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Quantitative Impacts of the Asset Price Channel in the Credit-Constrained Economy

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Abstract

We investigate under what conditions the quantitative impact of the asset price channel is *strong* in a credit-constrained model in which real estate inelasticity supplied, so-called, "land", is used for production and serves as collateral. The technological substitutability between capital and land and adjustment costs of investment play important roles in amplifying and propagating shocks to the economy through the interaction of accumulating capital and assets that serve for collateral. The financial acceleration is at work strongly as the elasticity of substitution becomes smaller, because firms accumulate greater amounts of land in early periods to finance investment in later periods. The adjustment cost of investment strengthens the asset price effect.

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1. Introduction

Credit market friction is widely believed to be one of primary sources of generating business fluctuations. Bernanke and Gertler (1989), Carlstrom and Fuerst (1997), Bernanke, *et al*. (1999), and others have developed business cycle models of a “financial accelerator” in which the change in borrowers’ net worth affects bank borrowing and investment. Net worth typically includes real estate, such as housing, buildings, and land, which serves as collateral to raise borrowing. Interestingly, real estate is a tangible asset, the evaluation of which reflects the looking-forward behavior of the economy(e.g., Shleifer and Vishny, 1992), and as Kiyotaki and Moore (1997, hereafter KM) have stressed, the endogenous fluctuation of the evaluation of the tangible asset is anticipated to adds further amplification effect to the financial accelerator.

The aim of this paper is to investigate under what conditions the quantitative impact of the asset price channel is *strong* by using an extended version of the KM model. This work is motivated by the observation that although there is a widespread belief that the asset price boom can give rise to credit expansion, few papers have reported quantitatively large impacts.

The evaluation of the quantitative significance of the asset price effect is mixed. Kocherlakota (2000) demonstrates a small amplification effect of the asset price channel in a small-open-economy version of the KM model by employing the Cobb-Douglas production function.[1] Arias (2003) reports a small amplification effect in the production economy version of the KM model when the production function is the Cobb-Douglas form and firms only hold land. Cordova and Ripoll (2004) calibrate a small amplification effect in the exchange economy version of the KM model.

On the other hand, a few papers suggest potentially large asset price effects. KM reports quantitatively significant effects of amplifying shocks in their calibration

[1] Kocherlakota (2000) uses the Cobb-Douglas production function that use capital and land, and reports that the quantitative significance of the amplification is negligible when shares of capital and land sum to less than 40 percent effect, as is approximately true in the U.S. and Japan.

exercise when capital and land are both necessary in the Leontief-type technology. Iacoviello (2005) estimates a monetary model of collateral constraints tied to housing values, and reports quantitatively successful results to match the data when the interest rate channel is reinforced by collateral effects and nominal debt effects. One common feature to these two papers is that business fluctuations involve the reallocation of real estate between credit-constrained firms and other sectors.

The survey of the existing literature suggests that the quantitative significance of the asset price channel is sensitive to the specification of the model. We highlight three respects as influencing quantitative effects of financial accelerator. The first is the allocation of land, the asset used for collateral, between credit-constrained firms and other sectors. The second is the substitutability/complementarity between capital and land in production. The third is the adjustment costs of investment.

The small elasticity of substitution, the adjustment cost of investment, and reallocation of land toward credit-constrained firms amplify the quantitative effect of financial accelerator. As capital and land are more complementary, entrepreneurs find it difficult to substitute land by capital, choosing to obtain loans for financing capital by buying more land. In addition, the adjustment cost of investment prevents firms from investing in capital in early periods; instead enabling them to buy even more land, which allows them to raise loans in later periods to finance investment. These two factors work to strengthen the amplification mechanism of financial accelerator.

The small elasticity of substitution is crucial to induce land to be reallocated to credit-constrained firms, and to give rise to the greater and more persistent effect on investment. Conversely, when capital and land are substitutable, entrepreneurs find it easy to substitute land by capital, and choose not to buy but rather to sell land to gain the cash flow to finance capital. The adjustment cost of investment plays a powerful role to strengthen financial accelerator. The adjustment cost dampens investment and output in the frictionless economy, but promote investment and output in the credit constrained economy. When the elasticity of substitution is small(0.5), the output increases by 1.6% at peak in the credit-constrained economy, while it does by 1.1 % in the frictionless economy.

The subject of this paper can go back to the more fundamental question on if the financial accelerator is virtually at work. Since Bernanke, *et al*. (1999) have stressed an important role of that channel, huge literature has attempted to consider financial frictions as one of important sources of business fluctuations. To the best of my small knowledge, however, few models have reported the quantitatively significant impacts of financial accelerator. For example, Christensen and Dib (2008) show that the presence of the financial accelerator magnifies and propagates the effects of demand shocks, but dampens the effects of supply shocks - technology and investment-specific shocks on investment.

Bernanke, *et al*. (1999) also incorporates the asset price effect in their costly-state-verification model in which borrowers own the capital stock, and the change in the price of capital directly affects their net worth.[2] By contrast, in ours, the collateralizable asset is not the capital stock, and we can see the interaction between the capital stock and land that serves as collateral in affecting the feedback between net worth and investment.

This paper is organized as follows. In Section 2 we set up the basic model. In Section 3 we feature some properties of the steady state. In Section 4 we evaluate the quantitative effects of the developed model.

2. Model

We consider an economy with one final good, labor, and land. There are two types of continuum of infinitely-lived *patient households* and *impatient entrepreneurs*. The term "patient/impatient" captures the assumption that impatient agents have a higher subjective discount rate than patient ones.

Households consume, work, and demand land for residential use. Entrepreneurs

[2] Sakuragawa and Sakuragawa (2009) develop an endogenous-growth economy version of the KM model, and demonstrate that the magnitude of the cumulative effect of the temporary shock on output is greater in the economy with collateral constraints than the frictionless economy.

produce the final good by hiring labor, physical capital, and collateralizable land. Measures of households and entrepreneurs are unity, respectively. All markets are perfectly competitive.

A. Patient Households

Households maximize a lifetime utility given by

(1) $$E_0 \sum_{t=0}^{\infty} \beta^t [\log c'_t + \phi \log h'_t - \frac{B}{\varpi}(N'_t)^{\varpi}]$$

where E_0 is the expectation operator, $\beta \in (0,1)$ is the discount factor, c'_t is consumption, h'_t denotes the holding of housing, N'_t is the amount of labor supply, and ϕ, ϖ, and B are positive constants. Households lend $-b'_t$ (or borrow b'_t) and receive back $-R_{t-1}b'_{t-1}$, where R_{t-1} is the real interest rate on lending between $t-1$ and t. Letting q_t denote the land price, and w_t the wage rate, the flow of funds is

(2) $$c'_t + q_t(h'_t - h'_{t-1}) = w_t N'_t - R_{t-1} b'_{t-1} + b'_t .$$

Optimum conditions are the first-order conditions for consumption, housing, and labor:

(3) $$\frac{1}{c'_t} = \beta E_t \frac{R_t}{c'_{t+1}},$$

(4) $$\frac{q_t}{c'_t} = \frac{\phi}{h'_t} + \beta E_t \frac{q_{t+1}}{c'_{t+1}},$$

and

(5) $$\frac{w_t}{c'_t} = B(N'_t)^{\varpi - 1}.$$

B. Entrepreneurs

Entrepreneurs produce the final good Y_t by employing labor N_t, capital K_{t-1}, and land L_{t-1}. We consider the production technology allowing for the variable elasticity of substitution between capital and land. In response to the short-run shock, firms may not be able to change the capital/land ratio quickly over the business cycle so that the short-run elasticity of substitution is expected to be smaller than the long-run one. We consider the following quasi-CES type technology;

(6) $$Y_t = A_t N_t^{1-\alpha}[\gamma K_{t-1}^{\frac{\sigma-1}{\sigma}} + (1-\gamma) L_{t-1}^{\frac{\sigma-1}{\sigma}}]^{\frac{\alpha\sigma}{1-\sigma}},$$

where A_t is the total factor productivity (TFP), σ is the elasticity of substitution between capital and land, and γ is the technological weight attached to capital. The larger σ implies greater substitutability. $\sigma = 1$ corresponds to the Cobb-Douglas case; then (6) reduces to $Y_t = A_t N_t^{1-\alpha} K_{t-1}^{\gamma\alpha} L_{t-1}^{(1-\gamma)\alpha}$. Then $\gamma\alpha$ is the output share of capital and $(1-\gamma)\alpha$ is the output share of land. $\sigma = 0$ corresponds to the Leontief technology in which capital and land are completely complementary.

The process to transform investment in equipment into capital ready for production involves installation and adjustment costs, $S_K(I_t, I_{t-1}) = \frac{\xi_K}{2}(\frac{I_t}{I_{t-1}} - 1)^2 I_t$, which increases in the rate of investment growth. Note that $I_t = K_t - (1-\delta)K_{t-1}$. The trade of land may also involve the adjustment cost, $S_L(L_t, q_t, L_{t-1}) = \frac{\xi_L}{2}(\frac{L_t - L_{t-1}}{L_{t-1}})^2 q_t L_{t-1}$, which will capture the market thinness of the land market and/or tax distortion to hamper the trade of land.[3]

We assume that there is no enforcement mechanism to fulfill financial contracts between debtors and creditors. In this society, lenders cannot enforce on borrowers to repay their debt unless the debts are secured. In order to secure their debt, creditors can only collect land that the debtor holds, and cannot seize output or capital of their debtors. In this environment, anticipating the possibility of the borrower's strategic default, the creditor limits the amount of credit so that the value of debt will not exceed the value of land that the borrower holds. The borrowing constraint that the entrepreneur faces is then typically expressed as

(7) $$b_t \leq mE_t(q_{t+1}L_t / R_t),$$

where $m \leq 1$ is motivated by the notion that the amount equal to a constant fraction of the value of land is dissipated in the process of bank monitoring and bankruptcy

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[3] Alternatively, the specification in which households incurs the adjustment cost yields the same dynamic effect. Iacoviello (2005) uses the specification in which household incurs the adjustment cost to change the stock of real estate (the housing stock).

procedure.[4]

Let the discount factor of entrepreneurs be $\theta\beta$, with $\theta < 1$ so that entrepreneurs are less patient than households. Entrepreneurs maximize $E_0 \sum (\theta\beta)^t \ln c_t^E$, subject to the technology (6), the borrowing constraint (7), and the following flow of funds;

$$(8) \quad c_t^E + K_t - (1-\delta)K_{t-1} + S_K(I_t, I_{t-1}) + q_t(L_t - L_{t-1}) + S_L(L_t, q_t, L_{t-1})$$

$$= Y_t + b_t - R_{t-1}b_{t-1} - w_t N_t .$$

Define η_t as the time t shadow value of the borrowing constraint. The first-order conditions for an optimum are the Euler equation for consumption, the demand functions for labor, land, and capital:

$$(9) \qquad \frac{1}{c_t^E} = \theta\beta E_t \frac{R_t}{c_{t+1}^E} + \eta_t ,$$

$$(10) \qquad w_t = (1-\alpha)\frac{Y_t}{N_t} ,$$

$$(11) \qquad \frac{1}{c_t^E}[q_t + \frac{\partial S_{L,t}}{\partial L_t}] = m\eta_t E_t[\frac{q_{t+1}}{R_{t-1}}] + \theta\beta E_t \frac{1}{c_{t+1}^E}[\frac{\partial Y_{t+1}}{\partial L_t} + q_{t+1} - \frac{\partial S_{L,t+1}}{\partial L_t}], \text{ and}$$

$$(12) \qquad \frac{1}{c_t^E}(1 + \frac{\partial S_{K,t}}{\partial K_t}) = (\theta\beta)E_t \frac{1}{c_{t+1}^E}[\frac{\partial Y_{t+1}}{\partial K_t} + (1-\delta) - \frac{\partial S_{K,t+1}}{\partial K_t}] - (\theta\beta)^2 E_t \frac{1}{c_{t+2}^E}\frac{\partial S_{K,t+2}}{\partial K_t} .$$

The demand functions for labor (10) and capital (12) are standard, but the Euler equation for consumption (9) and the demand function for land (11) are not standard. In each of the latter two, the multiplier on the borrowing constraint η_t is added. In (11) the first term of the RHS expresses the "down-payment effect" that captures the reduction in the effective land price.

The assumption $\theta < 1$ guarantees that entrepreneurs are constrained by the borrowing constraint at least around steady state. In fact, it follows from (3) and (9) that the multiplier is strictly positive at the steady state; $\eta = \frac{\beta(1-\theta)}{c^E}$ >0. Therefore, the borrowing constraint will hold with equality:

[4] The bank monitoring may be compatible with the borrowing constraint. Ogawa (2003) reports the evidence of the complementary role of collateral with bank monitoring. The value of m that is under close relationship with banks might be greater than not.

(13) $b_t = mE_t(q_{t+1}L_t / R_t)$.

Finally, we describe the evolution of the productivity as

(14) $\ln A_t = \rho_A \ln A_{t-1} + \varepsilon_{A,t}$,

with $\varepsilon_{A,t}$ being a white noise shock process with zero mean and variance σ_ε^2, and with the coefficient of autocorrelation ρ_A. Assume that the variance is sufficiently small that the borrowing constraint is always binding with equality for both positive and negative shocks.

C. Equilibrium

The equilibrium is a sequence of variables $\{Y_t, K_t, N_t, N'_t, L_t, h'_t, c'_t, c_t^E, b_t, b'_t, A_t\}_{t=0}^{\infty}$, together with the sequence of values $\{w_t, \eta_t, q_t, R_t\}_{t=0}^{\infty}$, satisfying equations (2) - (6), (8) - (13), and four market clearing conditions, $N_t = N'_t$ for labor, $h'_t + L_t = \overline{L}$ for land, $b_t + b'_t = 0$ for loans, and $Y_t = c'_t + c_t^E + K_t - (1-\delta)K_{t-1} + S_K(I_t, I_{t-1}) + S_L(L_t, q_t, L_{t-1})$ for the final good, and the sequence of productivity shock (14), together with the relevant transversally conditions and $\{K_{t-1}, L_{t-1}, b_{t-1}\}$. To solve the dynamics numerically, we log-linealize the system around the steady state using the method proposed by Uhlig (1999).

Absent shocks, the model has a unique stationary equilibrium in which entrepreneurs faces the borrowing constraint. The steady state is described as 10 variables $\{h', L, N, Y, c', c^E, K, b, q, R\}$, given A, satisfying 10 equations;

(S1) $h' + L = \overline{L}$,

(S2) $Y = c' + c^E + \delta K$,

(S3) $1 = \beta R$,

(S4) $(1-\beta)\dfrac{q}{c'} = \dfrac{\phi}{h'}$,

(S5) $B(N)^{\varpi} c'_t = (1-\alpha)Y$

(S6) $$Y = AN^{1-\alpha}[\gamma K^{\frac{\sigma-1}{\sigma}} + (1-\gamma)L^{\frac{\sigma-1}{\sigma}}]^{\frac{\alpha\sigma}{1-\sigma}},$$

(S7) $$q = m(1-\theta\beta R)\frac{q}{R} + \theta\beta(\frac{\partial Y}{\partial L} + q),$$

(S8) $$1 = (\theta\beta)(\frac{\partial Y}{\partial K} + 1 - \delta),$$

(S9) $$b = mqL/R,$$

(S10) $$c^E + \delta K = (1-R)b + \alpha Y,$$

where $\frac{\partial Y}{\partial L} = (1-\gamma)\alpha Y[\gamma K^{\frac{\sigma-1}{\sigma}} + (1-\gamma)L^{\frac{\sigma-1}{\sigma}}]^{-1}L^{-\frac{1}{\sigma}}$ and

$$\frac{\partial Y}{\partial K} = \gamma\alpha Y[\gamma K^{\frac{\sigma-1}{\sigma}} + (1-\gamma)L^{\frac{\sigma-1}{\sigma}}]^{-1}K^{-\frac{1}{\sigma}}.$$

3. Technological Substitutability and Land Allocation

In this section we investigate the steady state response of a change in the productivity shock on the land allocation, when the degree of substitutability between capital and land varies. This analysis is not intended to argue that the long-run analysis is important but intended to predict the magnitude of the asset price effect that is anticipated to vary with the technological interaction between capital and land. Note that here the labor supply is assumed constant, i.e., $N = \overline{N}$.

We investigate three production technologies that differ in the elasticity of substitution σ. We first consider the Leontief technology in which capital and land are perfect complements, with $\sigma = 0$. The production function (6) is then reduced to $Y_t = A_t N_t^{1-\alpha}\{\min[K_{t-1}, L_{t-1}]\}^{\alpha}$, and hence further to $Y_t = A_t N_t^{1-\alpha}K_{t-1}^{\alpha}$, with the restriction $K_{t-1} = L_{t-1}$. We use the latter equality to rewrite the entrepreneur's flow of funds (8) as

(15) $$c_t^E + q_t(L_t - L_{t-1}) + \{L_t - (1-\delta)L_{t-1}\} = Y_t + b_t - R_{t-1}b_{t-1} - w_t\overline{N}.$$

Note that the adjustment costs are deleted for convenience. The entrepreneur's first-order conditions are now (9), (10), and

(16) $$\frac{1}{c_t^E}(q_t+1)=m\eta_t E_t(\frac{q_{t+1}}{R_{t-1}})+E_t\frac{\theta\beta}{c_{t+1}^E}[\frac{\alpha Y_{t+1}}{K_t}+q_{t+1}+1-\delta].$$

Rearranging terms, we finally have

(17) $$\frac{(1-\beta)\{1-\theta\beta(1-\delta)\}\{(1+\phi m)L-\overline{L}\}}{A\overline{N}^{1-\alpha}}$$

$$=[\phi(1-\alpha)\{1-m(1-\theta)\beta-\theta\beta\}+(1-\beta)\theta\beta\alpha(1+\phi m)]L^{\alpha}-(1-\beta)\theta\beta\alpha\overline{L}L^{\alpha-1}$$

$$\equiv\Phi(L).$$

The LHS is a straight line with a positive slope, that goes through $(\overline{L}/(1+\phi m),0)$, while the $\Phi(.)$ function of the RHS is increasing and concave over $(0,\overline{L})$, with $\lim_{L\to 0}\Phi(L)=-\infty$. As illustrated in Figure 1, there are two steady states. An increase in A moves the straight line clockwise around $(\overline{L}/(1+\phi m),0)$, making the demand for land greater in any of the steady states. When the positive productivity shock occurs, the land is reallocated toward firms from households.

We next turn to the other extreme case when capital and land are perfect substitutes, with $\sigma\to+\infty$. The production function (6) is then reduced to $Y_t=A_tN_t^{1-\alpha}[\gamma K_{t-1}+(1-\gamma)L_{t-1}]^{\alpha}$. Taking into account the possible corner solution, the first-order conditions for land and capital are written at the steady state as

(18) $$1\geq m(1-\theta\beta R)+\theta\beta[\frac{\alpha Y}{q\{\gamma K+(1-\gamma)L\}}+1],$$ and

(19) $$1\geq\theta\beta\{\frac{\alpha Y}{\gamma K+(1-\gamma)L}+1-\delta\}.$$

With complementary slackness, either (18) or (19) should at least bind with equality. If (19) binds with equality, (18) should be met if the land price q is higher than some threshold $\overline{q}$. Conversely, if (18) binds with equality, (19) should be slack when q is smaller than the threshold.

Figure 2 illustrates the entrepreneur's demand for land in terms of the TFP. The demand is weakly decreasing as the TFP rises. The demand is not affected by the TFP when the firm uses only capital $(\overline{A} < A)$ or only land $(A < \overline{\overline{A}})$, whereas it is decreasing when the firm uses both capital and land $(\overline{\overline{A}} < A < \overline{A})$.

If the TFP is great, the land price is expensive, and entrepreneurs demand capital but no land, i.e., $L = 0$. If the TFP is at the intermediate level, entrepreneurs demand land by $L = \frac{\overline{L}}{1+m\phi} - \frac{\phi(1-\alpha)}{(1-\beta)\overline{q}(1+m\phi)}[\frac{\theta\beta\gamma\alpha}{1-\theta\beta(1-\delta)}]^{\frac{\alpha}{1-\alpha}}\overline{N}A^{\frac{1}{1-\alpha}}$, which is decreasing in TFP . Finally, if the TFP is low, the land price is cheaper than capital, and entrepreneurs demand some constant amount, $L = \frac{(1-\beta)\theta\beta\alpha\overline{L}}{\phi(1-\alpha)\{1-m(1-\theta)\beta-\theta\beta\}+(1+m\phi)(1-\beta)\theta\beta\alpha}$.

The Leontief case and other polar case reveal two offsetting effects on the land allocation. On one hand, a rise in the TFP raises the marginal productivity of land, and induces firms to demand more land, as captured by the Leontief case. On the other hand, it makes land more expensive than capital, and induces firms to demand less land, as captured by the perfect-substitutability case.

We finally study the Cobb-Douglas case with $\sigma = 1$. The entrepreneurs' demand for land becomes $L = \frac{(1-\beta)\theta\beta(1-\gamma)\alpha\overline{L}}{\phi(1-\alpha)\{1-m(1-\theta)\beta-\theta\beta\}+(1+m\phi)(1-\beta)\theta\beta(1-\gamma)\alpha}$, which is independent of TFP. For this case, the two effects cancel out. We summarize as

Proposition

Suppose that the TFP rises permanently.

(1) When $\sigma = 0$, the land is reallocated from households to firms

(2) When $\sigma \to +\infty$, if the TFP is high or low, the land is never reallocated between households and firms, while if the TFP is at the intermediate level, the land is reallocated from firms to households.

(3) When $\sigma = 1$, the land is never reallocated between households and firms.

The technological substitutability between capital and land significantly influences the land allocation. When the elasticity of substitution is small, entrepreneurs find it difficult to substitute land by capital, choosing to buy land to gain from putting up land as collateral. Firms become net demanders for land, and land is more allocated toward firm. By contrast, when it is high, entrepreneurs find it easy to substitute land by capital, and choose to sell land to gain the cash flow to finance investment in capital. Firms become net suppliers, and land tends to be more allocated to households. This analysis predicts that as σ is smaller, firms accumulate more net worth over time, and the quantitative effects of financial accelerator is strong.

4. Calibration Results

The asset price channel has been at work in Japan. In the post-war period of Japan, financial markets in Japan have been highly dependent on the banking sector and many of asymmetric information have been resolved by providing land as collateral for securing bank loans.[5] A number of empirical researches provide evidence of the collateral channel in the Japanese economy, including Ogawa, *et al*. (1996), Ogawa and Kitasaka (1998), and Ogawa and Suzuki (1998). Sakuragawa and Sakuragawa (2007) report the VAR-based response functions of aggregate variables including the land price, finding the important role of land collateral channel in propagating business fluctuations in Japan. Kwon (1998) and Bayoumi (2001) argue the important role of land collateral in the monetary transmission in their VAR analysis.

A. Parameter Choice

We choose parameter values following the Japanese economy. The time period is one quarter. We set the discount factor for patient households at β=0.995, which implies the steady-state annualized real interest rate of 2 percent. We set the value of θ at 0.995, implying that the discount factor for entrepreneurs $\theta\beta$ to be 0.99.

We set the depreciation rate on capital at δ=0.02, which implies an annual rate of 8 percent. We set the parameter on the adjustment cost of investment ξ_K at 0.6, the value of which is extensively used in the business cycle literature. The appropriate parameter on the adjustment cost of land is difficult to obtain, and so we use this

[5] As a matter of fact, land is easy to develop across industries so that among many assets, land is extensively used as collateral [e.g., Shleifer and Vishny (1992)].

parameter as a shift parameter. We set parameters for the labor supply function, B and ϖ to be unity and 1.01.

We set the entrepreneur's "loan-to-land-value ratio at $m = 0.7$, which reflects the business practice and tradition in the Japanese banking industry.[6] We set the weight for housing at $\phi = 0.1$. We calculate it by substituting the ratio of expenditure to housing to consumption in the household sector taken from the National Account into (S4).[7]

We set the "statistical" capital income share at $\alpha = 0.362$, which is the value used in Braun and Waki (2006), for example. Note that the statistical capital income includes income from both capital and land, but the parameter γ is attributed only to "real" capital. We set γ to meet $K/Y \cong 4.7$, which is the average of the quarterly data for the period 1980-2007, taken from the National Account. We set $\gamma = 0.85$ in case of $\sigma = 1/2$. We examine three values for the elasticity of substitution of land and capital, $1, 1/2$, and $1/3$. The coefficient of the autocorrelation ρ_A is set at 0.8.

The loan interest rate in the contractual arrangement that appears in (7) is specified before the productivity shock is revealed, and is different from the one actually repaid to investors. We motivate the inertia of loan rates in the lending practice, and calculate the loan interest rate by assuming that creditors set the same rate as the rate realized one period before.

B. Transmission Mechanism

The asset price channel is anticipated to add further amplification effects to financial accelerator through the endogenous fluctuation of the evaluation of assets used as collateral. However, simpler versions of the KM model report small effects (e.g., Kocherlakota, 2000). Now we use the more generalized version to evaluate the quantitative effects.

Hereafter all the figures illustrate impulse responses to a one percent positive

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6 We do not apply a Bayesian approach to look for parameter values because quarterly data are not available for several data in the land market.

7 Iacoviello (2005) uses the same value for the US economy.

productivity shock. Solid impulses correspond to the credit constrained economy, and dotted ones to the frictionless economy.

Figure 3 presents the case when firms incur neither adjustment cost of investment nor land.[8] In Figure 3A, the impulse of investment shows the greater amplification effect as the elasticity of substitution σ declines from 1 to $1/2$, and to $1/3$. In Figure 3B, the impulses of capital make the differential effects more transparent. Financial friction may or may not dampen investment, depending on the elasticity of substitution. Financial friction dampens investment in the Cobb-Douglas case $(\sigma = 1)$, but amplifies investment in cases of $\sigma = 1/2$ and $\sigma = 1/3$.

In Figure 3C, the impulses of the land price show greater effects as σ declines. The land allocation illustrate interesting impulses In Figure 3D, firms sell land in the Cobb-Douglas case, but purchase land in cases of $\sigma = 1/2$ and $1/3$, as has been predicted by the previous analysis. In case of $\sigma = 1$, entrepreneurs find it easy to substitute land by capital, and choose to sell land to gain the cash flow to finance investment in capital. By contrast, in cases of $\sigma = 1/2$ and $1/3$, entrepreneurs find it difficult to substitute land by capital, choosing to buy land to gain from putting up land as collateral. In Figure 3E, borrowers' net worth declines rapidly for $\sigma = 1$, but slowly for small σ's. The impulses of borrowers' net worth reflect the differential behavior in the land allocation, capturing the differential investment dynamics. In Figure 3F, the impulses of output show the small effect of the financial accelerator. Even in cases of $\sigma = 1/2$ and $1/3$, the output increase from financial accelerator is very small.

Figure 4 presents the impulse responses when firms incur the adjustment cost of investment but not of land, i.e. $\xi_K = 0.6$ and $\xi_L = 0$.[9] In Figure 4A, we find greater amplification and persistency of financial accelerator. For example, for $\sigma = 1/2$, the magnitude of investment at peak is about 2.5 times relative to the frictionless economy.

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[8] We set the parameter of the adjustment cost of land at $\xi_L = 0.1$ for MATLAB calculation.

[9] We set the parameter of the adjustment cost of land at $\xi_L = 0.2$ in case of $\sigma = 1$ for MATLAB calculation.

Even for the Cobb-Douglas case, we find greater amplification of investment. Note that the impulses of investment exhibit a hump-shaped behavior. In Figure 4B, the capital stock increases at peak by 1.5%, greater than the no adjustment cost case (1.0%). Interestingly, the adjustment cost dampens investment in the frictionless economy, but promote investment in the credit constrained economy. The interaction of the adjustment cost and financial friction reinforces the amplification effect.

The adjustment cost of investment boosts the land price, particularly in early periods. In Figure 4C, for $\sigma = 1/3$, the rise in the land price is about twice at peak than the no adjustment cost (see Figure 3C). The adjustment cost of investment promotes more purchase of land by firms, particularly in early periods. In Figure 4C, for $\sigma = 1/3$, the net increase in land holding is about four times at peak than the no adjustment cost case (see Figure 3D). Interestingly, in case of $\sigma = 1$, absent the adjustment cost, firms sell land, but now firms purchase land. Figure 4E illustrates the greater and more persistent impulses of net worth than the no adjustment cost case (see Figure 3E).

In the presence of adjustment cost of investment, firms find it difficult to invest in capital promptly, and instead buy more land in earlier periods. In later subsequent periods firms use the greater land holding to raise more loans to finance investment. Consequently, the adjustment cost of investment strengthens financial accelerator, giving rise to the greater and more persistent effect on investment.

In Figure 4F, the impulses of output show the large effect of the financial accelerator. In case of $\sigma = 1, 1/2$, and $1/3$, the output increases by 1.6%, 1.6%, and 1.7% at peak in the credit-constrained economy, while it does by 1.2%, 1.1 %, and 1.1% in the frictionless economy.

Figure 5 presents the impulse responses when firms incur both adjustment costs of investment and land. We take various values, $\xi_L = 0$, 1, 5, for the adjustment cost of land. We take $\xi_K = 0.6$ for the adjustment cost of investment. Here we illustrate the case for $\sigma = 1/2$. In Figure 5A, we find that investment peak out earlier and later declines more quickly as the adjustment cost of land is greater. The presence of adjustment cost of land prevents the land price from boosting (see Figure 5C), making land more immobile (see Figure 5D), weakening the asset price effect. Figure 5E captures the declining effect of net worth. This experiment indicates an important role of the reallocation of a collateralized asset as a transmission of the asset price channel.

5. Conclusion

This paper highlights three factors as generating the strong quantitative effect of the asset price channel in a credit-constrained economy, the small elasticity of substitution between capital and land in production, the adjustment cost of investment in capital, and the reallocation of the asset that serves as collateral toward credit-constrained agents. This finding gives some hint on evaluating the significance of the asset price channel as an amplification mechanism of financial accelerator.

One direction of research is to enrich the model to divide capital into tangible capital that serves as collateral and nontangible one that embodies high productivity but does not serve as collateral. This generalized model is anticipated to give rise to the stronger effect of financial accelerator than existing models of financial friction.

Other direction is to incorporate further channels of financial acceleration. In our model of imperfect enforcement both the loan and deposit rates of interest are the same, and there does not appear the channel through which the asset price affects the risk premium measured by the difference between both rates. One way is to use the costly-state-verification model, as in Bernanke, et al (1999).

Final important job is to estimate the elasticity of substitution between capital and land in production. Indeed, the short-run elasticity of substitution is expected to be smaller than the long-run one; firms may not change the capital/land ratio quickly over the business cycle. Anyway, the accurate estimation is expected to contribute to more accurate evaluation of the financial acceleration.

References

Arias, A.F., 2003, “Quantitative Implications of the Credit Constraint in the Kiyotaki-Moore (1997) Setup,” Documento CEDE 2003-28, ISSN 1657-7191.

Bayoumi, T., 2001, “The Morning After: Explaining the Slowdown in Japanese Growth in the 1990s,” *Journal of International Economics*, vol.53, 241-259.

Bernanke, B.S., and M. Gertler, 1989, “Agency Costs, Net Worth, and Business Fluctuations,” *American Economic Review*, vol.79, 14-31.

Bernanke, B.S., M. Gertler, and S. Gilchrist, 1999, “The Financial Accelerator in a Quantitative Business Cycle Framework,” in *Handbook of Macroeconomics*, vol.1, edited by Taylor J.B. and M. Woodford, Elsevier Science, ch.21, 1341-1393.

Braun, A., and Y. Waki, 2006, “Monetary Policy During Japan’s Lost Decade,” *Japanese Economic Review*, vol.57, 324-344.

Carlstrom, C.T. and T.S. Fuerst, 1997, “Agency costs, net worth, and business fluctuations: a computable general equilibrium analysis,” *American Economic Review*, Vol.87, 893-910.

Christensen,I., and A. Dib., 2008, “The financial accelerator in an estimated New Keynesian model”, *Review of Economic Dynamics* 11, 155-78.

Christiano, L. J., M. Eichenbaum, and C. L. Evans, 2005, “Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy”, *Journal of Political Economy*, vol.**113**, 1-44.

Cooley, T., R.Marimon, and V. Quadrini, 2004, Aggregate consequences of limited enforceability, *Journal of Political Economy*, vol.**114**, 847-

Cordoba, J.C. and M. Ripoll, 2004, “Credit Cycles Redux,” *International Economic Review*, vol.45, 1011-1046.

Fukuchi, H., I. Muto, and H. Ugai, 2005, “Historical Evaluation of Financial Accelerator Effects in Japanese Economy,” Bank of Japan Working Paper Series, No.05-E-8.

Gilchrist, S., and J.V. Leahy, 2002, Monetary policies and asset prices, *Journal of*

Monetary Economics 49, 75-97.

Hall, R.E., 2001, "The Stock Market and Capital Accumulation", *American Economic Review*, vol.91. 1185-1202.

Iacoviello. M., 2005, "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle", *American Economic Review*, Vol. 95, 739-764.

Kiyotaki, N, and J. Moore, 1997, "Credit Cycles", *Journal of Political Economy*, vol.**105**, 211-248.

Kocherlakota, N.R., 2000, "Creating Business Cycles through Credit Constraints, *Federal Reserve Bank of Minneapolis Quarterly Review,* Vol.24, No.3, 2-10.

Kwon, E., 1998, "Monetary Policy, Land Prices, and Collateral Effects on Economic Fluctuations: Evidence from Japan," *Journal of the Japanese and International Economies,* vol.12, pp.175-203.

Ogawa, K, 2003, *Daifukyo no Keizai Bunseki* (in Japanese), Nippon Keizai Shinbun Sha.

Ogawa K, 2009, *Ushinawareta jyu-nen no shinjitu* (in Japanese), Nippon Keizaqi Shinbun Sha.

Ogawa, K. and S. Kitasaka, 1998, *Sisan Shijyou to Keiki Hendou* (in Japanese), *Nippon Keizai Shinbun Sha.*

Ogawa, K., S. Kitasaka, H. Yamaoka and Y. Iwata, 1996, "Borrowing Constraints and the Role of Land Asset in Japanese Corporate Investment Decision", *Journal of the Japanese and International Economics*, Vol.10, 122-149.

Ogawa, K. and K. Suzuki, 1998, "Land Value and Corporate Investment: Evidence from Japanese Panel Data", *Journal of the Japanese and International Economics,* Vol.12, 232-249.

Sakuragawa, M., and Y. Sakuragawa, 2007, "Tika to Nihon no Keiki Jyunnkann," *Mita Gakkai Zasshi* 100, Vol.2,

Sakuragawa, M., and Y. Sakuragawa, 2009, "Land Price, Collateral, and Economic Growth," *The Japanese Economic Review*.60, No.4, 473-89.

Shleifer, A., and R. Vishny, 1992, "Liquidation values and debt capacity: a market equilibrium approach," *Journal of Finance*: 1343-1366.

Uhlig, H., 1999, "A Toolkit for Analyzing Nonlinear Dynamic Stochastic Models Easily," in Marimon and Scot, eds., *Computational Methods for the Study of Dynamic Economics*. Oxford University Press. 30-61.

Table1. Parameter Values

β : discount factor for patient households	0.995	This implies a steady-state annualized real interest rate of 2 percent (one period is a quarter).
θ	0.995	The discount factor for entrepreneur $\theta\beta$ is 0.99.
α : share of "capital income"	0.362	This figure follows Braun and Waki (2006)
γ : share of capital in "capital income"	0.85	This figure is inferred from the steady-state value at $\sigma = 1/2$.
δ : depreciation rate	0.02	An annual rate of depreciation on capital equal to 8%
ξ_K :parameter of adjustment cost of investment in capital	0 or 0.6	We set this figure extensively used in the literature on adjustment costs of investment.
ξ_L :parameter of adjustment cost of land	0 , 0.1, 1 or 5	
$\overline{N}$:labor supply per household	1	
ϕ : weight for housing in the households' utility	0.1	This figure follows Iacoviello (2005), and is almost the same inferred from the steady-state value.
m : entrepreneurs' loan-to-land-value ratio	0.7	We choose this figure from hearing in the business practice
ρ_A : autocorrelation coefficient of productivity shock	0.8	
B : a parameter of disutility of labor	1	
ϖ :a parameter of disutility of labor	1.01	
$\overline{L}$: endowment of land	1	

Figure 1

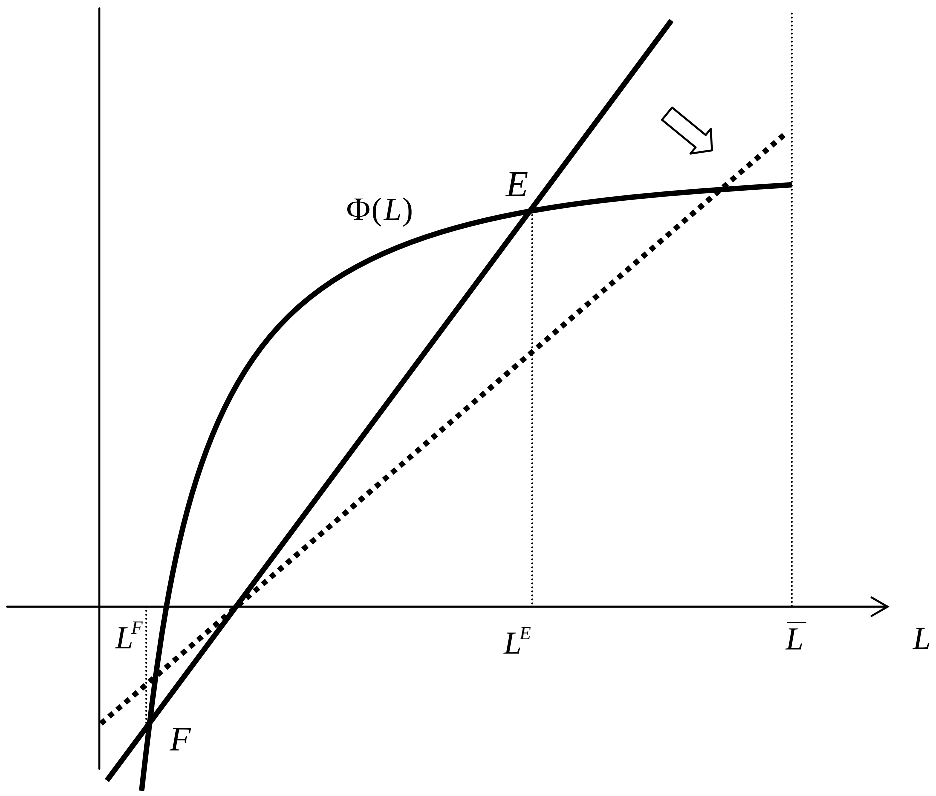


Figure 2

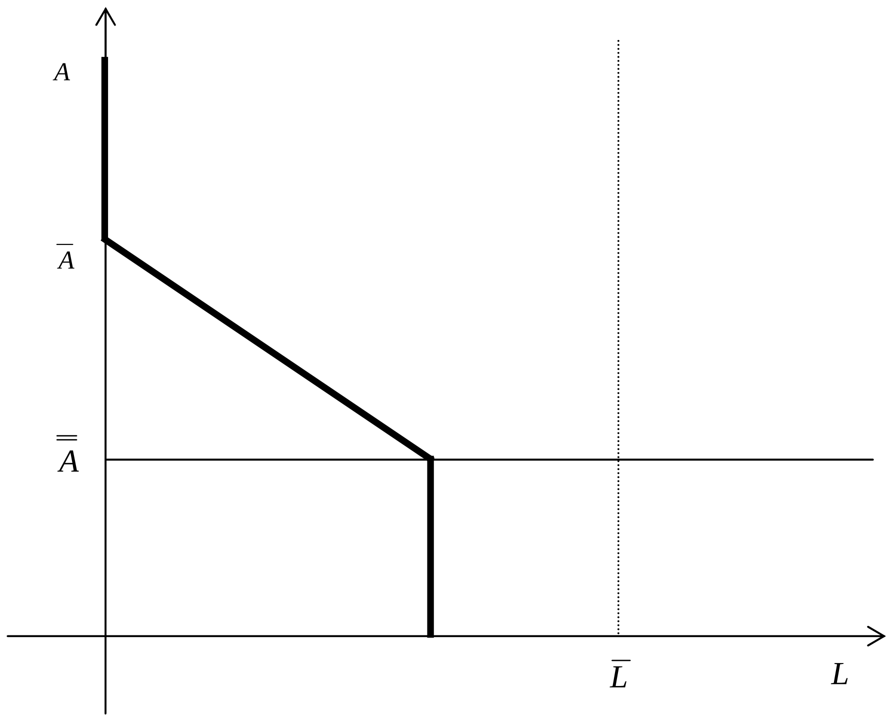


Figure 3. Impulse Responses to positive 1% productivity shock when $\chi\_K=0$ and $\chi\_L=0.1$.

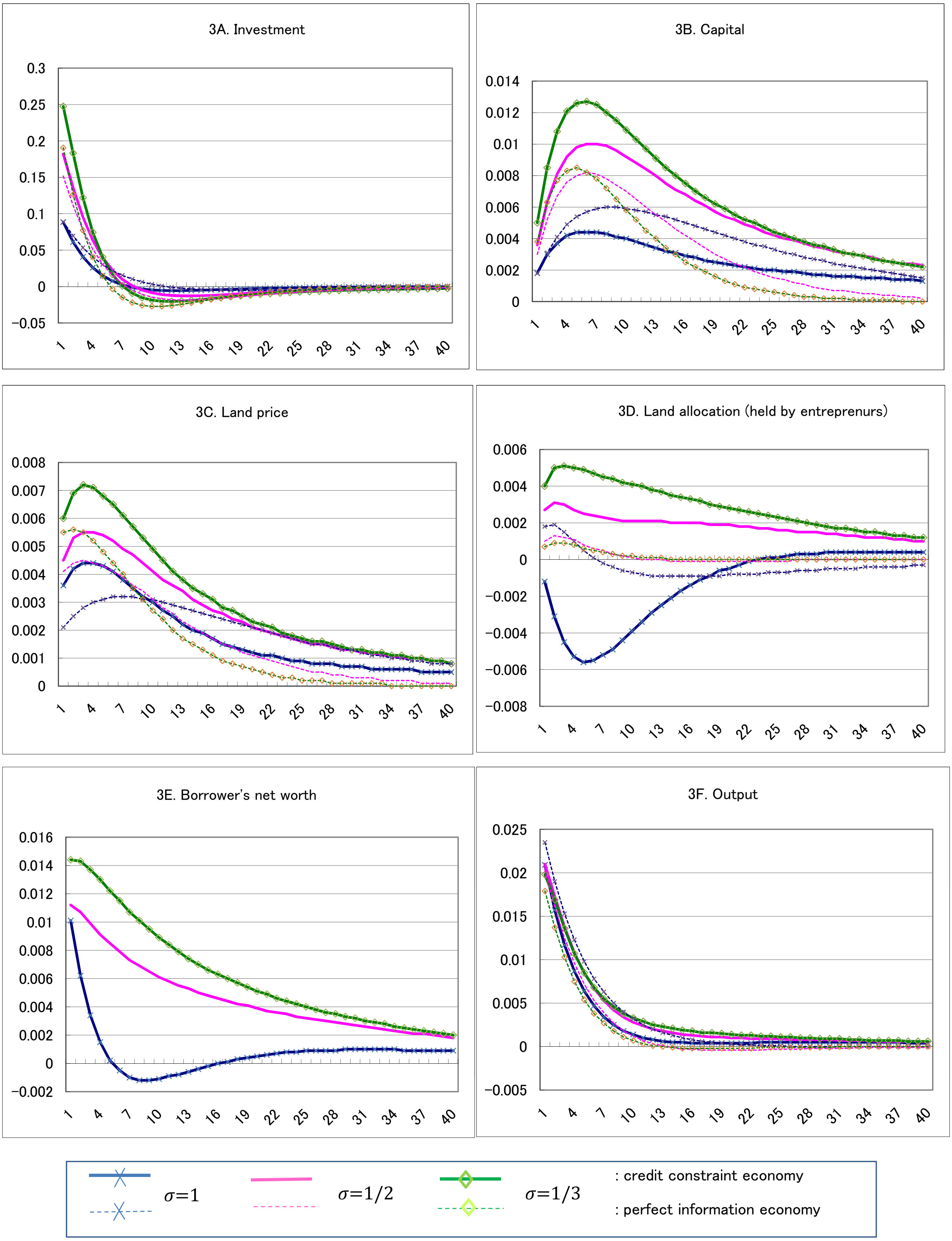


Figure 4. Impulse Responses to positive 1% productivity shock when $\chi_K=0.6$ and $\chi_L=0$.

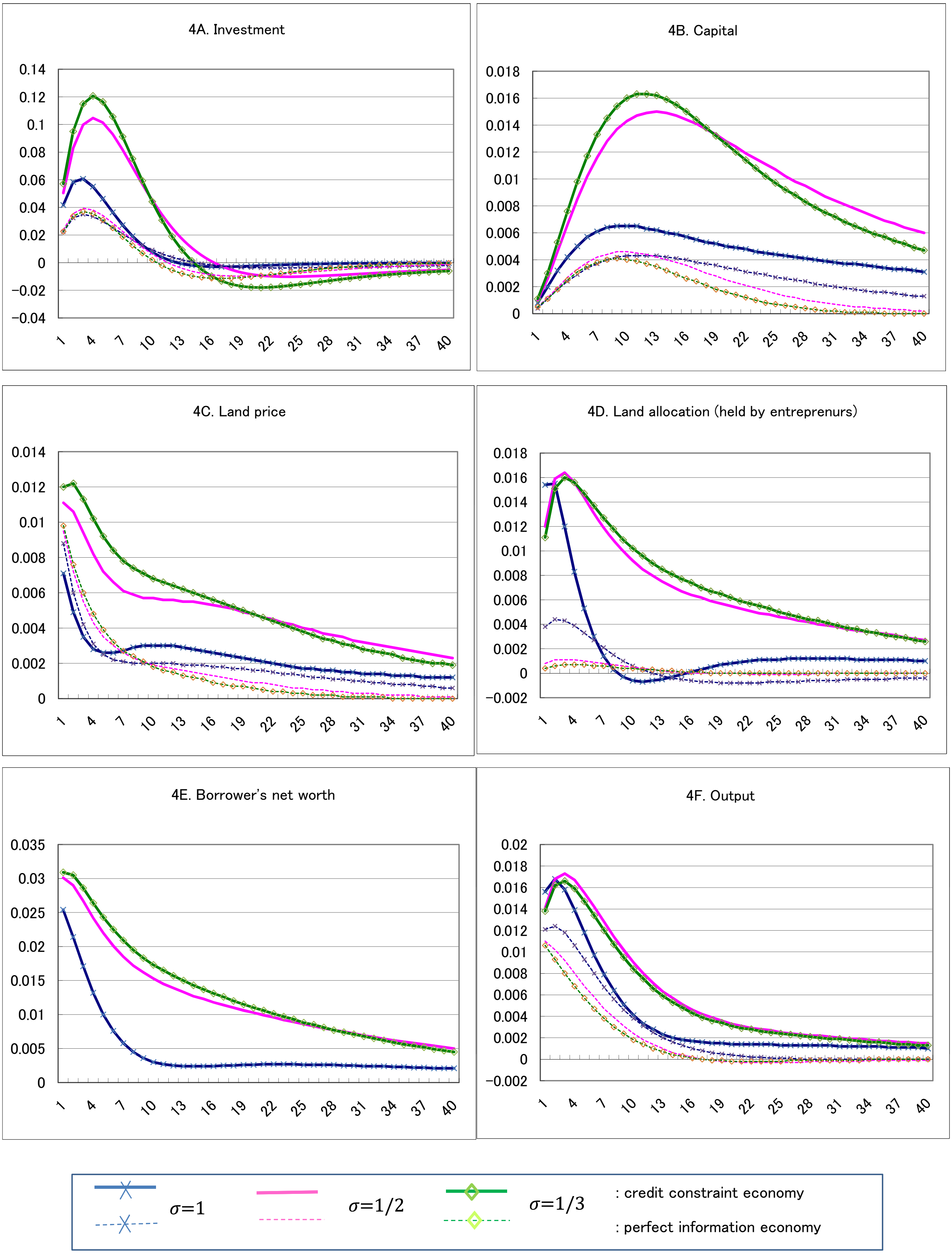
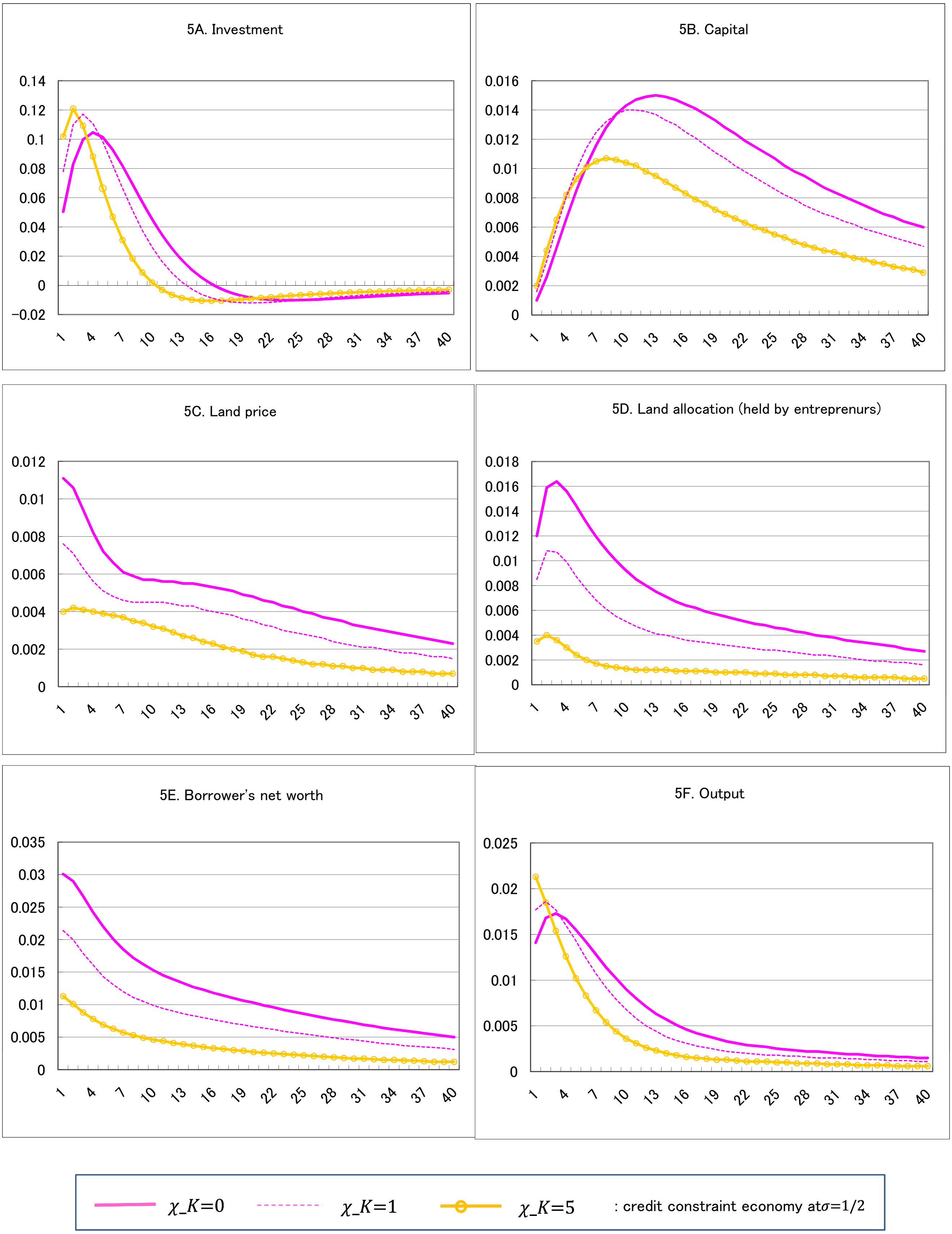


Figure 5. Impulse Responses to positive 1% productivity shock at σ=1/2 when χ_K=0.6 and various χ_L.



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