Financial Development and Amplification

Tomohiro Hirano*

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Abstract

Traditional wisdom about the relationship between the development of financial markets and volatility of the economy is that financial development stabilizes the economy. However, after the recent financial crisis of 2007-08, a new perspective has emerged: financial development destabilizes the economy by accelerating financial amplification. Why do we observe such seemingly contradicting views? Does financial development lead to instability while enhancing efficiency? This paper develops a theoretical model to answer these questions and attempts to reconcile both classical and new views. We find that the relationship between financial development and financial amplification is nonlinear: financial amplification initially increases with financial development and later falls down. Moreover, we examine the role of monetary policy to dampen downward amplification, and discuss its welfare implications.

1 Introduction

What are the effects of the development of financial markets on amplification over the business cycle? Traditional wisdom suggests that financial

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development stabilizes the economy by providing various channels for risk diversification. According to this view, financial innovation not only promotes long-run economic growth by enhancing efficiency in resource allocation, but also it helps to cushion consumers and producers from the effects of economic shocks[1]. This classical view seems to have been widely accepted. Indeed, several empirical studies support the positive role of financial development in reducing volatility (See Cecchetti et al, 2006; Dynan et al, 2006; Jerman and Quadrini, 2008).

However, the situation has begun to change dramatically since the outbreak of the credit crisis of 2007-08. A new perspective has emerged: financial development destabilizes the economy by accelerating financial amplification. Before the crisis, it was often pointed out that thanks to financial innovation, the leverage of borrowers increased, and this high leverage generated economic booms. However, once the credit crisis occurred, people began to state that high leverage caused by financial innovation could lead to significant damages in borrowers' balance sheets, and eventually in the financial system as a whole. Financial development is suddenly blamed for increasing volatility. Indeed, IMF (2006, 2008) supports this new view by presenting empirical evidences that in more-advanced financial systems, the shock propagation effects become stronger[2].

Thus, the question that naturally arises is why do we observe such seemingly contradicting views? Does financial development lead to instability while enhancing efficiency? This paper presents a theoretical model to answer these questions and attempts to reconcile both classical and new views. To this end, we develop a model of financial development with endogenous growth. The two key elements of this framework are the borrowing constraint and the heterogeneous investment projects—high and low productive investment. The former captures *balance sheet effects* that magnify shocks. The latter describes *shock cushioning effects*[3]. By changing the *degree* of the borrowing constraint, which is defined as financial development, this paper

[1] Levine(1997), Beck et al. (2000) show empirically that financial development causes long run economic growth.

[2] IMF reports argue that the sensitivity of real GDP growth rate, corporate investment, household consumption, and residential investment response to equity busts, or business cycles, is increasing in more market-based financial systems. Plantin et al. (2008) indicate that in the financial markets with a mark-to-market accounting system, the shock propagation effects are stronger.

[3] See Bernanke et al. (1996) for balance sheet effects.

shows that financial development not only impacts the magnitude of *balance sheet effects* through changing leverage, but also it produces *shock cushioning effects* through the adjustment of the real interest rate. The balance between these two competing forces determines whether financial development magnifies or dampens financial amplification. Moreover, the balance by itself changes according to the *degree* of financial development.

Our main result shows that in a low development region, shock cushioning effects do not work well, but *balance sheet effects* get strengthened with financial development, thereby accelerating financial amplification. However, once the level of development passes a certain degree, *shock cushioning mechanisms* start working, which in turn weakens *balance sheet effects*, thereby dampening financial amplification. Hence, the relationship between the development of financial markets and volatility is nonlinear: financial development initially increases instability and later leads to stability.

The implications of our model may present a difficult problem for a regulator. In low-level financial development, there is a trade-off between economic growth and financial amplification. For example, if the regulator wishes to achieve higher economic growth, it would relaxe some regulations in financial markets, which would soften the borrowing constraint[4]. As a result, the leverage increases, and more funds flow from low to high productive investment through credit markets. This improvement in resource allocation produces higher economic growth in the steady state. However, once negative shocks hit the economy, since the economy is highly leveraged, downward amplification becomes significant. On the other hand, if the regulator tightens the regulations, the leverage decreases, so that downward amplification becomes smaller. However, economic growth in the steady state also decreases. In this sense, higher economic growth and lower downward amplification—or in other words, improving efficiency and enhancing stability—do not go together. The question that now arises is whether there are any policies to achieve both improved efficiency and enhanced stability. From a welfare point of view, downward amplification impairs economic agents' welfare, while higher economic growth in the steady state improves it. Therefore, it is indeed worthwhile to consider policies. In this paper, we study the role of monetary policy, and discuss its welfare implications.

[4]For example, in the U.S., there is a rule on the broker-dealer leverage ratio; this rule has been set by SEC and is known as net capital requirements. A regulation was modified in August 2004. It is often pointed out that this change resulted in the rise in the leverage of major investment banks.

This paper is in line with business cycle theory which emphasizes the role of credit market imperfections. Following the seminal work by Bernanke and Gertler (1989) and Kiyotaki and Moore (1997), some researchers put financial factors a central role in accounting for business fluctuations (See Holmstrom and Tirole, 1997; Kiyotaki, 1998; Bernanke et al., 1999; Kocherlakota, 2000; Cordoba and Ripoll, 2004). These studies demonstrate how shocks are amplified, assuming a constant degree of the borrowing constraint and a constant real interest rate[5]. However, our study adds a kick to this environment. We change the *degree* of the borrowing constraint. As a result, our model produces a region with a flexible interest rate in which *shock cushioning effects* are generated.

Moreover, this paper also contributes to the literature on the relationship between financial development and financial amplification[6]. Rajan (2006) argues that financial development has made the world better off, however it can accentuate real fluctuations, and economies may be more exposed to financial-sector-induced turmoil than in the past. However, Rajan does not necessarily propose a formal model of how financial development accelerates amplification. Shin (2008) presents a theoretical model that securitization by itself may not enhance financial stability. Our study shows the mechanisms of how financial innovation not only accelerates financial amplification, but also decelerates it. In this regard, our paper would be related to Easterly et al. (2000) and Matsuyama (2007, 2008). Easterly et al. (2000) demonstrate empirically that financial development generally acts as a stabilizer and reduces growth volatility. However, the relationship is nonlinear. As financial systems grow, volatility becomes higher. Matsuyama (2007, 2008) develops a model of the borrowing constraint with various types of heterogeneities in an overlapping generations framework, and shows how it leads to a wide range of nonlinear phenomena. In one case, he examines how volatility is affected by an improvement of the financial system. He demonstrates that improving

[5] A recent study by Brunnermeier and Pedersen (2008) shows that amplification increases by the interaction between funding liquidity and market liquidity, which refer to the borrowing constraint and resaleability constraint, respectively.

[6] Concerning endogenous growth and volatility, King and Rebelo (1993), Stadler (1990), and Jones et al. (2000) analyze the relation between volatility and growth within endogenous growth models, but they do not consider the role of the borrowing constraint. Aghion et al. (2007) develop an endogenous growth model with the borrowing constraint, and examine how growth volatility is related with the allocation of short-term and long-term investments.

the credit market first leads to increased volatility and then reduced volatility. However, Matsuyama examines the volatility together with an increase in the output level, whereas our paper examines volatility together with a decline in economic growth in an infinitely lived agent model.

The remainder of the paper is organized as follows. Section 2 presents the model. We analyze the dynamics and derive implications for the relationship between financial development and financial amplification. In section 3, we examine the role of monetary policy to dampen downward amplification, and discuss its welfare implications in section 4. Section 5 presents conclusion.

2 The Model

Consider a discrete-time economy with one homogenous goods and two types of agents, entrepreneurs and workers. Let us start with the entrepreneurs, who are the central actors in the paper. At date t, a typical entrepreneur has expected discounted utility:

$$E_0\left[\sum_{t=0}^{\infty}\beta^t \log c_t\right], \tag{1}$$

where c_t is the consumption at date t, and $\beta \in (0,1)$ is the subjective discount factor, and $E_0[x]$ is the expected value of x conditional on information at date 0.

There are two types of entrepreneurs: H-entrepreneurs, who have high productive investment and L-entrepreneurs, who have low productive investment. The investment projects produce capital. The investment technology follows:

$$k_{t+1} = \alpha^i z_t, \tag{2}$$

where z_t is investment of goods at date t. α^i is the marginal productivity of investment, and $i \in \{H, L\}$ is the index for H-entrepreneurs and L-entrepreneurs, respectively. k_{t+1} is capital produced at date $t+1$. We assume $\alpha^H > \alpha^L$.

Each entrepreneur knows his own type at date t, but only knows it with probability after date $t+1$. That is, each entrepreneur shifts stochastically between two states according to a Markov process: the state with high productive investment and low productive investment. Specifically, an entrepreneur who has high (low) productive investment at date t may have low (high) productive investment at date $t+1$ with probability $1-p$ $(X(1-p))$. This switching probability is exogenous, and independent across entrepreneurs and over time. Assuming that the initial ratio of H-entrepreneurs and L-entrepreneurs is $X:1$, the population ratio is constant over time. We assume that the switching probability is not too large.

$$\text{Assumption}: p > X(1-p). \tag{3}$$

This assumption implies that there is a positive correlation between the present period and the next period. That is, the entrepreneur who has high productive investment in the current period continues to have it next period with higher probability than the one who has low productive investment in the current period.

In this economy, there are agency problems in credit markets. The entrepreneur can pledge at most a fraction θ of future returns from his investment to the creditor. This fraction θ can be collateral in borrowing. In such a situation, in order for debt contracts to be credible, debts repayment does not exceed the value of collateral. That is, the borrowing constraint becomes

$$r_t b_t \leq \theta q_{t+1}^e \alpha^i z_t, \tag{4}$$

where r_t and b_t are the gross real interest rate, and the amount of borrowing at date t, respectively. q_{t+1}^e is the relative price of capital to consumption goods at date $t+1$ expected at date t. The parameter θ partly reflects the legal structure and the transaction costs in the liquidation of investment, capturing the degree of agency problems in credit markets (Hart and Moore (1994), Tirole (2006)). In this sense, θ provides a simple measure of financial development. In this paper, we define an increase in θ as a financial development.

The entrepreneur's flow of funds constraint is given by

$$c_t + z_t = q_t k_t - r_{t-1} b_{t-1} + b_t. \tag{5}$$

The left hand side of (5) is expenditure: consumption and investment. The right hand side is financing: the returns from investment in the previous period minus debts repayment, which we call net worth in this paper, and the amount of borrowing.

Each entrepreneur chooses consumption, investment, capital, and borrowing $\{c_t, z_t, k_{t+1}, b_t\}$ to maximize the expected discounted utility (1) subject to (2), (4), and (5).

Now, let's turn to the workers. There is only one type of workers. Each worker is endowed with one unit of labor each period, and supplies it inelastically in the labor market. Workers do not have investment project to produce capital, and therefore, do not have any collateral asset in order to borrow. At date t, a typical worker has expected discounted utility:

$$E_0\left[\sum_{t=0}^{\infty}\beta^t \log c'_t\right], \tag{6}$$

where c'_t is consumption of workers at date t. Each worker chooses consumption, and the amount of borrowing to maximize (6) subject to the flow of funds constraint and the borrowing constraint.

$$c'_t = w_t - r_{t-1}b'_{t-1} + b'_t, \tag{7}$$

$$r_t b'_t \leq 0, \tag{8}$$

where w_t and b'_t are the wage rate and the borrowing of the worker at date t.

There is a competitive final goods market. Production function of a representative firm is

$$Y_t = AK_t^{\prime,\sigma}N_t^{1-\sigma}\bar{k}_t^{1-\sigma}, \tag{9}$$

where A is productivity, and Y_t is output of the representative firm at date t[7]. K'_t and N_t are capital and labor inputs of the firm at date t. $\bar{k}_t^{1-\sigma}$ is per-labor capital of this economy at date t, capturing the positive externality in the sense of Romer (1986).

Each firm chooses capital and labor inputs to maximize its profit, given the relative price of capital to consumption goods, q_t, the wage rate, w_t, and the externality, $\bar{k}_t$. Considering the equilibrium of $k'_t = \bar{k}_t$, we obtain $y_t = Ak'_t$, where k'_t, and y_t are per-labor capital and output of the firm. Because the worker's population is one, the aggregate capital input and output equal

[7] Here, we suppose that each firm is operated by workers. Since the net profit of each firm is zero in equilibrium, the flow of funds constraint of workers does not change, and is the same as (7).

per-labor capital and output. Competitive factor prices produce

$$q_t = \sigma A, \qquad w_t = A(1-\sigma)k'_t. \tag{10}$$

Let us denote aggregate consumption of H-entrepreneurs, L-entrepreneurs, and workers at date t as C_t^H, C_t^L, and C'_t. Similarly, let $Z_t^H, Z_t^L, B_t^H, B_t^L$, and B'_t be aggregate investment, and the amount of borrowing of each type. Then, the market clearing for goods, credit, and capital are

$$C_t^H + C_t^L + C'_t + Z_t^H + Z_t^L = Y_t, \tag{11}$$

$$B_t^H + B_t^L + B'_t = 0, \tag{12}$$

$$k'_t = K_t, \tag{13}$$

where K_t is the aggregate capital stock produced by the entrepreneurs at date t.

2.1 Equilibrium

The competitive equilibrium is defined as a set of prices $\{r_t, q_t, w_t\}_{t=0}^{\infty}$ and quantities $\left\{c_t, c'_t, b_t, b'_t, z_t, C_t^H, C_t^L, C'_t, B_t^H, B_t^L, B'_t, Z_t^H, Z_t^L, K'_t, K_t, Y_t\right\}_{t=0}^{\infty}$ which satisfies the conditions that (i) each entrepreneur and worker maximizes utility, and each firm maximizes its profit, and (ii) the market for goods, labor, credit, and capital all clear. Because there is no shock except for the idiosyncratic shocks to the productivity of investment of the entrepreneurs, there is no aggregate uncertainty, and the agents have perfect foresight about future prices, $q_{t+1}^e = q_{t+1}$ and aggregate quantities in the equilibrium.

We are now in a position to characterize equilibrium behavior of entrepreneurs. Let us consider the case where θ is lower than θ_1 (θ_1 is defined later in Proposition 1.). If θ is lower than θ_1, in the neighborhood of the steady state, the real interest rate equals the rate of return on L-entrepreneurs' investment (This can be verified in Proposition 1.). That is, we have

$$r_t = q\alpha^L. \tag{14}$$

And so, the borrowing constraint of H-entrepreneurs binds because the rate of return on their investment is greater than the real interest rate. Since the utility function is log, H-entrepreneurs consume a fraction $(1-\beta)$ of the net worth, $c_t = (1-\beta)(qk_t - r_{t-1}b_{t-1})$. Then, by using (4), and (5), the investment function of H-entrepreneurs becomes

$$z_t = \frac{\beta(qk_t - r_{t-1}b_{t-1})}{1 - \dfrac{q\theta\alpha^H}{r_t}}. \tag{15}$$

The numerator of (15) is the required down payment for unit investment. From (15), we see that the investment equals the leverage, $1/\left[1 - (q\theta\alpha^H/r_t)\right]$ times savings, $\beta(qk_t - r_{t-1}b_{t-1})$. The leverage is greater than one, and increases with θ. This implies that when θ is large, H-entrepreneurs can finance more investment with smaller net worth. We also see that the sensitivity of investment response to a change in the net worth becomes higher with θ, so that even a small decline (increase) in the net worth can have a large negative (positive) effect on the investment.

Concerning workers, in the neighborhood of the steady state, the borrowing constraint binds. Thus, they consume all the income at every date, $c_t' = w_t$. From this behavior of workers, credit market equilibrium, (12) becomes

$$B_t^H + B_t^L = 0. \tag{16}$$

L-entrepreneurs are indifferent between lending and investing by themselves because the real interest rate is the same as the return on their investment. Their saving rate is also a fraction β of their net worth. Then, the aggregate lending and investment of L-entrepreneurs are determined by goods market clearing condition, (11).

Since consumption, debt and investment are linear functions of the net worth, we can aggregate across agents to find the law of motion of the aggregate capital:

$$\begin{aligned} K_{t+1} &= K_{t+1}^H + K_{t+1}^L = \alpha^H \frac{\beta E_t^H}{1 - \dfrac{q\theta\alpha^H}{r_t}} + \alpha^L \left(\beta\sigma Y_t - \frac{\beta E_t^H}{1 - \dfrac{q\theta\alpha^H}{r_t}} \right) \\ &= \left[1 + \left(\frac{\alpha^H - \alpha^L}{\alpha^L - \theta\alpha^H} \right) s_t \right] A\beta\sigma\alpha^L K_t, \end{aligned} \tag{17}$$

where K_{t+1}^H and K_{t+1}^L are the aggregate capital stock produced by H-and L-entrepreneurs at date $t+1$, respectively. E_t^H is the aggregate net worth of H-entrepreneurs, and $s_t \equiv E_t^H/\sigma Y_t$ is the net worth share of H-entrepreneurs against the aggregate net worth of all entrepreneurs. Since $Y_t = AK_t$ holds in equilibrium, and from (17), economic growth rate becomes

$$g_{t+1} \equiv \frac{Y_{t+1}}{Y_t} = \left[1 + \left(\frac{\alpha^H - \alpha^L}{\alpha^L - \theta\alpha^H}\right) s_t\right] A\beta\sigma\alpha^L. \tag{18}$$

From (18), once s_t is determined, economic growth rate is also determined. (18) implies that economic growth rate increases with financial development. Intuitively, when financial development improves, the borrowing constraint of H-entrepreneurs becomes relaxed. In the credit market, more resources can be allocated to H-entrepreneurs, which promotes capital accumulation, and eventually economic growth. As in a traditional endogenous growth setting, capital accumulation is the engine of economic growth.

The movement of the aggregate net worth of H-entrepreneurs evolves according to

$$E_t^H = p(q_t K_t^H - r_{t-1} B_{t-1}^H) + X(1-p)(q_t K_t^L - r_{t-1} B_{t-1}^L). \tag{19}$$

The first term of (19) represents the aggregate net worth of the entrepreneurs who continue to have high productive investment from the previous period. The second term represents the aggregate net worth of the entrepreneurs who switch from the state of having low productive investment to the state of having high productive investment. By using (18) and (19), we can derive the law of motion of the net worth share of H-entrepreneurs:

$$s_{t+1} = \frac{p\dfrac{\alpha^H(1-\theta)}{\alpha^L - \theta\alpha^H} s_t + X(1-p)(1-s_t)}{1 + \dfrac{\alpha^H - \alpha^L}{\alpha^L - \theta\alpha^H} s_t} \equiv \Phi(s_t, \theta). \tag{20}$$

The dynamic evolution of the economy is characterized by the recursive equilibrium: $(w_t, K_{t+1}, Y_{t+1}, g_{t+1}, s_{t+1},)$ that satisfies (10), (13), (17), (18), and (20) as functions of the state variables (K_t, Y_t, s_t).

2.2 Steady State Equilibrium

The stationary equilibrium of this economy depends upon the degree of financial development. That is, we have the following proposition (See Figure 1.1 and 1.2. Proof is in Appendix 1).

Proposition 1 *There are three stages of financial development, corresponding to three different values of θ. The characteristics of each region are as follows:*

(a) Region 1: $0 \leq \theta < \theta_1 \equiv (1-p)/\left[\alpha^H/\alpha^L - p + X(1-p)\right]$. Since the real interest equals the rate of return on L-entrepreneurs' investment, the borrowing constraint of H-entrepreneurs binds. Both H-entrepreneurs and L-entrepreneurs produce capital. The steady state values of g^*, s^*, and r^* satisfy

$$g^* = \left[1 + \left(\frac{\alpha^H - \alpha^L}{\alpha^L - \theta\alpha^H}\right) s^*\right] A\beta\sigma\alpha^L,\ s^* = \Phi(s^*, \theta),\ r^* = \sigma A \alpha^L. \tag{21}$$

(b) Region 2: $\theta_1 \leq \theta < \theta_2 \equiv 1/(1+X)$. Since the real interest rate takes the value of $r^* \in \left[\sigma A\alpha^L, \sigma A \alpha^H\right)$, the borrowing constraint of H-entrepreneurs binds, and they produce capital. However, L-entrepreneurs do not produce capital because the real interest rate is greater than the rate of return on their investment. The steady state values satisfy

$$g^* = A\beta\sigma\alpha^H,\ s^* = p(1-\theta) + X(1-p)\theta,\ r^* = \frac{\sigma A \alpha^H}{(1-p)/\theta + p - X(1-p)}. \tag{22}$$

(c) Region 3: $\theta_2 \leq \theta \leq 1$. Since the real interest equals the rate of return on H-entrepreneurs' investment, the borrowing constraint of H-entrepreneurs does not bind. Only H-entrepreneurs produce capital. The steady state values satisfy

$$g^* = A\beta\sigma\alpha^H,\ s^* = \frac{X}{1+X},\ r^* = \sigma A\alpha^H. \tag{23}$$

In region 1 where financial markets are not so developed, the real interest rate becomes low in the credit market because the borrowing constraint is tight, so that even L-entrepreneurs have incentives to invest. In this region, as financial development improves, the leverage of H-entrepreneurs increases.

In the credit market, more resources are allocated to H-entrepreneurs. This rise in the leverage and the improvement of resource allocation promote capital accumulation, the wage rate, and economic growth (See Figure 1.1). However, in this region the real interest rate is unchanged. This property is similar to Stiglitz and Weiss (1981) model. In their model, when information asymmetry is large, the real interest rate is insensitive, and becomes constant where the bank's profit is maximized. Similarly, in our model, when financial development is low, the real interest rate is sticky (See Figure 1.2).

In region 2 where financial development is high, but not so high, the situation changes. As financial markets develop, the real interest rate starts rising because of the tightness in the credit market. Thus, L-entrepreneurs do not have incentives to invest anymore. Only H-entrepreneurs produce capital. In the credit market, although the borrowing constraint is still binding for H-entrepreneurs, all the savings are allocated to them, so that the growth rate of the economy becomes constant, and independent of θ. This implies that once the financial system is developed to some degree, it can transfer enough purchasing power to the entrepreneurs who have high productive investment from the entrepreneurs who do not. In addition, in region 1 and 2, since the interest rate is lower than the rate of return on H-entrepreneurs' investment, income distribution is different between H-and L-entrepreneurs.

When financial markets grow further, and reaches region 3, the real interest rate becomes equal to the rate of return on H-entrepreneurs' investment. Therefore, the borrowing constraint for them no longer binds[8]. As in region 2, the financial system can allocate all the savings to H-entrepreneurs. Moreover, since H-and L-entrepreneurs earn the same rate of return, there is no difference in income distribution.

2.3 Dynamics

Now, let us look at how this economy responds to an unexpected shock to productivity. Suppose that at date $\tau - 1$ the economy is in region 1, and in the steady state: $g_{\tau-1} = g^*, s_{\tau-1} = s^*$ and $r_{\tau-1} = r^*$. There is then an unexpected shock to productivity: A declines by ε, and becomes $A(1-\varepsilon)$ at date τ. However, the shock is known to be temporary. The productivity at date $\tau + 1$ and thereafter returns to A. Here since we consider a negative

[8] In our model, in the neighborhood of the steady state, the borrowing constraint for workers binds in all of three regions.

shock, we set ε to be positive.

Following Kocherlakota (2000), we measure financial amplification (volatility) of a downward shock ε to be how far economic growth rate from τ to $\tau+1$ jumps down from the steady-state growth rate through the borrowing constraint. From (18), (19), and (20), we obtain

$$\text{Amplification} \equiv \frac{dg_{\tau+1}}{d\varepsilon}|_{\varepsilon=0} = \left(\frac{\alpha^H-\alpha^L}{\alpha^L-\theta\alpha^H}\right)\frac{ds_\tau}{d\varepsilon}|_{\varepsilon=0}A\beta\sigma\alpha^L < 0. \tag{24}$$

Since H-entrepreneurs have a net debt in the aggregate, and debts repayment does not change by this shock, the net worth share of H-entrepreneurs decreases at date τ. Because the adjustment of the real interest rate does not work well in region 1, their borrowing constraint becomes tightened. As a result, the investment function of H-entrepreneurs is shifted to the left as in Figure 2, and they are forced to cut back on their investment. Moreover, these balance sheet effects cause more resources to flow to L-entrepreneurs. What is called "flight to quality" occurs. Through these effects, less capital is produced at date $\tau+1$, so that economic growth rate at date $\tau+1$ jumps down from the steady state growth rate. Note that when we call the "investment function" and the "saving function" in Figure 2, it implies the aggregate investment of H-entrepreneurs and the aggregate savings as a share against the aggregate savings.

Now, we are in a position to examine whether financial development accelerates or dampens these financial amplification effects.

First, let's check region 1. By differentiating (24) with respect to θ, we obtain

$$\frac{\partial^2 g_{\tau+1}}{\partial\theta\partial\varepsilon}|_{\varepsilon=0} = \underbrace{\frac{\partial}{\partial\theta}\left(\frac{\alpha^H-\alpha^L}{\alpha^L-\theta\alpha^H}\right)}_{\oplus}\underbrace{\frac{\partial s_\tau}{\partial\varepsilon}|_{\varepsilon=0}}_{\ominus}A\beta\sigma\alpha^L + \left(\frac{\alpha^H-\alpha^L}{\alpha^L-\theta\alpha^H}\right)\underbrace{\frac{\partial^2 s_\tau}{\partial\theta\partial\varepsilon}|_{\varepsilon=0}}_{\ominus}A\beta\sigma\alpha^L < 0. \tag{25}$$

The first term represents the sensitivity of the H-entrepreneurs' investment response to a change in the net worth share. Since it becomes higher with θ, with even a small decline in the net worth share, H-entrepreneurs are forced to reduce their investment substantially. The second term represents the degree of a decline in the net worth share. It says that the decline by itself becomes larger with θ (See Appendix 2). This implies that when θ is high, the leverage and debt/asset ratios of H-entrepreneurs also rise. In such a situation, even a small negative productivity shock can cause a large decline in the net worth share. Taken together, H-entrepreneurs have to make deeper cuts in their investment. Moreover, this causes a substantial credit shift from H-entrepreneurs to L-entrepreneurs. That is, balance sheet effects and flight to quality are significant. Hence, in region 1, financial development accelerates financial amplification effects, thereby leading to increased volatility.

Once the economy enters region 2, the situation changes dramatically. The shock absorbing effects start operating through the adjustment of the real interest rate. This weakens the balance sheet effects, and prevents flight to quality. In order to clarify this point, let's look at how the real interest rate responds to this shock. The equilibrium in the credit market at date τ becomes

$$\frac{s_\tau}{1 - \dfrac{q^e_{\tau+1}\theta\alpha^H}{r_\tau}} = 1. \tag{26}$$

The left hand side and the right hand side of (26) are the investment function and the saving function, respectively. From (26), the real interest rate is determined once s_τ is given. Remember that since the productivity shock is temporary, expected relative price of capital to consumption goods, $q^e_{\tau+1}$, becomes $q = \sigma A$.

Next, let's look at how the net worth share of H-entrepreneurs changes by this shock. The net worth share at date τ follows

$$s_\tau = \frac{p(1-\theta-\varepsilon) + X(1-p)\theta}{1-\varepsilon}. \tag{27}$$

And so, by using (26) and (27), we obtain an expression for the equilibrium interest rate at date τ:

$$r_\tau = \frac{\sigma A\theta\alpha^H(1-\varepsilon)}{(1-p)(1-\varepsilon) + [p - X(1-p)]\,\theta}. \tag{28}$$

From (28), we observe that the real interest rate declines at the time of a negative productivity shock. Intuitively, following the shock, the borrowing constraint becomes tightened as in region 1. And then, the investment function is shifted to the left. However, in region 2, together with this shift, the real interest rate goes down in the credit market as in Figure 3. This decline in the real interest rate in turn relaxes the borrowing constraint, thereby weakening the balance sheet effects and preventing flight to quality. As a result, financial amplification is dampened. This implies that once financial development passes a certain degree, the adjustment of the real interest rate recovers, so that the shock does not get amplified. Financial development leads to stability.

When financial development reaches region 3, even with the shock, the financial system can transfer enough purchasing power to those who have high productive investment from those who do not without the adjustment of the real interest rate (See Figure 4). Therefore, there is no financial amplification. The following proposition summarizes the results.

Proposition 2 *The relationship between financial development and financial amplification is nonlinear: financial amplification initially increases with financial development (in region 1) and later falls down (in region 2 and 3).*

This nonlinearity is also supported by empirical studies. Easterly et al. (2000) demonstrate that the relationship between financial development and growth volatility is nonlinear. While developed financial systems offer oppurtunities for stabilization, they may also imply higher leverage of firms and thus more risks and less stability.

Based on the above analysis, we might be able to explain why we observe two conflicting views. The traditional view might discuss region 2 or 3 where financial markets are well developed. On the other hand, the new view might discuss region 1 where financial development is not so high, and there are agency frictions to some degree in financial markets (See Figure 5). In this sense, the discrepancy between two views might arise from the difference in the degree of financial development[9].

Moreover, the model may have implications for asymmetric movements of business fluctuations. As Kocherlakota (2000) emphasizes, macroeconomics

[9] In this paper, we use an endogenous growth model to analyze volatility as in Aghion et al. (2007). However, the results of our papers do not change even if we extend the model without endogenous growth. One example is that each entrepreneur has investment technology for producing consumption goods by using capital and labor. The functional form of the technology takes cobb-douglas. In this type of the model, the economy does not grow in the steady state. We can derive the same results as in this paper. In this sense, our results are not specific to an endogenous growth setting.

looks for an asymmetric amplification and propagation mechanism that can turn small shocks to the economy into the business cycle fluctuations. Our model might deliver this. For example, if the economy is around θ_2, to positive productivity shocks, even though the borrowing constraint for H-entrepreneurs is binding, the economy will not respond upwardly because the interest rate will go up in the credit market. On the other hand, to negative productivity shocks, it will react downwardly because the interest rate does not adjust[10].

3 The Role of Monetary Policy

If the economy is in region 1, a regulator faces dilemma. If it tries to achieve higher economic growth by enhancing θ, which results in a rise in leverage, once negative productivity shocks hit the economy, then large downward amplification occurs. On the other hand, if it wants to achieve lower amplification by bringing down θ, economic growth also decreases because of a decline in leverage[11]. In this sense, there is a trade-off between higher economic growth and lower downward amplification (See Figure 6). Thus, the question we want to ask next is if the economy is in region 1, are there any policies to achieve both of them. In this section, we examine the role of monetary policy focusing on region 1, and discuss its welfare implications.

In order to study the role of monetary policy, we extend the model of the previous section, and get money into it. Then, the flow of funds constraints for the entrepreneurs and the workers, (5) and (7) can be rewritten as follows:

$$\text{for entrepreneurs, } \frac{m_t}{P_t} + c_t = q_t k_t - \frac{P_{t-1}}{P_t} i_{t-1} b_{t-1} + b_t + \frac{m_{t-1}}{P_t}, \quad (29)$$

$$\text{for workers, } \frac{m'_t}{P_t} + c'_t = w_t - \frac{P_{t-1}}{P_t} i_{t-1} b'_{t-1} + b'_t + \frac{m'_{t-1}}{P_t}, \quad (30)$$

[10] Here we consider small shocks. However, if we think about relatively large productivity shocks, business fluctuations may become asymmetric, even if the economy is far from θ_2. In the case with relatively large positive shocks, positive propagation occurs, but the degree of it is weakened because the adjustment of the interest rate works. However, to the negative shocks, because the adjustment does not work, the economy experiences large downward propagation.

[11] Financial regulations on loan to value ratio will affect θ directly.

where m_t and m'_t are the nominal money demand of the entrepreneurs and the workers, respectively. P_t is the price level at date t, and i_{t-1} is gross nominal interest rate at date $t-1$. We assume that debt contracts are nominal[12]. Then, the borrowing constraints become

$$\text{for entrepreneurs, } \frac{P_t}{P^e_{t+1}} i_t b_t \leq \theta q^e_{t+1} \alpha^i z_t, \quad \text{for workers, } \frac{P_t}{P^e_{t+1}} i_t b'_t \leq 0, \tag{31}$$

where P^e_{t+1} is the price level at date $t+1$ expected at date t.

In the monetary economy, all agents face cash-in-advance (CIA) constraint following Lucas and Stocky (1984):

$$\text{for entrepreneurs, } m_{t-1} \geq P_t c_t, \quad \text{for workers, } m'_{t-1} \geq P_t c'_t. \tag{32}$$

Each entrepreneur and worker holds money to consume. We consider the equilibria where CIA constraint for both agents binds.

The competitive equilibrium is defined as a set of prices $\{i_t, w_t, q_t, P_t\}_{t=0}^{\infty}$ and quantities $\left\{c_t, c'_t, b_t, b'_t, z_t, m_t, m'_t, C^H_t, C^L_t, C'_t, B^H_t, B^L_t, B'_t, Z^H_t, Z^L_t, K'_t, K_t, Y_t\right\}_{t=0}^{\infty}$ which satisfies the conditions that (i) each entrepreneur maximizes (1) subject to (29), (31), and (32), and each worker maximizes (6) subject to (30), (31), and (32), and each firm maximizes its profit, given the relative price of capital to consumption goods, the wage rate, and the externality. (ii) The markets for goods, labor, capital, credit, and money all clear. Since there is no aggregate uncertainty, all agents have perfect foresight about future prices and quantities in equilibrium. That is, $P^e_{t+1} = P_{t+1}$ and $q^e_{t+1} = q_{t+1}$ hold.

Since we focus on binding CIA constraint, and the utility function is log, then we have $m_t = P_t(1-\beta)(q_t k_t - r_{t-1} b_{t-1})$, and $m'_t = P_t w_t$. That is, each entrepreneur uses a fraction $(1-\beta)$ of the net worth to buy money. Each worker uses all income to buy money. When we aggregate across all agents, we obtain the aggregate money demand at date t, M^D_t:

$$M^D_t = P_t(1-\sigma\beta)Y_t. \tag{33}$$

(33) implies that when aggregate output declines, the aggregate demand for money also decreases.

[12] Iacoviello (2006) points out that in almost all the low inflation countries, debt contracts are nominal.

Government budget constraint is

$$P_tG_t = M_t - M_{t-1}. \tag{34}$$

where G_t and M_t are the government (consolidated government) expenditure and the money supply at date t, respectively. The government finances expenditure by printing money. We assume that the government expenditure does not affect utility of the agents.

Monetary policy rule is

$$M_t = \mu M_{t-1}, \tag{35}$$

where μ is gross money growth rate. The monetary authority keeps the money growth rate constant.

Money market clearing condition is

$$M_t = M_t^D. \tag{36}$$

The dynamic evolution of the economy is characterized by the recursive equilibrium: $(w_t, K_{t+1}, Y_{t+1}, g_{t+1}, s_{t+1}, G_t)$ that satisfies (10), (13), (17), (18), (20), (33), (34), and (36) as functions of the state variables, (K_t, Y_t, s_t) and monetary policy rule, (35).

In order to understand the dynamics in the monetary economy, we consider the same experiment as in section 2. At date τ, there is an unexpected negative shock to productivity by ε. Following the shock, if other things were kept constant, the net worth share of H-entrepreneurs would decrease. Then, the investment function would be shifted to the left through the balance sheet effects, which would cause flight to quality (See Figure 7). However, in the monetary economy, this does not happen in equilibrium. There is an additional feedback effect to the credit market, which is not generated in the nonmonetary economy. In order to make this point clear, let's look at the money market equilibrium at date τ:

$$M_\tau = P_\tau(1-\sigma\beta)(1-\varepsilon)Y_\tau^e, \tag{37}$$

where Y_τ^e is the aggregate output at date τ expected at date $\tau-1$. Given the negative shock of size ε, the aggregate output declines by ε. Together with this decline, since the net worth of all entrepreneurs and the wage rate of the workers decrease, the aggregate money demand also falls down. Then, from (37), for the money market to clear, the price level goes up. That is, an unexpected higher inflation occurs at date τ. This unexpected rise in the price level in turn reduces the real burden of debts repayment for borrowers (H-entrepreneurs at date $\tau - 1$) by ε, which produces a shift-back effect as in Figure 7. Consequently, in equilibrium, the net worth share of H-entrepreneurs at date τ, s_τ is unchanged, which implies that the aggregate net worth of H-entrepreneurs and the aggregate net worth of all entrepreneurs fall in the same proportion. As a result, no financial amplification occurs as if the economy were in region 2 or 3. We summarize this in proposition[13].

Proposition 3 *In the case of an unexpected productivity shock within region 1 of the monetary economy (low-development region), the money growth targeting policy dampens financial amplification by generating the shock absorbing effects.*

Proof: By using the money market clearing condition, the real debts repayment at date τ can be rewritten as follows: $i_{\tau-1}b_{\tau-1}P_{\tau-1}/P_\tau = (1-\varepsilon)i_{\tau-1}b_{\tau-1}P_{\tau-1}/P_\tau^e$, where P_τ^e is the price level at date τ expected at date $\tau - 1$. By putting this into (19), and then solving s_τ, we see that the net worth share at date τ remain unchanged.

4 Discussion: Welfare Implications

Although the money growth targeting policy weakens the financial amplification effects, does this policy improve welfare of each agent? In the final part of this paper, we discuss welfare implications. In order to do so, it is interesting to compare two policies, money growth targeting and inflation targeting, denoted by MG and IT, respectively.

Under IT, since the monetary authority tries to keep the inflation rate of each period the same as the one in the steady state, it decreases the money growth rate accommodatively with the fall in the aggregate money demand at the time of the shock (at date τ). Consequently, the unexpected higher

[13] Nominal contracts also play an important role to produce shock absorbing effects. If the contracts are index, the effects are not generated. This point is different from the existing view that nominal contracts magnify the shocks. Hirano (2007) shows that which types of contracts would be better to dampen amplification depends upon the source of the shocks. In the case of money demand shocks, index contracts dampen amplification while nominal contracts magnify it.

inflation does not occur, and therefore, the real burden of debt is unchanged. As a result, the shift-back effect is not generated. The shock is exacerbated through the balance sheet effects and flight to quality.

Now, let's compare welfare of each agent. Let $V_t^{MG}, V_t^{IT}, V_t^{\prime MG}, V_t^{\prime IT}$ be welfare of an entrepreneur and a worker under the MG and IT policies. Similarly, let $c_t^{i,MG}, c_t^{\prime,MG}, c_t^{i,IT}, c_t^{\prime,IT}, w_t^{MG}, w_t^{IT}, e_t^{i,MG}, e_t^{i,IT}$, and π_t^{MG}, π_t^{IT} be consumption of the entrepreneurs and workers, the wage rate, the net worth of the entrepreneurs, and the inflation rate at date t, where $\pi_t \equiv P_{t-1}/P_t$.

For the worker, the welfare becomes

$$V^{\prime MG} = \sum_{n=0}^{\infty} \beta^n \log c_{\tau+n}^{\prime,MG} = \sum_{n=0}^{\infty} \beta^n \log \left(\frac{w_{\tau+n-1}^{MG}}{\pi_{\tau+n}^{MG}} \right), \tag{38}$$

$$V^{\prime IT} = \sum_{n=0}^{\infty} \beta^n \log c_{\tau+n}^{\prime,IT} = \sum_{n=0}^{\infty} \beta^n \log \left(\frac{w_{\tau+n-1}^{IT}}{\pi_{\tau+n}^{IT}} \right). \tag{39}$$

The welfare depends upon the inflation rate and the wage rate at date τ and thereafter. By subtracting (39) from (38), we obtain

$$V^{MG} - V^{IT} = \underbrace{\log \left(\frac{\pi_\tau^{IT}}{\pi_\tau^{MG}} \right)}_{\ominus} + \underbrace{\sum_{n=1}^{\infty} \beta^{n+1} \log \left(\frac{w_{\tau+n}^{MG}}{w_{\tau+n}^{IT}} \right)}_{\oplus}. \tag{40}$$

From (40), we can understand whether or not the MG policy improves welfare of the worker compared to the IT policy. The first term of (40) represents the difference in the inflation rate at date τ under the two policies. Under the MG policy, following the shock, the higher inflation occurs unexpectedly at date τ. That is, we have $\pi_\tau^{MG} > \pi_\tau^{IT}$. This reduces the purchasing power of money, so that the worker's consumption at date τ decreases. Thus, the first term is negative. Note that the inflation rate after $\tau + 1$ is the same under the two policies[14].

The second term represents the difference in the wage rate. Under the MG policy, because of the unexpected higher inflation, the redistribution of wealth occurs at date τ from L-entrepreneurs at date $\tau - 1$, who are lenders, to H-entrepreneurs at date $\tau - 1$, who are borrowers (note that $p > X(1-p)$). This increases the aggregate net worth of H-entrepreneurs at

[14] Under the MG policy, since no financial amplification occurs, the inflation rate after date $\tau + 1$ equals to the one in the steady state.

date τ. Consequently, the borrowing constraint of H-entrepreneurs at date τ becomes relaxed, so that more capital is going to be produced at date $\tau+1$ and thereafter, which pushes up the wage rate after date $\tau+1$, $w_{\tau+n}^{MG} > w_{\tau+n}^{IT}$ $(n \geq 1)$. Thus, the second term is positive. Note that the wage rate at date τ is the same, $w_{\tau}^{MG} = w_{\tau}^{IT}$. Hence, whether or not the MG policy improves the worker's welfare compared to the IT policy depends upon the above two effects. If A is high or σ is low, there is a large positive spillover effect on the wage rate. Then, the positive effect might become larger than the negative effect.

Similarly, for the entrepreneur, we obtain

$$V^{MG} - V^{IT} = \underbrace{\log\left(\frac{\pi_{\tau}^{IT}}{\pi_{\tau}^{MG}}\right)}_{\ominus} + \underbrace{\sum_{n=0}^{\infty}\beta^{n+1}\log\left(\frac{e_{\tau+n}^{i,MG}}{e_{\tau+n}^{i,IT}}\right)}_{\substack{\oplus \text{ for H-entrepreneurs at date } \tau-1. \\ \ominus \text{ for L-entrepreneurs at date } \tau-1.}}. \tag{41}$$

The first term is the same as the worker. The second term represents the difference in the net worth under the two policies. Under the MG policy, for the entrepreneurs who had high productive investment at date $\tau-1$, who are borrowers, they gain at date τ, $e_{\tau}^{H,MG} > e_{\tau}^{H,IT}$ because the real burden of debts repayment is reduced. Therefore, their net worth after $\tau+1$ will also increase, $e_{\tau+n}^{H,MG} > e_{\tau+n}^{H,IT}$ $(n \geq 1)$. For them, if the positive effect becomes larger than the negative effect (the first term), their welfare improves under the MG policy. On the other hand, for the entrepreneurs who had low productive investment at date $\tau-1$, who are lenders, they lose at date τ, $e_{\tau}^{L,MG} < e_{\tau}^{L,IT}$. Therefore, their net worth after $\tau+1$ will also decrease, $e_{\tau+n}^{L,MG} < e_{\tau+n}^{L,IT}$ $(n \geq 1)$. For them, the MG policy impairs their welfare. Hence, since our model has heterogeneity among agents, the welfare impacts of a particular monetary policy rule are also heterogeneous between the agents[15][16].

[15] Woodford (2003) discusses optimal monetary policy with a single agent model.

[16] In stead of monetary policy, we can think of a tax cut policy. For example, suppose that the government imposes tax on the entrepreneur's net worth. Imagine that the economy experiences an unexpected negative productivity shock at date τ as in section 2. Under laisser-fair economy, since the net worth of all entrepreneurs at date τ decreases by this shock, downward amplification occurs. However, if the government conducts a tax

5 Concluding Remarks

In this paper, we propose a theoretical model in order to examine the relationship between the development of financial markets and financial amplification. By so doing, this paper takes a small step toward reconciling two conflicting views about the relationship. We find that financial development initially accelerates financial amplification and later weakens it. This implies that financial development first leads to increased instability of the economy, however once the level of financial development passes a certain degree, it leads to stability. This nonlinearity might help us unify classical and new views in a single model. The traditional view might discuss region 2 or 3 where financial markets are well developed. On the other hand, the new view might discuss region 1 where the financial system is not so developed, and there are agency frictions to some degree in financial markets. In this sense, the discrepancy between two views might arise from the difference in the degree of financial development.

Moreover, we study the role of monetary policy to dampen downward amplification, and discuss its welfare implications. We find that in the case of unexpected productivity shocks within the low-development region, the money growth targeting policy weakens financial amplification compared to the inflation targeting policy. However, the welfare impacts of the policy are heterogeneous between the agents.

As future research, the next step would be that we want to develop quantitative assessment into the relationship between the development of financial markets and volatility of the economy. Another step would be to consider the welfare cost of volatility in a heterogeneous agents model with aggregate uncertainty. These directions will be promising.

cut policy at date τ (at the same time of the shock), then the entrepreneurs' net worth increases at date τ. As a result, downward amplification is dampened. The economy is insulated from the negative shock. Moreover, this policy improves all the entrepreneurs' welfare because their consumption increases at date τ and thereafter.

Appendix 1

In order to verify that (14) holds in equilibrium, we only need to check that L-entrepreneurs invest positive amounts of goods, and produce capital:

$$Z_t^L = \beta\sigma Y_t \left(1 - \frac{s_t}{1 - \dfrac{\theta\alpha^H}{\alpha^L}} \right). \tag{42}$$

Using (20), we find that (42) becomes positive in the neighborhood of the steady state if, and only if θ is lower than θ_1.

Moreover, from (22), if $\theta < 1/(1+X)$, then $r^* < \sigma A\alpha^H$. That is, the real interest rate is lower than the marginal productivity of H-entrepreneurs' investment. Thus, the borrowing constraint for H-entrepreneurs binds. For L-entrepreneurs, since the real interest rate is greater than the rate of return on their investment, they would prefer lending to investing by themselves.

We also see that if $\theta = 1/(1+X)$, then $r^* = \sigma A\alpha^H$. Thus, the borrowing constraint for H-entrepreneurs no longer binds. Furthermore, If θ is greater than $1/(1+X)$, then for the credit market to clear, the real interest rate has to equal $\sigma A\alpha^H$ (If the real interest rate is greater than $\sigma A\alpha^H$, nobody is willing to borrow in the credit markets. This can not be an equilibrium.).

Appendix 2

By using (19), we obtain

$$\frac{\partial s_\tau}{\partial \epsilon}|_{\varepsilon=0} = [p - X(1-p)] \frac{-\theta\alpha^H s^*}{\alpha^L - \theta\alpha^H + (\alpha^H - \alpha^L)s^*} < 0. \tag{43}$$

And then, by using (43), we have

$$\frac{\partial^2 s_\tau}{\partial\theta\partial\epsilon}|_{\varepsilon=0} = [p - X(1-p)]\,\alpha^H \frac{-\theta\dfrac{\partial s^*}{\partial\theta}(\alpha^L - \theta\alpha^H) - \alpha^L s^* - (\alpha^H - \alpha^L)s^{*2}}{[\alpha^L - \theta\alpha^H + (\alpha^H - \alpha^L)s^*]^2} < 0. \tag{44}$$

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Figure 1.1

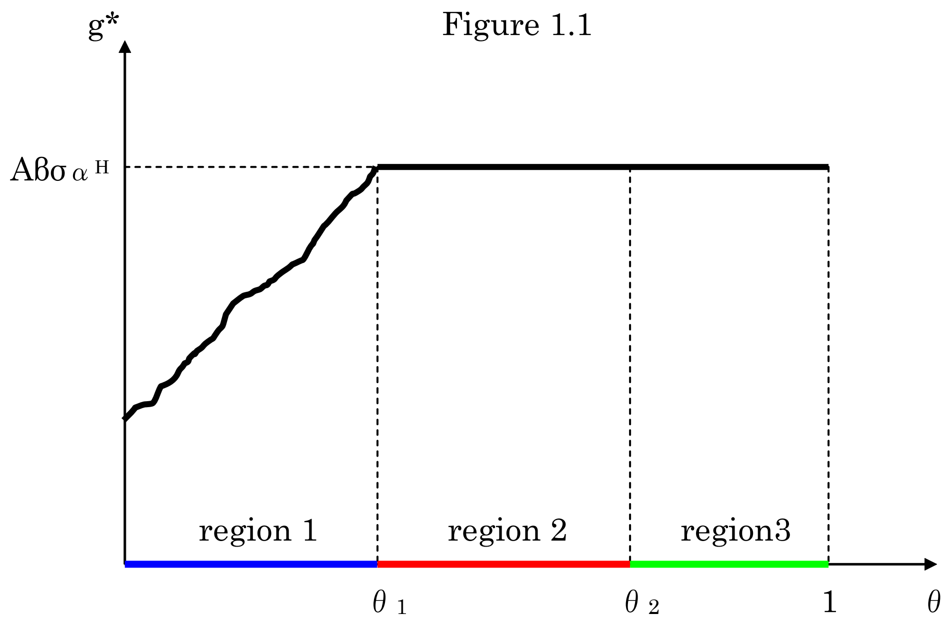
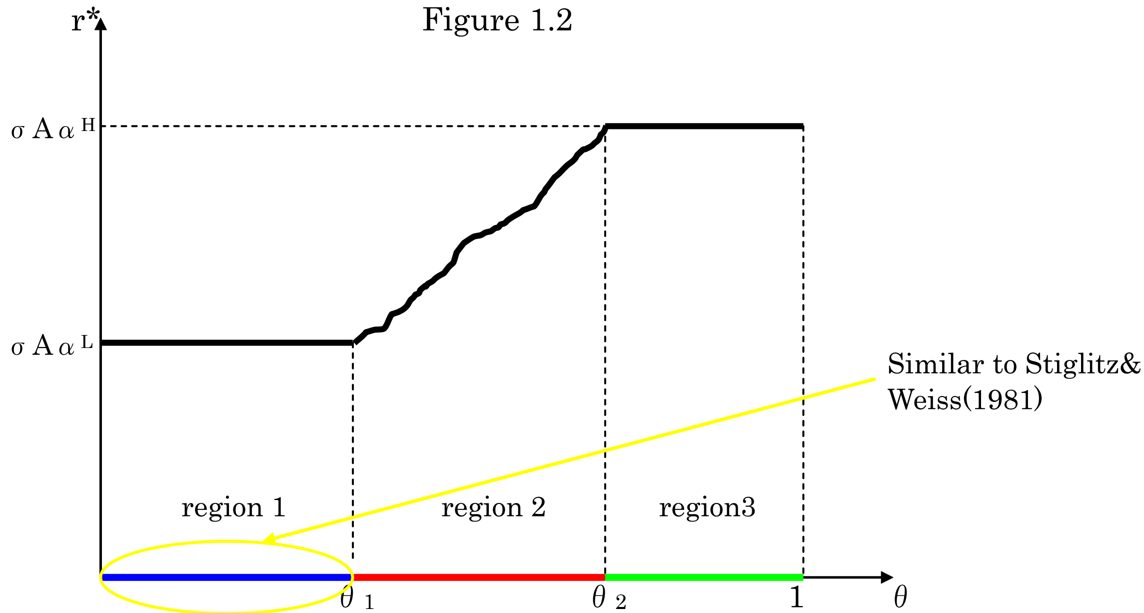
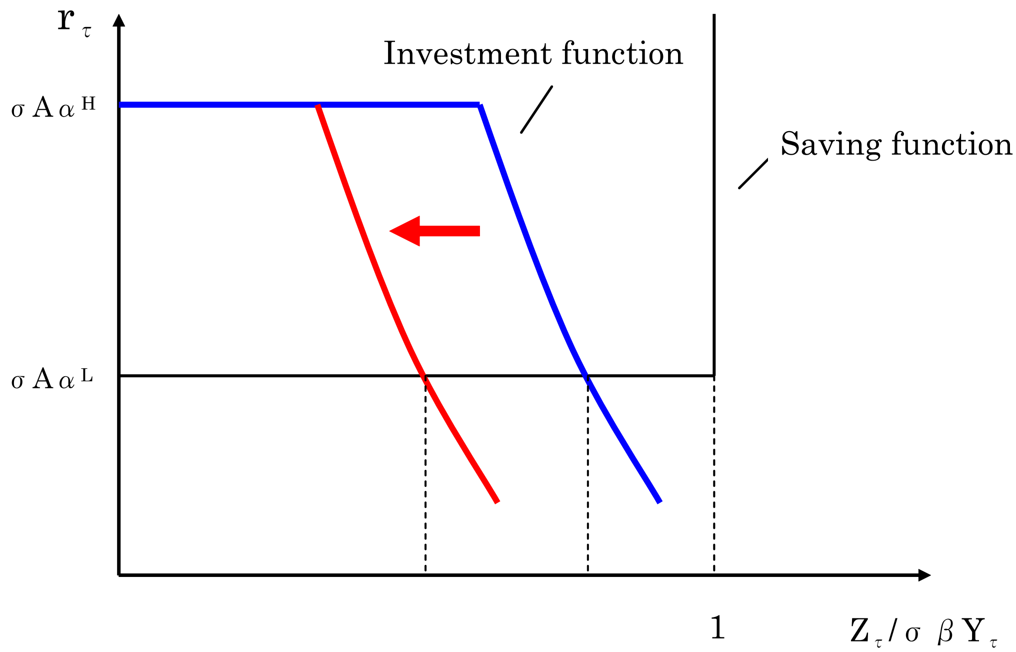


Figure 1.2



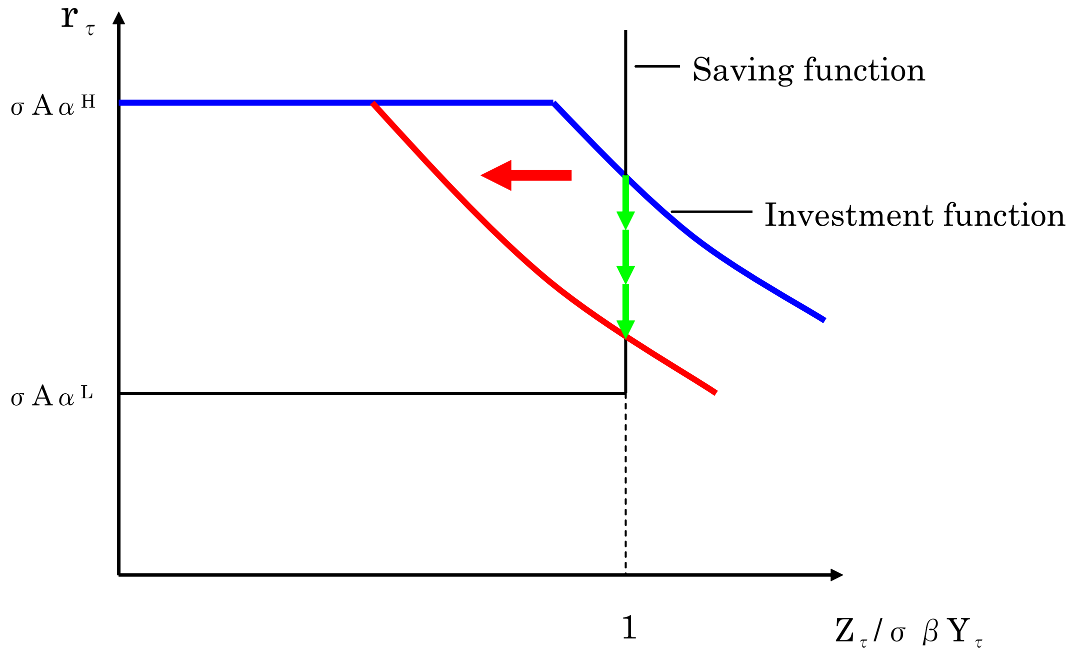
r*
σ A α H
σ A α L
Similar to Stiglitz&
Weiss(1981)
region 1
region 2
region3
θ 1
θ 2
1
θ

Figure 2



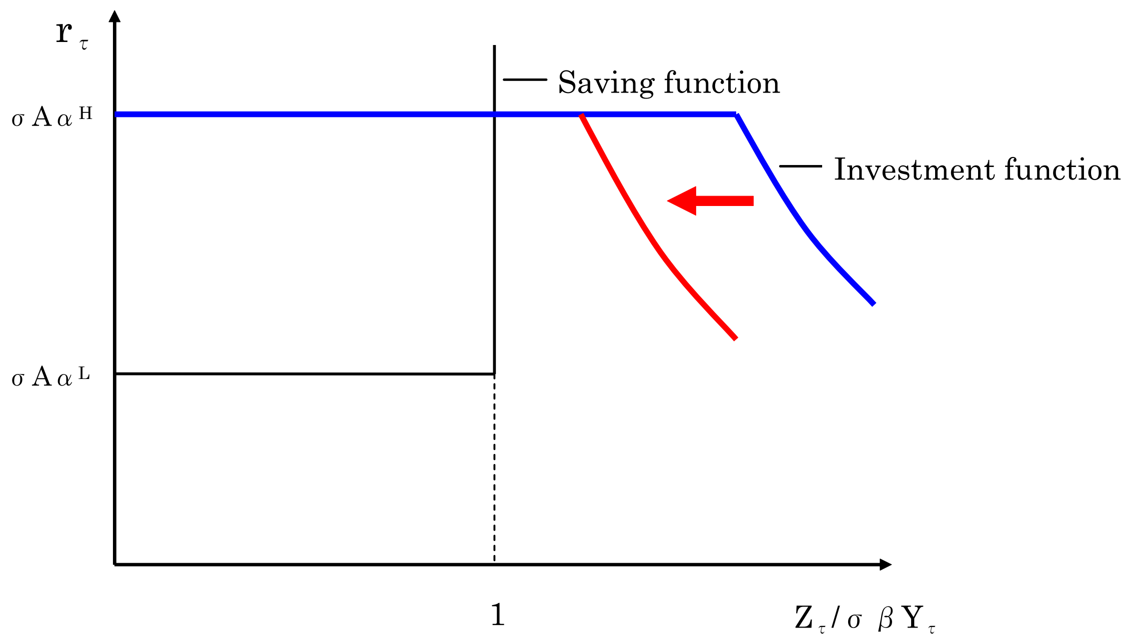
r_τ
$\sigma A \alpha^H$
Investment function
Saving function
$\sigma A \alpha^L$
1
$Z_\tau / \sigma\ \beta Y_\tau$

Figure 3



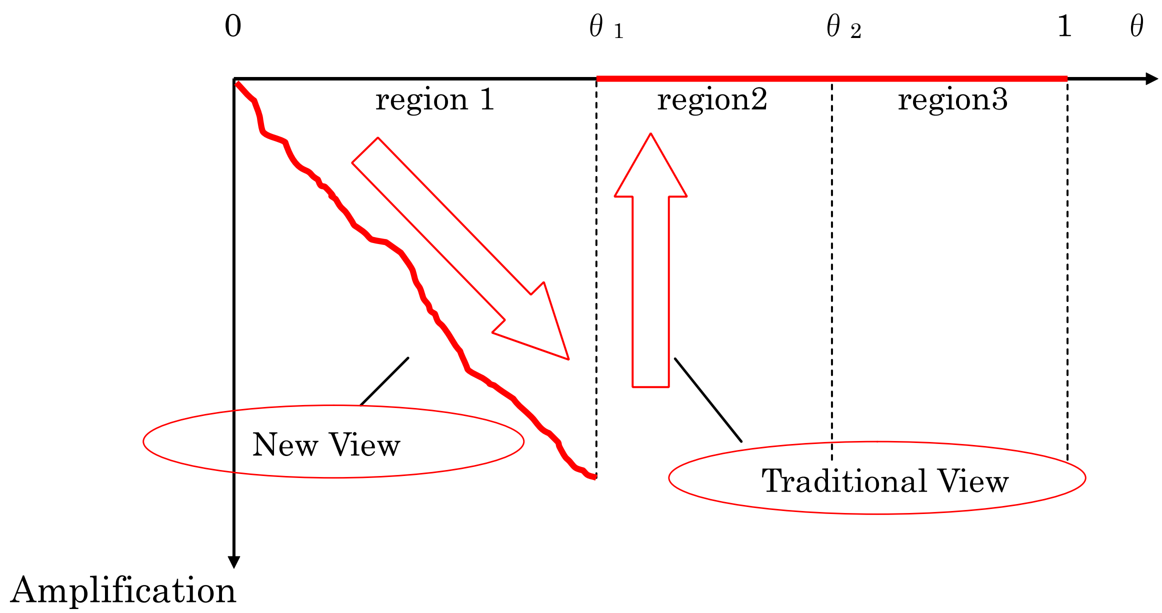
r_τ
$\sigma A \alpha^H$
Saving function
Investment function
$\sigma A \alpha^L$
1
$Z_\tau / \sigma \beta Y_\tau$

Figure 4



r_τ
Saving function
$\sigma A \alpha^H$
Investment function
$\sigma A \alpha^L$
1
$Z_\tau / \sigma \beta Y_\tau$

Figure 5



0
θ 1
θ 2
1
θ
region 1
region2
region3
New View
Traditional View
Amplification

Figure 6

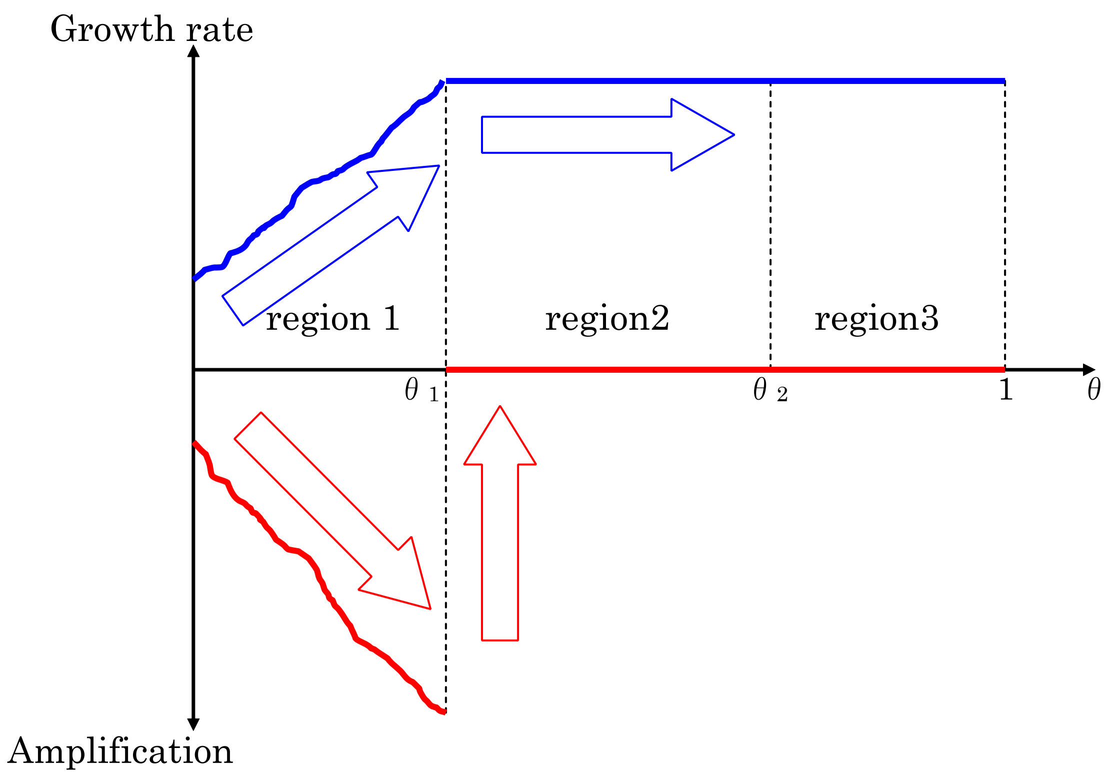
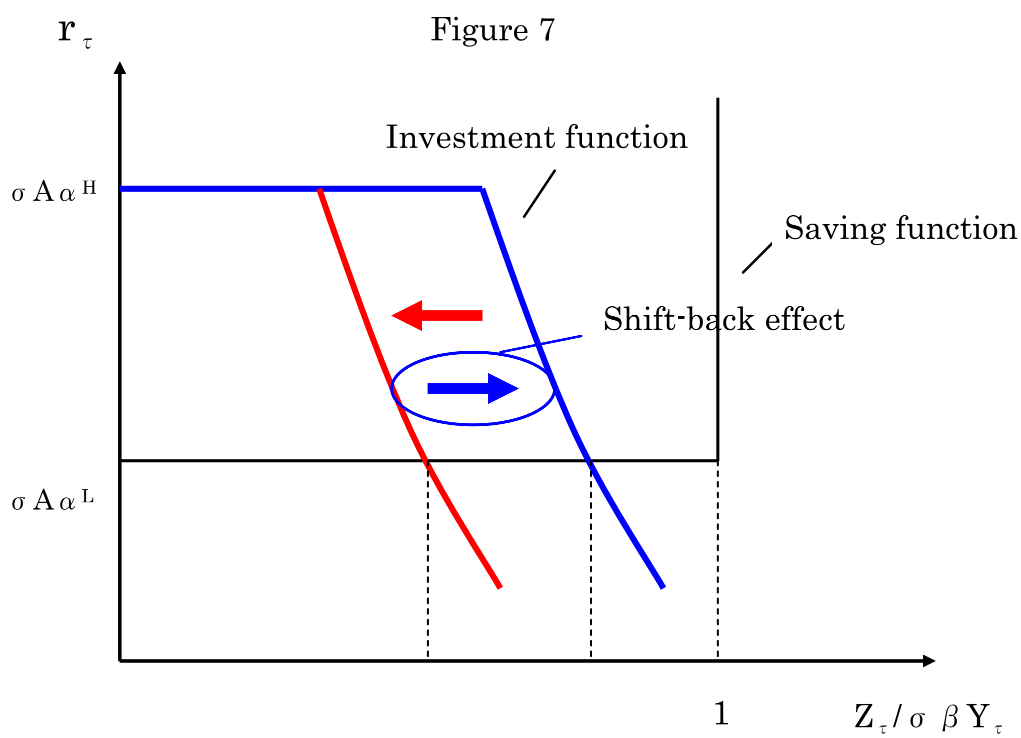

Growth rate
region 1
region2
region3
θ_1
θ_2
1
θ
Amplification

Figure 7



r_τ
Investment function
$\sigma A \alpha^H$
Saving function
Shift-back effect
$\sigma A \alpha^L$
1
$Z_\tau / \sigma \beta Y_\tau$