Anonymous Matching and Group Reputation

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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 is constructed to characterize the strategic behavior of potential bribers and civil servants. We analyze the possible steady states and their feasible conditions under the anonymous matching and acquaintance matching respectively, as well as the dynamic analysis. Then, we show that the regime change from acquaintance matching to anonymous matching will cause the rampancy of corruption if the supervision effort level is small. Finally, we investigate the effectiveness of anti-corruption policy and show that to turn around a high level of corruption, the level of supervision effort has to reach some minimum level. In addition, the effectiveness of the anti-corruption policy is not monotonic with respect to the level of supervision effort. 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

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... a few bad apples spoil 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 (2009) 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 disjoint 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 her 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 her 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.

We consider two different regimes: anonymous matching and acquaintance matching. Under anonymous matching, potential bribers do not know the true type of the civil servants they are matched with and thus will decide whether or not to offer a bribe according to the current group reputation of the civil servants, whereas under acquaintance matching, potential bribers know the true type of the civil servants they are matched with and thus will decide whether or not to offer a bribe according to the current private reputation of the civil servants. As in Tönnies (2001), the transition from community to civil society may change the way of interaction among the individuals. In particular, originally potential bribers know the true type of the civil servants they are matched with. Now with the enlarged group, the true type of the civil servants may not be known anymore.

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 "bad" or "opportunist." The bad type always accepts bribes and is dereliction of duty (intentionally place obstacles) during the tests if there is no bribe. The opportunist type will weigh the advantages and disadvantages to decide whether to accept bribes or dereliction of duty during the tests if there is no bribe.

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.

We analyze the possible steady states and their feasible conditions under the anonymous matching and acquaintance matching respectively, as well as the dynamic analysis. Our main results shows that the regime change from acquaintance matching to anonymous matching will cause the rampancy of corruption, if the supervision effort level of the government regarding the corruption behavior of accepting bribes is small. Further, we investigate the effectiveness of anti-corruption policy and show that to turn around a high level of corruption, the level of supervision effort has to reach some minimum level. In addition, the effectiveness of the anti-corruption policy is not monotonic with respect to the level of supervision effort. As there are two types of corruption behavior of civil servants: accepting bribes and dereliction of duty, anti-corruption should work along both lines.

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 her managerial ability. As time goes by, her 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 (2008), 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 rest of the paper is organized as follows. Section 2 describes the stage game and the state transition of the dynamic game. Section 3 and 4 describe the possible steady states and their feasible conditions under the anonymous matching and acquaintance matching respectively, as well as the dynamic analysis. Section 5 studies the regime change from acquaintance matching to anonymous matching and the possible rampancy of corruption. Section 6 investigates the effectiveness of anti-corruption policy. Section 7 concludes.

2 The Model

There exist a benevolent government, a group of civil servants, and a population of private agents. The benevolent government selects and supervises civil servants who delegate the government to examine and approve some projects of the private agents by some criterion.

2.1 Stage Game

Time is discrete, indexed by t, and the horizon is infinite. 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 her 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 dereliction of duty (intentionally place obstacles) during the tests. The timing of the stage game for a matched pair civil servant and private agent in any arbitrary period t is shown in figure 1.

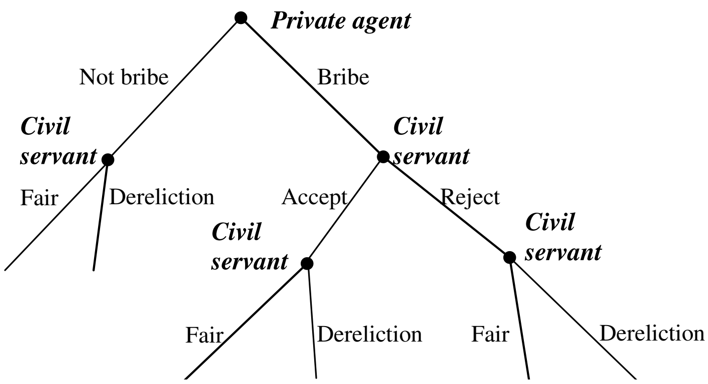

Figure 1: Timing of the Stage game

Private agents are short lived. Each generation of short-run private agents plays only in one period, and is replaced by another generation of short-run private agents in the next period. Civil servants are long lived with a continuum of mass 1 and common discount factor $\delta \in (0,1)$, who may be the type of "opportunist" or "bad," denoted as type "BG" and "B" respectively. The bad type "B" always accepts bribes and implements a fair test if there are any bribes and is dereliction of duty (intentionally place obstacles) during the tests if there is no bribe. The opportunist type "BG" will weigh the advantage and disadvantage to decide whether to accept bribes or dereliction of duty during the tests if there is no bribe. Thus, there are two types of corruption behavior for the civil servants: accepting bribes and dereliction of duty.

Let (α, β) represent the fixed amount of ***supervision effort*** level of the government regarding to these two types of corruption behavior in period t, where α and $\beta \in [0,1]$. That is, if there is a mass of Γ_t civil servants accepting bribe, then the probability for each of them to be detected $p_{\alpha,t} = \min\{\alpha/\Gamma_t, 1\}$.[2] Similarly, if there is a mass of Θ_t civil servants being dereliction of duty during the test, then the probability for each of them to be detected $p_{\beta,t} = \min\{\beta/\Theta_t, 1\}$.[3]

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

$$u_t^n = q_{\beta,t}[\mu_B X] + (1 - q_{\beta,t})[\mu_G X]$$
$$u_t^b = q_{\alpha,t}[(1 - p_{\alpha,t})\mu_G X - C] + (1 - q_{\alpha,t})[\mu_G X - \eta C]$$

where $q_{\alpha,t}$ is the probability that the civil servant she meets will accept a bribe if there is any; and $q_{\beta,t}$ is the probability that the civil servant she meets will be dereliction of duty during the test if there is no bribe.[4] μ_G is the probability of the project being approved under a fair test. μ_B is the probability of the project being approved under an unfair test, in which the civil servant is dereliction of duty. X is benefit from an approved project. C is the cost of bribe. $\eta \in (0,1)$ is the share of loss on a bribe if it is rejected. If the project is rejected, the benefit is normalized to zero.

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

$$\eta C + q_{\alpha,t}[(1-\eta)C + p_{\alpha,t}\mu_G X] \geq q_{\beta,t}[(\mu_G - \mu_B)X] \tag{1}$$

For the long-lived civil servants, we need to consider the continuation payoff, beyond the stage payoff. In period t, if there is a bribe, the payoff of the "opportunist"

[2] In this case, both the briber and bribee will get punished. The bribe will be confiscated; the civil servant will be removed from the office, and the project from the briber will be disqualified.

[3] In this case, the civil servant will be removed from the office, but the private agent will not be compensated for the unfair test.

[4] $\{q_{\alpha,t}, q_{\beta,t}\}$ represents the ***group reputation*** of the civil servants in period t, which is the belief of the private agents on the two types of corruption behavior of the civil servants: accepting bribes and dereliction of duty.

type "BG" civil servant from rejecting it and accepting it are as follows:

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

where Y is the wage of the civil servant in each period and V_{t+1} is the continuation payoff in period $t + 1$. The stage game for the matched pair of private agents and "BG" type civil servants are as described in the top panel of figure 2.

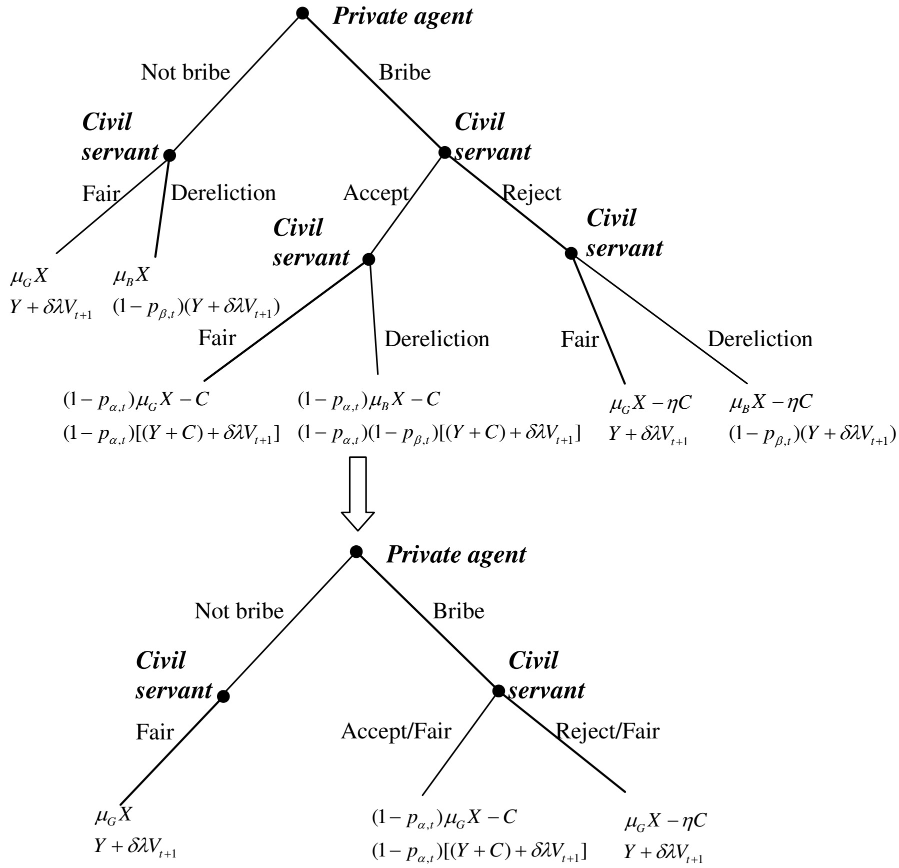

Figure 2: Stage Game with "BG" Type Civil Servant

It is easy to see that 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. Thus, the stage game with a "BG" type civil servants can be reduced and described as the bottom panel of figure 2. Clearly, we have $q_{\alpha,t} \geq q_{\beta,t}$ as the "opportunist" type "BG" civil servant will always implement fair tests. Further, we assume $(1-\alpha)\mu_G X - \mu_B X > C$.[5]

The "opportunist" type "BG" civil servant will reject a bribe, if there is any, at period t if $V_t^R \geq V_t^A$. That is,

$$p_{\alpha,t}[Y + \delta\lambda V_{t+1}] \geq (1 - p_{\alpha,t})C \tag{2}$$

Since the bad type "B" always accepts bribes and implements a fair test if there are any bribes and is dereliction of duty (intentionally place obstacles) during the tests if there is no bribe. The stage payoffs for the matched pair of private agents and "B" type civil servants are as described in figure 3.

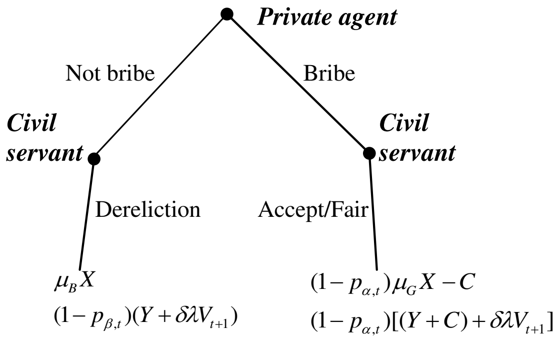

Figure 3: Stage Game with "B" Type Civil Servant

Finally, denote f_t as the fractions of "B" type of civil servants in period t. The remaining $1-f_t$ will be the fractions of "BG" type of civil servants in period t. Then $\{f_t, 1-f_t\}$ represents the state of the economy in period t. The civil servants alive in date t remain in the economy in date $t+1$ with probability $\lambda \in (0,1)$. Assume that each quit is offset by the arrival of a new civil servant selected by the government from a pool of candidates with proportion of the two types "B" and "BG": $(f, 1-f)$. So the size of the civil servants remains constant mass of 1. Further, at the beginning of each period, each civil servant will be assigned exactly one test. That is, all the civil servants will be involved in some test. In each period the mass of private agents chosen by the government to get their projects tested is equal to the mass of the civil servants, which is equal to one.

2.2 Dynamic Game: State Transition

Now, we need to characterize the evolution of proportions of the two types of civil servants as time goes by. In period $t+1$, the transition of the state of the economy is

[5]Otherwise, from inequality 1, the gain from "bribing" is definitely less than or equal to the cost and therefore the private agents will for sure not have incentive to offer a bribe.

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. For simplicity, consider 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 $q_{\alpha,t} = f_t$ or $q_{\alpha,t} = 1$. Further, since only the "bad" type "B" civil servant will be dereliction of duty during the tests if there is no bribe, $q_{\beta,t} = f_t$.

Case 1: private agents NOT offering bribes in period t

$$p_{\beta,t} = \begin{cases} \beta/f_t & \text{if } \beta < f_t \\ 1 & \text{if } \beta \geq f_t \end{cases}$$

The state of transition is as follows.

$$\begin{aligned} f_{t+1} &= \lambda(1 - p_{\beta,t})f_t + [(1-\lambda) + \lambda p_{\beta,t} f_t]f \\ &= \begin{cases} \lambda f_t - \lambda\beta + (1 - \lambda + \lambda\beta)f & \text{if } \beta < f_t \\ (1 - \lambda + \lambda f_t)f & \text{if } \beta \geq f_t \end{cases} \end{aligned} \tag{3}$$

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

$$p_{\alpha,t} = \begin{cases} \alpha/f_t & \text{if } \alpha < f_t \\ 1 & \text{if } \alpha \geq f_t \end{cases}$$

The state of transition is as follows.

$$\begin{aligned} f_{t+1} &= \lambda(1 - p_{\alpha,t})f_t + [(1-\lambda) + \lambda p_{\alpha,t} f_t]f \\ &= \begin{cases} \lambda f_t - \lambda\alpha + (1 - \lambda + \lambda\alpha)f & \text{if } \alpha < f_t \\ (1 - \lambda + \lambda f_t)f & \text{if } \alpha \geq f_t \end{cases} \end{aligned} \tag{4}$$

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

$$p_{\alpha,t} = \alpha$$

The state of transition is as follows.

$$\begin{aligned} f_{t+1} &= \lambda(1 - p_{\alpha,t})f_t + [(1-\lambda) + \lambda p_{\alpha,t}]f \\ &= \lambda(1-\alpha)f_t + [(1-\lambda) + \lambda\alpha]f \end{aligned} \tag{5}$$

3 Anonymous Matching

Suppose now private agents do not know the true type of the civil servants they are matched with. Before moving to the dynamic analysis, let us first identify the possible steady states and their feasible conditions.

Low Corruption Steady State I (LCSS-I) The first steady state is Low Corruption Steady State I (LCSS-I), in which the private agents do not offer bribes and an "opportunist" type "BG" civil servant would reject a bribe if there were any. By equation 3, we can derive the proportion of "bad" type "B" civil servant at LCSS-I, denoted as f_I.

$$f_I = \begin{cases} \frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda} & \text{if } \beta < \underline{f} \\ \underline{f} & \text{if } \beta \geq \underline{f} \end{cases}$$

where $\underline{f} = \frac{(1-\lambda)f}{1-\lambda f}$.

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 an "opportunist" type "BG" civil servant would accept a bribe if there were any. As there is no bribe from the private agents, the proportion of "bad" type "B" civil servant at LCSS-II is same as the proportion in the LCSS-I.

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 4, we can derive the proportion of "bad" type "B" civil servant at LCSS-III, denoted as f_{III}.

$$f_{III} = \begin{cases} \frac{(1-\lambda)f-\lambda\alpha(1-f)}{1-\lambda} & \text{if } \alpha < \underline{f} \\ \underline{f} & \text{if } \alpha \geq \underline{f} \end{cases}$$

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 5, we can derive the proportion of "bad" type "B" civil servant at HCSS, denoted as f_H.

$$f_H = f$$

Figure 4 illustrates the proportion of "bad" type "B" civil servant at these four steady states as functions of α, given the value of β. Similarly, we may draw the proportion of "bad" type "B" civil servant at these four steady states as functions of β.

The following lemma shows the feasible conditions of the four steady states above.

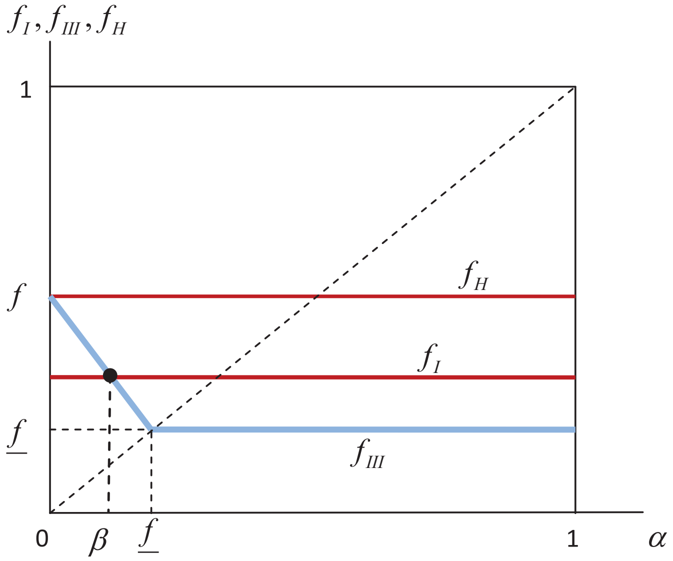

Figure 4: The Proportion of "Bad" Type "B" Civil Servant at the Steady States

Lemma 1 **LCSS-I** *is feasible if* $\alpha \geq \alpha_I$*;*

LCSS-II *is feasible if* $\overline{\alpha_{II}} > \alpha \geq \alpha_{II}$*;*

LCSS-III *is feasible if* $\overline{\alpha_{III}} > \alpha \geq \overline{\alpha_{II}}$*;*

HCSS *is feasible if* $\alpha < \alpha_H$*;*

where

$$\alpha_I = \begin{cases} \max\left\{ \frac{\frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}[(\mu_G-\mu_B)X-(1-\eta)C]-\eta C}{\mu_G X}, \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}} \right\} & \textit{if } \beta < \underline{f} \\ \max\left\{ \frac{\underline{f}[(\mu_G-\mu_B)X-(1-\eta)C]-\eta C}{\mu_G X}, \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}} \right\} & \textit{if } \beta \geq \underline{f} \end{cases}$$

$$\overline{\alpha_{II}} = \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}}$$

$$\alpha_{II} = \begin{cases} \frac{\frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}(\mu_G-\mu_B)X-C}{\mu_G X} & \textit{if } \beta < \underline{f} \\ \frac{\underline{f}(\mu_G-\mu_B)X-C}{\mu_G X} & \textit{if } \beta \geq \underline{f} \end{cases}$$

$$\overline{\alpha_{III}} = \frac{f[(\mu_G-\mu_B)X-(1-\eta)C]-\eta C}{\mu_G X + \frac{\lambda(1-f)}{1-\lambda}[(\mu_G-\mu_B)X-(1-\eta)C]}$$

$$\alpha_H = \min\left\{ \frac{f(\mu_G-\mu_B)X-C}{\mu_G X}, \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}} \right\}$$

Proof. See the Appendix. ■

Figure 5 sketches out the state space partition when $\frac{f(\mu_G-\mu_B)X-C}{\mu_G X} < \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}}$. Figure 6 sketches out the state space partition when $\frac{f(\mu_G-\mu_B)X-C}{\mu_G X} > \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}}$. There

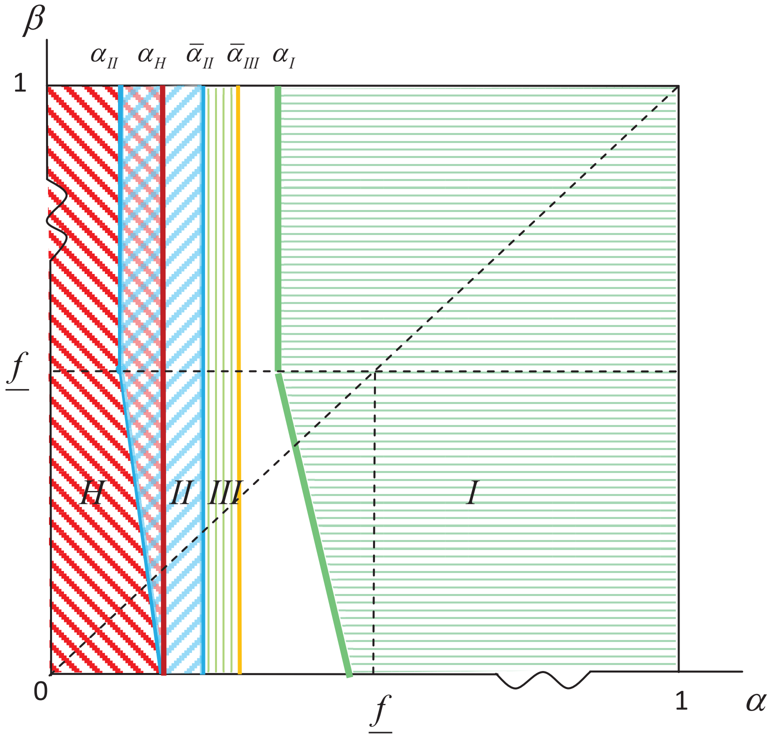

Figure 5: The State Space Partition: $\frac{f(\mu_G-\mu_B)X-C}{\mu_G X} < \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}}$

are some more minor variations of the state space partitions depending on the values of parameters. But the basic shapes are described as in figure 5 and 6. Generally speaking, if the supervision effort level of the government regarding the corruption behavior of accepting bribes α is high, LCSS-I is feasible; if α is low, LCSS-H is feasible; if α is in the middle, LCSS-II and LCSS-III maybe feasible.

3.1 Dynamic Analysis

In this section, we analyze the dynamical situation if the economy in period t is at some arbitrary state: $\{f_t, 1-f_t\}$.

Lemma 2 *Suppose in period t the economy is at some state: $\{f_t, 1-f_t\}$. There are two scenarios for the transition of state from period t to $t+1$.*

(i) *If $\alpha \geq \overline{\alpha_{II}}$, a civil servant will reject a bribe if there is any at period t. In particular, if $f_t \leq m_1$, a private agent will not offer a bribe at the beginning of period*

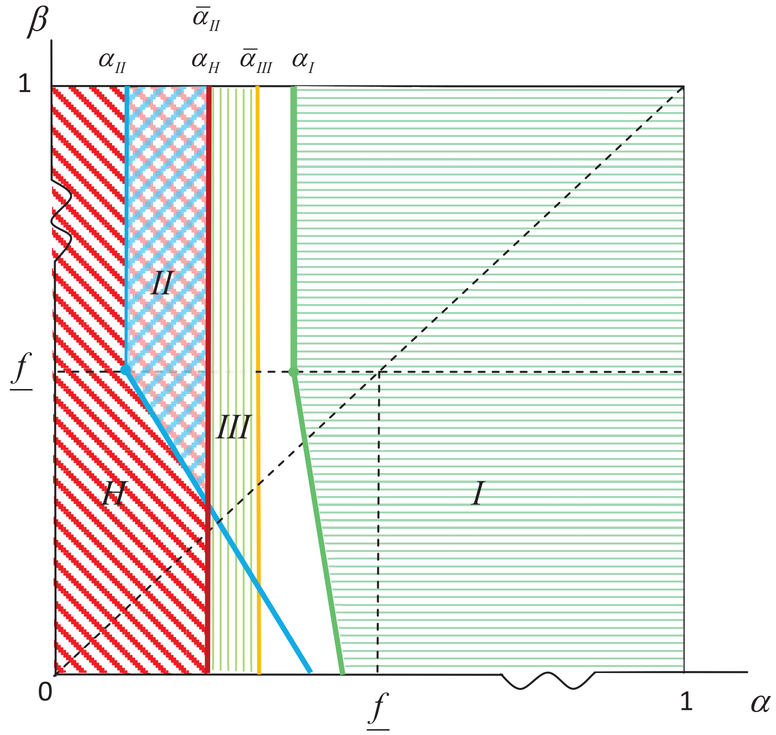

Figure 6: The State Space Partition: $\frac{f(\mu_G-\mu_B)X-C}{\mu_G X} > \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}}$

t. The transition of the state of the economy from period t to period $t+1$ follows equations 3. If $f_t > m_1$, a private agent will offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 4.

***(ii)** If $\alpha < \overline{\alpha_{II}}$, a civil servant will accept a bribe if there is any. In particular, if $f_t \leq m_2$, a private agent will not offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 3. If $f_t > m_2$, a private agent will offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 5.*

Here, $\overline{\alpha_{II}} = \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}}$, $m_1 = \frac{\eta C+\alpha\mu_G X}{(\mu_G-\mu_B)X-(1-\eta)C}$, $m_2 = \frac{C+\alpha\mu_G X}{(\mu_G-\mu_B)X}$.

Proof. See the Appendix. ■

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. The following lemma shows that when α is large, f_t will converge to f_I or f_{III}, or oscillate around m_1; when α is small, f_t will converge to f_H or f_I, or oscillate around m_2.

Lemma 3 *Suppose in period t the economy is at some state: $\{f_t, 1 - f_t\}$. There are two scenarios for the transition of state in the long run.*

(i) *If $\alpha \geq \overline{\alpha_{II}}$, f_t will converge to f_I or f_{III}, or oscillate around m_1. In particular, if $\alpha \geq \alpha_I$, f_t will converge to f_I. If $\overline{\alpha_{III}} > \alpha \geq \overline{\alpha_{II}}$, f_t will converge to f_{III}. If $\alpha_I > \alpha \geq \max\{\overline{\alpha_{II}}, \overline{\alpha_{III}}\}$, f_t will oscillate around m_1.*

(ii) *If $\alpha < \overline{\alpha_{II}}$, f_t will converge to f_H or f_I, or oscillate around m_2. In particular, if $\alpha < \min\{\alpha_{II}, \alpha_H\}$, f_t will converge to f_H. If $\max\{\alpha_{II}, \alpha_H\} \leq \alpha < \overline{\alpha_{II}}$, f_t will converge to f_I. If $\alpha_{II} \leq \alpha < \alpha_H$, there are two subcases: if $f_t > m_2$, it will converge to f_H; if $f_t \leq m_2$, it will converge to f_I. If $\alpha_H \leq \alpha < \min\{\alpha_{II}, \overline{\alpha_{II}}\}$, f_t will oscillate around m_2.*

Proof. See the Appendix. ■

4 Acquaintance Matching

As a benchmark, consider the acquaintance matching, in which private agents know the true type of the civil servants they are matched with.[6] If the civil servant is a "BG" type, from figure 2, the best response for the private agent is to "not bribe," as a "BG" type civil servant will always implement a fair test. In this case, the "BG" type civil servants are passive and there is no loss of bribe.

If the civil servant is a "B" type, from figure 3, $q_{\alpha,t} = q_{\beta,t} = 1$. From inequality 1, the private agent will not "bribe" whenever

$$C + p_{\alpha,t}\mu_G X \geq (\mu_G - \mu_B)X \tag{6}$$

where $p_{\alpha,t} = \min\{\alpha/f_t, 1\}$.

The state of transition follows equation 3 if private agents do not bribe, and equation 4 if private agents bribe. Similar to the analysis for the case of anonymous matching, we have two possible steady states and their feasible conditions as follows.

Low Corruption Steady State I' (LCSS-I') The first steady state is Low Corruption Steady State I' (LCSS-I'), in which the private agents do not offer bribes. By equation 3, we can derive the proportion of "bad" type "B" civil servant at LCSS-I', which is same as the proportion in the LCSS-I, f_I.

Low Corruption Steady State III' (LCSS-III') The second steady state is Low Corruption Steady State III' (LCSS-III'), in which the private agents offer bribes. By

[6] Still, the government does not know the true type of the civil servants.

equation 4, we can derive the proportion of "bad" type "B" civil servant at LCSS-III, which is same as the proportion in the LCSS-III, f_{III}.[7]

The following lemma shows the feasible conditions of the two steady states above.

Lemma 4 **LCSS-I'** *is feasible if* $\alpha \geq \alpha_I'$;

LCSS-III' *is feasible if* $\alpha < \overline{\alpha_{III}}'$;

where

$$\alpha_I' = \begin{cases} \frac{\frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}[(\mu_G-\mu_B)X-C]}{\mu_G X} & \text{if } \beta < \underline{f} \\ \frac{\underline{f}[(\mu_G-\mu_B)X-C]}{\mu_G X} & \text{if } \beta \geq \underline{f} \end{cases}$$

$$\overline{\alpha_{III}}' = \frac{f[(\mu_G-\mu_B)X-C]}{\mu_G X + \frac{\lambda(1-f)}{1-\lambda}[(\mu_G-\mu_B)X-C]}$$

Proof. See the Appendix. ■

Figure 7 sketches out the state space partition. Generally speaking, if the super-

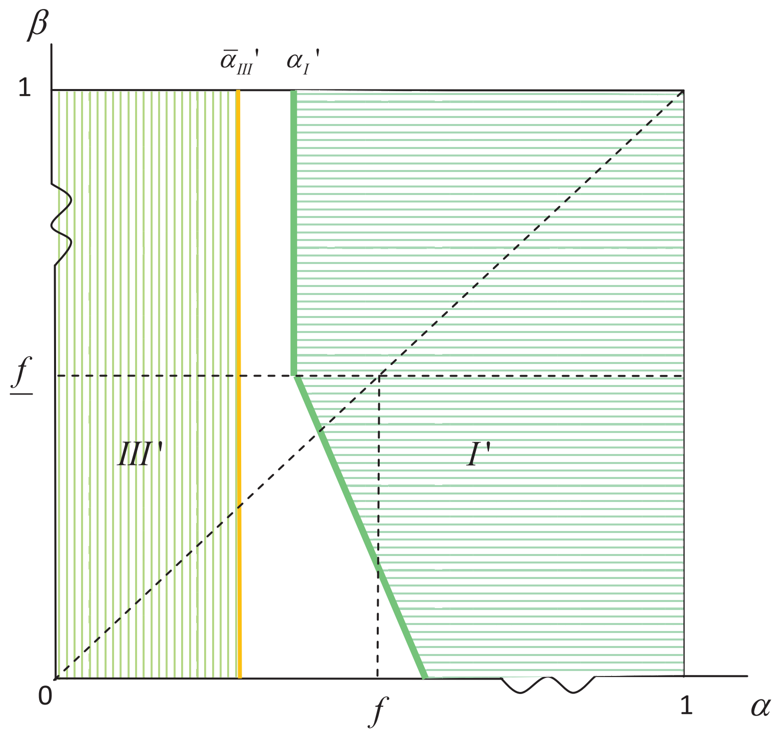

Figure 7: The State Space Partition: Acquaintance Matching

vision effort level of the government regarding the corruption behavior of accepting bribes α is high, LCSS-I' is feasible; if α is low, LCSS-III' is feasible.

[7]Note, there are no LCSS-II and HCSS as in the anonymous matching case.

4.1 Dynamic Analysis

In this section, we analyze the dynamical situation if the economy in period t is at some arbitrary state: $\{f_t, 1 - f_t\}$.

Lemma 5 *Suppose in period t the economy is at some state: $\{f_t, 1 - f_t\}$. In particular, if $f_t \leq m'_1$, a private agent will not offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 3. If $f_t > m'_1$, a private agent will offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 4. Here, $m'_1 = \frac{\alpha \mu_G X}{(\mu_G - \mu_B)X - C}$.*

Proof. See the Appendix. ■

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. The following lemma shows that f_t will converge to f_I or f_{III}, or oscillate around m'_1.

Lemma 6 *Suppose in period t the economy is at some state: $\{f_t, 1 - f_t\}$. f_t will converge to f_I or f_{III}, or oscillate around m'_1. In particular, if $\alpha \geq \alpha'_I$, f_t will converge to f_I. If $\alpha < \overline{\alpha_{III}}'$, f_t will converge to f_{III}. If $\alpha'_I > \alpha \geq \overline{\alpha_{III}}'$, f_t will oscillate around m'_1.*

Proof. See the Appendix. ■

5 Acquaintance Matching to Anonymous Matching – the Rampancy of Corruption

Consider the regime change from acquaintance matching to anonymous matching. As in Tönnies (2001), the transition from community to civil society may change the way of interaction among the individuals. In particular, originally private agents know the true type of the civil servants they are matched with. Now with the enlarged group, the true type of the civil servants may not be known anymore and thus private agents will decide whether or not to offer a bribe according to the current group reputation of the civil servants.

The following proposition shows the regime change from acquaintance matching to anonymous matching will cause the rampancy of corruption, if the supervision effort level of the government regarding the corruption behavior of accepting bribes α is small.

Proposition 1 *Suppose there is a regime change from acquaintance matching to anonymous matching at the beginning of period t. If* $\alpha < \min\{\alpha_{II}, \alpha_H\}$*,* f_t *will converge to* f_H*.*

Intuitively, under the acquaintance matching, by lemma 6, f_t will converge to f_I or f_{III}, or oscillate around m_1'. If there is a regime change from acquaintance matching to anonymous matching at the beginning of period t, by lemma 3, f_t will converge to f_H, if $\alpha < \min\{\alpha_{II}, \alpha_H\}$. Therefore, there will be a rampancy of corruption.

6 Anti-Corruption

In this section, assume that the economy currently suffers from a high level of corruption. The government introduces a permanent anti-corruption policy, i.e., permanently adjusting the level of supervision effort from $\{\alpha, \beta\}$ to $\{\alpha^*, \beta^*\}$, aiming to lead to a low level of corruption.

The following proposition shows that to turn around a high level of corruption, α^* has to reach some minimum level, which is a decreasing function of β^*. In addition, the effectiveness of the anti-corruption policy is not monotonic with respect to $\{\alpha^*, \beta^*\}$. In particular, as α^* reaches the minimum threshold, we could end up with some lower level of corruption, which is a decreasing function of β^*. But further increasing of α^* may not help till to some point that the level of corruption is a decreasing function of α^*. Then, if α^* increases even further, the level of corruption could be even higher. Finally, if α^* is large enough, it is no use to increase α^* and the level of corruption depends on β^*. In this sense, anti-corruption should work along both lines: not only does the government 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 dereliction of duty (intentionally place obstacles) during the test (β).

Proposition 2 *Suppose in period t the economy is at some state:* $\{f_t, 1 - f_t\}$*, where* $f_t = f_H$ *or in the vicinity of some high level of corruption, say* m_2 *from lemma 3. The government introduces a permanent anti-corruption policy, i.e., permanently adjusting the level of supervision effort from* $\{\alpha, \beta\}$ *to* $\{\alpha^*, \beta^*\}$ *starting from period t.*

(i) *To turn around the high level of corruption,* $\alpha^* \geq \max\{\alpha_H, \min\{\alpha_{II}, \overline{\alpha_{II}}\}\}$*, which is a decreasing function of* β^**.*

(ii) *The effectiveness of the anti-corruption policy is not monotonic with respect to* $\{\alpha^*, \beta^*\}$*. In particular, we have the following scenarios.*

(ii.i) *If* $\max\{\alpha_{II}, \alpha_H\} \leq \alpha^* < \overline{\alpha_{II}}$*,* f_t *will converge to* f_I*, which is a decreasing function of* β^**.*

(ii.ii) *If* $\overline{\alpha_{III}} > \alpha^* \geq \overline{\alpha_{II}}$, f_t *will converge to* f_{III}, *which is a decreasing function of* α^*. *In this case,* β^* *is irrelevant.*

(ii.iii) *If* $\alpha_I > \alpha^* \geq \max\{\overline{\alpha_{II}}, \overline{\alpha_{III}}\}$, f_t *will oscillate around* m_1.

(ii.iv) *If* $\alpha^* \geq \alpha_I$, f_t *will converge to* f_I, *which is a decreasing function of* β^*. *In this case, increasing* α^* *further does not help.*

Intuitively, by lemma 2 and 3, if $\max\{\alpha_{II}, \alpha_H\} \leq \alpha < \overline{\alpha_{II}}$, f_t will converge to f_I; if $\overline{\alpha_{III}} > \alpha^* \geq \overline{\alpha_{II}}$, f_t will converge to f_{III}; if $\alpha_I > \alpha^* \geq \max\{\overline{\alpha_{II}}, \overline{\alpha_{III}}\}$, f_t will oscillate around m_1; if $\alpha^* \geq \alpha_I$, f_t will converge to f_I. Further, the following corollary says that there is no one time anti-corruption policy to lead to a low level of corruption permanently.[8]

Corollary 1 *There is no one time anti-corruption policy to effectively turn around the high level of corruption.*

Intuitively, if $\alpha < \max\{\alpha_H, \min\{\alpha_{II}, \overline{\alpha_{II}}\}\}$, one time anti-corruption will only have temporary effect. Once the supervision effort back to its original level, the level of corruption will converge back to f_H or oscillate around m_2 from lemma 3.

Moreover, from proposition 2, it is easy to see that it is no use to set the supervision effort greater than some upper limit.

Corollary 2 $\alpha^* \leq \alpha_I$ *and* $\beta^* \leq \underline{f}$.

7 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 her 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 possible steady states and their feasible conditions under the anonymous matching and acquaintance matching respectively, as well as the dynamic analysis.

Then, we show that the regime change from acquaintance matching to anonymous matching will cause the rampancy of corruption if the supervision effort level of the

[8] One time anti-corruption policy means a combination of new level of supervision effort $\{\alpha_t, \beta_t\}$ 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 (HCSS) f_I or f_{III}, or oscillating around some lower corruption level, say m_1 from lemma 3.

government regarding the corruption behavior of accepting bribes α is small. This capture the idea that the transition from community to civil society may change the way of interaction among the individuals as in Tönnies (2001).

Finally, we investigate the effectiveness of anti-corruption policy. We show that to turn around a high level of corruption, the level of supervision effort $\{\alpha, \beta\}$ has to reach some minimum level. In addition, the effectiveness of the anti-corruption policy is not monotonic with respect to $\{\alpha, \beta\}$. Anti-corruption should work along both lines: not only does the government 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 dereliction of duty (intentionally place obstacles) during the test (β).

Appendix

Proof of Lemma 1

Feasible Conditions of LCSS-I:

At LCSS-I, the private agents do not offer bribes and an "opportunist" type "BG" civil servant would reject a bribe if there were any. By equation 3, we can derive the proportion of "bad" type "B" civil servant at LCSS-I, denoted as f_I.

$$f_I = \begin{cases} \frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda} & \text{if } \beta < \underline{f} \\ \underline{f} & \text{if } \beta \geq \underline{f} \end{cases}$$

where $\underline{f} = \frac{(1-\lambda)f}{1-\lambda f}$.

Suppose the economy is currently at LCSS-I in period t. Backward induction, consider the opportunist type "BG" civil servant's problem: reject or accept bribes if there are any. Back to inequality 2, to induce an "opportunist" type "BG" civil servant rejects a bribe if there is any, the following condition must hold.

$$p_{\alpha,t}[Y + \delta\lambda V_{t+1}] \geq (1 - p_{\alpha,t})C$$

which implies that

$$p_{\alpha,t} \geq \frac{C}{Y + \delta\lambda V_{t+1} + C} \tag{7}$$

Consider the symmetric equilibrium, either all "opportunist" type "BG" civil servants reject bribes if there are any or all accepts. If all rejects, the payoff for the "opportunist" type "BG" civil servant, denoted as V_L, is

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

Similarly, if all accepts, $p_{\alpha,t} = \alpha$ and we have

$$V_H = (1-\alpha)[(Y+C) + \delta\lambda V_H] \Longrightarrow V_H = \frac{(1-\alpha)}{1-(1-\alpha)\delta\lambda}(Y+C)$$

It is easy to see that V_{t+1} is bounded below by V_L. If $\alpha < \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}} = \overline{\alpha_{II}}$, $V_H > V_L$. If $\alpha \geq \overline{\alpha_{II}}$, we end up with V_L. In this case, V_H does not exist.

Suppose currently all "opportunist" type "BG" civil servants reject bribes if there are any. Let us check if there is incentive to deviate to all accepting, in which $p_{\alpha,t} = \alpha$. Back to inequality 7, to induce an "opportunist" type "BG" civil servant accepts a bribe if there is any,

$$p_{\alpha,t} = \alpha < \frac{C}{Y + \delta\lambda V_{t+1} + C} = \frac{C}{Y + \delta\lambda V_H + C} = \frac{C}{Y + \delta\lambda \frac{(1-\alpha)}{1-(1-\alpha)\delta\lambda}(Y+C) + C}$$

which implies $\alpha < \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}} = \overline{\alpha_{II}}$.

To the opposite, suppose currently all "opportunist" type "BG" civil servant accept bribes if there are any. Let us check if there is incentive to deviate to all rejecting. Obviously, as long as $V_H > V_L$, in which $\alpha < \overline{\alpha_{II}}$, there is no way for them to deviate. Thus, there are two scenarios: (i) if $\alpha \geq \overline{\alpha_{II}}$, all "opportunist" type "BG" civil servants reject bribes if there are any; (ii) if $\alpha < \overline{\alpha_{II}}$, all "opportunist" type "BG" civil servants accept bribes if there are any. Therefore, at LCSS-I, an "opportunist" type "BG" civil servant would reject a bribe if there were any, which requires $\alpha \geq \overline{\alpha_{II}} = \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}}$.

Back to the private agent's problem at the beginning of period t, $f_t = f_I$.

$$\begin{aligned} q_{\alpha,t} &= f_I \\ q_{\beta,t} &= f_I \\ p_{\alpha,t} &= \begin{cases} \alpha/f_I & \text{if } \alpha < f_I \\ 1 & \text{if } \alpha \geq f_I \end{cases} \end{aligned}$$

Back to inequality 1, to induce a private agent not to offer a bribe

$$\eta C + f_I[(1-\eta)C + p_{\alpha,t}\mu_G X] \geq f_I[(\mu_G - \mu_B)X] \tag{8}$$

We have the following subcases.

(i) $\beta \geq \underline{f}$ **and** $\alpha \geq f_I$**:**

If $\beta \geq \underline{f}$, $f_I = \underline{f}$. Further, if $\alpha \geq f_I = \underline{f}$, $p_{\alpha,t} = 1$. The condition in (8) becomes

$$\eta C + \underline{f}[(1-\eta)C + \mu_G X] \geq \underline{f}[(\mu_G - \mu_B)X]$$

which always holds.

(ii) $\beta < \underline{f}$ **and** $\alpha \geq f_I$**:**

If $\beta < \underline{f}$, $f_I = \frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}$. Further, if $\alpha \geq f_I = \frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}$, $p_{\alpha,t} = 1$. The condition in (8) becomes

$$\eta C + f_I[(1-\eta)C + \mu_G X] \geq f_I[(\mu_G - \mu_B)X]$$

which always holds.

(iii) $\beta \geq \underline{f}$ **and** $\alpha < f_I$**:**

If $\beta \geq \underline{f}$, $f_I = \underline{f}$. Further, if $\alpha < f_I = \underline{f}$, $p_{\alpha,t} = \alpha/f_I = \alpha/\underline{f}$. The condition in (8) becomes

$$\eta C + \underline{f}[(1-\eta)C + \frac{\alpha}{\underline{f}}\mu_G X] \geq \underline{f}[(\mu_G - \mu_B)X]$$

Thus, we have

$$\underline{f} \leq \frac{\eta C + \alpha\mu_G X}{(\mu_G - \mu_B)X - (1-\eta)C} = m_1$$

which implies $\alpha \geq \frac{\underline{f}[(\mu_G-\mu_B)X-(1-\eta)C]-\eta C}{\mu_G X}$.

(iv) $\beta < \underline{f}$ **and** $\alpha < f_I$**:**

If $\beta < \underline{f}$, $f_I = \frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}$. Further, if $\alpha < f_I = \frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}$, $p_{\alpha,t} = \alpha/f_I$. The condition in (8) becomes

$$\eta C + f_I[(1-\eta)C + \frac{\alpha}{f_I}\mu_G X] \geq f_I[(\mu_G - \mu_B)X]$$

Thus, we have

$$f_I \leq \frac{\eta C + \alpha\mu_G X}{(\mu_G - \mu_B)X - (1-\eta)C} = m_1$$

which implies $\alpha \geq \frac{f_I[(\mu_G-\mu_B)X-(1-\eta)C]-\eta C}{\mu_G X}$.

Note that when $\beta = \underline{f}$, $\frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda} = \underline{f}$. Combining these four subcases, we have the feasible conditions of LCSS-I as follows.

$$\alpha \geq \alpha_I = \begin{cases} \max\left\{\frac{\frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}[(\mu_G-\mu_B)X-(1-\eta)C]-\eta C}{\mu_G X}, \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}}\right\} & \text{if } \beta < \underline{f} \\ \max\left\{\frac{\underline{f}[(\mu_G-\mu_B)X-(1-\eta)C]-\eta C}{\mu_G X}, \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}}\right\} & \text{if } \beta \geq \underline{f} \end{cases}$$

Note that $\overline{\alpha_{II}} \leq \alpha_I$ for any β.

Feasible Conditions of LCSS-II:

At LCSS-II, the private agents do not offer bribes and an "opportunist" type "BG" civil servant would accept a bribe if there were any. As there is no bribe from the private agents, the proportion of "bad" type "B" civil servant at LCSS-II is same as the proportion in the

LCSS-I. Same logic as in the previous proof, at LCSS-II, an "opportunist" type "BG" civil servant would accept a bribe if there were any, which requires $\alpha < \overline{\alpha_{II}} = \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}}$.

Back to the private agent's problem at the beginning of period t, $f_t = f_I$.[9]

$$
\begin{aligned}
q_{\alpha,t} &= 1 \\
q_{\beta,t} &= f_I \\
p_{\alpha,t} &= \alpha
\end{aligned}
$$

Back to inequality 1, to induce a private agent not to offer a bribe

$$\eta C + [(1-\eta)C + \alpha\mu_G X] \geq f_I[(\mu_G - \mu_B)X] \tag{9}$$

We have the following subcases.

(i) $\beta \geq \underline{f}$**:**

If $\beta \geq \underline{f}$, $f_I = \underline{f}$. The condition in (9) becomes

$$\eta C + [(1-\eta)C + \alpha\mu_G X] \geq \underline{f}[(\mu_G - \mu_B)X]$$

Thus, we have

$$\underline{f} \leq \frac{C + \alpha\mu_G X}{(\mu_G - \mu_B)X} = m_2$$

which implies $\alpha \geq \frac{\underline{f}(\mu_G-\mu_B)X-C}{\mu_G X}$.

(ii) $\beta < \underline{f}$**:**

If $\beta < \underline{f}$, $f_I = \frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}$. The condition in (9) becomes

$$\eta C + [(1-\eta)C + \alpha\mu_G X] \geq f_I[(\mu_G - \mu_B)X]$$

Thus, we have

$$f_I \leq \frac{C + \alpha\mu_G X}{(\mu_G - \mu_B)X} = m_2$$

which implies $\alpha \geq \frac{\frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}(\mu_G-\mu_B)X-C}{\mu_G X}$.

Note that when $\beta = \underline{f}$, $\frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda} = \underline{f}$. Combining these two subcases, we have the feasible conditions of LCSS-II as follows.

$$\frac{1}{1+\frac{Y}{C(1-\delta\lambda)}} = \overline{\alpha_{II}} > \alpha \geq \alpha_{II} = \begin{cases} \frac{\frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}(\mu_G-\mu_B)X-C}{\mu_G X} & \text{if } \beta < \underline{f} \\ \frac{\underline{f}(\mu_G-\mu_B)X-C}{\mu_G X} & \text{if } \beta \geq \underline{f} \end{cases}$$

[9] Here, again consider the symmetric equilibrium, either all private agents offer bribes or all not. If all private agents offer bribes, $p_{\alpha,t} = \alpha$, given "opportunist" type "BG" civil servant would accept a bribe if there were any.

Note that $\alpha_{II} < \alpha_I$ for any β.

Feasible Conditions of LCSS-III:

At LCSS-III, the private agents offer bribes and an "opportunist" type "BG" civil servant would reject a bribe if there were any. By equation 4, we can derive the proportion of "bad" type "B" civil servant at LCSS-III, denoted as f_{III}.

$$f_{III} = \begin{cases} \frac{(1-\lambda)f - \lambda\alpha(1-f)}{1-\lambda} & \text{if } \alpha < \underline{f} \\ \underline{f} & \text{if } \alpha \geq \underline{f} \end{cases}$$

Same logic as in the previous proof, at LCSS-III, an "opportunist" type "BG" civil servant would reject a bribe if there were any, which requires $\alpha \geq \overline{\alpha_{II}} = \frac{1}{1+\frac{Y}{C(1-\delta\lambda)}}$.

Back to the private agent's problem at the beginning of period t, $f_t = f_{III}$.[10]

$$\begin{aligned} q_{\alpha,t} &= f_{III} \\ q_{\beta,t} &= f_{III} \\ p_{\alpha,t} &= \begin{cases} \alpha/f_{III} & \text{if } \alpha < f_{III} \\ 1 & \text{if } \alpha \geq f_{III} \end{cases} \end{aligned}$$

Back to inequality 1, to induce a private agent to offer a bribe

$$\eta C + f_{III}[(1-\eta)C + p_{\alpha,t}\mu_G X] < f_{III}[(\mu_G - \mu_B)X] \tag{10}$$

We have the following subcases.

(i) $\alpha \geq \underline{f}$**:**

If $\alpha \geq \underline{f}$, $f_{III} = \underline{f} \leq \alpha$ and $p_{\alpha,t} = 1$. The condition in (10) becomes

$$\eta C + \underline{f}[(1-\eta)C + \mu_G X] < \underline{f}[(\mu_G - \mu_B)X]$$

which does not hold.

(ii) $\alpha < \underline{f}$**:**

If $\alpha < \underline{f}$, $f_{III} = \frac{(1-\lambda)f - \lambda\alpha(1-f)}{1-\lambda} > \alpha$ and $p_{\alpha,t} = \alpha/f_{III}$. The condition in (10) becomes

$$\eta C + f_{III}[(1-\eta)C + \frac{\alpha}{f_{III}}\mu_G X] < f_{III}[(\mu_G - \mu_B)X]$$

Thus, we have

$$f_{III} > \frac{\eta C + \alpha\mu_G X}{(\mu_G - \mu_B)X - (1-\eta)C} = m_1$$

which implies $\alpha < \frac{f[(\mu_G - \mu_B)X - (1-\eta)C] - \eta C}{\mu_G X + \frac{\lambda(1-f)}{1-\lambda}[(\mu_G - \mu_B)X - (1-\eta)C]} = \overline{\alpha_{III}}$.

[10] Here, again consider the symmetric equilibrium, either all private agents offer bribes or all not. If all private agents offer bribes, $p_{\alpha,t} = \min\{\alpha/f_{III}, 1\}$, given "opportunist" type "BG" civil servant would reject a bribe if there were any.

Combining these two subcases, we have the feasible conditions of LCSS-III as follows.

$$\frac{f[(\mu_G-\mu_B)X-(1-\eta)C]-\eta C}{\mu_G X+\frac{\lambda(1-f)}{1-\lambda}[(\mu_G-\mu_B)X-(1-\eta)C]}=\overline{\alpha_{III}}>\alpha\geq\overline{\alpha_{II}}=\frac{1}{1+\frac{Y}{C(1-\delta\lambda)}}$$

Note that $\overline{\alpha_{III}}<\underline{f}$ and $\overline{\alpha_{III}}<\alpha_I$ for any β.

Feasible Conditions of HCSS:

At HCSS, the private agents offer bribes and an "opportunist" type "BG" civil servant accepts bribes if there are any. By equation 5, we can derive the proportion of "bad" type "B" civil servant at HCSS, denoted as f_H.

$$f_H=f$$

Same logic as in the previous proof, at HCSS, an "opportunist" type "BG" civil servant would accept a bribe if there were any, which requires $\alpha<\overline{\alpha_{II}}=\frac{1}{1+\frac{Y}{C(1-\delta\lambda)}}$.

Back to the private agent's problem at the beginning of period t, $f_t=f_H$.

$$q_{\alpha,t}=1$$
$$q_{\beta,t}=f_H$$
$$p_{\alpha,t}=\alpha$$

Back to inequality 1, to induce a private agent to offer a bribe

$$\eta C+[(1-\eta)C+\alpha\mu_G X]<f_H[(\mu_G-\mu_B)X] \tag{11}$$

Thus, we have

$$f_H>\frac{C+\alpha\mu_G X}{(\mu_G-\mu_B)X}=m_2$$

These imply that if $\alpha<\alpha_H=\min\left\{\frac{f(\mu_G-\mu_B)X-C}{\mu_G X},\frac{1}{1+\frac{Y}{C(1-\delta\lambda)}}\right\}$, HCSS is feasible. Note that $\alpha_H\leq\overline{\alpha_{II}}$. ■

Proof of Lemma 2

Suppose in period t the economy is at some state: $\{f_t,1-f_t\}$. Backward induction, consider the opportunist type "BG" civil servant's problem: reject or accept bribes if there are any. Same logic as in the proof of lemma 1, there are two scenarios: (i) if $\alpha\geq\overline{\alpha_{II}}$, all "opportunist" type "BG" civil servants reject bribes if there are any; (ii) if $\alpha<\overline{\alpha_{II}}$, all "opportunist" type "BG" civil servants accept bribes if there are any.

(i) $\alpha\geq\overline{\alpha_{II}}$

Back to the private agent's problem at the beginning of period t,

$$\begin{aligned} q_{\alpha,t} &= f_t \\ q_{\beta,t} &= f_t \\ p_{\alpha,t} &= \begin{cases} \alpha/f_t & \text{if } \alpha < f_t \\ 1 & \text{if } \alpha \geq f_t \end{cases} \end{aligned}$$

Back to inequality 1, to induce a private agent not to offer a bribe

$$\eta C + f_t[(1-\eta)C + p_{\alpha,t}\mu_G X] \geq f_t[(\mu_G - \mu_B)X]$$

If $\alpha \geq f_t$, $p_{\alpha,t} = 1$. The condition above becomes

$$\eta C + f_t[(1-\eta)C + \mu_G X] \geq f_t[(\mu_G - \mu_B)X]$$

which always holds.

If $\alpha < f_t$, $p_{\alpha,t} = \alpha/f_t$. The condition above becomes

$$\eta C + f_t[(1-\eta)C + \frac{\alpha}{f_t}\mu_G X] \geq f_t[(\mu_G - \mu_B)X]$$

which implies

$$f_t \leq \frac{\eta C + \alpha\mu_G X}{(\mu_G - \mu_B)X - (1-\eta)C} = m_1$$

Note, $m_1 > \alpha$. Combining the two cases above, if $f_t \leq m_1$, a private agent will not offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 3. Instead, if $f_t > m_1$, a private agent will offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 4.

(ii) $\alpha < \overline{\alpha_{II}}$

Back to the private agent's problem at the beginning of period t,

$$\begin{aligned} q_{\alpha,t} &= 1 \\ q_{\beta,t} &= f_t \\ p_{\alpha,t} &= \alpha \end{aligned}$$

Back to inequality 1, to induce a private agent not to offer a bribe

$$\eta C + [(1-\eta)C + \alpha\mu_G X] \geq f_t[(\mu_G - \mu_B)X]$$

which implies

$$f_t \leq \frac{C + \alpha\mu_G X}{(\mu_G - \mu_B)X} = m_2$$

If $f_t \leq m_2$, a private agent will not offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 3. If $f_t > m_2$, a private agent will offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 5. Note, $m_2 > m_1$.
■

Proof of Lemma 3

Following lemma 1 and 2, there are two scenarios for the transition of state in the long run.

(i) $\alpha \geq \overline{\alpha_{II}}$

In this case, all "opportunist" type "BG" civil servants reject bribes if there are any. Further, if $f_t \leq m_1$, a private agent will not offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 3.

$$\begin{aligned} f_{t+1} &= \lambda(1-p_{\beta,t})f_t + [(1-\lambda) + \lambda p_{\beta,t} f_t]f \\ &= \begin{cases} \lambda f_t - \lambda\beta + (1-\lambda+\lambda\beta)f & \text{if } \beta < f_t \\ (1-\lambda+\lambda f_t)f & \text{if } \beta \geq f_t \end{cases} \end{aligned}$$

Since both λ and λf are less than 1, $f_{t+1} < f_t$ if $f_t > f_I$; $f_{t+1} > f_t$ if $f_t < f_I$; $f_{t+1} = f_t = f_I$ if $f_t = f_I$. Thus, f_t will monotonically converge to f_I, if LCSS-I is feasible.

If $f_t > m_1$, a private agent will offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 4.

$$\begin{aligned} f_{t+1} &= \lambda(1-p_{\alpha,t})f_t + [(1-\lambda) + \lambda p_{\alpha,t} f_t]f \\ &= \begin{cases} \lambda f_t - \lambda\alpha + (1-\lambda+\lambda\alpha)f & \text{if } \alpha < f_t \\ (1-\lambda+\lambda f_t)f & \text{if } \alpha \geq f_t \end{cases} \end{aligned}$$

Since both λ and λf are less than 1, $f_{t+1} < f_t$ if $f_t > f_{III}$; $f_{t+1} > f_t$ if $f_t < f_{III}$; $f_{t+1} = f_t = f_{III}$ if $f_t = f_{III}$. Thus, f_t will monotonically converge to f_{III}, if LCSS-III is feasible.

Back to lemma 1, LCSS-I is feasible if $\alpha \geq \alpha_I$; LCSS-III is feasible if $\overline{\alpha_{III}} > \alpha \geq \overline{\alpha_{II}}$; and $\overline{\alpha_{III}} < \alpha_I$. Therefore, we have three disjoint areas: if $\alpha \geq \alpha_I$, only LCSS-I is feasible and f_t will converge to f_I; if $\overline{\alpha_{III}} > \alpha \geq \overline{\alpha_{II}}$, only LCSS-III is feasible and f_t will converge to f_{III}; if $\alpha_I > \alpha \geq \max\{\overline{\alpha_{II}}, \overline{\alpha_{III}}\}$, both LCSS-I and LCSS-III are not feasible and f_t will oscillate around m_1.

(ii) $\alpha < \overline{\alpha_{II}}$

In this case, all "opportunist" type "BG" civil servants accept bribes if there are any. Further, if $f_t \leq m_2$, a private agent will not offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 3. Same argument, since both λ and λf are less than 1, $f_{t+1} < f_t$ if $f_t > f_I$; $f_{t+1} > f_t$ if $f_t < f_I$; $f_{t+1} = f_t = f_I$ if $f_t = f_I$. Thus, f_t will monotonically converge to f_I, if LCSS-II is feasible.

If $f_t > m_2$, a private agent will offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 5.

$$\begin{aligned} f_{t+1} &= \lambda(1-p_{\alpha,t})f_t + [(1-\lambda) + \lambda p_{\alpha,t}]f \\ &= \lambda(1-\alpha)f_t + [(1-\lambda) + \lambda\alpha]f \end{aligned}$$

Since $\lambda(1-\alpha)$ is less than 1, $f_{t+1} < f_t$ if $f_t > f_H$; $f_{t+1} > f_t$ if $f_t < f_H$; $f_{t+1} = f_t = f_H$ if $f_t = f_H$. Thus, f_t will monotonically converge to f_H, if HCSS is feasible.

Back to lemma 1, LCSS-II is feasible if $\overline{\alpha_{II}} > \alpha \geq \alpha_{II}$; HCSS is feasible if $\alpha < \alpha_H$; and $\alpha_H \leq \overline{\alpha_{II}}$. Therefore, if $\alpha < \min\{\alpha_{II}, \alpha_H\}$, only HCSS is feasible and f_t will converge to f_H. If $\max\{\alpha_{II}, \alpha_H\} \leq \alpha < \overline{\alpha_{II}}$, only LCSS-II is feasible and f_t will converge to f_I. If $\alpha_{II} \leq \alpha < \alpha_H$, both HCSS and LCSS-II are feasible. There are two subcases: if $f_t > m_2$, it will converge to f_H; if $f_t \leq m_2$, it will converge to f_I. If $\alpha_H \leq \alpha < \min\{\alpha_{II}, \overline{\alpha_{II}}\}$, both HCSS and LCSS-II are not feasible and f_t will oscillate around m_2. ■

Proof of Lemma 4

Feasible Conditions of LCSS-I':

At LCSS-I', the private agents do not offer bribes. By equation 3, we can derive the proportion of "bad" type "B" civil servant at LCSS-I', which is same as the proportion in the LCSS-I, f_I.

$$f_I = \begin{cases} \frac{(1-\lambda)f - \lambda\beta(1-f)}{1-\lambda} & \text{if } \beta < \underline{f} \\ \underline{f} & \text{if } \beta \geq \underline{f} \end{cases}$$

Back to inequality 6, to induce a private agent not to offer a bribe, the following condition must hold.

$$C + p_{\alpha,t}\mu_G X \geq (\mu_G - \mu_B)X \tag{12}$$

where $p_{\alpha,t} = \min\{\alpha/f_t, 1\}$.

At LCSS-I',

$$p_{\alpha,t} = \begin{cases} \alpha/f_I & \text{if } \alpha < f_I \\ 1 & \text{if } \alpha \geq f_I \end{cases}$$

We have the following subcases.

(i) $\beta \geq \underline{f}$ **and** $\alpha \geq f_I$**:**

If $\beta \geq \underline{f}$, $f_I = \underline{f}$. Further, if $\alpha \geq f_I = \underline{f}$, $p_{\alpha,t} = 1$. The condition in (12) becomes

$$C + \mu_G X \geq (\mu_G - \mu_B)X$$

wich always holds.

(ii) $\beta < \underline{f}$ **and** $\alpha \geq f_I$**:**

If $\beta < \underline{f}$, $f_I = \frac{(1-\lambda)f - \lambda\beta(1-f)}{1-\lambda}$. Further, if $\alpha \geq f_I = \frac{(1-\lambda)f - \lambda\beta(1-f)}{1-\lambda}$, $p_{\alpha,t} = 1$. The condition in (12) becomes

$$C + \mu_G X \geq (\mu_G - \mu_B)X$$

which always holds.

(iii) $\beta \geq \underline{f}$ **and** $\alpha < f_I$**:**

If $\beta \geq \underline{f}$, $f_I = \underline{f}$. Further, if $\alpha < f_I = \underline{f}$, $p_{\alpha,t} = \alpha/f_I = \alpha/\underline{f}$. The condition in (12) becomes

$$C + \frac{\alpha}{\underline{f}}\mu_G X \geq (\mu_G - \mu_B)X$$

Thus, we have

$$\underline{f} \leq \frac{\alpha\mu_G X}{(\mu_G - \mu_B)X - C}$$

which implies $\alpha \geq \frac{\underline{f}[(\mu_G-\mu_B)X-C]}{\mu_G X}$.

(iv) $\beta < \underline{f}$ **and** $\alpha < f_I$**:**

If $\beta < \underline{f}$, $f_I = \frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}$. Further, if $\alpha < f_I = \frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}$, $p_{\alpha,t} = \alpha/f_I$. The two conditions in (12) become

$$C + \frac{\alpha}{\underline{f}}\mu_G X \geq (\mu_G - \mu_B)X$$

Thus, we have

$$f_I \leq \frac{\alpha\mu_G X}{(\mu_G - \mu_B)X - C}$$

which implies $\alpha \geq \frac{\frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}[(\mu_G-\mu_B)X-C]}{\mu_G X}$.

Note that when $\beta = \underline{f}$, $\frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda} = \underline{f}$. Combining these four subcases, we have the feasible conditions of LCSS-I' as follows.

$$\alpha \geq \alpha'_I = \begin{cases} \frac{\frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}[(\mu_G-\mu_B)X-C]}{\mu_G X} & \text{if } \beta < \underline{f} \\ \frac{\underline{f}[(\mu_G-\mu_B)X-C]}{\mu_G X} & \text{if } \beta \geq \underline{f} \end{cases}$$

<u>Feasible Conditions of LCSS-III':</u>

At LCSS-III', the private agents offer bribes. By equation 4, we can derive the proportion of "bad" type "B" civil servant at LCSS-III', which is same as the proportion in the LCSS-III, f_{III}.

$$f_{III} = \begin{cases} \frac{(1-\lambda)f-\lambda\alpha(1-f)}{1-\lambda} & \text{if } \alpha < \underline{f} \\ \underline{f} & \text{if } \alpha \geq \underline{f} \end{cases}$$

Back to inequality 6, to induce a private agent to offer a bribe, the following condition must hold.

$$C + p_{\alpha,t}\mu_G X < (\mu_G - \mu_B)X \tag{13}$$

where $p_{\alpha,t} = \min\{\alpha/f_t, 1\}$.

At LCSS-III',

$$p_{\alpha,t} = \begin{cases} \alpha/f_{III} & \text{if } \alpha < f_{III} \\ 1 & \text{if } \alpha \geq f_{III} \end{cases}$$

We have the following subcases.

(i) $\alpha \geq \underline{f}$**:**

If $\alpha \geq \underline{f}$, $f_{III} = \underline{f} \leq \alpha$ and $p_{\alpha,t} = 1$. The condition in (13) becomes

$$C + \frac{\alpha}{\underline{f}}\mu_G X < (\mu_G - \mu_B)X$$

which does not hold.

(ii) $\alpha < \underline{f}$**:**

If $\alpha < \underline{f}$, $f_{III} = \frac{(1-\lambda)f - \lambda\alpha(1-f)}{1-\lambda} > \alpha$ and $p_{\alpha,t} = \alpha/f_{III}$. The condition in (13) becomes

$$C + \frac{\alpha}{f_{III}}\mu_G X < (\mu_G - \mu_B)X$$

Thus, we have

$$f_{III} > \frac{\alpha\mu_G X}{(\mu_G - \mu_B)X - C}$$

which implies $\alpha < \overline{\alpha_{III}}' = \frac{f[(\mu_G - \mu_B)X - C]}{\mu_G X + \frac{\lambda(1-f)}{1-\lambda}[(\mu_G - \mu_B)X - C]}$.

Combining these two subcases, we have the feasible conditions of LCSS-III' as follows.

$$\alpha < \overline{\alpha_{III}}' = \frac{f[(\mu_G - \mu_B)X - C]}{\mu_G X + \frac{\lambda(1-f)}{1-\lambda}[(\mu_G - \mu_B)X - C]}$$

Here, $\overline{\alpha_{III}}' < \underline{f}$. Note that $\overline{\alpha_{III}}' < \alpha_I'$ for any β. ■

Proof of Lemma 5

Suppose in period t the economy is at some state: $\{f_t, 1 - f_t\}$. For acquaintance matching, private agents know the true type of the civil servants they are matched with. If the civil servant is a "BG" type, the best response for the private agent is to "not bribe," as a "BG" type civil servant will always implement a fair test. In this case, the "BG" type civil servants are passive and there is no loss of bribe.

If the civil servant is a "B" type, from figure 3, $q_{\alpha,t} = q_{\beta,t} = 1$. From inequality 1, to induce a private agent not to offer a bribe

$$\eta C + [(1-\eta)C + p_{\alpha,t}\mu_G X] \geq [(\mu_G - \mu_B)X]$$

where $p_{\alpha,t} = \min\{\alpha/f_t, 1\}$.

If $\alpha \geq f_t$, $p_{\alpha,t} = 1$. The condition above becomes

$$\eta C + [(1-\eta)C + \mu_G X] \geq [(\mu_G - \mu_B)X]$$

which always holds.

If $\alpha < f_t$, $p_{\alpha,t} = \alpha/f_t$. The condition above becomes

$$\eta C + [(1-\eta)C + \frac{\alpha}{f_t}\mu_G X] \geq [(\mu_G - \mu_B)X]$$

which implies

$$f_t \leq \frac{\alpha \mu_G X}{(\mu_G - \mu_B)X - C} = m_1'$$

Note, $m_1' > \alpha$. Combining the two cases above, if $f_t \leq m_1'$, a private agent will not offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 3. Instead, if $f_t > m_1'$, a private agent will offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 4. ■

Proof of Lemma 6

Following lemma 5, if $f_t \leq m_1'$, a private agent will not offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 3.

$$\begin{aligned} f_{t+1} &= \lambda(1-p_{\beta,t})f_t + [(1-\lambda) + \lambda p_{\beta,t} f_t]f \\ &= \begin{cases} \lambda f_t - \lambda\beta + (1-\lambda+\lambda\beta)f & \text{if } \beta < f_t \\ (1-\lambda+\lambda f_t)f & \text{if } \beta \geq f_t \end{cases} \end{aligned}$$

Since both λ and λf are less than 1, $f_{t+1} < f_t$ if $f_t > f_I$; $f_{t+1} > f_t$ if $f_t < f_I$; $f_{t+1} = f_t = f_I$ if $f_t = f_I$. Thus, f_t will monotonically converge to f_I, if LCSS-I' is feasible.

If $f_t > m_1'$, a private agent will offer a bribe at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equations 4.

$$\begin{aligned} f_{t+1} &= \lambda(1-p_{\alpha,t})f_t + [(1-\lambda) + \lambda p_{\alpha,t} f_t]f \\ &= \begin{cases} \lambda f_t - \lambda\alpha + (1-\lambda+\lambda\alpha)f & \text{if } \alpha < f_t \\ (1-\lambda+\lambda f_t)f & \text{if } \alpha \geq f_t \end{cases} \end{aligned}$$

Since both λ and λf are less than 1, $f_{t+1} < f_t$ if $f_t > f_{III}$; $f_{t+1} > f_t$ if $f_t < f_{III}$; $f_{t+1} = f_t = f_{III}$ if $f_t = f_{III}$. Thus, f_t will monotonically converge to f_{III}, if LCSS-III' is feasible.

Back to lemma 4, LCSS-I' is feasible if $\alpha \geq \alpha_I'$; LCSS-III' is feasible if $\alpha < \overline{\alpha_{III}}'$; and $\overline{\alpha_{III}}' < \alpha_I'$. Therefore, we have three disjoint areas: if $\alpha \geq \alpha_I'$, only LCSS-I' is feasible and f_t will converge to f_I; if $\alpha < \overline{\alpha_{III}}'$, only LCSS-III' is feasible and f_t will converge to f_{III}; if $\alpha_I' > \alpha \geq \overline{\alpha_{III}}'$, both LCSS-I' and LCSS-III' are not feasible and f_t will oscillate around m_1'. ■

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