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Group Reputation, Anonymous Matching, and External Monitoring in a Model of Corruption

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Abstract

We explore what group reputation is and model its formation and evolution. Based solely on group signals, we define a player's group reputation as the belief that others have about the characteristics of the group the player belongs to. A model of group reputation of civil servants with anonymous matching and external monitoring is constructed to characterize the strategic behavior of potential bribers and civil servants, the corresponding levels of corruption, possible anti-corruption policies, and the effects of these policies. Our results indicate that as there are two types of corruption behavior of civil servants: accepting bribes and dereliction of duty, anti-corruption should work along both lines.

JEL classification: C73, D72, D83

Keywords: Group Reputation, Anonymous Matching, External Monitoring, Corruption

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... one bad apple spoils the bunch ...

1 Introduction

Reputation matters not only when players want to establish long-term relationship with others, but also in various one-shot interactions, policy makings, and institutional setups. The issue of individual reputation is well studied. But in the real world, people often make decisions based on the group reputation of unfamiliar persons. How does group reputation form and evolve? What effects does group reputation have on social activities?

The starting point of the reputation model is incomplete information, which induces either adverse selection, moral hazard, or both. Tirole (1996) is the first attempt to model the idea of group reputation as an aggregate of individual reputations. Due to group pooling (individual players' unknown ages and imperfect signals of players' history records), individual reputations relate to group reputation; and the new members may suffer from the original sin of their elders. Levin (2001) adopts a similar idea that a player cannot be perfectly distinguished from others and argues that peers' past behaviors affect players' record of performance. Both papers focus on individual reputation and do not clarify the difference between individual reputation and group reputation.

A big problem is that one can get a group's reputation with receiving any information about a specific individual in the group. In this paper, we define Individual Reputation and Group Reputation as follows:

> A player A_i's **individual reputation** to do X with respect to some others P_j is the belief of P_j on the type or behavior of A_i to do X.[1]
>
> Group G_k's **group reputation** to do X with respect to P_j is the belief of P_j on the type or behavior of any player $A_s \in G_k$, to whom P_j does not have individual information, to do X.

According to this definition, we divide group G_k into two separate subgroups: players whom P_j is familiar with (P_j has additional individual signals on these players), players whom P_j is not familiar with. For players belonging to the first subgroup, each player's individual reputation with respect to P_j may vary upon the individual signals P_j has. But for players belonging to the second subgroup, each player's individual reputation with respect to P_j is same as the group reputation because P_j does not have additional individual signals on these players.

[1] According to Hardin (1993), trust is a three-part relationship: A trust B to do X. Similarly, reputation is also a three-part relationship: B's reputation to do X with respect to A is A's belief on the type or behavior of B to do X.

For a sufficiently large group, it is safe to say that there are always some players within the group unfamiliar to some others P_j. If indeed P_j is familiar with everyone in a group G_k, we can define the group reputation of G_k with respect to P_j as follows: imagining if there were a player who belongs to G_k but P_j does not have individual information regarding to this player, what is his individual reputation? And this represents the group reputation.

In other words, a player's group reputation is the belief others have about the characteristics of the player's group, which is based solely on group signals. A player's individual reputation is derived from his group reputation by adding individual signals. In this paper, a model of group reputation of civil servants is constructed to characterize the strategic behavior of potential bribers and civil servants, the corresponding levels of corruption, possible anti-corruption policies, and the effects of these policies.

According to Bardhan (1997), the definition of corruption is "the use of public office for private gains, where an official (the agent) entrusted with carrying out a task by the public (the principal) engages in some sort of malfeasance for private enrichment which is difficult to monitor for the principal". Most current literature on corruption focuses on the principal-agent relationship between officials and the government, in which the officials delegate the government to allocate some scarce resources.

In this paper, we focus on two types of corruption behavior of civil servants: accepting bribes and dereliction of duty. Civil servants have the right to examine and approve some project of the private agents by some criteria, such as the road test for a driver license. The civil servants could belong to the type of "good", "bad", or "opportunist". The good type always rejects bribes and implements fair tests. The bad type always accepts bribes and intentionally places obstacles during the tests if there is no bribe. And the opportunist type will weigh the advantages and disadvantages to decide whether to accept bribes or intentionally place obstacles during the tests if there is no bribe. Since a private agent does not know the true type of a civil servant, he will decide whether or not to offer a bribe according to the current group reputation of the civil servants.

The reason to focus on these two types of corruption is that bribes accepted by civil servants are actually "protection money" to prevent them from dereliction of duty, which is different from the "grease money" as in the corruption on allocating scarce resources. The former is more closely linked to the civilians. And the result of this type of corruption is much more severe because "protection money" directly affect the welfare of the civilians. The corruption related to "grease money" only affect the welfare of the civilians indirectly through embezzling the public resources by the officials and the bribers. In some cases, "grease money" even could reduce the inefficiency in public administration. For instance, Lui (1985) argues "the server could choose to speed up the services when briber is allowed" and as a result the outcome is socially optimal.

There are several related strands of literature. The first is on individual reputation. Holmstrom (1999) investigates the dynamic incentive problem – the agent has the strongest incentive to work hard to reveal his managerial ability. As time goes by, his ability is learned, and thus the reputation effect on incentive also decreases. Kreps and Wilson (1982), Milgrom and Roberts (1982), Fudenberg and Levine (1989), Ely, Fudenberg and Levine (2004), and many others investigate the settings of a single long-run player and a sequence of short-run opponents – the long-run player tries to commit to some type to achieve highest possible utility. Hörner (2002) introduces competition to keep high efforts sustainable.

The second is on statistical discrimination. Because agents cannot perfectly signal their characteristics, the multiplicity of equilibria becomes possible as the possibility of a differential treatment of agents based on some observable characteristics. Cornell and Welch (1996) develop a model on "screening discrimination" merely based on "unfamiliarity", which makes it more difficult to make accurate assessments. Fang (2001) shows that by allowing the firm to give preferential treatment to workers based on some "cultural activity", the society can partially overcome the informational free-riding problem. The critique on the statistical discrimination theory is that it is a static theory, which does not say much about reputation formation and its persistence.

For the dynamic reputation model, Diamond (1989) constructs a model in debt markets. His key point is that as time goes by, bad type drops out, which drives up the reputation for the remaining agents.

The paper is structured as follows. Section 2 describes the basic model and establishes the conditions for the possible steady states. Section 3 provides the dynamic analysis and studies the effectiveness of one time anti-corruption policy. Section 4 concludes.

2 Model

2.1 Basic Settings

In this section, we develop a model in which there exist a benevolent government, a group of social servants, and a large number of private agents. The benevolent government selects and supervises social servants who delegate the government to examine and approve some projects of the private agents by some criterion.

The civil servants could be the type of "good", "bad", or "opportunist", denoted as type "G", "B", "BG" respectively. The good type "G" always rejects bribes and implement fair tests. The bad type "B" always accepts bribes if there are any and intentionally place obstacles during the tests if there is no bribe. And the opportunist type "BG" will weigh the advantage and disadvantage to decide whether to accept bribes or intentionally place obstacles during the tests if there is no bribe. Because the behavior for the type "G", "B" is fixed, we only need to study the strategic behavior of the "opportunist" type "BG".

If a civil servant accepts a bribe, there is probability $\alpha \in (0, 1)$ he will be detected and removed from the office by the government. If a civil servant intentionally places obstacles during a test, there is probability $\gamma \in (0, 1)$ he will be detected and removed from the office by the government. Thus, there are two types of corruption behavior for the civil servants: accepting bribes and dereliction of duty. And (α, γ) represents the supervision effort level of the government regarding to these two types of corruption behavior.

The civil servants alive in date t remain in the economy in date $t+1$ with probability $\lambda \in (0, 1)$. We assume that each quit is offset by the arrival of a new civil servant selected by the government from a population with proportion of the three types "G", "B", "BG": f_G, f_B, f_{BG}. So the size of the civil servants remains constant.

At the beginning of each period, a number of private agents is selected by the government to get their projects tested. Each private agent included in the tests will decide to offer a bribe or not to the civil servant who is assigned to test his project. Then the civil servants will decide to reject or accept bribes if there are any. If there is no bribe, the civil servants will decide to implement fair tests or intentionally place obstacles during the tests. The timing of the model in any arbitrary period t is summarized in the figure below.

Figure 1: Timing in period t

In period t, the expected utility of each private agent included in the tests from offering a bribe and not offering a bribe are as follows:

$$U_t^b = P_{A,t}[\mu_G(1-\alpha)X - C] + (1 - P_{A,t})[\mu_G X - \eta C]$$
$$U_t^n = P_{B,t}[\mu_B X] + (1 - P_{B,t})[\mu_G X]$$

where $P_{A,t}$ is the probability that the civil servant he meets will accept a bribe if there is any; and $P_{B,t}$ is the probability that the civil servant he meets will intentionally place obstacles during the test if there is no bribe.[2] μ_G is the probability of the

[2] $\{P_{A,t}, P_{B,t}\}$ represents the group reputation of the civil servants in period t, which is the belief

project being approved under a fair test. μ_B is the probability of the project being approved under an unfair test. X is benefit from an approved project. C is the cost of bribe.[3] $\eta \in (0, 1)$ is the share of loss on a bribe if it is rejected.

The private agent will not offer a bribe at the beginning of period t if $U_t^b \leq U_t^n$. That is,

$$P_{B,t}[(\mu_G - \mu_B)X] \leq \eta C + P_{A,t}[(1-\eta)C + \alpha\mu_G X] \tag{1}$$

In period t, if there is a bribe, the utility of the "opportunist" type "BG" civil servant from rejecting it and accepting it are as follows:

$$V_t^R = Y + \delta\lambda V_{t+1}$$
$$V_t^A = Y + C + \delta(1-\alpha)\lambda V_{t+1} - \Gamma(P_{A,t})$$

where Y is the wage of the civil servant in each period. $\delta \in (0, 1)$ is the discount factor. V_{t+1} is the continuation payoff in period $t+1$. $\Gamma(P_{A,t})$ is the cost from accepting a bribe, which is a decreasing function of $P_{A,t}$.[4]

So, the "opportunist" type "BG" civil servant will reject bribes in period t if $V_t^R \geq V_t^A$. That is,

$$\delta\alpha\lambda V_{t+1} \geq C - \Gamma(P_{A,t}) \tag{2}$$

The utility of the "opportunist" type "BG" civil servant in period t from implementing a fair test or intentionally placing obstacles during the test if there is no bribe are as follows:

$$V_t^G = Y + \delta\lambda V_{t+1}$$
$$V_t^B = Y + \delta(1-\gamma)\lambda V_{t+1}$$

Since $V_t^G \geq V_t^B$, the "opportunist" type "BG" civil servant will always implement fair tests no matter the private agent offers bribes or not. The logic behind is that even though the "opportunist" type "BG" civil servants may accept bribes, they are still not so "bad" as the bad type "B" civil servants are. They are not willing to harm others while not benefit themselves.

In this paper, we focus on the symmetric equilibrium. For simplicity, we assume that the number of civil servants and private agents are so large that in each period the pairs of the civil servants and private agents who have matched before are relatively small. Thus, the effect of re-match could be omitted upon updating the private

of the private agents on the two types of corruption behavior of the civil servants: accepting bribes and dereliction of duty.

[3]Here, we assume the size of bribe fixed. Later, we may incorporate the endogenous size of bribe.

[4]We assume that the "opportunist" type "BG" civil servant who accepts bribes will suffer some cost. It may be due to the secrecy of bribery behavior and mental burden of pursuing private gains by using public office. And this cost will decrease as accepting bribe becomes a general mood of the society.

agents' belief of the entire group of civil servants, which is the group reputation for the entire group of civil servants.[5] If indeed re-match occurs, then the private agent in this re-match will update the belief on the civil servant in this re-match based on the current group belief and the history record of this civil servant, which is the individual reputation of this civil servant.

Now, we need to characterize the evolution of proportions of the three types of civil servants as time goes by. Denote $f_{G,t}$, $f_{B,t}$, $f_{BG,t}$ as the fractions of "G", "B", "BG" type of civil servants respectively in period t. Then $\{f_{B,t}, f_{BG,t}, f_{G,t}\}$ represents the state of the economy in period t. In period $t+1$, the transition of the state of the economy is described in the following three cases, depending on the actions chosen by the private agents and the "opportunist" type "BG" civil servants in period t.

Case 1: private agents NOT offering bribes in period t

$$\begin{aligned} f_{G,t+1} &= \lambda f_{G,t} + [(1-\lambda) + \lambda\gamma f_{B,t}]f_G \\ f_{BG,t+1} &= \lambda f_{BG,t} + [(1-\lambda) + \lambda\gamma f_{B,t}]f_{BG} \\ f_{B,t+1} &= \lambda(1-\gamma) f_{B,t} + [(1-\lambda) + \lambda\gamma f_{B,t}]f_B \end{aligned} \tag{3}$$

Case 2: private agents offering bribes and the "opportunist" type "BG" civil servants rejecting the bribes in period t

$$\begin{aligned} f_{G,t+1} &= \lambda f_{G,t} + [(1-\lambda) + \lambda\alpha f_{B,t}]f_G \\ f_{BG,t+1} &= \lambda f_{BG,t} + [(1-\lambda) + \lambda\alpha f_{B,t}]f_{BG} \\ f_{B,t+1} &= \lambda(1-\alpha) f_{B,t} + [(1-\lambda) + \lambda\alpha f_{B,t}]f_B \end{aligned} \tag{4}$$

Case 3: private agents offering bribes and the "opportunist" type "BG" civil servants accepting the bribes in period t

$$\begin{aligned} f_{G,t+1} &= \lambda f_{G,t} + [(1-\lambda) + \lambda\alpha (f_{B,t} + f_{BG,t})]f_G \\ f_{BG,t+1} &= \lambda(1-\alpha) f_{BG,t} + [(1-\lambda) + \lambda\alpha (f_{B,t} + f_{BG,t})]f_{BG} \\ f_{B,t+1} &= \lambda(1-\alpha) f_{B,t} + [(1-\lambda) + \lambda\alpha (f_{B,t} + f_{BG,t})]f_B \end{aligned} \tag{5}$$

Since only the "bad" type "B" civil servant will intentionally place obstacles during the tests if there is no bribe, $P_{B,t} = f_{B,t}$. For the symmetric equilibrium, either only the "bad" type "B" civil servant will accept bribes or both the "bad" type "B" civil servant and the "opportunist" type "BG" civil servant will accept bribes if there are any. That is to say, either $P_{A,t} = f_{B,t}$ or $P_{A,t} = f_{B,t} + f_{BG,t}$.

2.2 Steady States

In this section, we analyze the four possible steady states and their feasible conditions.

[5] In other words, the setting of our model is equivalent to the setting of a group of long-run players and a sequence of short-run opponents.

2.2.1 Low Corruption Steady State I (LCSS-I)

The first one is Low Corruption Steady State I (LCSS-I), in which the private agents do not offer bribes and the "opportunist" type "BG" civil servants reject bribes if there are any. By equation 3, we can derive the proportions of three types of civil servants at LCSS-I, denoted as $\underline{f_G^I}$, $\underline{f_B^I}$, $\underline{f_{BG}^I}$.

$$\begin{aligned} \underline{f_G^I} &= \frac{1-\lambda+\lambda\gamma}{1-\lambda+\lambda\gamma(1-f_B)} f_G \\ \underline{f_{BG}^I} &= \frac{1-\lambda+\lambda\gamma}{1-\lambda+\lambda\gamma(1-f_B)} f_{BG} \\ \underline{f_B^I} &= \frac{1-\lambda}{1-\lambda+\lambda\gamma(1-f_B)} f_B \end{aligned}$$

The utility for the "opportunist" type "BG" civil servant at LCSS-I, denoted as V_L, is

$$V_L = Y + \delta\lambda V_L \Longrightarrow V_L = \frac{1}{1-\delta\lambda} Y$$

At LCSS-I, $P_{B,t} = P_{A,t} = \underline{f_B^I}$. Back to inequality 1 and 2, to induce a private agent not to offer a bribe and an "opportunist" type "BG" civil servant reject a bribe if there is any, the following conditions must hold.

Feasible Conditions of LCSS-I:

$$\begin{aligned} &(1-\delta\lambda)\Gamma(\underline{f_B^I}) \geq (1-\delta\lambda)C - \delta\alpha\lambda Y \\ &\underline{f_B^I}[(\mu_G - \mu_B)X] \leq \eta C + \underline{f_B^I}[(1-\eta)C + \alpha\mu_G X] \end{aligned}$$

2.2.2 Low Corruption Steady State II (LCSS-II)

The second steady state is Low Corruption Steady State II (LCSS-II), in which the private agents do not offer bribes and the "opportunist" type "BG" civil servants accept bribes if there are any. By equation 3, we can derive the proportions of three types of civil servants at LCSS-II. Because the private agents do not offer bribes, the proportions of three types of civil servants at LCSS-II are same as the proportions of three types of civil servants at LCSS-I.

Same logic, the utility for the "opportunist" type "BG" civil servant at LCSS-II is same as the utility for the "opportunist" type "BG" civil servant at LCSS-I, V_L.

At LCSS-II, $P_{B,t} = \underline{f_B^I}$, and $P_{A,t} = \underline{f_B^I} + \underline{f_{BG}^I}$. Back to inequality 1 and 2, to induce a private agent not to offer a bribe and an "opportunist" type "BG" civil servant accept a bribe if there is any, the following conditions must hold.

Feasible Conditions of LCSS-II:

$$(1-\delta\lambda)\Gamma(\underline{f_B^I}+\underline{f_{BG}^I}) < (1-\delta\lambda)C - \delta\alpha\lambda Y$$
$$\underline{f_B^I}[(\mu_G-\mu_B)X] \leq \eta C + (\underline{f_B^I}+\underline{f_{BG}^I})[(1-\eta)C+\alpha\mu_G X]$$

2.2.3 Low Corruption Steady State III (LCSS-III)

The third steady state is Low Corruption Steady State III (LCSS-III), in which the private agents offer bribes and the "opportunist" type "BG" civil servants reject bribes if there are any. By equation 3, we can derive the proportions of three types of civil servants at LCSS-III, denoted as $\underline{f_G^{III}}$, $\underline{f_B^{III}}$, $\underline{f_{BG}^{III}}$.

$$\underline{f_G^{III}} = \frac{1-\lambda+\lambda\alpha}{1-\lambda+\lambda\alpha(1-f_B)} f_G$$
$$\underline{f_{BG}^{III}} = \frac{1-\lambda+\lambda\alpha}{1-\lambda+\lambda\alpha(1-f_B)} f_{BG}$$
$$\underline{f_B^{III}} = \frac{1-\lambda}{1-\lambda+\lambda\alpha(1-f_B)} f_B$$

Due the the rejection of the bribe, the utility for the "opportunist" type "BG" civil servant at LCSS-III is the same as the utility for the "opportunist" type "BG" civil servant at LCSS-I and LCSS-II, V_L.

At LCSS-III, $P_{B,t} = P_{A,t} = \underline{f_B^{III}}$. Back to inequality 1 and 2, to induce a private agent offer a bribe and an "opportunist" type "BG" civil servant reject a bribe if there is any, the following conditions must hold.

Feasible Conditions of LCSS-III:

$$(1-\delta\lambda)\Gamma(\underline{f_B^{III}}) \geq (1-\delta\lambda)C - \delta\alpha\lambda Y$$
$$\underline{f_B^{III}}[(\mu_G-\mu_B)X] > \eta C + \underline{f_B^{III}}[(1-\eta)C+\alpha\mu_G X]$$

2.2.4 High Corruption Steady State (HCSS)

The last possible steady state is High Corruption Steady State (HCSS), in which the private agents offer bribes and the "opportunist" type "BG" civil servants accept bribes if there are any. By equation 3, we can derive the proportions of three types of civil servants at HCSS, denoted as $\overline{f_G}$, $\overline{f_{BG}}$, $\overline{f_B}$.

$$\begin{aligned}
\overline{f_G} &= \frac{1-\lambda+\lambda\alpha}{1-\lambda+\lambda\alpha(1-f_B-f_{BG})} f_G \\
\overline{f_{BG}} &= \frac{1-\lambda}{1-\lambda+\lambda\alpha(1-f_B-f_{BG})} f_{BG} \\
\overline{f_B} &= \frac{1-\lambda}{1-\lambda+\lambda\alpha(1-f_B-f_{BG})} f_B
\end{aligned}$$

At HCSS, $P_{B,t} = \overline{f_B}$, and $P_{A,t} = \overline{f_{BG}} + \overline{f_B}$. The utility for the "opportunist" type "BG" civil servant at HCSS, denoted as V_H, is

$$\begin{aligned}
V_H &= Y + C - \Gamma(\overline{f_{BG}} + \overline{f_B}) + \delta\lambda(1-\alpha)V_H \\
\Longrightarrow V_H &= \frac{1}{1-\delta\lambda(1-\alpha)}(Y + C - \Gamma(\overline{f_{BG}} + \overline{f_B}))
\end{aligned}$$

Back to inequality 1 and 2, to induce a private agent to offer a bribe and an "opportunist" type "BG" civil servant accept a bribe if there is any, the following conditions must hold.

Feasible Conditions of HCSS:

$$\begin{aligned}
&(1-\delta\lambda)\Gamma(\overline{f_{BG}} + \overline{f_B}) < (1-\delta\lambda)C - \delta\alpha\lambda Y \\
&\overline{f_B}[(\mu_G - \mu_B)X] > \eta C + (\overline{f_{BG}} + \overline{f_B})[(1-\eta)C + \alpha\mu_G X]
\end{aligned}$$

3 Dynamic Analysis and Anti-Corruption

In this section, we analyze the dynamical situation if the economy in period t is currently at some arbitrary state: $\{f_{B,t}, f_{BG,t}, f_{G,t}\}$. Then we discuss the effectiveness of possible anti-corruption policies.

3.1 Dynamic Analysis

Proposition 1 *Suppose in period t the economy is currently at some state: $\{f_{B,t}, f_{BG,t}, f_{G,t}\}$. There are only four possible areas of the state space.*

> ***Low corruption area I (L-I):*** *in period t, private agents will not offer bribes and the "opportunist" type "BG" civil servants will reject bribes if there are any. The transition of the state of the economy from period t to period $t+1$ follows equations 3.*
>
> ***Low corruption area II (L-II):*** *in period t, private agents will not offer bribes and the "opportunist" type "BG" civil servants will accept*

bribes if there are any. The transition of the state of the economy from period t to period $t+1$ follows equations 3.

Low corruption area III (L-III): *in period t, private agents will offer bribes and the "opportunist" type "BG" civil servants will reject bribes if there are any. The transition of the state of the economy from period t to period $t+1$ follows equations 4.*

High corruption area (H): *in period t, private agents will offer bribes and the "opportunist" type "BG" civil servants will accept bribes if there are any. The transition of the state of the economy from period t to period $t+1$ follows equations 5.*

i) *If $f_{B,t} \leq \min\{f_B^*, f_B^{**}\}$, $f_{B,t} \in$ L-I.*

ii) *If $f_B^* < f_{B,t} \leq f_B^{**}$, $f_{B,t} \in$ L-III.*

iii) *If $f_B^{**} < f_{B,t} \leq f_B^*$ and $f_{BG,t} \geq f_{BG}^*(f_{B,t})$, $f_{B,t} \in$ L-I or L-II.*

iv) *If $\max\{f_B^*, f_B^{**}\} < f_{B,t}$ and $f_{BG,t} \geq f_{BG}^*(f_{B,t})$, $f_{B,t} \in$ L-II or L-III.*

v) *If $f_{B,t} > f_B^{**}$ and $f_{BG,t} < f_{BG}^*(f_{B,t})$, $f_{B,t} \in$ or L-III or H.*

where $f_B^*, f_B^{**}, f_{BG}^*(f_B)$ are the solutions of the following equations.[6]

$$f_B^*[(\mu_G - \mu_B)X] = \eta C + f_B^*[(1-\eta)C + \alpha\mu_G X] \tag{6}$$

$$(1-\delta\lambda)\Gamma(f_B^{**}) = (1-\delta\lambda)C - \delta\alpha\lambda Y \tag{7}$$

$$f_{BG}^*(f_B) = -\frac{\eta C}{(1-\eta)C + \alpha\mu_G X} + \frac{(\mu_G - \mu_B)X - [(1-\eta)C + \alpha\mu_G X]}{(1-\eta)C + \alpha\mu_G X} f_B \tag{8}$$

Proof. See the Appendix. ■

Figure 2 sketches out the state space partition in the case of $f_B^{**} > f_B^*$ and $(\mu_G - \mu_B)X - [(1-\eta)C + \alpha\mu_G X] > 0$.[7] Figure 3 sketches out the state space partition in the case of $f_B^{**} \leq f_B^*$ and $(\mu_G - \mu_B)X - [(1-\eta)C + \alpha\mu_G X] > 0$. Figure 4 sketches out the state space partitions in the case of $(\mu_G - \mu_B)X - [(1-\eta)C + \alpha\mu_G X] \leq 0$. In the last case, both Low corruption area III (L-III) and High corruption area (H) disappear.[8]

[6] f_B^* and f_B^{**} must be in between 0 and 1. If the solutions of equation 6 and/or equation 7 out of this range, we say f_B^* and/or f_B^{**} do not exist.

[7] Note, in this case, $f_{BG}^*(f_B^*) = 0$. Thus, the extended line of $f_{BG}^*(f_{B,t})$ will go through the point $(f_{B,t} = f_B^*, f_{BG,t} = 0)$.

[8] In this case, f_B^* is negative. Since the solution of equation 6 has negative solution, this means private agents never offer bribes.

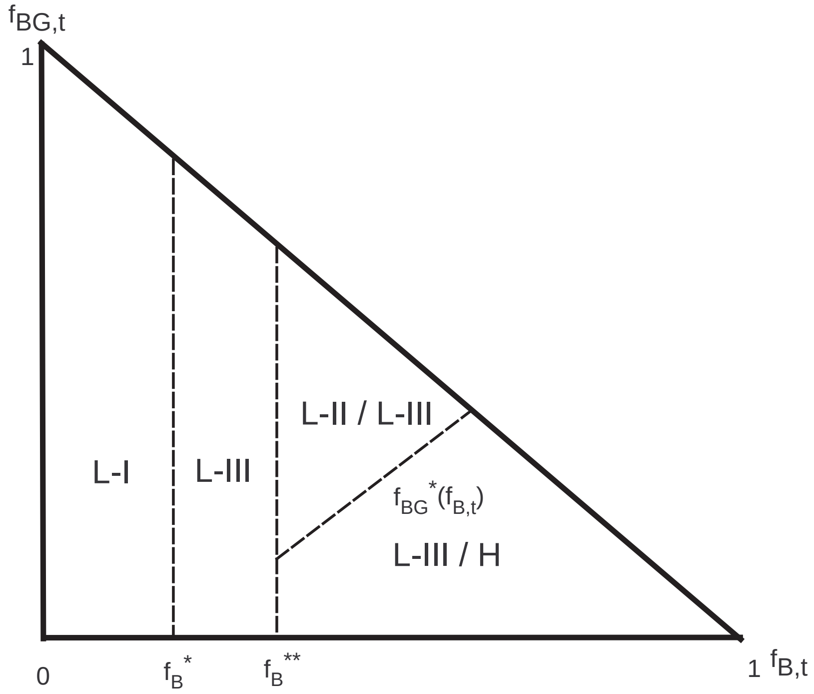

Figure 2: $f_B^{**} > f_B^*$ and $(\mu_G - \mu_B)X - [(1-\eta)C + \alpha\mu_G X] > 0$

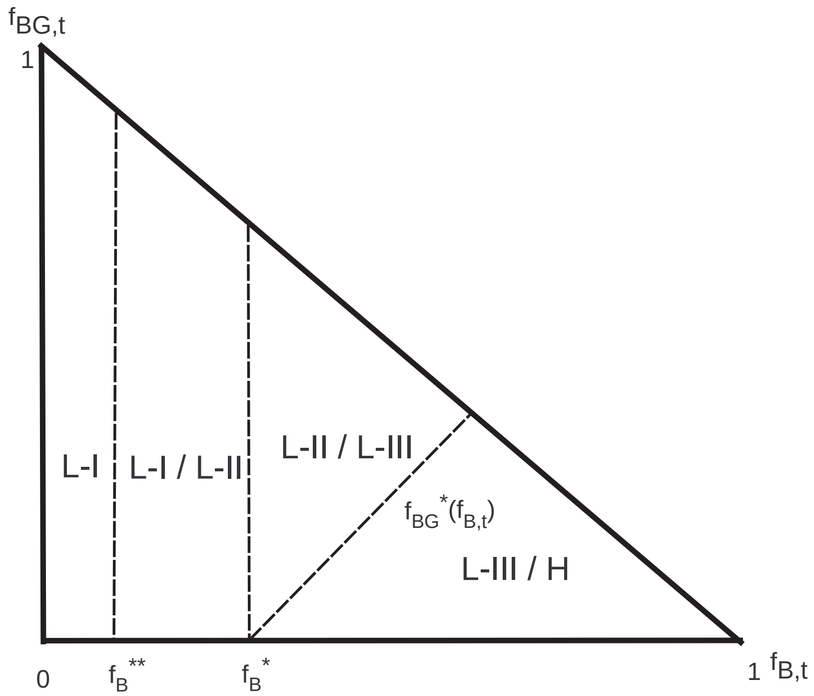

Figure 3: $f_B^{**} \leq f_B^*$ and $(\mu_G - \mu_B)X - [(1-\eta)C + \alpha\mu_G X] > 0$

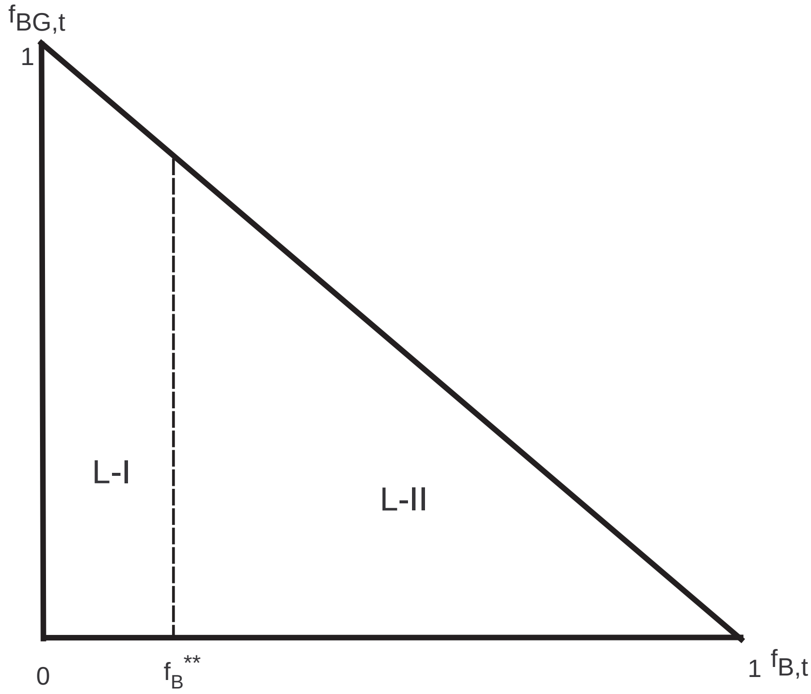

Figure 4: $(\mu_G - \mu_B)X - [(1-\eta)C + \alpha\mu_G X] \leq 0$

There are some more minor variations of the state space partitions depending on the values of $f_B^*, f_B^{**}, f_{BG}^*(f_B)$. But the basic shapes are described as in figure 2 to 4.

After discussing the transition of the state in period $t+1$, the natural extension is to characterize the long run properties, that is, whether the economy can converge to some steady state. From proposition 1, we have the following corollary.

Corollary 1 *Low Corruption Steady State I (LCSS-I) is feasible if* $\{\underline{f_G^I}, \underline{f_B^I}, \underline{f_{BG}^I}\}$ *is in the Low corruption area I (L-I). Similarly, Low Corruption Steady State II (LCSS-II) is feasible if* $\{\underline{f_G^I}, \underline{f_B^I}, \underline{f_{BG}^I}\}$ *is in the Low corruption area II (L-II); Low Corruption Steady State III (LCSS-III) is feasible if* $\{\underline{f_G^{III}}, \underline{f_B^{III}}, \underline{f_{BG}^{III}}\}$ *is in the Low corruption area III (L-III); High Corruption Steady State (HCSS) is feasible if* $\{\overline{f_G}, \overline{f_{BG}}, \overline{f_B}\}$ *is in the High corruption area (H).*

Further, if a steady state is feasible and the economy is currently at some state in the same area of this steady state, the economy will converge to this steady state.

Proof. See the Appendix. ■

In the long run, if no steady state is feasible, then the state of the economy will fluctuate back and forth among these four possible areas of state space. Even in the case that some steady state is feasible, the state of the economy may not converge to it.

For instance, suppose the state space partition is described in figure 1 and Low Corruption Steady State I (LCSS-I) is in the the Low corruption area III (L-III) and Low Corruption Steady State III (LCSS-III) is in the the Low corruption area I (L-I). In period t, if $\{f_{B,t}, f_{BG,t}, f_{G,t}\}$ is in the Low corruption area I (L-I), the transition of the state of the economy from period t to period $t+1$ still follows equations 3 and it will be on the path of converging to the Low Corruption Steady State I (LCSS-I). But once it crosses the boundary of the Low corruption area I (L-I) and goes into the Low corruption area III (L-III), the transition of the state of the economy will follow equations 4 and will be on the path of converging to the Low Corruption Steady State III (LCSS-III) and go back to the Low corruption area I (L-I). The state of the economy will fluctuate back and forth between the Low corruption area I (L-I) and the Low corruption area III (L-III). In this case, if High Corruption Steady State (HCSS) is in the High corruption area (H), the state of the economy may not converge to it even though it is feasible. Thus, we have the following corollary.

Corollary 2 *In the long run, the state of the economy may not converge to any steady state, even in the case that some steady state is feasible.*

3.2 One Time Anti-Corruption

In this section, we assume that the economy currently suffers from high level corruption, i.e., the economy is at the High Corruption Steady State (HCSS) or fluctuating in between the High corruption area (H) and some Low corruption area. The government introduces a one time anti-corruption policy, aiming to lead to a low corruption level permanently.

One time anti-corruption policy means a combination of new level of supervision effort $\{\alpha_t, \gamma_t\}$ in period t. And it only lasts one period. After period t, the supervision effort goes back to the original level. We say a one time anti-corruption policy is effective if after period t the economy converges to some Low Corruption Steady State or fluctuates in between some Low corruption areas.

Proposition 2 *One time anti-corruption policy may or may not be effective depending on the environment of the economy.*

i) *In the case when there does not exist one time anti-corruption policy to effectively turn around the high level corruption, the government must introduce a permanent anti-corruption policy, i.e., permanently adjusting the level of supervision effort.*

ii) *In the case when there exists one time anti corruption policy to effectively turn around the high level corruption, when the government sets a one time anti-corruption policy, not only does it have to increase the supervision effort on detecting the bribery behavior (α), but also it needs to consider the the supervision* *effort on detecting the behavior of intentionally placing obstacles (dereliction of duty) during the test (γ). Anti-corruption should work along both lines.*

Proof. See the Appendix. ■

3.3 Re-match

Since we assume that the number of civil servants and private agents are so large that in each period the pairs of the civil servants and private agents who have matched before are relatively small. Thus, the effect of re-match could be omitted upon updating the private agents' belief of the entire group of civil servants, which is the group reputation for the entire group of civil servants as we have discussed so far.

If indeed re-match occurs, then the private agent in this re-match will update the belief on the civil servant in this re-match based on the current group belief and the history record of this civil servant, which is the individual reputation of this civil servant.

For instance, if the the civil servant has rejected this private agent's bribe before, the private agent will not offer a bribe because he knows that this civil servant is "G" type. If the civil servant has intentionally placed obstacles during the test before, the private agent knows that this civil servant is "B" type. He is more likely to offer a bribe to keep this civil servant from intentionally placing obstacles during the test.

4 Conclusion

This paper presents a group reputation model of corruption. Based solely on group signals, we define a player's group reputation as the belief that others have about the characteristics of the player's group. A player's individual reputation is derived from his group reputation by adding individual signals. Then a model of group reputation of civil servants is constructed to characterize the strategic behavior of potential bribers and civil servants. We analyze the four possible steady states and their feasible conditions, provide dynamic analysis and study the effectiveness of one time anti-corruption policy. We show that one time anti-corruption policy may or may not be effective in successfully overturning the high corruption steady state depending on the economic environment.

In the case when there does not exist one time anti-corruption policy to effectively turn around the high level corruption, the government must introduce a permanent anti-corruption policy, i.e., permanently adjusting the level of supervision effort. In the case when there exists one time anti corruption policy to effectively turn around the high level corruption, then when the government sets a one time anti-corruption policy, not only does it have to increase the supervision effort on detecting the bribery behavior (α), but also it needs to consider the the supervision effort on detecting the behavior of intentionally placing obstacles (dereliction of duty) during the test (γ). Anti-corruption should work along both lines.

Finally, we assume the effect of re-match could be omitted upon updating the private agents' belief of the entire group of civil servants. This simplifies the model a lot. If we relax this assumption, we may get much richer dynamic scenarios on the interactions between group reputation and individual reputation.

Appendix

Proof of Proposition 1

i) If $f_{B,t} \leq \min\{f_B^*, f_B^{**}\}$, $f_{B,t} \in$ L-I.

Since the continuation payoff of the civil servants is bounded below by $V_L = \frac{1}{1-\delta\lambda}Y$, if $f_{B,t} \leq \min\{f_B^*, f_B^{**}\}$, by equation 7, we have

$$\delta\alpha\lambda V_{t+1} \geq \delta\alpha\lambda\frac{1}{1-\delta\lambda}Y = C - \Gamma(f_B^{**}) \geq C - \Gamma(f_{B,t})$$

By inequality 2, this means in period t the "opportunist" type "BG" civil servants will reject bribes if there are any.[9] By equation 6, we have

$$f_{B,t}[(\mu_G - \mu_B)X] \leq \eta C + f_{B,t}[(1-\eta)C + \alpha\mu_G X]$$

By inequality 1, private agents in period t will not offer bribes. The transition of the state of the economy from period t to period $t+1$ follows equations 3.

ii) If $f_B^* < f_{B,t} \leq f_B^{**}$, $f_{B,t} \in$ L-III.

Similar to the proof before, since the continuation payoff of the civil servants is bounded below by $V_L = \frac{1}{1-\delta\lambda}Y$, if $f_B^* < f_{B,t} \leq f_B^{**}$, by equation 7 we have

$$\delta\alpha\lambda V_{t+1} \geq \delta\alpha\lambda\frac{1}{1-\delta\lambda}Y = C - \Gamma(f_B^{**}) \geq C - \Gamma(f_{B,t})$$

By inequality 2, this means in period t the "opportunist" type "BG" civil servants will reject bribes if there are any.[10]

By equation 6, we have

$$f_{B,t}[(\mu_G - \mu_B)X] > \eta C + f_{B,t}[(1-\eta)C + \alpha\mu_G X]$$

[9] Similar to the multiple equilibria issue in the coordination game, there could be another equilibrium, in which the "opportunist" type "BG" civil servants will accept bribes if there are any.

[10] Same as the multiple equilibria issue in the coordination game, there could be another equilibrium, in which the "opportunist" type "BG" civil servants will accept bribes if there are any.

By inequality 1, private agents in period t will offer bribes. The transition of the state of the economy from period t to period $t+1$ follows equations 4.

iii) If $f_B^{**} < f_{B,t} \leq f_B^*$ and $f_{BG,t} \geq f_{BG}^*(f_{B,t})$, $f_{B,t} \in$ L-I or L-II.

Since $f_B^{**} < f_{B,t}$, we do not have a definite answer whether the "opportunist" type "BG" civil servants will accept or reject bribes in period t. There are two possible situations.

First, if the continuation payoff of the civil servants V_{t+1} is small such that

$$\delta\alpha\lambda V_{t+1} < C - \Gamma(f_{B,t})$$

by inequality 2, this means in period t the "opportunist" type "BG" civil servants will accept bribes if there are any. If $f_{BG,t} \geq f_{BG}^*(f_{B,t})$, by equation 8, we have

$$f_{B,t}[(\mu_G - \mu_B)X] \leq \eta C + (f_{B,t} + f_{BG,t})[(1-\eta)C + \alpha\mu_G X]$$

By inequality 1, private agents in period t will not offer bribes. The transition of the state of the economy from period t to period $t+1$ follows equations 3. Thus, in this case, $f_{B,t} \in$ L-II.

Second, if the continuation payoff of the civil servants V_{t+1} is large such that

$$\delta\alpha\lambda V_{t+1} \geq C - \Gamma(f_{B,t})$$

by inequality 2, this means in period t the "opportunist" type "BG" civil servants will reject bribes if there are any. If $f_{B,t} \leq f_B^*$, by equation 6, we have

$$f_{B,t}[(\mu_G - \mu_B)X] \leq \eta C + f_{B,t}[(1-\eta)C + \alpha\mu_G X]$$

By inequality 1, private agents in period t will not offer bribes. The transition of the state of the economy from period t to period $t+1$ follows equations 3. Thus, in this case, $f_{B,t} \in$ L-I.

iv) If $\max\{f_B^*, f_B^{**}\} < f_{B,t}$ and $f_{BG,t} \geq f_{BG}^*(f_{B,t})$, $f_{B,t} \in$ L-II or L-III.

Similar to the proof before, since $f_B^{**} < f_{B,t}$, we do not have a definite answer whether the "opportunist" type "BG" civil servants will accept or reject bribes in period t. There are two possible situations.

First, if the continuation payoff of the civil servants V_{t+1} is small such that

$$\delta\alpha\lambda V_{t+1} < C - \Gamma(f_{B,t})$$

by inequality 2, this means in period t the "opportunist" type "BG" civil servants will accept bribes if there are any. If $f_{BG,t} \geq f_{BG}^*(f_{B,t})$, by equation 8, we have

$$f_{B,t}[(\mu_G - \mu_B)X] \leq \eta C + (f_{B,t} + f_{BG,t})[(1-\eta)C + \alpha\mu_G X]$$

By inequality 1, private agents in period t will not offer bribes. The transition of the state of the economy from period t to period $t+1$ follows equations 3. Thus, in this case, $f_{B,t} \in$ L-II.

Second, if the continuation payoff of the civil servants V_{t+1} is large such that

$$\delta\alpha\lambda V_{t+1} \geq C - \Gamma(f_{B,t})$$

by inequality 2, this means in period t the "opportunist" type "BG" civil servants will reject bribes if there are any. If $f_{B,t} > f_B^*$, by equation 6, we have

$$f_{B,t}[(\mu_G - \mu_B)X] > \eta C + f_{B,t}[(1-\eta)C + \alpha\mu_G X]$$

By inequality 1, private agents in period t will offer bribes. The transition of the state of the economy from period t to period $t+1$ follows equations 4. Thus, in this case, $f_{B,t} \in$ L-III.

v) If $f_{B,t} > f_B^{**}$ and $f_{BG,t} < f_{BG}^*(f_{B,t})$, $f_{B,t} \in$ L-III or H.

If $f_{BG,t} < f_{BG}^*(f_{B,t})$, by equation 8, we have

$$\begin{aligned} f_{B,t}[(\mu_G - \mu_B)X] &> \eta C + (f_{B,t} + f_{BG,t})[(1-\eta)C + \alpha\mu_G X] \\ &\geq \eta C + f_{B,t}[(1-\eta)C + \alpha\mu_G X] \end{aligned}$$

By inequality 1, private agents in period t will offer bribes.

Since $f_B^{**} < f_{B,t}$, we do not have a definite answer whether the "opportunist" type "BG" civil servants will accept or reject bribes in period t. There are two possible situations.

First, if the continuation payoff of the civil servants V_{t+1} is small such that

$$\delta\alpha\lambda V_{t+1} < C - \Gamma(f_{B,t} + f_{BG,t})$$

by inequality 2, this means in period t the "opportunist" type "BG" civil servants will accept bribes if there are any. The transition of the state of the economy from period t to period $t+1$ follows equations 5. Thus, in this case, $f_{B,t} \in$ H.

Second, if the continuation payoff of the civil servants V_{t+1} is large such that

$$\delta\alpha\lambda V_{t+1} \geq C - \Gamma(f_{B,t} + f_{BG,t})$$

by inequality 2, this means in period t the "opportunist" type "BG" civil servants will reject bribes if there are any. The transition of the state of the economy from period t to period $t+1$ follows equations 4. Thus, in this case, $f_{B,t} \in$ L-III. ■

Proof of Corollary 1

From section 2.2.1, we have $\{\underline{f_G^I}, \underline{f_B^I}, \underline{f_{BG}^I}\}$. If Low Corruption Steady State I (LCSS-I) is in the the Low corruption area I (L-I), we can easily check that the feasible conditions of Low Corruption Steady State I (LCSS-I) described in section 2.2.1 are satisfied.

In L-I, the transition of the state of the economy follows equations 3. In period $s+1$, where $s \geq t+1$

$$\begin{aligned} f_{B,s+1} &= \lambda(1-\gamma)f_{B,s} + [(1-\lambda) + \lambda\gamma f_{B,s}]f_B \\ &= (1-\lambda)f_B + \lambda[1-\gamma(1-f_B)]f_{B,s} \end{aligned}$$

Since $\lambda[1 - \gamma(1 - f_B)] < 1$, $f_{B,s+1} < f_{B,s}$ if $f_{B,s} > \underline{f_B^I}$; $f_{B,s+1} > f_{B,s}$ if $f_{B,s} < \underline{f_B^I}$; $f_{B,s+1} = f_{B,s} = \underline{f_B^I}$ if $f_{B,s} = \underline{f_B^I}$. Thus, $f_{B,s}$ will converge to $\underline{f_B^I}$. Once $f_{B,s}$ converges to $\underline{f_B^I}$, by equations 3, similarly $f_{G,s}$ and $f_{BG,s}$ will converge to $\overline{f_G^I}$ and $\underline{f_{BG}^I}$ respectively. This means if a steady state is feasible and the economy is currently at some state in the same area of this steady state, the economy is on the LCSS-I path and will monotonously converge to LCSS-I.

Similarly, we can check the feasible conditions for all others steady states if they are in the corresponding areas and the convergence property if the economy is at some state in the same area of the state states. ■

Proof of Proposition 2

i) For instance, suppose the state space partition is described in figure 1 and all the steady states are in the High corruption area (H). Thus, High Corruption Steady State (HCSS) is feasible and no matter where the state of the economy is, the economy will converge to High Corruption Steady State (HCSS). In this case, any one time anti-corruption policy never works. It only can low the level of corruption for a period of time, then the corruption level will increase back. The government must permanently adjust the level of supervision effort to change the environment of the economy.

ii) For instance, suppose the state space partition is described in figure 1 without Low corruption area II (L-II) and Low Corruption Steady State I (LCSS-I) is in the Low corruption area I (L-I), Low Corruption Steady State III (LCSS-III) and High Corruption Steady State (HCSS) in the High corruption area (H). Thus, Low Corruption Steady State I (LCSS-I) and High Corruption Steady State (HCSS) are feasible. If the the state of the economy is in the Low corruption area I (L-I), it will converge to Low Corruption Steady State I (LCSS-I). Otherwise, it will converge to High Corruption Steady State (HCSS). Therefore, to let a one time anti-corruption policy in some period t effective, the state of the economy in period $t + 1$ must be in the Low corruption area I (L-I), i.e., $f_{B+1} \leq f_B^*$, where where f_B^* are the solutions of the equation 6.

Suppose the economy is currently at HCSS, then the sufficient condition to let the one time anti-corruption successfully covert the economy from HCSS to LCSS-I is $\alpha_t \geq \alpha_I^*$ and $\gamma_t \geq \gamma_I^*$, where α_I^*, γ_I^* are the solutions of following equations.

$$\overline{f_B}[(\mu_G - \mu_B)X] = \eta C + \overline{f_B}[(1 - \eta)C + \alpha_I^* \mu_G X] \tag{9}$$

$$f_{B,I}^* = (1 - \lambda)f_B + \lambda[1 - \gamma_I^*(1 - f_B)]\overline{f_B} \tag{10}$$

The logic is as follows. In current period t, $f_{G,t} = \overline{f_G}$, $f_{B,t} = \overline{f_B}$, $f_{BG,t} = \overline{f_{BG}}$. To induce the private agent not to offer bribe in period t and possibly go to LCSS-I, by inequality 1 we must have

$$\overline{f_B}[(\mu_G - \mu_B)X] \leq \eta C + \overline{f_B}[(1 - \eta)C + \alpha_t \mu_G X]$$

From equation 9, we can solve α_I^*. Clearly, if $\alpha_t \geq \alpha_I^*$, above inequality will hold. Then in period $t+1$, the supervision effort goes back to the original level.To let a one time anti-corruption policy in some period t effective, the state of the economy in period $t+1$ must be in the Low corruption area I (L-I), i.e., $f_{B+1} \leq f_B^*$, where where f_B^* are the solutions of the equation 6.

By equation 3, in period $t+1$

$$\begin{aligned} f_{B,t+1} &= \lambda(1-\gamma_t)\overline{f_B} + [\gamma_t\overline{f_B} + (1-\lambda)(1-\gamma_t\overline{f_B})]f_B \\ &= (1-\lambda)f_B + \lambda[1-\gamma_t(1-f_B)]\overline{f_B} \end{aligned}$$

So, we must have

$$f_{B,I}^* \geq (1-\lambda)f_B + \lambda[1-\gamma_t(1-f_B)]\overline{f_B}$$

From equation 10, we can solve γ_I^*. Clearly, if $\gamma_t \geq \gamma_I^*$, above inequality will hold.

Therefore, when the government sets a one time anti-corruption policy, not only does it have to increase the supervision effort on detecting the bribery behavior (α), but also it needs to consider the the supervision effort on detecting the behavior of intentionally placing obstacles (dereliction of duty) during the test (γ). Anti-corruption should work along both lines. ■

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