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# The Occurrence of Potential Complementary among Industries and the Behavior of Bank as Coordinator

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**Abstract:** *The effect of investment is often dependent on the degree of the potential complementarity among industries. However, we frequently find out that enterprises concerned with investment cannot find such a situation, and there are few chances for the occurrence of potential complementarity. However, if banks behave as coordinators among enterprises or as complements to industries, such complementarity can occur and social welfare can be improved. The present study examines the behavior of banks as coordinators and the occurrence of complementarity in the economy.*

**Keywords:** *Mutual effect of investment, Market Failure, Bank (Coordinator), Strategic Complementary*

**Abbreviations:** *Potential Complementary and Bank (Coordinator)*

## 1. INTRODUCTION

Investment, which is important for an economy, is done by each firm. However, the effect of investment is often dependent on the occurrence of complementarity among various industries or firms. Aghion and Howitt (1998) show that complementarity among various industries induces rapid economic growth. In fact, during the rapid economic growth period of Japan, the introduction of petroleum not only strengthened the electronic power but also helped petrochemistry industries flourish, which contributed to the rapid growth of the Japanese economy.

Sometimes, to ensure that such a complementarity occurs in an economy, each subject must make a certain scale of investment. Azariadis and Drazen (1990) show the growth model in which productivity of human capital and growth rate depend on the scale of investment by each individual. In Japan's rapid economic growth periods, many firms in the petrochemical industry invested in the construction of a certain scale of facilities, which contributed to strong complementarity among industries and led to economic growth.

In order to describe the above situation, we consider the existence of potential complementarity among firms and present a model in which the increase in productivity and growth rate depend on such a complementarity. However, we also consider that whether the occurrence of complementarity in an economy depends on the scale of investment by each enterprise. If an enterprise invests below a certain scale, complementarity does not occur.

If all the funds needed for investment are not covered by an enterprise's wealth, the enterprise must borrow from the monetary market or other sources. In the monetary market, the scale of funds an enterprise can borrow often depends on his/her credit. Therefore, we must also consider the relationship between complementarity and credit in the monetary market.

Hart and Moore (1984) analyze the relationship between an enterprise's credit and scale of investment to show that enterprises with less wealth or less productivity cannot borrow enough funds from the monetary market.

Thus, in conjunction with Azariadis and Drazen (1990), we also use the framework of Hart and Moore (1994) as a tool to analyze the relationship between the credit constraints of enterprises and occurrence of complementarity.

However, we put more weight on the productivity of enterprises than their wealth as credit.

Moreover, in our model, the chance of increasing productivity due to the occurrence of complementarity increases the credit.

This way, we show the mutual effect between complementarity among industries and credit in a monetary economy.

In the market where many subjects gather, each subject may doubt whether others have invested enough, and thus the subject may not invest to the level required to cause complementarity.

Consequently, although the economy has a chance to increase productivity and growth rate due to the occurrence of complementarity, if the monetary transaction is done only in the market, this chance would not be realized. However, if an observer other than the subjects who invest could identify potential complementary and ensure proper coordination among enterprises, such a chance may be realized.

Therefore, we assert that banks are needed to solve the problem of nonoccurrence of complementarity and credit.

## 2. Materials and Methods -1 (Set up of Model)

There are many enterprises and stock holders in economy, both whose population are one. Both can live for two periods and have utility function *V*, as below.

$$V = c_0 + \frac{1}{R} c_1 \qquad (1)$$

where, $c_0$ is their consumption in the first period, $c_1$ is consumption in the second period, $R$ is the sum of time preference of each household plus 1. In the first period, enterprises have wealth $e_0$, while stock holders have wealth $w_0$.

Each enterprise has his/her own investment project and ability to realize that project. If enterprises remain connected to their projects until completion, the product function is as follows:

$$y_1 = \alpha k_0 \qquad (2)$$

where, $k_0$ is investment in one period, $\alpha$ is productivity parameter, $y_1$ is output in second period.

However, each project faces two limited conditions. First, if the enterprise is not connected to the project until the end, the following holds:

$$y_1 = \theta \alpha k_0 \qquad 0 < \theta < 1 \qquad (3)$$

Moreover, the parameters assumed to face the next relation.

$$\theta\alpha < R < \alpha \qquad (4)$$

If an enterprise cannot cover all the funds for investment with his/her wealth $e_0$, the enterprise must borrow the rest. We assume that there is a credit market in an economy in which enterprises propose that stockholders lend debt $b_0$ in the zero period, which they will return plus interest in the first period. So, in the zero period, stockholders decide how to distribute their wealth $w_0$ for consumption in the zero period $c_0$ and credit $b_0$ based on their expectations about the credit market, while enterprises decide the sum of the received credit $b_0$ and scale of investment $w_0$ based on their expectations.

Here, their expectations include those about the rise in productivity $\alpha$ after investment.

Thus, investment $k_0$ is the sum of an enterprise's wealth $e_0$ and debtas follows:

$$k_0 = e_0 + b_0 \qquad (5)$$

If an enterprise stops his/her project and another person succeeds, the output becomes $\theta k_0$. Therefore, outputis distributed to stockholders and output 1-θis distributed to enterprises; thus, the bargaining

powers of both enterprises and stockholders are balanced.This argument is detailed in Hart and Moore (1994) and Kiyotaki(1993).

Because payment against credit by the stockholder is done through such a distribution, the following relationship is also satisfied:

$$rb_0 \le \theta\alpha k_0 \qquad (6)$$

Therefore, the demand curve can be shown as follows (see Figure 1):

$$b_0 \le \frac{\theta\alpha}{r-\theta\alpha} e_0 \qquad (7)$$

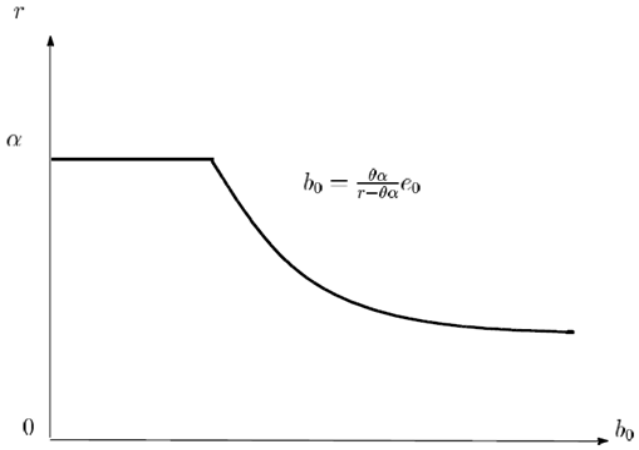


**Figure1.** *The Credit Demand Curve*

where credit $b_0$ increases as productivity $\alpha$ and wealth of the enterprise $e_0$ increase or the rate*r* decreases.

Stockholders' decisions about the distribution of their wealth $w_0$ against $c_0$ and credit $b_0$ are made by comparing *R* with *r*. When *R* is smaller than *r*, stockholders use all their wealth $w_0$ for consumption $c_0$ in the zero period. When *R* is bigger than *r*, they invest all their wealth $w_0$ into credit $b_0$ .So, the credit supply curve is drawn as in Figure 2, which is kinked at *r*=*R*.

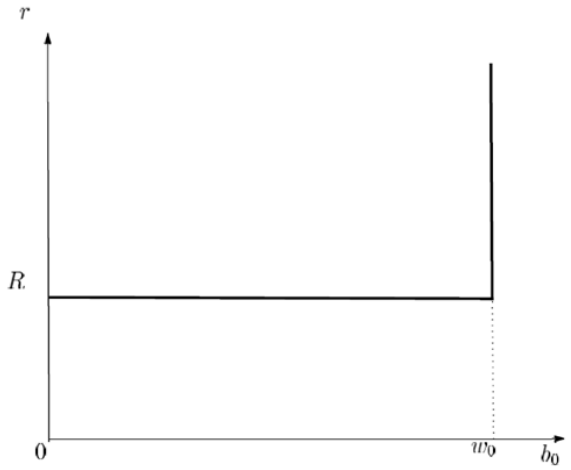


**Figure2.** *The Credit Supply Curve*

## 3. Materials and Methods-2 (Classification of Eurbliium According with Enterprise's Wealth)

The equilibrium is divided into the next three cases.

Case (1): The enterpriser asset $e_0$ is relatively less as follows:

$$e_0 < \frac{R-\theta\alpha}{\theta\alpha} w_0 \quad (8)$$

Case (2): The enterpriser asset $e_0$ is relatively more abandoned as follows:

$$\frac{R-\theta\alpha}{\theta\alpha}w_0 < \bar{e}_0 < \frac{1-\theta}{\theta}w_0 \quad (9)$$

Case (3): The enterpriser asset $e_0$ is much more abandoned as follows:

$$e_0 > \frac{1-\theta}{\theta}w_0 \quad (10)$$

Case (3) is omitted in the following analysis.

In Case (1) (see Figure 3), the demand and supply curves are crossed at the horizon of the supply curve.In equilibrium, $r$ is equal to $R$ . Even if productivity $\alpha$ is over $R$ and an enterprise wants to borrow more, all the wealth $w_0$ is not invested and credit $b_0$ is limited, as shown below:

$$b_0 = \frac{\theta\alpha}{R-\theta\alpha}e_0 \quad (11)$$

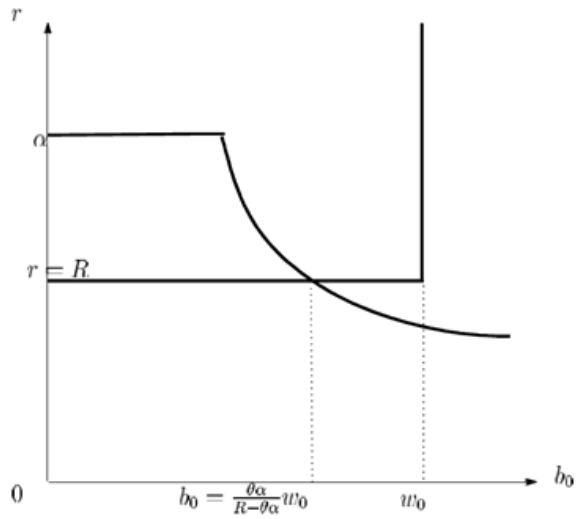


**Figure3.** *The equilibrium in the case that enterprise's assets is abandoned*

Thus, the economy does not enjoy social welfare.

In Case (2) (see Figure 4), the demand and supply curves are crossed at the axis of the supply curve. Rate $r$ in equilibrium is over the time preference rate $R$ and productivity $\alpha$, as shown below:

$$r = e_0\frac{\theta\alpha}{w_0} + \theta\alpha \quad (12)$$

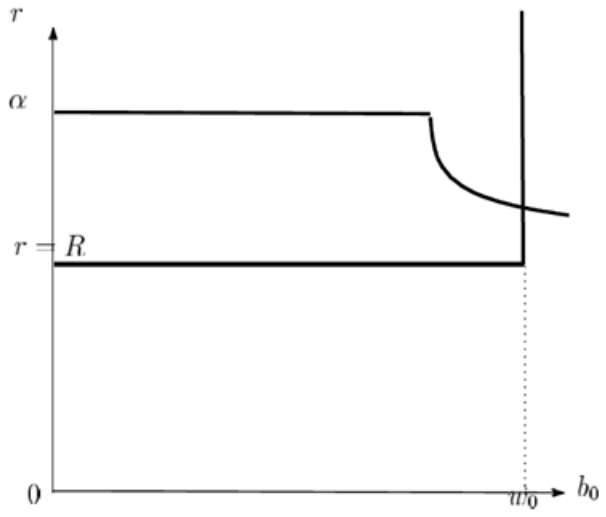


**Figure4.** *The equilibrium in the case that enterprise's assets is small*

So, households invest all the wealth $w_0$ to the credit $b_0$ in the zero period without limitation, as follows:

$$b_0 = \frac{\theta\alpha}{r-\theta\alpha} e_0 = w_0 \qquad (13)$$

In our model, although productivity $\alpha$ rises, when the scale of its rise is small, the situations before and after investment are categorized into the same case, as in Hart and Moore (1984) or Kiyotaki(1994), in which productivity $\alpha$ remains constant.

## 4. Materials and Methods -3 (The Argument about Existence of Multiple Equilibrium in Market)

In our model, in a boom, when productivity $\alpha$ rises significantly, the realized case is different from that before the investment. Moreover, although the wealth of the enterprise $e_0$ is less and credit $b_0$ is constrained before investment (see Case 1 or Figure 3), there is a chance that productivity $\alpha$ rises after investment and all the wealth of the household $w_0$ is used for credit $b_0$ (see Case 2 or Figure 4).

This situation is illustrated in Figure 5. Here, as enterprise wealth is $e_0$, the credit needed for investment over $\overline{K}$ is $\overline{K}$-$e_0$.Before the investment, as the wealth of the enterprise $e_0$ is small and productivity is $\alpha$, the credit $b_0 < \overline{K} - e_0$ is small and the expected scale of the investment is below $\overline{K}$. But, after investment or in the first period, if productivity $\alpha$ is $\alpha_H$, the credit $b_0 = w_0 > \overline{K}$-$e_0$ is abundant and investment $k_0 > \overline{K}$ is realized. Thus, potential complementarity occurs and social welfare improves.

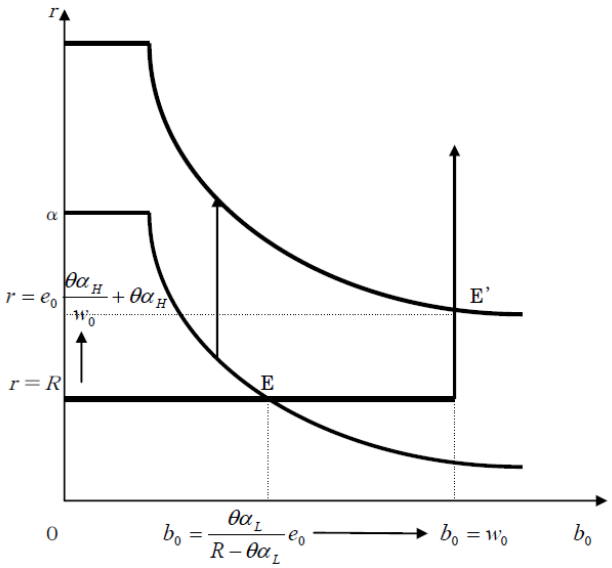


**Figure5.** *The mutual affect between occurrence of complementarity and improvement in credit constraints*

However, it should be noted that the rise of productivity $\alpha$ depends on the number of enterprises who invest over $\overline{K}$.Therefore, unless all stockholders and enterprises expect that productivity $\alpha$ will rise and investment will be over $\overline{K}$ in the zero period, such an investment is in fact not realized.Thus, the rise in productivity $\alpha$ and improvement in social welfare are not realized.

There are many stockholders and enterprises in the market; an enterprise is not always confident that all other enterprises will invest over $\overline{K}$, and so he/she does not invest over $\overline{K}$.Similarly, a stockholder in the market is not always confident that all other stockholders will invest all the wealth $w_0$, and so he/she does not invest all the wealth $w_0$.

Therefore, if money is transacted only in the market, the chance of rise in productivity is not realized in the economy.

In short, if the money is transacted only in the market, we could have multiple equilibria. The first equilibrium is similar to Case 2, wherein all enterprises and stockholders expect that investment $k_0$ will be over $\overline{K}$, and thus all the wealth of stockholders $w_0$ is used for the credit $b_0$ and enterprises invest over $\overline{K}$.The second equilibrium is similar to Case 1, wherein all enterprises expect that credit $b_0$ will be under $\overline{K}$, and they invest under $\overline{K}$. Therefore, before investment, each subject in the market does not know with confidence that the credit will not become constrained, even though there is potential complementarity.

## 5. Result And Discussion（The Roll of Bank as Coordinator）

Note that *r* rises with the rise in productivity $\alpha$. So, if an observer other than the enterprises (such as a bank) exists in an economy and identifies such a difference in *r* as the profit margin and behaves as a coordinator among enterprises, the multiple-equilibria problem may be solved.

In addition, we assume that 1-n number of firms do not invest but act as intermediaries among enterprises, while the number of enterprises who invest is assumed to be*n* .

Under such an assumption, for example, the observer or coordinator (bank) proposes that stockholders lend some of their wealth $w_0$ in the zero period on the condition that the coordinator would pay it back at $(R+\varepsilon)w_0$, which is $w_0$ timed by the rate of time preference $R$plus premium for the stockholder $\varepsilon$ in the first period. Thus, stockholders can obtain premium $\varepsilon>0$ with certainty if they accept the proposal. Because the multiple-equilibria problem exists only in the market, stockholders do not expect with certainty that $r>R$is realized only in the market.\footnote{If we use a more complicated model that includes probability decisions, we could state with accuracy that investments by stockholders are decided under $w_0$ ; see Hart and Moore (1984).}

The observer or coordinator (bank) proposes that enterprises borrow $w_0>\overline{K}-e_0$ in the zero period on the condition that enterprises should be obliged to pay back $r>w_0$ ,where *r* represents the rate plus one that is expected to be decided in the market equilibrium when productivity $\alpha$ rises. Enterprises accept such a proposal because they do not expect with certainty that $r>R$ is realized only in the market.

Therefore, through such behavior by the observer or coordinator (bank), the needed credit $\overline{K}-e_0$ is realized, investment over$\overline{K}$ is done, and $r>R$ is realized in equilibrium as follows:

$$r_H = e_0 \frac{\theta \alpha_H(n)}{w_0} + \theta \alpha_H \qquad (14)$$

where *n* is the number of enterprises who invest over $\overline{K}$.Here, as *n* increases, productivity $\alpha$ and interest *r* also increase. As a result, credit $b_0$ sometimes becomes limitless (as like in Case 2) after investment, although it remains limited (as like in Case 1) before investment. Therefore, an enterprise could lend all the wealth of households as credit ($b_0 = w_0$) for investment, and investment over$\overline{K}$ is done. Complementarity occurs, and social welfare is improved.

Next, we consider the economic distribution of each subject and compare social welfare when a banks are at work with when banks are not at work. We consider the effect of the operation of banks. We assume that the operation cost of each bank is zero for simplicity.

Under this setting, we obtain the profits of all banks$\pi_b$, consumption of the enterprises in the first period$c_{e1}^b$, and consumption of the stockholder in the first period $c_{s1}^b$when a bank acts, as shown on the left-hand sides of inequality in the equations below. While, the right-hand sides of inequality in the equations indicate the sum of distribution of each subject (the profit of banks$\pi_m$, consumption of enterprise in the first period$c_{m1}^b$, consumption of the stockholder in the zero period and first period and in the zero period, $c_{m(0+1)}^b$, without the operation of the banks or only in the market. Notice that the stockholders consume their goods only in the first period when banks operate, while they consume both in the first period and in the zero period when the financial transactions work only in the market.

$$\pi_b = (r-\epsilon)w_0 = \left(e_0 \frac{\vartheta \alpha_H(n)}{w_0} + \theta \alpha_H(n) - \epsilon\right) w_0 > \pi_m = 0 \qquad (15)$$

$$c_{e1}^b = (1-\theta)\alpha_H(n)(e_0 - w_0) > c_{e1}^b = (1-\theta)\alpha_L(e_0 - b_0) \qquad (16)$$

$$c_{s1}^b = (R+\varepsilon)w_0 > c_{e(0+1)}^b = Rb_0 + (w_0 - b_0) \qquad (17)$$

We find out that the economic social welfare when the banks are at work improves more than when the banks are not at work. Even when there is a potential complementary of productivity in economy but is not occurred only in the market, it can be occurred by the roll of bank and social welfare improve. Here, we apply simple model in this article in order to describe the basic mechanism distinctly and we could use a more complicated model that includes probability decisions in order to state such mechanism accuracy.

## 6. Conclusion

In this study, we consider the relationship between the occurrence of complementarity and the credit of enterprises. As a result, we find out that there is a mutual effect between the two. In short, as the productivity of enterprises and complementarity increase (decrease), the credit of enterprises increases (decreases).However, only in the market, the strategic problem occurs, and we assert that the role of a coordinator is important for the subjects to solve this problem.

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