Financial Innovation and Volatility

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Abstract

Does financial innovation stabilize or destabilize the economy? Traditional view about the relationship between the development of financial markets and volatility of the economy is that financial innovation stabilizes the economy. However, after the recent financial crisis of 2007-08, a new perspective has emerged: financial innovation 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 innovation and volatility of the economy is nonlinear: financial innovation first increases instability and then leads to stability.

1 Introduction

Does financial innovation stabilize or destabilize the economy? Traditional wisdom suggests that financial innovation stabilizes the economy by provid-

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ing 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. However, the situation has begun to change dramatically since the credit crisis of 2007-08. A new perspective has emerged: financial innovation 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 started to state that it is the high leverage caused by financial innovation that could lead to significant damages in borrowers' balance sheet, and eventually in the financial system as a whole. Financial innovation is suddenly blamed for increasing volatility[2].

Thus, the question that naturally arises is why do we observe such seemingly conflicting views? Does financial innovation 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 innovation. 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* which magnify shocks. The latter describes *shock cushioning effects*[3]. Both effects are affected by financial innovation. By changing the *degree* of the borrowing constraint, which is defined as financial innovation, this paper shows that financial innovation 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 innovation magnifies or dampens financial amplification. Moreover, the balance by itself changes according to the *degree* of financial innovation.

Our main result shows that in a low-development region, *shock cushion-*

[1]Levine(1997) and Beck et al. (2000) show empirically that financial development causes long run economic growth. Empirical studies such as Cecchetti et al. (2006), Dynan et al. (2006), and Jerman and Quadrini (2008) support the positive role of financial innovation in reducing volatility.

[2]Indeed, IMF (2006, 2008) supports this new view by showing empirical evidences that in more-advanced financial systems, the shock propagation effects become stronger.

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

ing effects do not work well, but *balance sheet effects* get strengthened with financial innovation, 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 financial innovation and volatility of the economy is nonlinear: financial innovation initially increases instability and later leads to stability.

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 macroeconomic researchers put financial factors a central role in accounting for business fluctuations (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[4]. 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.

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 innovation and financial amplification. In section 3, we discuss policy implications. Section 4 presents the conclusion.

2 The Model

Consider a discrete-time economy with one homogenous goods and a continum of entrepreneurs. 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.

[4]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.

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

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

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. y_{t+1} is output 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.

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

$$r_t b_t \le \theta \alpha^i z_t, \tag{4}$$

where r_t and b_t are the gross real interest rate, and the amount of borrowing at date t, respectively. 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 innovation. In this paper, we define an increase in θ as a financial innovation.

The entrepreneur's flow of funds constraint is given by

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

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, output, and borrowing $\{c_t, z_t, y_{t+1}, b_t\}$ to maximize the expected discounted utility (1) subject to (2), (4), and (5).

Let us denote aggregate consumption of H-entrepreneurs and L-entrepreneurs at date t as C_t^H and C_t^L. Similarly, let Z_t^H, Z_t^L, B_t^H, and B_t^L be aggregate investment, and the amount of borrowing of each type. Then, the market clearing for goods, and credit are

$$C_t^H + C_t^L + Z_t^H + Z_t^L = Y_t, \tag{6}$$

$$B_t^H + B_t^L = 0, \tag{7}$$

where Y_t is the aggregate output at date t.

2.1 Equilibrium

The competitive equilibrium is defined as a set of prices $\{r_t\}_{t=0}^{\infty}$ and quantities $\left\{c_t, b_t, z_t, y_t, C_t^H, C_t^L, B_t^H, B_t^L, Z_t^H, Z_t^L, Y_t\right\}_{t=0}^{\infty}$ which satisfies the conditions that (i) each entrepreneur maximizes utility, and (ii) the market for goods, and credit 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 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, as we will show later, 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

$$r_t = \alpha^L. \tag{8}$$

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 their net worth, $c_t = (1-\beta)(y_t - r_{t-1}b_{t-1})$. Then, by using (4), and (5), the investment function of H-entrepreneurs becomes

$$z_t = \frac{\beta(y_t - r_{t-1}b_{t-1})}{1 - \dfrac{\theta\alpha^H}{r_t}}. \tag{9}$$

The numerator of (9) is the required down payment for unit investment. From (9), we see that the investment equals the leverage, $1/\left[1-(\theta\alpha^H/r_t)\right]$ times savings, $\beta(y_t - r_{t-1}b_{t-1})$. 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.

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, (6).

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 output:

$$\begin{aligned} Y_{t+1} &= Y_{t+1}^H + Y_{t+1}^L = \alpha^H \frac{\beta E_t^H}{1-\dfrac{\theta\alpha^H}{r_t}} + \alpha^L \left(\beta Y_t - \frac{\beta E_t^H}{1-\dfrac{\theta\alpha^H}{r_t}} \right) \\ &= \left[1 + \left(\frac{\alpha^H - \alpha^L}{\alpha^L - \theta\alpha^H} \right) s_t \right] \beta\alpha^L Y_t, \end{aligned} \tag{10}$$

where Y_{t+1}^H and Y_{t+1}^L are the aggregate output by H-and L-entrepreneurs at date $t+1$, respectively. E_t^H is the aggregate net worth of H-entrepreneurs, and $s_t \equiv E_t^H/Y_t$ is the net worth share of H-entrepreneurs against the aggregate output. From (10), economic growth rate becomes

$$g_{t+1} \equiv \frac{Y_{t+1}}{Y_t} = \left[1 + \left(\frac{\alpha^H - \alpha^L}{\alpha^L - \theta\alpha^H}\right) s_t\right] \beta\alpha^L. \tag{11}$$

From (11), once s_t is determined, economic growth rate is also determined. (11) implies that economic growth rate increases with financial innovation. Intuitively, when financial innovation improves, the borrowing constraint of H-entrepreneurs becomes relaxed. As a result, in the credit market, more resources flow from L-entrepreneurs to H-entrepreneurs, which promotes economic growth.

Aggregate TFP at date t is defined as follows:

$$\mathrm{TFP_t} = \frac{Y_{t+1}}{Z_t^H + Z_t^L} = \left[1 + \left(\frac{\alpha^H - \alpha^L}{\alpha^L - \theta\alpha^H}\right) s_t\right] \alpha^L. \tag{12}$$

By using (11), and (12), economic growth rate is rewritten as

$$g_{t+1} = \beta\mathrm{TFP_t}. \tag{13}$$

From (13), we see that economic fluctuations are caused by the changes in the aggregate TFP. In this sense, our model seems to be simillar to standard real business cycle model. However, in the present model, the aggregate TFP changes and is endogenously determined depending on credit allocations between H-and L-entrepreneurs, which in turn depends on the level of financial innovation.

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

$$E_t^H = p(Y_t^H - r_{t-1}B_{t-1}^H) + X(1-p)(Y_t^L - r_{t-1}B_{t-1}^L). \tag{14}$$

The first term of (14) 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 (10) and (14), we can derive the law of motion of the net worth share of H-entrepreneurs:

$$s_{t+1} = \frac{p\dfrac{\alpha^H(1-\theta)}{\alpha^L - \theta\alpha^H} s_t + X(1-p)(1-s_t)}{1 + \dfrac{\alpha^H - \alpha^L}{\alpha^L - \theta\alpha^H} s_t} \equiv \Phi(s_t, \theta). \tag{15}$$

The dynamic evolution of the economy is characterized by the recursive equilibrium: $(Y_{t+1}, g_{t+1}, \mathrm{TFP_t}, s_{t+1},)$ that satisfies (10), (11), (12), (13), and (15) as functions of the state variables (Y_t, s_t).

2.2 Steady State Equilibrium

The stationary equilibrium of this economy depends upon the degree of financial innovation. 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 innovation, 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 invest. The steady state values of g^*, TFP^*, s^*, and r^* satisfy

$$g^* = \beta TFP^*, \; TFP^* = \left[1 + \left(\frac{\alpha^H - \alpha^L}{\alpha^L - \theta\alpha^H}\right) s^*\right] \alpha^L, \; s^* = \Phi(s^*, \theta), \; r^* = \alpha^L. \tag{16}$$

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

$$\begin{aligned} g^* &= \beta TFP^*, \; TFP^* = \alpha^H, \; s^* = p(1-\theta) + X(1-p)\theta, \\ r^* &= \frac{\alpha^H}{(1-p)/\theta + p - X(1-p)}. \end{aligned} \tag{17}$$

(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 invest. The steady state values satisfy

$$g^* = \beta TFP^*, \; TFP^* = \alpha^H, \; s^* = \frac{X}{1+X}, \; r^* = \alpha^H. \tag{18}$$

In region 1 where financial innovation 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 innovation 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 increase the aggregate TFP, so that economic growth gets promoted (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 innovation is low, the real interest rate is sticky and is not determined by demand and supply curves in the credit market (See Figure 1.2).

In region 2 where financial innovation is high, but not so high, the situation changes. As financial innovation develops, 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 invest. In the credit market, although the borrowing constraint is still binding for H-entrepreneurs, all the savings are allocated to them, so that the aggregate TFP and the growth rate of the economy become 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 innovation grows 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. 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: both H-and L-entrepreneurs find that the returns from their investment at date τ are $(1-\varepsilon)$ times their expectations. However, the shock is known to be temporary. The productivity at date $\tau+1$ and thereafter returns to the normal level as in (2). Here since we consider a negative 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 (10), (11), and (14), we obtain

$$\text{Amplification} \equiv \frac{dg_{\tau+1}}{d\varepsilon}|_{\varepsilon=0} = \left(\frac{\alpha^H-\alpha^L}{\alpha^L-\theta\alpha^H}\right)\frac{ds_\tau}{d\varepsilon}|_{\varepsilon=0}\beta\alpha^L < 0. \tag{19}$$

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, the aggregate TFP declines, so that economic growth rate at date $\tau+1$ jumps down from the steady state growth rate. Note that when we call "investment function" and "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 innovation accelerates or dampens these financial propagation effects.

First, let's check region 1. By differentiating (19) with respect to θ, we obtain

$$\frac{\partial^2 g_{\tau+1}}{\partial\theta\partial\varepsilon}|_{\varepsilon=0} = \underbrace{\frac{\partial}{\partial\theta}\left(\frac{\alpha^H-\alpha^L}{\alpha^L-\theta\alpha^H}\right)}_{\oplus}\underbrace{\frac{\partial s_\tau}{\partial\varepsilon}}_{\ominus}|_{\varepsilon=0}\beta\alpha^L + \left(\frac{\alpha^H-\alpha^L}{\alpha^L-\theta\alpha^H}\right)\underbrace{\frac{\partial^2 s_\tau}{\partial\theta\partial\varepsilon}}_{\ominus}|_{\varepsilon=0}\beta\alpha^L < 0. \tag{20}$$

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, making the aggregate TFP decline to a large extent. That is, balance sheet effects and flight to quality are significant. Hence, in region 1, financial innovation accelerates the propagation 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

$$\frac{s_\tau}{1-\dfrac{\theta\alpha^H}{r_\tau}} = 1. \tag{21}$$

The left hand side and the right hand side of (21) are the investment function and the saving function, respectively. From (21), the real interest rate is determined once s_τ is given.

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

$$s_\tau = \frac{p(1-\theta-\varepsilon)+X(1-p)\theta}{1-\varepsilon}. \tag{22}$$

And so, by using (21) and (22), we obtain an expression for the equilibrium interest rate at date τ:

$$r_\tau = \frac{\theta\alpha^H(1-\varepsilon)}{(1-p)(1-\varepsilon)+\left[p-X(1-p)\right]\theta}. \tag{23}$$

From (23), 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 innovation passes a certain degree, the adjustment of the real interest rate recovers, so that the shock does not get amplified. Financial innovation leads to stability.

When financial innovation 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[5]. The following proposition summarizes the results.

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

This nonlinearity is also supported by empirical studies. Easterly et al. (2000) show empirically that financial innovation generally acts as a stabilizer and reduces growth volatility. But the relationship is nonlinear depending on the interaction between shock weakening effects and shock exacerbating effects.

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 innovation 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 innovation.

3 Policy Implications

Our model's implications may present a difficult problem for a regulator. If the economy is in region 1, there is a trade-off between economic growth

[5] When θ gets close to 1, the behavior of this economy becomes near to the one in the standard real business cycle model, although our model uses heterogeneous agents, not a representative agent.

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[6]. As a result, the leverage increases, and more funds flow from low to high productive investment through credit markets, thereby producing 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 gets lower. In this sense, higher economic growth and lower downward amplification—or in other words, improving efficiency and enhancing stability—do not go together (See Figure 6).

So, the question is if the economy is in region 1, how does government achieve both of them. Here let us discuss a tax policy[7]. 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. What should the government do in order to offset the negative effects on the economy? Think about a tax 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 productivity shock. Moreover, this policy improves all the entrepreneurs' welfare because their consumption increases at date τ and thereafter.

4 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

[6] 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

[7] Hirano (2009) analyzes the role of monetary policy to achieve both higher economic growth and lower downward amplification.

conflicting views about the relationship. We find that financial innovation initially accelerates financial amplification and later weakens it. This implies that financial innovation first leads to increased instability of the economy, however once the level of financial innovation 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 innovation.

Appendix 1

In order to verify that (8) holds in equilibrium, we only need to check that L-entrepreneurs invest positive amounts of goods, and produce capital:

$$Z_t^L = \beta Y_t \left(1 - \frac{s_t}{1 - \dfrac{\theta \alpha^H}{\alpha^L}} \right). \tag{24}$$

Using (15), we find that (24) becomes positive in the neighborhood of the steady state if, and only if θ is lower than θ_1.

Moreover, from (17), if $\theta < 1/(1+X)$, then $r^* < \alpha^H$. 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 $r^* = \alpha^H$. 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 α^H (If the real interest rate is greater than α^H, nobody is willing to borrow in the credit market. This can not be an equilibrium.).

Appendix 2

By using (14), we obtain

$$\frac{\partial s_\tau}{\partial \epsilon}|_{\varepsilon=0} = [p - X(1-p)] \frac{-\theta \alpha^H s^*}{\alpha^L - \theta \alpha^H + (\alpha^H - \alpha^L) s^*} < 0. \tag{25}$$

And then, by using (25), we have

$$\frac{\partial^2 s_\tau}{\partial \theta \partial \epsilon}|_{\varepsilon=0} = [p - X(1-p)] \, \alpha^H \frac{-\theta \dfrac{\partial s^*}{\partial \theta}(\alpha^L - \theta \alpha^H) - \alpha^L s^* - (\alpha^H - \alpha^L) s^{*2}}{[\alpha^L - \theta \alpha^H + (\alpha^H - \alpha^L) s^*]^2} < 0. \tag{26}$$

References

[1] Bernanke, B. and M. Gertler(1989), "Agency Costs, Net Worth, and Business Fluctuations," *American Economic Review*, 79, pp14–31.

[2] Bernanke, B., M. Gerlter, and S. Gilchrist(1996), "The Financial Accelerator and the Flight to Quality," *Review of Economics and Statistics*, 78, pp1-15.

[3] Bernanke, B., M. Gerlter, and S. Gilchrist(1999), "The Financial Accelerator in a Quantitative Business Cycle Framework," in J. Taylor and M. Woodford eds, *the Handbook of Macroeconomics*, pp1341-1393 (Amsterdam, North-Holland)

[4] Brunnermeier, M. and L. Pedersen, "Market Liquidity and Funding Liquidity," *Review of Financial Studies*, forthcoming.

[5] Ceccehtti, S., A. Flores-Lagunes, and S. Krause(2006), "Assessing the Sources of Changes in the Volatility of Real Growth," NBER Working Paper, 11946.

[6] Cordoba, J., and M. Ripoll(2004), "Credit Cycles Redux," *International Economic Review*, 45, pp1011-1046.

[7] Dynan, E., W. Elmendorf, E. Sichel(2006), "Can financial innovation help to explain the reduced volatility of economic activity?," *Journal of Monetary Economics*, 53, pp123-150.

[8] Easterly, W., R. Islam, and J. Stiglitz, "Shaken and Stirred: Explaining Growth Volatility," in B. Pleskovic and N. Stern eds, Annual Bank Conference on Development Economics. Washington, DC: World Bank, pp191-213.

[9] Hart, O. and J. Moore(1994), "A Theory of Debt Based on the Inalienability of Human Capital," *Quarterly Journal of Economics*, 109, pp841–879.

[10] Hirano, T(2009), "Financial Development and Amplification," mimeo.

[11] Holmstrom, B and J. Tirole(1997), "Financial Intermediation, Loanable Funds, and the Real Sector," *Quarterly Journal of Economics*, 112, pp663-91.

International Monetary Fund, (2006), *World Economic Outlook, Financial System and Economic Cycles* (Washington, September)

[12] International Monetary Fund, (2008), *World Economic Outlook, Financial Stress, Downturns, and Recoveries* (Washington, October)

[13] Jermann, U. and V. Quadrini(2008), "Financial Innovations and Macroeconomic Volatility," NBER Working Papers, 12308.

[14] Kiyotaki, N. and J. Moore(1997), "Credit Cycles," *Journal of Political Economy*, 105, pp211–248.

[15] Kiyotaki, N.(1998), "Credit and Business Cycles," *The Japanese Economic Review*, 49, pp18–35.

[16] King, R. and S. Rebelo(1993), "Transitional Dynamics and Economic Growth in the Neoclassical Model," *American Economic Review,* 83, pp908-31.

[17] Kocherlakota, N.(2000), "Creating Business Cycles Through Credit Constraints," *Quarterly Review*, Federal Reserve Bank of Minneapolis.

[18] Levine, R., "Financial Development and Economic Growth: Views and Agenda(1997)," *Journal of Economic Literature*, 35, pp688-726.

[19] Levine, R., N. Loyaza, and T. Beck(2000), "Financial Intermediation and Growth: Causality and Causes," *Journal of Monetary Economics,* 46, pp31-77.

[20] Matsuyama, K.(2007), "Credit Traps and Credit Cycles," *American Economic Review*, 97, pp503-516.

[21] Matsuyama, K. Aggregate Implications of Credit Market Imperfections, in D. Acemoglu, K. Rogoff, and M. Woodford, eds., *NBER Macroeconomics Annual 2007*, pp1-60.

[22] Stiglitz, J. and A. Weiss(1981), "Credit Rationing in Markets with Imperfect Information," *American Economic Review,* 71, pp393-410.

[23] Tirole, J(2005), *The Theory of Corporate Finance* (Princeton, New Jersey: Princeton University Press).

Figure 1.1

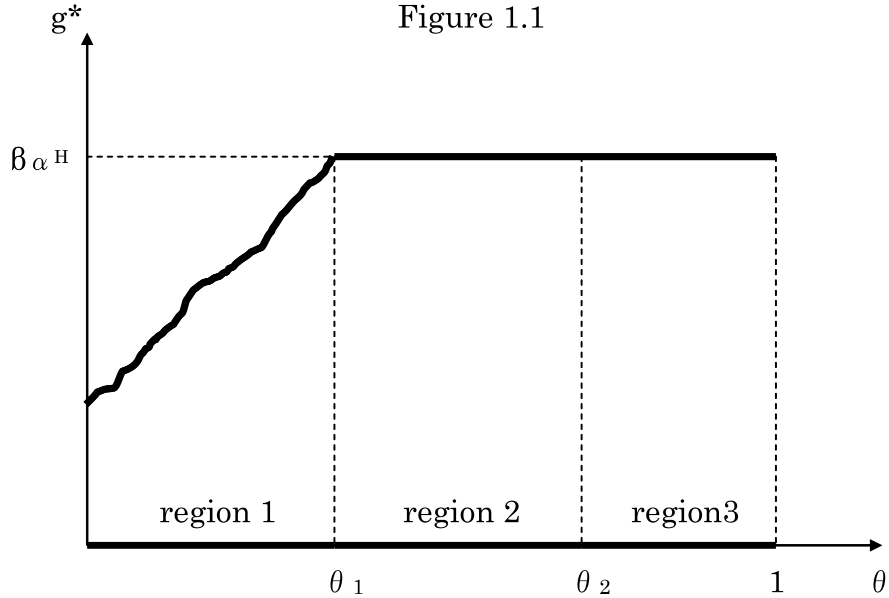
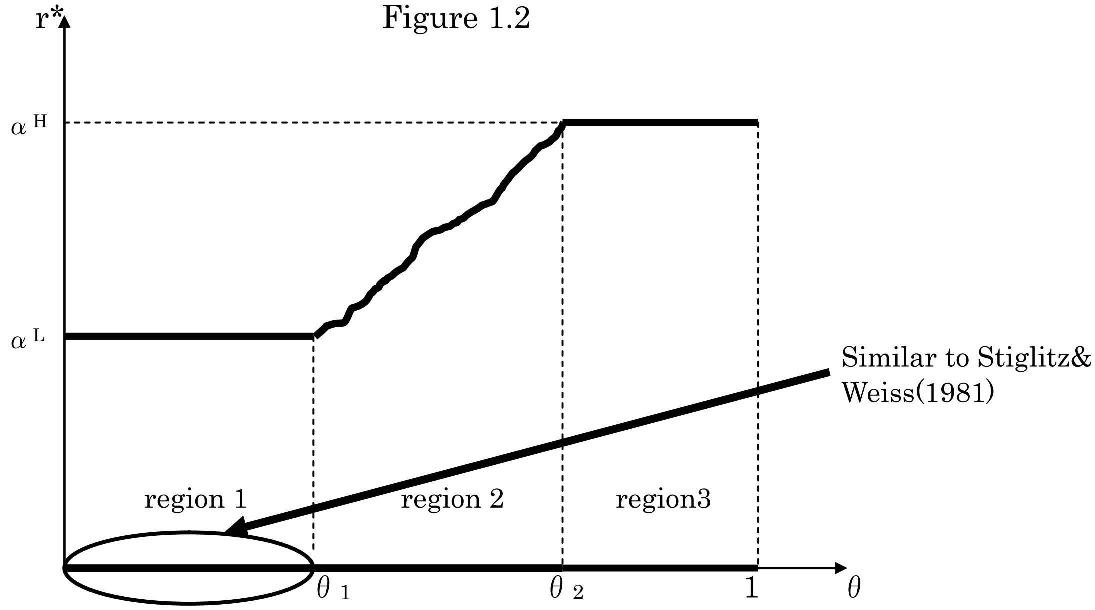
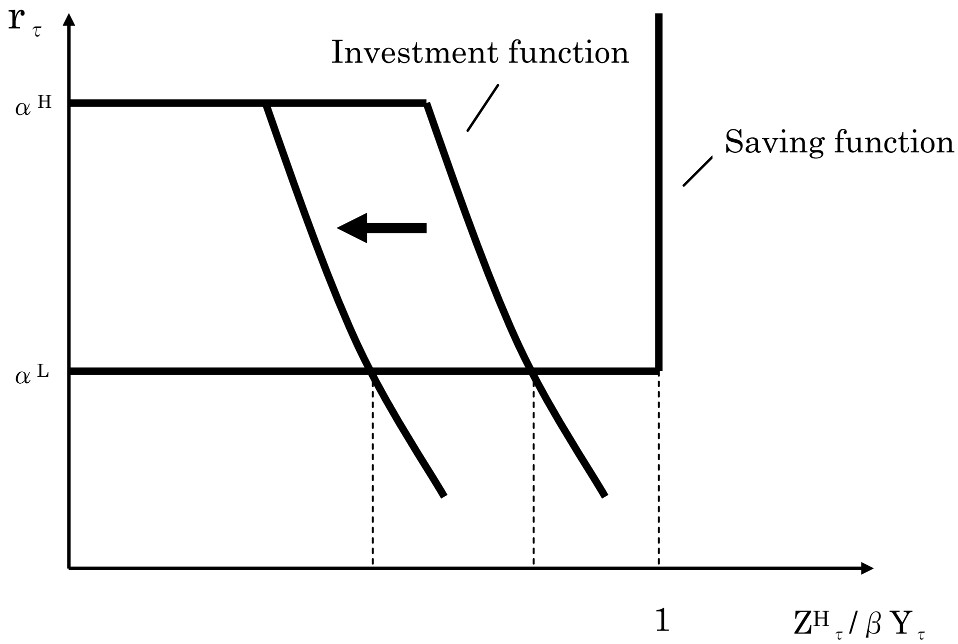


Figure 1.2



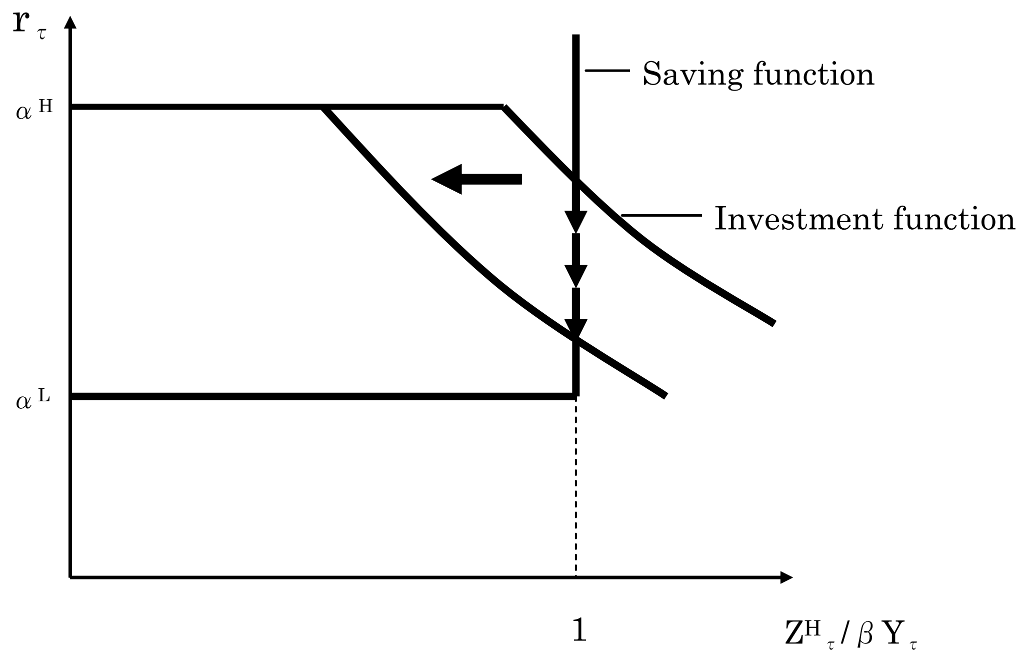
r*
α H
α L
Similar to Stiglitz& Weiss(1981)
region 1
region 2
region3
θ 1
θ 2
1
θ

Figure 2



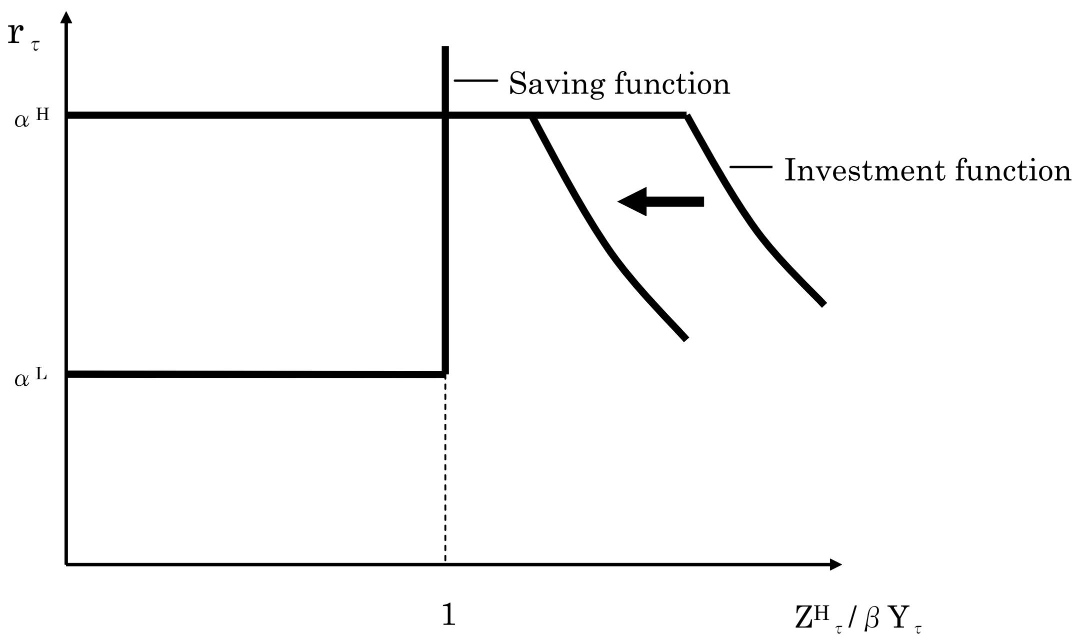
r_τ
α^H
α^L
Investment function
Saving function
1
$Z^H_\tau / \beta Y_\tau$

Figure 3



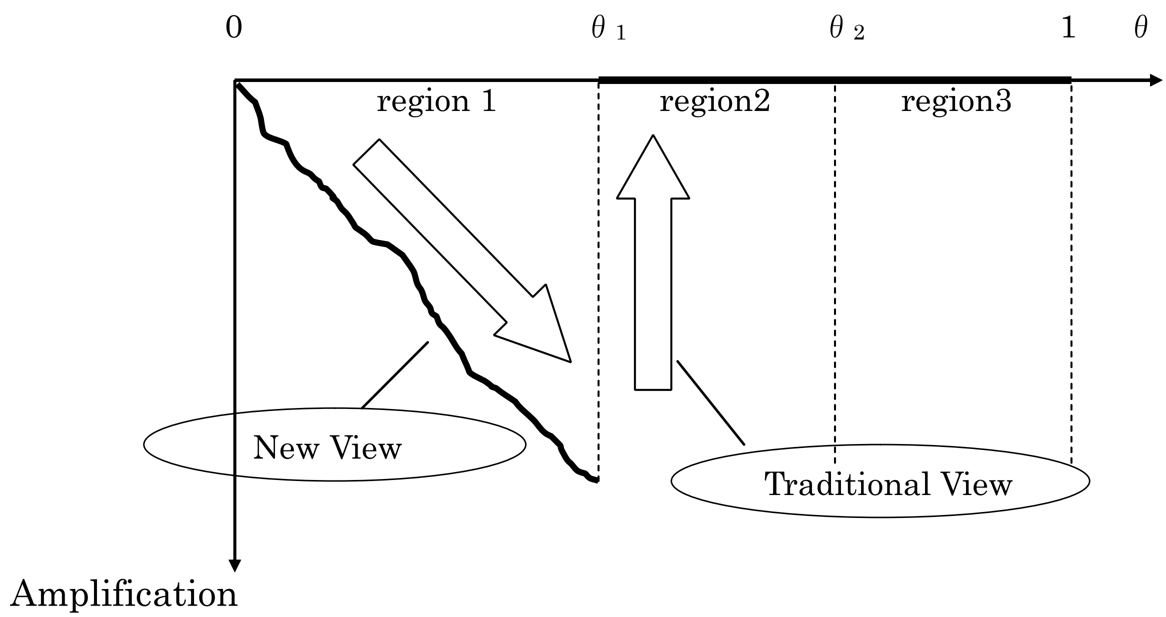
r_τ
α^H
Saving function
Investment function
α^L
1
$Z^H_\tau / \beta Y_\tau$

Figure 4



r_τ
Saving function
α^H
Investment function
α^L
1
$Z^H{}_\tau / \beta Y_\tau$

Figure 5


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