Bribery and Resource Allocation: An Asymmetric Information Case

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1. Introduction

Through the periods of low economic growth among the developed countries, we observed many incidents which suggest the strong relationship between political system and economic performance. Many developing countries, can not expect much support from the developed countries because of the low economic growth, suffer from political instabilities and stagnant economic activities. Internal and external forces caused significant changes in political and economic system of many communist countries.

The subject of this paper is the effects of governmental corruption on economic activities. In a market economy, a public sector is expected to correct the market failure in order to attain efficiency. However, in reality, it is difficult for the public sector to perfectly simulate the market activities. The discrepancy between the market activities, which could have attained the efficient outcome, and the public sector's activitiy implies a room for a third party to extract gains by narrowing the discrepancy. The activity of the third party often manifest itself as a form of corruption which is the view taken by Krueger (1974), Ehrlich and Lui (1992). In this sense, corruption is an inevitable counterpart of the public sector's intervention into market mechanism. Lui (1985) analyzed a queuing model of corruption. In a situation where people have to wait on a queue to get services from a government official, there is an opportunity for corruption such that a customer on a queue may bribe the official to affect waiting time. The assumption that transactions take time implies that the market structure is not frictionless. This is a sort of market imperfection from which the opportunity for corruption arises. In fact, Lui showed that the corruption (bribery) may attain the second best outcome in the sense that the average value of the time costs of queue is minimized in equilibrium.

On the other hand, there are many attempts which describe corruption as one form of the principal-agent problems, and design an optimal contract to attain possibly the second best outcome. Some of the well known researches are; Becker and Stigler (1974), Banfield (1975) and Rose-Ackerman (1975). If the best action for a principal is not necessarily the best for an agent when no restriction is imposed on the agent, then the agent will deviate from the best interest of the principal. In order to avoid this kind of inefficiency (for the principal), the principal must design a contract which gives the agent an incentive to take actions which will narrow the discrepancy between the principal's interest and the agent's. Given this principal-agent framework, some attempts are made to identify the determinants of the level of corruption, and their implications on economic efficiency. Rose-Ackerman (1975), Shleifer and Vishny (1993) focused on the relationship between corruption and market structure, including the inside structure of public sector. In these researches, the level of corruption depends on the degree of competition over the goods and services in concern. In addition, Murphy, Shleifer and Vishny (1993) looked at the technology side of corruption. They argued that corruption spreads because of increasing returns, properties prominent to rent-seeking activities.

In Futamura (1994), I also looked at the relationship between market structure and the level of corruption. In the model, there is a government which owns a resource demanded by firms as an input for production. With respect to the allocation of the resource among firms, the government corrupts if the amount of the resource allocated by the government to a firm depends on the amount of bribe paid by the firm to the government. In order to analyze a situation in which the firms take the interdependence among their actions explicitly into account, i. e., they foresee the effect of the difference among their bribe payments on their profits, I employed a duopoly model for the market structure. The results of the analysis are summarized as follows. If the firms have to deal with a corrupt government, then the duopoly competition between the firms forces them to pay bride which could have been used for more productive activities. The firms would not have paid the bribe if they were able to collude. However, each firm has an incentive to deviate from the collusion since one firm can capture the significant portion of the input resource from the corrupt government by paying some positive amount of bribe if the other firm does not do so.

From the view point of each firm, the bribe is a waste of resource. From the view point of the entire society, however, it is not necessarily a waste. If it costs $1 to raise $1 bribe, then the bribe is a pure transfer from the firms to the corrupt government, like a lump-sum tax, which does not change the social welfare.

Even if this observation is true in the short-run, corruption may cause a significant social loss in the long-run since the resources set aside for the bribe activities could have been used for more productive purpose such as R&D activities which will increase output in the long-run.[1] As the time horizon gets longer, the difference between the social welfare of corrupt economy and that of non-corrupt economy gets larger because of the lower output growth rate in the former.

In the above analysis, the firms are assumed to be identical mainly for analytical simplicity. However, the asymmetric characteristics of the firms may have a significant implication for the outcomes and the role of government.[2] In this paper, the effects of the informational asymmetry across firms on the level of corruption and social welfare will be analyzed. Instead of the informational symmetry between the duopoly firms, it is assumed that one firm knows whether the government is corrupt or not, while the other firm does not. The duopoly competition in the final good market induces the uninformed firm to obtain the information about the degree of governmental corruption since the firm has to choose the profit maximizing level of bribe spending which determines the amount of the government-owned input resource allocated to the firm. The uninformed firm may try to obtain the information by looking at what the informed firm does. That is, the action of the informed firm is taken by the uninformed firm as a signal of the degree of governmental corruption. (Naturally, the informed firm may send "noisy" signals if it is profitable to do so.) It will be shown that the equilibrium outcomes depend on two key parameters. First, the parameter which captures the costliness of the corruption. Second, the parameter which captures the importance of the government-owned in-

1) Murphy, Shleifer and Vishny (1993) observed that the public rent-seeking is more harmful on innovation activities than on production "since innovators need government-supplied goods such as permits, licenses, import quotas, and so on." (p 412)

2) Dasgupta and Stiglitz (1988) analyzed the relationship between the differences in firms, such as the difference in productivity, the difference in the initial size of the firms, etc., and the market structure.

put resource in the production process. The more costly the bribe activity, and/or the more important the government-owned input resource in the production process, the larger the loss in the social welfare. It will be shown that, under the corrupt government, the social welfare in the asymmetric information tends to be smaller than that in the symmetric information for the following reason. In the symmetric information, the duopoly firms pay the same amount of bribe, and produce the same amount of output. On the other hand, they pay the different amount of bribe, and produce the different amount of output in the asymmetric information. If the technology set is convex, then the total output in the asymmetric information is smaller than that in the symmetric information because of the asymmetry in the actions taken by the firms. Therefore, the consumer's surplus in the asymmetric information is also smaller than that in the symmetric information.[3)]

Even if the government is not corrupt, there is a social welfare loss in the asymmetric information. The uninformed firm pays bribe since it does not know for sure whether the government is corrupt or not. If the uninformed firm does not pay bride, and if the government turns out to be corrupt, then the rival firm may obtain the significant portion of the input resource from the government as well as the market share through the duopoly competition. In order to avoid such a risky situation, the uninformed firm pays bribe even if the true identity of the government is non-corrupt. For this reason, even if the government is not corrupt, the social welfare in the asymmetric information tends to be smaller than that in the symmetric information.

This paper is organized as follows. In section 2, the structure and

3) In this case, the duopoly may be less preferable than monopoly to the consumers.

the outcome of the symmetric information model (Futamura, 1994) are summarized as basis for comparison. Then I proceed to the analysis of the asymmetric information model. In section 3, a comparison of social welfare under the different information structure will be made. In the comparison, I also look at each component of the social welfare; consumer's surplus, profits and bribe payment from the firms to the government. Summary and concluding remarks will be made in section 4.

2. Information and Equilibrium Analysis

Case 1. Symmetric Information: In Futamura (1994), I analyzed a duopoly model of governmental corruption in the symmetric information assumption. The structure of the model is described as follows. There are non-cooperative duopoly firms, firm 1 and firm 2, and a government which owns a resource demanded by the firms as an input for production. The government is either one of two types with respect to the allocation of the resource between the firms. A *fair* government allocates the resource according to a rule which is not affected by the actions taken by the firms. On the other hand, a *rotten* government allocates the resource according to the relative size of bribes paid by the firms to the government. Denote v as the total amount of the government-owned resource, v_i, $i=1, 2$, as the amount of the government-owned resource allocated to firm i, and x_i, $i=1, 2$, as the amount of bribe paid by firm i. Then the resource allocation rule is defined as, for $i=1, 2$,

$$v_i=\begin{cases}\dfrac{1}{2}v, & \textit{if the government is fair} \\[2ex] \dfrac{x_i}{x_1+x_2}v, & \textit{if the government is rotten.}\end{cases}$$

Given this allocation rule, firm i, $i=1, 2$, chooses bribe, x_i, and employs l_i units of labor from a competitive labor market at wage w to maximize profit, π_i, in a duopoly market which is defined as

$$\pi_i=p(q_1, q_2)q_i(l_i, v_i)-wl_i-c_i(x_i), \qquad i=1, 2$$

where $p(q_1, q_2)$ is the (inverse) market demand function, $q_i(l_i, v_i)$ is firm i's production function, and $c_i(x_i)$ is firm i's bribe cost function.

There are interdependences between the firms in two aspects. First, in the duopoly market through the choice of output. Second, in the allocation of the government-owned resource through the choice of bribe. Each firm has to take these interdependences into account when it attempts to maximize the profit. In a symmetric information framework, the type of the government is assumed to be a *common knowledge.* Each firm knows whether the government is *fair* or *rotten.* A standard type Cournot-Nash equilibrium is employed as a solution concept in both aspects of the interdependences. Therefore, firm i's optimization problem is expressed as

$$\max_{\{l_i, x_i\}} \pi_i$$

subject to the allocation rule and firm j's choice $\{l_j, x_j\}$ taken as given, for $i, j=1, 2, \quad i\neq j$.

For a numerical exposition, I specified the functional forms as follows.

$$p(q_1, q_2)=\frac{m}{\sqrt{q_1q_2}} \tag{1}$$

$$q_i=l_i^{\alpha_i}v_i^{1-\alpha_i}, \quad 0<\alpha_i<1, \qquad i=1, 2 \tag{2}$$

$$c_i(x_i)=\frac{1}{2}c_ix_i^2, \quad c_i>0, \qquad i=1, 2 \tag{3}$$

Though equation (1) seems to suggests that one price is quoted for q_1 and q_2 even if they are not perfect substitutes from the view point of consumers, I use (1) in order to obtain closed form solutions. In addition, a linear (inverse) demand function such as

$$p(q_1, q_2) = \frac{m}{(q_1+q_2)/2} \tag{1}'$$

does not give us a well-defined consumer's surplus even if specification (1)′ seems more natural than (1) for the description of duopoly market.[4] Equation (3) implies a convex (increasing) bribe cost. As the amount of bribe increases, the marginal cost of bribe also increases. In addition to the actual costs of rasing bribe, it may also include the implicit costs of bribery such as the (expected) value of penalties on illegal bribe activities since the probability of detection and the size of penalty may positively depend on the size of bribe. Equation (3) also implies that it takes less than \$1 to raise \$1 bribe when the size of the bribe is less than $1/c_i$. When the size of the bribe is very small, then the probability of detection and the size of penalty may be small, too. In a principal-agent framework, Shleifer and Vishny (1993) considered a situation in which a corruption is defined as the sale by government officials of government property for personal gain. An official (agent) who is in charge of the sales may not turn over the proceed from the sales to his/her boss (principal) by hiding the transaction. In this case, the marginal cost of the corruption for the agent is zero since the cost of providing an additional unit of the government property may accrue to the principal. The agent may quote buyers a charge well below the official price.[5] If the bribe is a

4) In a symmetric equilibrium, (1) and (1)′ give the same outcome. The point is that the price level depends on the average of q_1 and q_2 in both specifications; the geometric average, $(q_1q_2)^{1/2}$, in (1) and the arithmetic average, $(q_1+q_2)/2$, in (1)′.

5) Of course, this argument may not be valid in a general equilibrium social welfare analysis since the losses and the gains of all the participants are included.

pure transfer from the firms to the government, then the bribe cost function may be expressed as

$$c_i(x_i)=x_i, \qquad i=1,\ 2. \tag{3$'$}$$

In this case, the bribe is much like a lump-sum tax. Shleifer and Vishny also pointed out the similarity and the difference between bribery and taxation. They noted that despite their similarity, bribes are more distortionary than taxes because of the efforts by corrupt bureaucrats to avoid detection. For these reasons, I employ equation (3) for the specification of the bribe cost in the hope that it will capture such properties of the bribe.

Finally, I also assumed the symmetry in technology, i. e.,

$$\alpha_1=\alpha_2\equiv\alpha$$

$$c_1=c_2\equiv c.$$

These two parameters, α, which captures the importance of the government-owned input resource in the production process, and c, which captures the costliness of the bribe activity, will play an important role in the social welfare analysis.

The symmetric information Cournot-Nash equilibrium outcomes are summarized as follows. If the government is *fair,* then

$$l_1^*=l_2^*\equiv l^*=\frac{m\alpha}{2w}$$

$$x_1^*=x_2^*\equiv x^*=0$$

$$q_1^*=q_2^*\equiv q^*=(l^*)^{\alpha}(v/2)^{1-\alpha}=\left(\frac{m\alpha}{2w}\right)^{\alpha}\left(\frac{v}{2}\right)^{1-\alpha}$$

$$p^*=\frac{m}{\sqrt{q_1^*q_2^*}}=\frac{m}{q^*}=\frac{m}{\left(\frac{m\alpha}{2w}\right)^{\alpha}\left(\frac{v}{2}\right)^{1-\alpha}}$$

$$\pi_1^*=\pi_2^*\equiv\pi^*=p^*q^*-wl^*-\frac{1}{2}c(x^*)^2=m\left(1-\frac{\alpha}{2}\right)$$

where the superscript "*" on the variables indicates the solution under the *fair* government. If the government is *rotten,* then

$$l_1^{**}=l_2^{**}\equiv l^{**}=l^*$$

$$x_1^{**}=x_2^{**}\equiv x^{**}=\left(\frac{m(1-\alpha)}{2c}\right)^{1/2}$$

$$q_1^{**}=q_2^{**}\equiv q^{**}=q^*$$

$$p^{**}=p^*$$

$$\pi_1^{**}=\pi_2^{**}\equiv\pi^{**}=m\left(\frac{3-\alpha}{4}\right)$$

where the superscript "**" on the variables indicates the solution under the *rotten* government.

The comparison of the outcome under the *fair* government and that under the *rotten* government reveals several points of the governmental corruption. While the optimal amount of bribe is zero if the government is *fair,* it becomes positive if the government is *rotten.* The size of the bribe positively depends on the share of the government-owned input resource in the production process, $1-\alpha$, and negatively depends on the costliness of the bribe activity, c. Since $x_1^{**}=x_2^{**}$ in the symmetric equilibrium, the *rotten* government allocates $v/2$ to each firm, the same as the amount prevails under the *fair* government. Therefore, even if the type of the government is different, the output and the price are the same. The only difference between the outcome under the *fair* government and that under the *rotten* government is in the profit of the firms. Since the price, the output and the labor input under the *fair* government and those under the *rotten* government are the same, $\pi^{**}=\pi^*-c(x^{**})<\pi^*$ holds. In this sense, the bribe is a waste from the view point of each firm since it merely lowers its profit. Suppose $v_1=v_2=v/2$ when $x_1=x_2=0$. If the firms could collude, then they would have chosen not to pay bribe. However, it is difficult to sustain the collusion since one firm always has an incentive to deviate if the other firm sticks to the zero bribe. The deviant can capture all of the government-owned resource by paying some positive amount of bribe, however small it is, while its competitor gets no input resource from the government, produces no output and earns no profit. For this reason, $x_1 = x_2 = 0$ does not constitutes a Nash Equilibrium. In other words, each firm is trapped in the *prisoner's dilemma.* The duopoly competition between the firms in the final good market forces them to pay the bribe even if they know that the bribe is unproductive, that the bribe payment may merely lower their profit.

Case 2. Asymmetric Information: The basic structure of the model is the same as that of the symmetric information model except one point. Instead of the assumption that the type of the government is a common knowledge, only firm 2 is assumed to know whether the government is *fair* or *rotten* while firm 1 does not. The order of moves by firm 1 and firm 2 are specified as a two-stage process. In stage 1, firm 1 and firm 2 simultaneously choose the amount of bribe. In stage 2, when the government-owned input resource is allocated to firm 1 and firm 2, the firms simultaneously choose the amount of labor input, and engage in production. Then the output of each firm is sold in the duopoly market, and the profit of each firm is realized.

Firm 1's choice of bribe in stage 1 depends on its initial belief (prior) about the type of the government. At the beginning of stage 2, firm 1 updates the initial belief based on new information, firm 2's bribe payment. The amount of firm 2's bribe payment is perceived by firm 1 as a signal which conveys information about the type of the government. Firm 1's choice of labor in stage 2 is based on the updated belief (posterior) about the type of the government. On the other hand, firm 2 takes this signaling effect on firm 1's action into account when it chooses the amount of bribe in stage 1. Firm 2 may send a noisy signal (for example, paying a positive amount of bribe even if the government is *fair*) to firm 1 if it is profitable to do so.

This model is a version of Milgrom and Robert's (1982). Therefore, I employ the sequential equilibrium (cf., Kreps and Wilson, 1982) as a solution concept. The equilibrium is defined by the strategy profile consisting of the strategy of firm 1, that of firm 2 with the *fair* government and that of firm 2 with the *rotten* government, and the system of belief held by firm 1. There may be either pooling equilibrium in which firm 2 takes the same action regardless of the type of the government, or separating equilibrium in which firm 2 takes different action depending on the type of the government. In the following, I will concentrate on a separating equilibrium in which firm 1 can identify the type of the government by observing firm 2's choice of bribe as a signal. Specifically, I will seek the following type of separating equilibrium with respect to firm 2's strategy:

$$x_2=\begin{cases}0, & \textit{if the government is fair}\\ \tilde{x}_2>0, & \textit{if the government is rotten.}\end{cases}$$

In the separating equilibrium, firm 1's system of belief is well defined by Bayes' updating formula as

$$\mu\equiv Pr(fair|\tilde{x}_2)$$

$$=\frac{Pr(\tilde{x}_2|fair)Pr(fair)}{Pr(\tilde{x}_2|fair)Pr(fair)+Pr(\tilde{x}_2|rotten)Pr(rotten)}.$$

Therefore,

$$\mu=\begin{cases}1, & \textit{if } x_2=0\\ 0, & \textit{if } x_2=\tilde{x}_2>0.\end{cases}$$

The analysis will be made by backward induction. That is, given firm 1's choice of bribe, x_1, and the system of belief, μ, each firm solves the optimization problem of the subgame starting at firm 1's information set. The Nash equilibrium for this subgame can be expressed as a function of x_1. Then we will go back one step before, i. e., the first stage at which firm 1 chooses x_1 to maximize its profit with respect to the entire game given its initial belief about the type of the government.[6)]

The outcomes of the sequential equilibrium are summarized as follows. If the government is *fair,* then

$$\hat{l}_1=\hat{l}_2=l^*=\frac{m\alpha}{2w}$$

$$\hat{x}_1=\left(\frac{m}{c}\right)^{1/2}\left(\frac{2-\alpha}{3}\right)^{3/4}\left(\frac{2}{1-\alpha}\right)^{1/4}$$

$$\hat{x}_2=0$$

$$\hat{q}_1=\hat{q}_2=q^*=\left(\frac{m\alpha}{2w}\right)^{\alpha}\left(\frac{v}{2}\right)^{1-\alpha}$$

$$\hat{p}=p^*=m\Big/\left[\left(\frac{m\alpha}{2w}\right)^{\alpha}\left(\frac{v}{2}\right)^{1-\alpha}\right]$$

$$\hat{\pi}_1=\pi^*-\frac{1}{2}c(\hat{x}_1)^2=\frac{m}{2}\left[(2-\alpha)-\left(\frac{2-\alpha}{3}\right)^{3/2}\left(\frac{2}{1-\alpha}\right)^{1/2}\right]$$

$$\hat{\pi}_2=\pi^*=m\left(1-\frac{\alpha}{2}\right)$$

where "ˆ" above the variables indicates the solution under the *fair* government. If the government is *rotten,* then

6) Cournot-Nash equilibrium is employed for the subgame as a solution concept. One may model the situation as a Stackelberg leader-follower game. The choice is dependent on the assumption that who moves first. However, there are several issues concerning the choice of the game specification which will be discussed later in section 4.

$$\tilde{l}_1=\left(\frac{m\alpha}{2w}\right)\left(\frac{2}{1-\alpha}\right)^{1/2}\left(\frac{2-\alpha}{3}\right)^{1/2}$$

$$\tilde{l}_2=\left(\frac{m\alpha}{2w}\right)\left(\frac{2}{1-\alpha}\right)^{-1/2}\left(\frac{2-\alpha}{3}\right)^{-1/2}$$

$$\tilde{x}_1=\left(\frac{m}{c}\right)^{1/2}\left(\frac{2-\alpha}{3}\right)^{3/4}\left(\frac{2}{1-\alpha}\right)^{1/4}$$

$$\tilde{x}_2=\left(\frac{m}{c}\right)^{1/2}\left(\frac{1-\alpha}{2}\right)^{3/4}\left(\frac{3}{2-\alpha}\right)^{1/4}$$

$$\tilde{q}_1=\left[\left(\frac{m\alpha}{2w}\right)\left(\frac{2}{1-\alpha}\right)^{1/2}\left(\frac{2-\alpha}{3}\right)^{1/2}\right]^{\alpha}\left[v\Big/\left(1+\left(\frac{3}{2-\alpha}\right)\left(\frac{1-\alpha}{2}\right)\right)\right]^{1-\alpha}$$

$$\tilde{q}_2=\left[\left(\frac{m\alpha}{2w}\right)\left(\frac{2}{1-\alpha}\right)^{-1/2}\left(\frac{2-\alpha}{3}\right)^{-1/2}\right]^{\alpha}\left[v\Big/\left(1+\left(1+\left(\frac{2-\alpha}{3}\right)\left(\frac{2}{1-\alpha}\right)\right)\right)\right]^{1-\alpha}$$

$$\tilde{p}=m\Big/\left[\left(\frac{m\alpha}{2w}\right)^{\alpha}\left(\frac{6(2-\alpha)(1-\alpha)}{(7-5\alpha)^2}v\right)^{(1-\alpha)/2}\right]$$

$$\tilde{\pi}_1=m\left(\frac{2}{1-\alpha}\right)^{1/2}\left(\frac{2-\alpha}{3}\right)^{1/2}\left(\frac{2-\alpha}{3}\right)$$

$$\tilde{\pi}_2=m\left(\frac{2}{1-\alpha}\right)^{-1/2}\left(\frac{2-\alpha}{3}\right)^{-1/2}\left(\frac{3-\alpha}{4}\right)$$

where "~" above the variables indicates the solution under the *rotten* government. Notice that firm 1 pays the same amount of bribe regardless of the type of the government since it does not know whether the government is *fair* or *rotten* when it chooses the bribe. Therefore, we denote $\hat{x}_1=\tilde{x}_1\equiv\bar{x}_1$ in the following discussion.

If the government is *fair,* then there is little difference between the outcome in the asymmetric information and that in the symmetric information. Firm 2 knows the type of the government, and firm 1 can identify the type when it observes $x_2=0$. The only difference is the loss in the profit of firm 1 which is the consequence of the uncertainty about the type of the government at the beginning of the game. Firm

1 has to spend bribe, even if the true identity of the government is *fair,* since it does not know the type.

On the other hand, when the government is *rotten,* the outcomes are very different. The informed firm does not necessarily outperform the uninformed firm which is known as "the first mover disadvantage" (cf., Gal-Or, 1985, 1987). In the signaling equilibrium, the informed firm earns less profit than the uninformed firm does. The intuitive reason behind this is that, in the separating equilibrium, even if firm 1 does not know the type of the government at the beginning, it can identify the type for sure when it observes firm 2's choice of bribe, x_2. Furthermore, given the system of belief and the order of moves specified above, firm 1 acts as if it is a Stackelberg leader when it chooses bribe, x_1, at the beginning of the game, even though both firms behave as Cournot-Nash game players in the subgame given x_1 as a predetermined variable. It can be shown that firm 1's bribe is larger than that of firm 2. Therefore, the *rotten* government allocates larger portion of v to firm 1 than to firm 2, and consequently the labor input of firm 1 is larger than that of firm 2. Hence, firm 1's output, as well as the profit, is larger than firm 2's.

$\bar{x}_1$ and $\tilde{x}_2$ are rewritten as

$$\bar{x}_1 = x^{**}\left(\frac{2}{3}\,\frac{2-\alpha}{1-\alpha}\right)^{3/4}$$

$$\tilde{x}_2 = x^{**}\left(\frac{2}{3}\,\frac{2-\alpha}{1-\alpha}\right)^{-1/4}$$

From this, it can be shown that

$$\tilde{x}_2 < x^{**} < \bar{x}_1.$$

x^{**}, as well as $\bar{x}_1$ and $\tilde{x}_2$, decreases as the costliness of the bribe activity, c, increases. On the other hand, $\bar{x}_1$ and $\tilde{x}_2$ diverge as the share of the government owned input resource in the production process, $1-\alpha$, decreases.

The output pattern reflects the difference in the bribes. $\tilde{q}_1$ and $\tilde{q}_2$ are rewritten as

$$\tilde{q}_1 = q^{**}\left(\frac{2}{3}\,\frac{2-\alpha}{1-\alpha}\right)^{\alpha/2}\left(\frac{2-\alpha}{7-5\alpha}\right)^{1-\alpha}$$

$$\tilde{q}_2 = q^{**}\left(\frac{2}{3}\,\frac{2-\alpha}{1-\alpha}\right)^{-\alpha/2}\left(\frac{3}{2}\,\frac{1-\alpha}{7-5\alpha}\right)^{1-\alpha}.$$

Notice that $q^* = q^{**}$. From this, we obtain

$$\tilde{q}_2 < q^{**} < \tilde{q}_1.$$

$\tilde{q}_1$ and $\tilde{q}_2$ diverge, as well as $\tilde{x}_1$ and $\tilde{x}_2$, as the share of the government-owned input resource, $1-\alpha$, decreases.

In the symmetric information equilibrium, firm 1 and firm 2 use the same amount of inputs. On the other hand, because of the convexity of the technology set, the total output in the asymmetric information is smaller than that in the symmetric information when the government is *rotten*. Therefore,

$$p^{**} < \tilde{p}$$

(Notice also that $p^* = p^{**}$.) As $1-\alpha$ decreases, $\tilde{p}$ increases up to a certain point. After this point, the increase in $\tilde{q}_1$ may offset the decrease in $\tilde{q}_2$ so that the price begins to decrease.[7] When the share of the government-owned input resource in the production process, $1-\alpha$, is large, it is expected that the loss in profit due to the bribe cost is also large. However, as $1-\alpha$ gets smaller, because of the first mover disadvantage and the decrease in the loss in profit due to the bribe cost, firm 1's profit gets larger while firm 2's profit gets smaller under the

7) The outputs do not depend the costliness of the bribe activity, c, even though the bribes do, since c is cancelled when the ratio of the bribes is taken in the allocation rule of the government-owned resource. Therefore, the prices do not depend on c since the outputs do not depend on c.

rotten government when the information is asymmetric. When the government is *fair* and the information is asymmetric, we saw that firm 2, the informed, earns the same level of profit as it does in the symmetric information, i. e., $\tilde{\pi}_2=\pi^*$. On the other hand, the loss in firm 1's profit due to the unnecessary bribe payment to the *fair* government is large. In fact, the difference in the type of the government has a significant impact on firm 1's profit. When the government is *rotten,* the observations about the bribes and the outputs suggest that firm 2's profit in the asymmetric information, $\tilde{\pi}_2$, is smaller than π^{**}, the profit attained by firm 1 and firm 2 in the symmetric information, and π^{**} is smaller than firm 1's profit in the asymmetric information, $\tilde{\pi}_1(\tilde{\pi}_2<\pi^{**}<\tilde{\pi}_1)$.[8)]

3. Social Welfare Analysis

Define the social welfare, W, as the sum of consumer's surplus, producers' profit and bribes paid to the government, i. e.,

$$W\equiv CS+[\pi_1+\pi_2]+[x_1+x_2]$$

where

$$CS\equiv\int_0^{q_1}\int_0^{q_2}p(q_1,\ q_2)dq_1dq_2-pq_1q_2$$

is the consumer's surplus defined as the mass below the demand func-

8) The profits do not depend on the costliness of the bribe activity, c. The outputs and the prices do not depend on c. The labor inputs depend on the relative price of the labor and the government-owned input resource which does not depend on c. The bribes depend on c. They decrease (increase) as c increases (decreases). However, in the definition of the cost function, $c\cdot x^2/2$, these adjustments in the bribe cancel c in the reduced form expression.

9) The definition of the consumer's surplus is somewhat different from standard type definitions. As noted in footnote 4, an alternative definition (equation (1)′) for the demand function does not yield a well-defined consumer's surplus.

tion minus the total expenditure for q_1 and q_2.[9] With the functional forms chosen in section 2, it can be shown that $CS=3m(q_1 \cdot q_2)^{1/2}$.

Given the information structure, symmetric or asymmetric, the difference between the social welfare under the *fair* government and that under the *rotten* government is regarded as a loss (or a gain) due to the change in the type of the government, i. e., the loss (gain) in the social welfare due to the governmental corruption. Similarly, given the type of the government, *fair* or *rotten*, the difference between the social welfare in the symmetric information and that in the asymmetric information is regarded as a loss (or a gain) in the social welfare due to the change in the information structure. Therefore, there are four conceivable situations: (i) the loss (gain) in the social welfare due to the corruption in the symmetric information, (ii) the loss (gain) in the social welfare due to the corruption in the asymmetric information, (iii) the loss (gain) in the social welfare due to the information structure under the *fair* government and (iv) the loss (gain) in the social welfare due to the information structure under the *rotten* government. Each of these situations will be considered below.

(i) The loss (gain) in the social welfare due to the corruption in the symmetric Information: In the symmetric information, we saw that the firms produce the same amount of output regardless of the type of the government. Therefore, the consumer's surplus is also the same regardless of the type of the government. Denote W_{FS} and W_{RS} as the social welfare under the *fair* government and that under the *rotten* government, respectively, in the symmetric information. Then,

$$W_{FS}=3mq^*+2\pi^*$$

$$W_{RS}=3mq^{**}+2\pi^{**}+2x^{**}.$$

Since $q^*=q^{**}$ and $\pi^{**}=\pi^*-c(x_{**})$, it can be shown that

$$W_{FS}-W_{RS}=2[c(x^{**})-x^{**}]$$
$$=\left[\frac{1-\alpha}{4}-\left(\frac{m(1-\alpha)}{2c}\right)^{1/2}\right].$$

Depending on the parameter values, this can be either positive or negative. In fact, $W_{FS}>W_{RS}$ holds when the bribe activity is costly (c is large) and when the share of the government-owned input resource in the production process is large ($1-\alpha$ is large). Intuitively, large c and large $1-\alpha$ imply that the loss in the social welfare due to the bribery is large so that the social welfare under the *rotten* government is smaller than that under the *fair* government. On the other hand, $W_{FS}<W_{RS}$ holds when $c(x^{**})<x^{**}$ i. e., it costs less than $1 to raise $1 bribe when the bribe activity is not very costly and when the government-owned input resource is not very important in the production process. However, as noted in footnote 5, it may be unlikely to have $W_{FS}<W_{RS}$ in a general equilibrium social welfare analysis. When all the losses and gains are included in the framework, it may cost at least $1 to raise $1 bribe.

(ii) The loss (gain) in the social welfare due to the corruption in the asymmetric information: Denote W_{FA} and W_{RA} as the social welfare under the *fair* government and that under the *rotten* government, respectively, in the asymmetric information. Then,

$$W_{FA}=3m\sqrt{\hat{q}_1\hat{q}_2}+[\hat{\pi}_1+\hat{\pi}_2]+\hat{x}_1$$
$$W_{RA}=3m\sqrt{\tilde{q}_1\tilde{q}_2}+[\tilde{\pi}_1+\tilde{\pi}_2]+[\tilde{x}_1+\tilde{x}_2].$$

For a fixed a, W_{FA} and W_{RA} decrease as the costliness of the bribe activity, c, increases. Since the outputs and the profits do not depend on c, the decrease in the social welfare solely reflects the decrease in the bribes. When c and $1-\alpha$ are large, the loss in the social welfare due to the governmental corruption is large so that $W_{FA}>W_{RA}$ holds. However, even if the government is *fair,* the informational asymmetry induces firm 1 to pay bribe since it wants to avoid the risk that the government turns out to be *rotten* which firm 1 does not know for sure. Because of this risk aversion by firm 1, $W_{FA} < W_{RA}$ holds when c and $1-\alpha$ are small. Small c and small $1-\alpha$ imply that the social welfare could have been small had the government been *rotten.* In other words, when the potential cost of corruption is not large, the informational asymmetry makes the social welfare under the *fair* government smaller than that under the *rotten* government due to the unnecessary bribe payment by firm 1, the uninformed.

(iii) The loss (gain) in the social welfare due to the information structure under the *fair* government: When the government is *fair,* the social welfare in the symmetric information is larger than that in the asymmetric information unless the costliness of bribe activity, c, is very small. As we saw before, the difference in the outcome in the symmetric information and that in the asymmetric information is the loss in firm 1's profit due to the unnecessary bribe payment. (Firm 1 pays bribe to the *fair* government since it does not know the type at the beginning.) In fact, it can be shown that

$$W_{FS} - W_{FA} = c_1(\bar{x}_1) - \bar{x}_1$$

which is positive if it costs at least \$1 to raise \$1 bribe.

(iv) The loss (gain) in the social welfare due to the information structure under the *rotten* government: When the government is *rotten,* then the social welfare in the symmetric information and that in the asymmetric information decrease as the costliness of the bribe activity, c, increases. As before, this change solely reflects the change in the bribes, x^{**}, $\bar{x}_1$ and $\bar{x}_2$. In general, we expect $W_{RS} > W_{RA}$ to hold because of the loss in the social welfare due to the informational asymmetry. When the government is *rotten,* the difference between firm 1's bribe and firm 2's results in the difference between firm 1's output and firm 2's. (Remember that firm 1's output and firm 2's are the same in the symmetric information.) Since the technology set is convex, the total output in the asymmetric information is smaller than that in the symmetric information. Therefore, the consumer's surplus in the asymmetric information is also smaller than that in the symmetric information.

However, as we saw before, when the share in the government-owned input resource, $1-\alpha$ is small, the difference between firm 1's bribe and firm 2's is large. Firm 1 pays much larger bribe than firm 2 does so that firm 1's output is also much larger than firm 2's. Because of this, for some α, firm 1's profit may become large enough to improve the social welfare, i. e., for small $1-\alpha$ and small c, $W_{RS} < W_{RA}$ may hold even if the inequality is reversed as c gets larger.

4. Summary and Conclusion

In this paper, we saw the effects of governmental corruption and information structure on the performance of an economy. In the symmetric information, when the government is corrupt, the duopoly competition forces the firms to pay bribes in order to obtain the government-owned input resource. Therefore, the governmental corruption is costly from the view point of the firms. However, if it costs \$1 to raise \$1 bribe, then the difference between the social welfare under the *fair* government and that under the *rotten* government may be small since the bribe is a transfer from the firms to the government, like a lump-sum tax. For this reason, we expect that the loss in the social welfare due to the corruption is large when the bribe activity is costly and when the government-owned input resource is important in the production process. However, when the information structure is asymmetric, there is a loss in the social welfare even if the government is not corrupt. If a firm does not know whether the government is corrupt or not, then the firm pays bribe in order to avoid the situation in which the government turns out to be corrupt. In the asymmetric information, the social welfare under the *fair* government becomes even smaller than that under the *rotten* government, because of the risk averting behavior of the uninformed firm, when the potential loss from the corruption is small, i. e., when the bribe activity is not costly, and when the government-owned input resource is not important in the production process.[10)]

Under the *fair* government, the difference between the social welfare in the symmetric information and that in the asymmetric information is attributed to the loss in the profit of the uninformed firm due to its risk averting behavior. Under the *fair* government, the uninformed firm pays bribe, but the informed firm does not. Other than the difference in the bribe, the output and the price, as well as the consumer's surplus, in the asymmetric information is the same as those in the symmetric information.

Under the *rotten* government, the firms pay the same bribe and produce the same output in the symmetric information. However, in the asymmetric information, we saw that the uninformed firm's bribe is larger than the informed firm's, and the difference in the bribe results in the difference in the output and the difference in the profit. If the technology set is convex, then the total output in the asymmetric information is smaller than that in the symmetric information. Therefore, the consumer's surplus in the asymmetric information is also smaller than that in the symmetric information. For this reason, the social welfare in the asymmetric information is smaller than that in the symmetric information. In such a situation, monopoly could have been better than oligopoly because of the asymmetry in the duopoly firms.

When the asymmetry between the firms is very large, however, the profit of the uninformed firm becomes large enough to improve the social welfare so that the social welfare in the asymmetric information becomes even larger than that in the symmetric information. This may be true when the potential loss from the corruption is not large, i. e., when the bribe activity is not costly and when the government-owned input resource is not important in the production process.

In the analysis of the asymmetric information case, we saw that the informed firm's profit is smaller than the uninformed firm's, the observation known as the first mover disadvantage. One may ask, then, why not the informed firm decides not to use the information, or to inform the uninformed firm so as to eliminate the informational asymmetry since the informational advantage results in the economic disadvantage. One of the problems associated with game theoretic approach is that the outcome of a game is highly dependent on the specification of the model such as the assumption about the order of moves of players, equilibrium concepts employed, etc. For example, it is often argued that Nash equilibrium conept may generate multiple equilibria some of which are unreasonable. Or, the multiplicity of the sequential equilibrium is also well known which leads to the refinement researches such as Van Damme (1983), Cho (1987), Banks and Sobel (1987). Such multiplicity of equilibria of game theoretic approach may be used to explain the cross-country difference in the performance of economies. However, as we discussed above, the outcomes are highly dependent on which equilibrium concepts are employed, as well as on

10) This efficiency loss is similar to the one in Spence's (1973) signaling model. In the adverse selection framework, Spence showed that, even if education is not directly related to labor productivity, job seekers have to spend for education as long as employer believes that the productivity is positively related to the education.

the choice of the refinement concept. Therefore, if we proceed the research toward this direction, we need stories to justify the choice of some specific equilibrium concepts.[11)]

In the model, the *fair* government is assumed to allocate the resource equally between the firms no matter what the amount of bribe payment by each firm is. It may be possible to relate the resource allocation rule to the degree of asymmetry between the firms. For example, if one firm is more productive than the other, then more resource is given to the former. Or, the resource allocation rule may as well depend on the informational asymmetry between the firms. By explicitly specifying the preference of the government, the resource allocation rule may arise endogenously as a result of the government's optimization behavior which is related to the optimal contract design in principal-agent problems.

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11) Mailath (1988) showed that the first mover disadvantage can not be eliminated by the standard type equilibrium refinement procedures.

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