Countercyclical Monetary Policy and Land Prices Under Collateral Contracts

November 2005

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This paper presents a dynamic general equilibrium model that synthesizes the financial intermediation model based on collateral contracts and the limited participation model of monetary policy. Focusing on the relative shares of land use of a household and firm, the model shows that the firm can increase production at the expense of the household's land use. This explains intuitively why countercyclical monetary policy without the threat of inflation is needed from the welfare perspective. The model also exhibits the novel feature of a land-price bubble that is activated by a more pessimistic recognition by the central bank.

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* Many thanks to Kazaumi Asako, Shin-ichi Fukuda, Kaoru Hosono, Yuzo Honda, Yasuyuki Iida, Hidehiko Ishihara, Hideki Konishi, Tsutomu Miyagawa, Satoru Nakanishi, Soichi Ota, Akiya Sakurakawa, Yusuke Takeda, and Yuichiro Waki for their invaluable comments. This work is partially supported by the Grant-in-Aid for the 21st Century COE program "Microstructure and Mechanism Design in Financial Markets" from the Ministry of Education, Culture, Sports, Science and Technology of Japan.

I. Introduction

The bubble and subsequent burst of 1990 was an unprecedented shock for the Japanese economy.[1] Many think that these shocks were largely the result of unsuccessful monetary policy, and the controversy over monetary policy initiated by Krugman (1998) has continued. Many of these arguments, however, are not persuasive, because they ignore the so-called land standard system in Japan, under which bank loans are secured by land collateral.

To analyze this situation, the primary objective of this paper is to synthesize the financial intermediation model of collateral contracts and the limited participation model of monetary policy, and consider the effect of land collateral from a general-equilibrium perspective. The model presented clarifies the necessity of countercyclical monetary policy through the allocation of land across sectors.

The following features of the Japanese economy and the bubble experience are widely acknowledged:

1. Land collateral contracts form the core of bank lending, which has become known as the land standard system.
2. The bubble was initiated by expansionary monetary policy, and the resulting excess money supply in the banking sector caused real estate speculation by firms, which reduced the land ownership share of households (see Figure 1).
3. Although land prices and stock prices increased during the bubble period, the wholesale price index remained stable. Land prices decreased suddenly when the bubble burst.
4. The Bank of Japan continued its monetary expansion to stabilize the wholesale price index during the bubble period (see Okina and Shiratsuka, 2002). That is, from the traditional perspective of the central bank, for which price stability was the primary goal, there was no need to tighten monetary policy even though asset prices had been increasing.
5. Land prices have been falling for more than 10 years since the bubble collapsed (see Figure 1). However, land-collateral lending continues.

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[1] See Kiyotaki and West (1996), Okina and Shiratsuka (2002), Hoshi and Kashyap (2004) and references therein for surveys of the Japanese economy during the bubble period and the 1990s.

Bubble

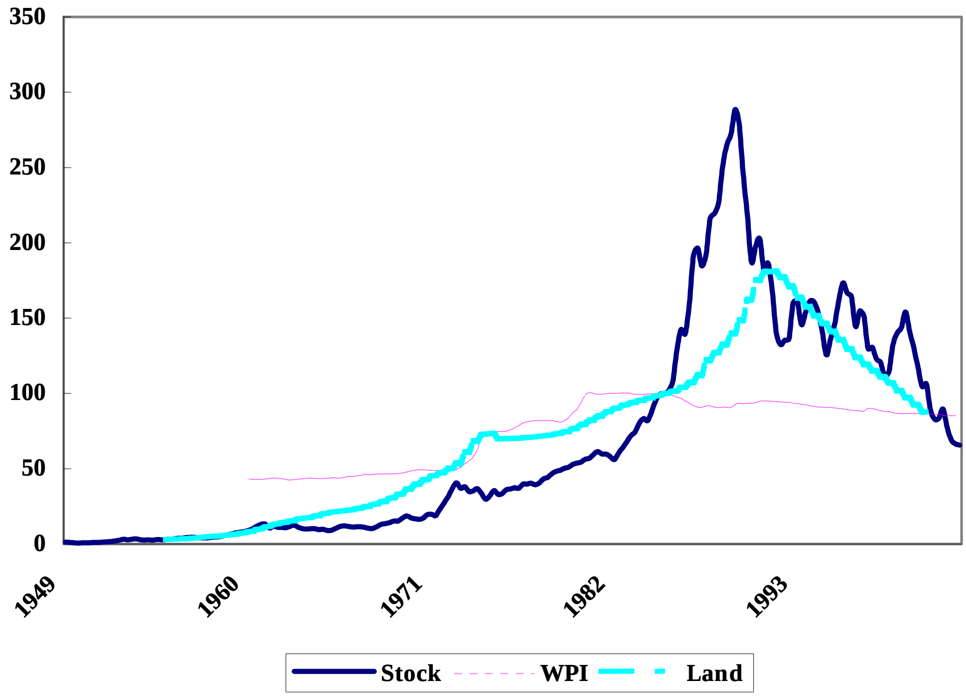

Fig. 1: Stock and land prices and WPI

These observations give rise to the following questions:

- What should the relation between central bank monetary policy and asset prices be? Is the view that central bank monetary policy can do little to check soaring asset values correct (see Gilchrist and Leahy, 2002, for a survey)?
- Is it correct to treat land prices and stock prices similarly as asset values? In particular, under collateral contracts, since land performs the dual role of production factor and collateral, should it be treated differently from stock, which is pure asset?
- What are the implications of collateral contracts for social welfare? Is the excessive use of land by firms desirable? In this context, households' share of land holding decreased in the bubble period (see Figure 2).
- Although many argue that the Japanese bubble arose in a period of expansionary monetary policy, the bubble was not necessarily caused by monetary policy. Hence, what additional factors contributed to the bubble?

This paper presents a model that addresses these questions. From a theoretical point

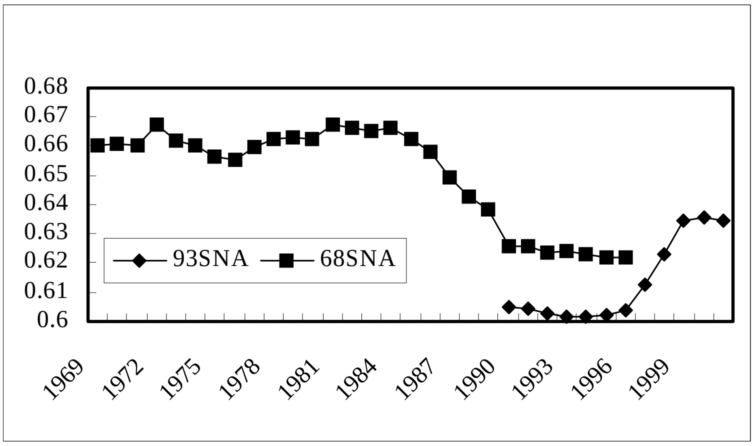

Fig. 2: **Household land ownership ratio in SNA**

of view, this paper attempts to develop a simple model that synthesizes two types of model: (i) limited participation models of monetary policy (such as Lucas, 1990; Fuerst, 1992; Christiano and Eichenbaum, 1992; and Carlstrom and Fuerst, 1995); and (ii) financial intermediation models that assume that land is collateral (such as Bernanke and Gertler, 1989; and Kiyotaki and Moore, 1998).

Although the well-known model of Kiyotaki and Moore (1998) deals with land collateral, their main point is that the movement of land prices amplifies external shocks through credit limitation. Further, as their model does not explicitly introduce money, the relationship between monetary policy and land prices is not analyzed. Agency cost models of financial intermediation, such as Bernanke and Gertler (1989, 1999),[2] analyze the relationship between net worth, the money supply, interest rates, and economic conditions. By contrast, our model proposes a more direct effect of monetary policy on land prices based on the Ricardo–Viner specific factor model, under the assumption that land supply is constant.

In addition to synthesizing these models, our model is able to analyze the triggering of land price bubbles, based on misperceptions of the central bank and its expansionary monetary policies for preventing recession. In practice, bubbles sometimes arise immediately after pessimistic forecasts. It is argued that the cause of the Japanese bubble of the late 1980s was the expansionary monetary policy that was implemented to prevent recession following the G-5 Plaza Agreement of September 1985. Furthermore, a loose monetary policy to combat the Y2K (2000) problem caused the IT bubble. In many countries, rising real-estate prices are a prominent feature of booms. Thus, sharp changes from pessimism to optimism can trigger bubbles. Thus, our model uses this insight to explain this historical experience.

The structure of this paper is as follows. In section II, we present the basic model. In

2 Based on these theoretical studies, Ogawa et al. (1996), Kwon (1998), and Bayoumi (2001) empirically showed the importance of land collateral on stagnation.

section III, we discuss optimal monetary policy. In section IV, we discuss the relationship between monetary policy and the bubble. Section V concludes the paper.

II. The Basic Model

The economy comprises households, firms, banks, and a central bank. As explained in the introduction, we investigate the role of land as: (1) a production factor; (2) collateral for the firm; (3) a durable consumer good; and (4) a means of asset accumulation by households. These four roles affect the model and require modifications to standard neoclassical models. The timing in the model follows the standard limited participation model. That is: (a) households choose their portfolios; (b) new money is provided by the central bank; and (c) firms monopolize the new funds (see Figure 3).

Banks and Collateral Contracts

First, consider bank lending to firms, B_t, backed by land collateral as a prerequisite. The projected profits of banks are non-negative if the following inequality is satisfied:

$$\theta_t(1+r_t)B_t+(1-\theta_t)\, q_{t+1}c_{ft} \geq (1+i_t)B_t\,, \tag{1}$$

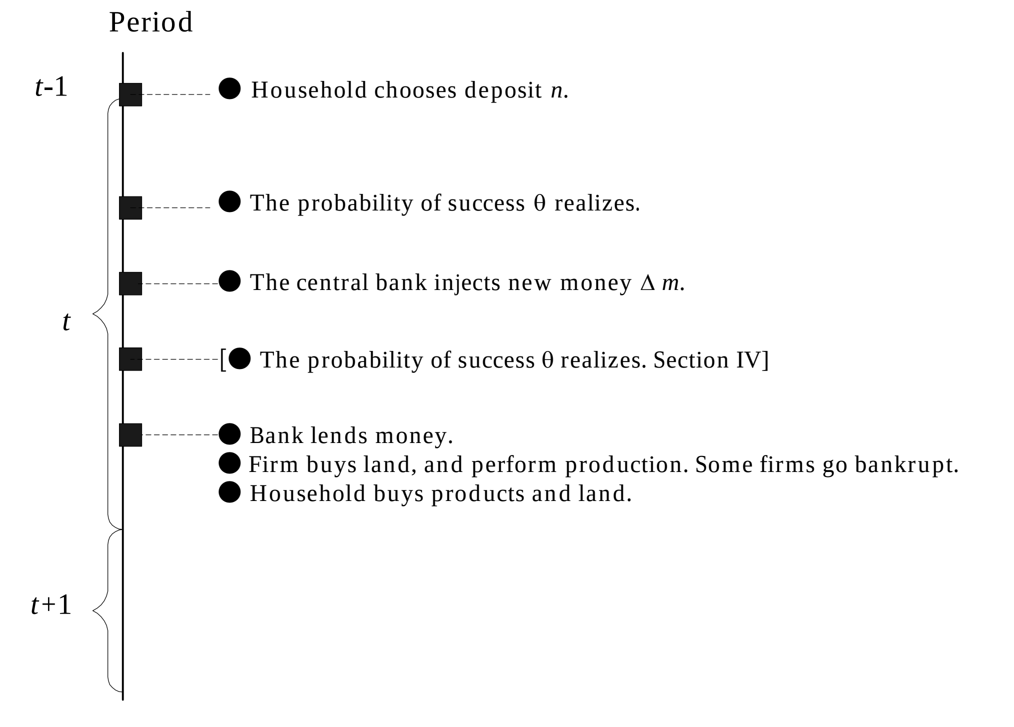

Fig. 1.- Timing assumption

where θ is the probability of success for the project, c_{ft} is land collateral owned by firm, and q is the land price. There are two types of interest rate: r is the interest rate on B if the project succeeds; that is, r is the nominal interest rate on bank lending to firms with a prerequisite collateral value of qc_f; the interest rate on deposits for households is denoted by i. Banks must earn a higher interest rate than i. If the project fails, equation (1) indicates that collateral is surrendered to the bank. Note that this form of collateral contract is a traditional one (see Coco, 2000), and differs from that in the model of Kiyotaki and Moore (1998), which is based on an incomplete contract.

Banks receive injections of money, denoted by Δm_t, from the central bank. Given deposits, n_t, from households, the amount that can be lent is:

$$\Delta m_t + n_t \geq B_t. \tag{2}$$

Optimization by Firms

Consider profit maximization by firms. The production function is assumed to be Cobb–Douglas, with land c_{ft} and real capital k:

$$y_t = k_t^{1-a} c_{ft}^{\ a}, \tag{3}$$

where a is the intensity of land use, and y_t is production. We assume that k depreciates by 100% every period, for simplicity.

The problem is to maximize the following expected profit:

$$\max E(\pi) = E_t[\theta_t[p_t y_t - \frac{1+r_t}{1+i_t} B_t + \frac{q_{t+1} c_{ft}}{1+i_t}] + (1-\theta_t) R_t^F] \tag{4}$$

subject to the contract with land collateral:

$$E_t[\theta_t \frac{1+r_t}{1+i_t} B_t + (1-\theta_t) \frac{q_{t+1} c_{ft}}{1+i_t}] \geq B_t, \tag{5}$$

and the cash-in-advance constraint:

$$B_t \geq p_t k_t + q_t c_{ft}, \tag{6}$$

where π is profit, $p_t y_t$ is sales when the project succeeds, and p_t is the product price. Sales when the project fails, R^F, are assumed to be zero. The firm earns profits of py when the project is successful, and repays the amount borrowed, B, at the interest rate r and holds assets of $q_{t+1}c_{ft}$. If the project fails, the entire collateral is surrendered to the bank. In addition, the price of k is the same as the price of consumer goods, p.

It is assumed that the firm's cash-in-advance constraints in (6) are always binding, and hence, B_t is eliminated in (4) and (5). Using the Lagrange multiplier, λ_{ft}, we obtain the following Lagrangian:

$$L \equiv E_t[\theta_t[p_t y_t - \frac{1+r_t}{1+i_t}(p_t k_t + q_t c_{ft}) + \frac{q_{t+1}c_{ft}}{1+i_t}] + \lambda_{ft}[\theta_t \frac{1+r_t}{1+i_t}(p_t k_t + q_t c_{ft}) + (1-\theta_t)\frac{q_{t+1}c_{ft}}{1+i_t} - (p_t k_t + q_t c_t)]]. \tag{7}$$

Assuming interior solutions, the first-order conditions are:

$$k: \qquad \frac{\partial L}{\partial k} = E_t[\theta_t[p_t(1-a)k_t^{-a}c_{ft}^{a} - \frac{1+r_t}{1+i_t}p_t] + \lambda_{ft}[\theta_t \frac{1+r_t}{1+i_t}p_t - p_t]] = 0, \tag{8}$$

$$c_f: \qquad \frac{\partial L}{\partial c_f} = E_t[\theta_t[p_t a k_t^{1-a}c_{ft}^{a-1} - \frac{1+r_t}{1+i_t}q_t + \frac{q_{t+1}}{1+i_t}] + \lambda_{ft}[\theta_t \frac{1+r_t}{1+i_t}q_t + (1-\theta_t)\frac{q_{t+1}}{1+i_t} - q_t]] = 0, \tag{9}$$

$$r: \qquad \frac{\partial L}{\partial r} = E_t[-\theta_t \frac{1}{1+i_t}[p_t k_t + q_t c_{ft}] + \lambda_{ft}\theta_t \frac{1}{1+i_t}[p_t k_t + q_t c_{ft}]] = 0, \tag{10}$$

and $\frac{\partial L}{\partial \lambda_{ft}} = 0$. These four equations determine the solutions for k_t, c_{ft}, r_t, and λ_{ft}. Note that r is an endogenous variable that depends on the amount of land collateral. Rearranging (10) yields $\lambda_{ft} = 1$, and using the property of Cobb–Douglas, eliminating k_t from (8) and (9) yields:

$$p_t y_t = E_t[\frac{1}{a\theta_t}\left[1 - \frac{1+\mu_t}{1+i_t}\right] q_t c_{ft}], \tag{11}$$

where μ_t ($\equiv E_t((q_{t+1} - q_t)/q_t)$) is the rate of change of q, which satisfies $E_t[q_{t+1} - (1+\mu_t)q_t] = 0$.

Optimization by Households

The representative household has the following objective function over an infinite horizon:

$$\max_{x_t, c_{ht}, n_t} E_0 \sum_{t=0}^{\infty} \beta^t u(x_t, \sigma_{ht} c_{ht}), \tag{12}$$

where β is the subjective discount rate, x_t denotes consumption goods, $\sigma_{ht} c_{ht}$ is the household's land, and σ_{ht} is a preference shock related to land.

The household is also subject to the cash-in-advance constraint on x_t and c_t:

$$M_t - n_t = p_t x_t + q_t c_{ht}, \tag{13}$$

and the budget constraint is:

$$M_t + q_t c_{ht-1} + (1 + i_{t-1}) n_{t-1} + \pi_{ft} + \pi_{bt} - p_t x_t - q_t c_{ht} - n_t - M_{t+1} = 0, \tag{14}$$

where q_t is the land price, i_t is the interest on bank deposits, n_{t-1}, π_{ft} is the dividend based on the firm's profit, and π_{bt} is the dividend based on the bank's profit.

Following the limited participation model, n_t is determined on the basis of information at the end of period t–1, and therefore, the first-order conditions are:

x : $$E_{t-1}\left[\frac{\partial u}{\partial x_t} - p_t\left(\lambda_{2ht} + \lambda_{3ht}\right)\right] = 0, \tag{15}$$

c : $$E_{t-1}\left[\sigma_{ht}\frac{\partial u}{\partial c_{ht}} - q_t\left(\lambda_{2ht} + \lambda_{3ht}\right) + \sigma_{ht+1} q_{t+1} \lambda_{3ht+1}\right] = 0, \tag{16}$$

n : $$E_{t-1}[-\lambda_{2ht} - \lambda_{3ht} + \lambda_{3ht+1}(1 + i_t)] = 0, \tag{17}$$

in addition to constraints (13) and (14).

Rearranging equations (15) to (17), and assuming the log utility function, $u(x_t, c_{ht}) = (1 - b) \log x_t + b \log(\sigma_{ht} c_{ht})$, yields:

$$p_t x_t = \frac{1-b}{b} \frac{q_t c_{ht}}{\sigma_{ht}} E_{t-1}\left(1 - \sigma_{ht+1} \frac{1 + \mu_t}{1 + i_t}\right). \tag{18}$$

It is clear that the land ownership ratio, c_{ht}, is increasing with the expected rate of increase in land prices.

The Central Bank and Social Optimization

Consider the central bank's optimal monetary policy. The central bank's objective is to maximize the representative household's utility, which is as follows:

$$\max_{x_t, c_{ht}, k_t} E_0 \sum_{t=0}^{\infty} \beta^t u(x_t, \sigma_{ht} c_{ht}), \tag{19}$$

subject to the following constraints:

$$y_t = \theta_t k_t^{1-a} c_{ft}^{\ a}, \tag{20}$$

$$c_{ft} + c_{ht} = \bar{c}, \tag{21}$$

$$y_t = x_t + k_t, \tag{22}$$

where $\bar{c}$ is the total amount of land in the economy.

By eliminating c_{ht} and y_t from (20) and (21), the problem can be rewritten as:

$$\max_{x_t, c_{ft}, k_t} E_0 \sum_{t=0}^{\infty} \beta^t \left((1-b)\log(x_t) + b\log(\sigma_{ht}(\bar{c} - c_{ft})) \right), \tag{23}$$

$$\text{subject to } x_t + k_t = \theta_t k_t^{1-a} c_{ft}^{\ a}. \tag{24}$$

The first-order conditions with respect to c_{ft}, x_t, k_t are:

c_f: $$\frac{\partial u}{\partial c_{ft}} + \lambda_{bt} \frac{\partial y_t}{\partial c_{ft}} = \frac{-b}{\bar{c} - c_{ft}} + \lambda_{bt}[a\theta_t k_t^{1-a} c_{ft}^{\ a-1}] = 0, \tag{25}$$

x_t: $$\frac{\partial u}{\partial x_t} - \lambda_{bt} = \frac{1-b}{x_t} - \lambda_{bt} = 0, \tag{26}$$

k_t: $$-\theta_t \lambda_{bt} + \lambda_{bt} \frac{\partial y_t}{\partial k_t} = \lambda_{bt}(-1 + (1-a)\theta_t k_t^{-a} c_{ft}^{\ a}) = 0, \tag{27}$$

where λ_b is the Lagrange multiplier. The Cobb–Douglas generates the following simple social optimality conditions:

$$x_t = a y_t, \ k_t = (1-a) y_t, \ c_{ft}^* = (1-b)\bar{c}. \tag{28}$$

Note that monetary policy must consider the land-ownership ratio for the above equations to be satisfied.

III. Optimal Monetary Policy

This section provides a detailed analysis of monetary policy based on the simple and static conditions for a social optimum. First, eliminating the relative price, p/q, from the first-order conditions of the firm and household, given by equations (11) and (18) respectively, yields:

$$\frac{p^*}{q^*}=\left[1-\frac{1+\mu_t}{1+i_t}\right]\frac{c_{ft}^{\;*}}{\theta_t a y_t^{\;*}}=\left[1-\sigma_{ht+1}\frac{1+\mu_t}{1+i_t}\right]\frac{1-b}{b}\,\frac{c_{ht}^{\;*}}{\sigma_{ht}x_t^{\;*}}, \tag{29}$$

where an asterisk (*) denotes the equilibrium value.

Second, from the optimal policy of the central bank, substituting (28) into (29) yields the following expression for the expected rate of increase in land prices, μ:

$$1+\mu_t=(1+i_t)\left(\frac{\theta_t-\sigma_{ht}}{\theta_t\sigma_{ht+1}-\sigma_{ht}}\right). \tag{30}$$

Equation (30) is derived on the basis that the central bank chooses the optimal Δm_t to satisfy (28).

Third, using the cash-in-advance constraint, the demand for land from the firm and the household can be related to the injection of new money. From the household's cash-in-advance constraint, (18), demands for land and consumption goods of the household following the injection of money are:

$$c_{ht}=q_t^{-1}\omega_{ht}[M_t-n_t],\; x_t=p_t^{-1}(1-\omega_{ht})[M_t-n_t], \tag{31}$$

where $\omega_{ht}=\left(1+\frac{1-b}{\sigma_{ht}b}\left(1-\sigma_{ht+1}\frac{1+\mu_t}{1+i_t}\right)\right)^{-1}$ is the household's land expenditure ratio. From (6), the firm's demands for land and capital are:

$$c_{ft}=q_t^{-1}\omega_{ft}[\Delta m_t+n_t],\; k_t=p_t^{-1}(1-\omega_{ft})[\Delta m_t+n_t], \tag{32}$$

where $\omega_{ft}=\left(1+\frac{1-a}{a}\left[1-\frac{1+\mu_t}{1+i_t}\right]\right)^{-1}$ is the firm's land expenditure ratio. An increase in θ_t raises the land expenditure ratios of firms and households if $\sigma_{ht+1}>1$. The firm's land-use ratio, δ, is

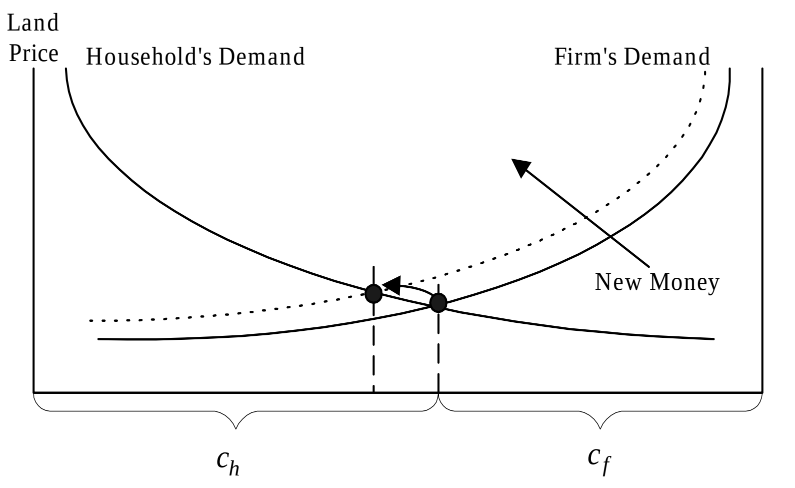

Fig. 4: Land distribution

given by $\delta^{*}=\dfrac{\omega_{ft}\left[\Delta m_t+n_t\right]}{q_t\bar{c}}$.

Figure 4 summarizes the above relationships. Clear analytical results can also be obtained. An injection of new money, Δm, appears in the condition for the firm, equation (32), but not in the condition for the household, equation (31). Figure 4 can be analyzed by using the procedure applied to the traditional Ricardo–Viner (specific-factor) model of international trade.

Eliminating q_t from (31) and (32) and adding $M_t - n_t$ to both sides yields:

$$M_t+\Delta m_t = g(\theta_t)[M_t - n_t]. \tag{33}$$

The function, $g(\theta_t)\left(\equiv 1+\dfrac{c_{ft}{}^{*}}{c_{ht}{}^{*}}\dfrac{\omega_{ht}}{\omega_{ft}}\right)$, is important because it determines the optimal money supply. If the household recognizes the correct value of θ_t by chance, that is, if $\theta_t=\bar{\theta}$, the central bank need not adjust the money supply, in which case, Δm=0. In this case, (32) can be rewritten as:

$$n_t = M_t\left[1-\frac{1}{g\left(\bar{\theta}\right)}\right]. \tag{34}$$

Substituting this equation into (33), denoting the recognition error by $\varepsilon_t\,(\equiv\theta_t-\bar{\theta})$, yields:

$$\Delta m_t=\frac{g(\bar{\theta}+\varepsilon_t)-g(\bar{\theta})}{g(\bar{\theta})}\,M_t, \tag{35}$$

which indicates that the injection of new money, Δm_t, eliminates the difference between $g(\theta)$, which is evaluated at the actual value of θ, and $g(\bar{\theta})$, which is evaluated at the value predicted by the household.

Partially differentiating (35) with respect to ε yields:

$$\frac{\partial \Delta m_t}{\partial \varepsilon_t} = \frac{\partial g}{\partial \varepsilon_t}\frac{M_t}{g(\bar{\theta})}, \tag{36}$$

where:

$$\frac{\partial g}{\partial \varepsilon_t} = \frac{c_{ft}^*}{c_{ht}^*}\frac{1}{\omega_{ft}^2}\left[\frac{\partial \omega_{ht}}{\partial \theta_t}\omega_{ft} - \frac{\partial \omega_{ft}}{\partial \theta_t}\omega_{ht}\right] = \frac{(b-1)\left(\theta_t(a-1+\sigma_{ht+1}) - a\sigma_{ht}\right)}{a\left(1-\sigma_{ht+1} + b((1-\theta_t)\sigma_{ht+1} + \sigma_{ht} - 1)\right)}. \tag{37}$$

Although the sign of $\frac{\partial g}{\partial \varepsilon_t}$ seems unclear, the intuitive meaning of (37) is clear: it expresses the partial derivatives of ω_{ht}/ω_{ft} with ε_t. Hence, the larger the marginal increase in the rate of the firm's land expenditure ratio in relation to θ, the more countercyclical is monetary policy; $\frac{\partial g}{\partial \varepsilon_t}<0$. This is because the central bank needs to suppress land acquisition by the firm. Assuming that $\frac{\partial g}{\partial \varepsilon_t}<0$, we investigate countercyclical monetary policy subsequently.

The intuition for money non-neutrality in this model is the same as in the limited participation model. Determining deposits n_t without knowing the actual value of θ_t for period t means that consumption and land acquisition are subject to the cash-in-advance constraint. In our model, after realizing a low (high) θ_t, the central bank increases (decreases) Δm, which also increases (decreases) land prices, primarily because of acquisition by firms. This is because Δm goes directly to firms while no money goes to households, which limits their acquisition of land.

The Price Index and Land Prices

In this model, the land price, q, and goods prices, p, can be explicitly determined. Substituting (31) and (32) into (21) yields the land price:

$$q_t = \frac{M_t}{\bar{c}g(\bar{\theta})}\left[\omega_{ht} + \omega_{ft}\left(g(\bar{\theta}+\varepsilon_t) - 1\right)\right]. \tag{38}$$

Substituting (31) and (32) into (3) yields production:

$$y_t=\theta_t\left(\frac{1-\omega_{ft}}{p_t}\right)^{1-a}\left(\frac{\sigma_{ft}\omega_{ft}}{q_t}\right)^{a}[\Delta m_t+n_t]. \tag{39}$$

Eliminating p_tk_t from (8) and (32) yields $\theta_t(1-a)p_ty_t = (1-\omega_{ft})[\Delta m_t + n_t]$, and substituting this into (39) yields:

$$\frac{q_t}{p_t}=\sigma_{ft}\left(\frac{\omega_{ft}}{1-\omega_{ft}}\right)\left((1-a)\theta_t^{2}\right)^{1/a}, \tag{40}$$

which indicates that increases in $\overline{\theta}$ and ε increase the relative price. On the other hand, increases in $\overline{\theta}$ and ε reduce the nominal prices of land and goods.

IV. The Potential for Bubbles and Biased Monetary Policy

The basic model focuses on countercyclical monetary policy, which depends on the household's limited ability, relative to the central bank, to recognize θ. In this section, we consider the case in which the central bank cannot perfectly recognize the actual value of θ. Suppose that a recognition error, ξ_t, exists ($\hat{\theta}+\xi_t=\theta_t$). If ξ_t is positive, the actual probability of firm bankruptcy, $1-\theta$, is smaller than expected.

The analysis is divided into two stages:

- *First Stage:* The central bank, firms, and banks make a recognition error of ξ_t while households make the error $\varepsilon_t+\xi_t$. In this stage, the variables are denoted by the superscript *e*.
- *Second Stage:* After the central bank has supplied money, the actual value is observed by households, firms, and banks. In this stage, the variables are denoted by the superscript *.

First, when all participants in the economy make a recognition error, the forecast rate of increase in land prices, μ^e, for firms and households, and any injection of new money, Δm^e, by the central bank, is based on the following recognition error ξ_t. Substituting $\hat{\theta}_t = \overline{\theta}+\varepsilon_t-\xi_t$ into (30) and (35) yields:

$$1+\mu_t^{e}=(1+i_t)\left(\frac{\left(\overline{\theta}+\varepsilon_t-\xi_t\right)-\sigma_{ht}}{\left(\overline{\theta}+\varepsilon_t-\xi_t\right)\sigma_{ht+1}-\sigma_{ht}}\right), \tag{41}$$

$$\Delta m_t^e = \frac{g(\bar{\theta}_t + \varepsilon_t - \xi_t) - g(\bar{\theta})}{g(\bar{\theta})} M_t. \tag{42}$$

The equations above show that excessively pessimistic recognition prevails, and therefore, the forecast rate of increase in land prices, μ^e, for firms and households increases. Furthermore, (42) shows that the injection of new money, Δm^e, is greater than that needed to prevent a recession.

The allocation of land satisfies the demand functions of firms and households:

$$c_{ht} = (q_t^e)^{-1}\omega_{ht}^e[M_t - n_t],\ c_{ft} = (q_t^e)^{-1}\omega_{ft}^e[\Delta m_t^e + n_t], \tag{43}$$

where $\omega_{ht}^e = \left(1 + \frac{1-b}{\sigma_{ht} b}\left(1 - \sigma_{ht+1}\frac{1+\mu_t^e}{1+i_t}\right)\right)^{-1}$ is the land-expenditure ratio of household land based on the recognition value, $\omega_{ft}^e = \left(1 + \frac{1-a}{a}\left[1 - \frac{1+\mu_t^e}{1+i_t}\right]\right)^{-1}$ is that of firm land, and μ_t^e is an expected value based on the recognition value, which includes the recognition error. The land-expenditure ratios of both firms and households decrease with ξ_t. Furthermore, as n_t is determined on the basis of the average value, $\bar{\theta}$, it continues to be given by equation (43).

When all participants in the economy make a recognition error, the land price is:

$$q_t^e = \frac{M_t}{\bar{c}g(\bar{\theta})}\left[\omega_{ht}^e + \omega_{ft}^e\left(g(\bar{\theta}_t + \varepsilon_t - \xi_t) - 1\right)\right]. \tag{44}$$

In the first stage, since g increases and ω_{ft}^e decreases, the sign of the effect of the recognition error is indeterminate. In the second stage, however, the pessimistic forecast is corrected.

The land demand functions of households and firms change following the revision.

$$c_{ht}^* = (q_t^*)^{-1}\omega_{ht}[M_t - n_t], \quad c_{ft}^* = (q_t^*)^{-1}\omega_{ft}[\Delta m_t^e + n_t]. \tag{45}$$

Denoting by q^* the land price following the revised recognition, we obtain:

$$q_t^* = \frac{1}{\bar{c}}(\omega_{ft}\Delta m_t^e + n_t[\omega_{ft} - \omega_{ht}] + \omega_{ht}M_t). \tag{46}$$

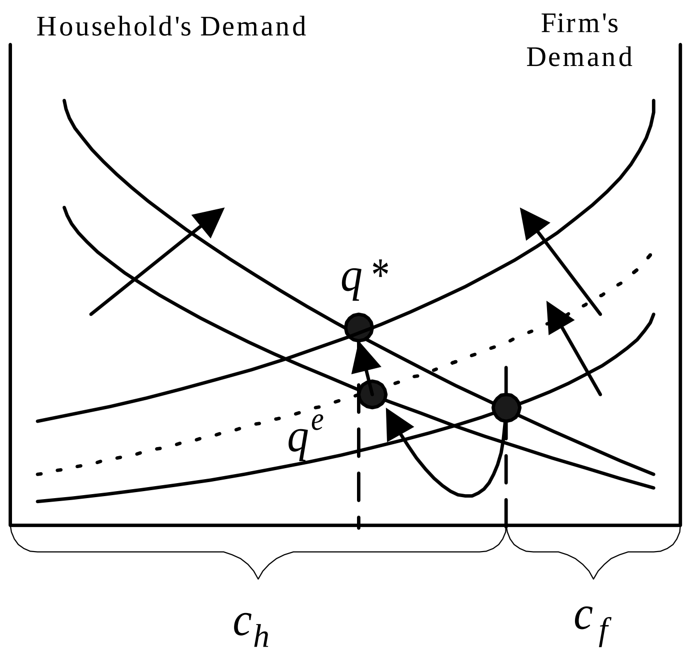

Fig. 5: Correction of recognition and bubble

Under the assumption of countercyclical monetary policy, the effect on the land price of the recognition error is:

$$\frac{\partial q_t^*}{\partial \xi_t} = \frac{\omega_{ft}}{\bar{c}} \frac{\partial \Delta m_t^e}{\partial \xi_t} > 0. \tag{47}$$

This equation shows that a positive ξ_t , which implies pessimistic recognition, increases land prices in the second stage.

Figure 6 shows the results of a simulation in which numerical values are assigned to variables affected by the recognition error. In the first stage, goods prices increase while land prices decrease. However, in the second stage, both prices move in the reverse direction; in particular, the land price increases without a change in either the money supply or underlying fundamentals.

Although optimistic recognition is considered to characterize the bubble, the model exhibits the paradoxical result that pessimistic recognition triggers a land-price bubble. It should be noted that this result is derived on the basis of monetary policy interaction. If the central bank were optimistic, it would rather tighten monetary policy. However, an easing of monetary policy due to a pessimistic forecast would, consequently, have brought about a sharp increase in asset values. This recognition revision in an economy in which there is credit

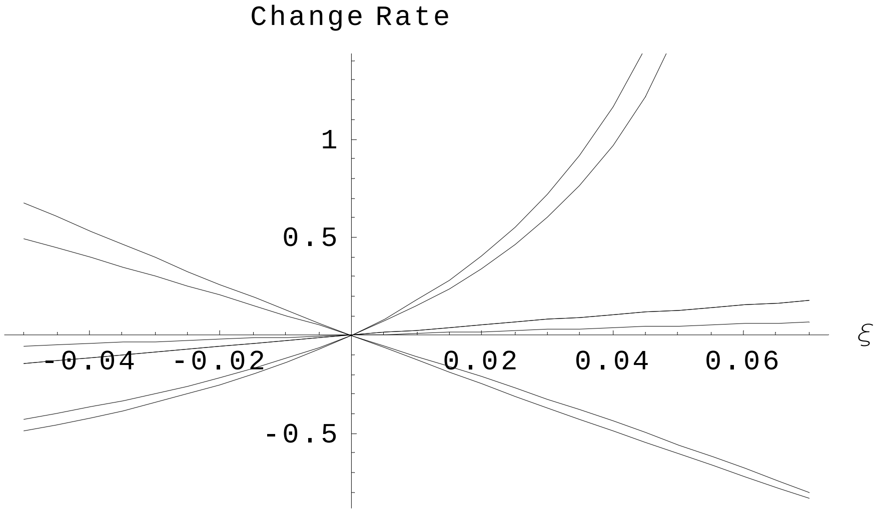

Fig. 6: **Size of recognition error ξ**

and new money injection, land price, goods price.

When a=0.6, b=0.3, σ_{ht+1} =0.7, σ_{ht} =0.5, σ_{ft} =1, $\bar{\theta}$=0.8, from the top the (graph) plots are

[1] second stage land price increase rate,$(q^*-q^e)/q^e$,[2] first stage price increase rate, p^e,

[3] overall price, Land price increase rate, p,q, [4] money increase rate, Δm ,

[5] second stage price increase rate, p^*, and [6] second stage land price increase rate, q^e

expansion generates an unjustifiably optimistic view of the underlying fundamentals, which may contribute to land-price bubbles.

Although further dynamic analysis is beyond the scope of paper, we suggest that this model has provided new insights into the relationship between monetary policy and the bubble.

V. Conclusion

This paper has presented a model of monetary policy and the land-price bubble by focusing on bank loans backed by land collateral. The results and structure of the model can be interpreted with reference to models of macroeconomic policy based on optimal taxation (see Lucas and Stokey, 1983; and Chari and Kehoe, 1999). As the optimal allocation fluctuates against θ, monetary policy plays the role of a state-contingent tax and / or a subsidy.

The model is simple and understandable in the context of analyzing the basic logic of monetary policy, and for synthesizing the limited participation model and the land-collateral model. In addition to this simplicity, the following three insights are obtained. First, the model explicitly determines the situations in which a tightening of monetary policy is required, and, unlike existing models, which emphasize the effectiveness of easy monetary policy, countercyclical monetary policy remains important, even if fears of inflation have disappeared in an integrated world.

Second, new insights into social welfare issues have been obtained by focusing on sectoral allocation, and, in particular, the household's demand for land. This distinguishes our model from that of Kiyotaki and Moore (1997), and from existing models of collateral. The excessive utilization of land by firms puts pressure on household land ownership, and reduces economic welfare. In practice, central banks tend to have to tighten monetary policy in real-estate booms and when there are shortages of consumer goods. The model captures this situation.

Third, the model explains how monetary policy might trigger a land-price bubble. In contrast to the widely held view that optimistic forecasts cause bubbles, our model shows that the central bank's pessimistic recognition leads it to supply extra money, and a revision of this recognition leads to a land-price bubble. Thus, pessimism, rather than optimism, potentially triggers bubbles. The model is too simple to incorporate dynamics analysis, but, unlike in other models, an explicit analysis of expectations errors made by the central bank is possible.

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