,t}^{d'}. \tag{A.37}$$

<Assumptions>

$$Q'_{h,t} = GQ'^{\rho_{qh1}}_{h,t-1} S^{\rho_{qh2}}_{h,t-1} e_{qh,t}, \tag{A.38}$$

$$e'_{qh,t} = \varepsilon_{qh,t}, \tag{A.39}$$

where $e'_{qh,t} \equiv \ln(e_{qh,t})$ and $\varepsilon_{qh,t} \sim i.i.d.(0, \sigma^2_{qh})$.

$$X_t = \overline{X}(\overline{Y}/Y_{t-1})^{\rho_x}. \tag{A.40}$$

Appendix B: Data and data sources

Real consumption: Real personal consumption expenditures, seasonally adjusted annual rate, billions of chained 2005 dollars, Bureau of Economic Analysis (BEA)

Hours in business sector: Hours put in by all persons in the business sector, seasonally adjusted (s.a.), index (2005=100), Bureau of Labor Statistics (BLS)

Compensation per hour in business sector: Compensation per hour in the business sector, s.a., index (2005=100), BLS

House price: House price index for the United States, not seasonally adjusted (n.s.a), index (1980:Q1=100), Federal Housing Finance Agency

Housing stock: Quarterly estimates of the total housing inventory for the United States, all housing, n.s.a., numbers in thousands, U.S. Census Bureau

Real residential investment: Real private residential fixed investment, seasonally adjusted annual rate, billions of chained 2005 dollars, BEA

Consumer price: Personal consumption expenditures: chain-type price index, s.a., index (2005 =100), BEA

Money supply: M2 money stock, s.a., billions of dollars, Board of Governors of the Federal Reserve System (FRB)

One-period interest rate: Quarterly average of federal funds rate, FRB

One-period holding returns on the long-term bond: 10-year zero-coupon yield ($r_{l,t}$), n.s.a., FRB. $H_{l,t}$ is calculated by $H_{l,t} = 10\left\{\ln\left(\frac{1}{1+r_{l,t+1}}\right) - \ln\left(\frac{1}{1+r_{l,t}}\right)\right\}$.

Short-term bond outstanding: Active investor liability sum of federal funds, security repurchase agreements and open market paper, n.s.a., amounts outstanding at the end of the quarter, billions of dollars, FRB

Long-term bond outstanding: Sum of corporate and foreign bonds and agency- and GSE-backed securities, amounts outstanding at the end of the quarter, billions of dollars, FRB. B_l is calculated based on the total liabilities of long-term bond outstandings; $B_{1,l}$, based on the active investor liability of long-term bond outstandings; and $B_{2,l}$, based on $B_l - B_{1,l}$.

Reserve: Active investor asset sum of reserves in the federal reserves, vault cash, checkable deposits and currency, amounts outstanding at the end of the quarter, n.s.a., billions of dollars, FRB

Central bank loans to financial institutions: Loans to domestic banks by the monetary authority, amounts outstanding at the end of the quarter, n.s.a., billions of dollars, FRB

Notes

1) Sudo [2011] presents a brief survey on previous studies.

2) $B^d_{2,I,t}$ is calculated as $B^d_{2,I,t}=B^s_{I,t}-B^d_{1,I,t}$, because we have not clearly defined passive investors.

3) As mentioned above, we assume that $C_{1,t}/C_t=N_{1,t}/N_t=\tau_1$; hence, φ_1, φ_2 and φ are equivalent based on equation (A.29) in Appendix A (the same shall apply hereinafter).

4) In conducting Bayesian MCMC estimation, we have employed the DYNARE software (version 4.04) for MATLAB.

5) In addition, results from posterior maximization indicate that the estimated standard deviation of parameters is low enough to be statistically significant.

6) This would imply what has been described as a 'conundrum' by Alan Greenspan.

7) In this economy, short-term bonds are also treated as risk-free assets.

8) In the model without active investors, it is assumed that $X_t=(\overline{Y}/Y_t)^{\rho_x}$ instead of $X_t=(\overline{Y}/Y_{t-1})^{\rho_x}$, in order to meet the Blanchard and Kahn [1980] condition. Since the structure of the model without active investors is considerably different from that of our basic model, we need to re-estimate the following relevant parameters: γ, $v_{2,I}$, ρ_{qh1}, ρ_{qh2}, ρ_x, ρ_h, ρ_a, ρ_R and the standard deviation on disturbances.

9) Since the parameter setting of $\overline{X}=0$ and $\rho_x \leq 0.7$ does not fulfil the Blanchard and Kahn [1980] condition, we retain $\rho_x=0.7130$ and set the value of $\overline{X}$ as low as possible.

10) For the model with $\overline{X}=0.07$, the influences of shocks to house prices are much larger than those for the base model, whereas the influences of housing preference are smaller. In contrast, the model with $\overline{X}=0.001$ shows almost the same influences of shocks as the base model.

11) Adrian, Moench and Shin [2010b] and Verona, Martins and Drumond [2011] present models with the active investor sector and calculate the impulse responses of macroeconomic variables to various shocks to the economy. However, the responses in their studies indicate very few cyclical properties as compared to the responses in this study. This may be because our base model specifies the relationship between the active investor sector and other sectors in the economy more elaborately than their models.

12) The influences of the other shocks are also virtually the same as in the case of the original value.

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