Social Transformation, Group Reputation, and Reputation Matching

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Revised: March 2015‡

Abstract

Unlike in small communities where one can strategically interact with another according to the latter's individual reputation, players in complex societies often have to interact with strangers whose individual reputations cannot be easily acquired. They often have to infer their counterparts' characteristics from the latters' group reputation to simplify decision making. We provide a game theoretical model of reputation matching concerning corruption during social transformation. We show that the regime change from acquaintance matching to anonymous matching tends to cause rampant corruption and the effectiveness of anti-corruption policies is non-monotonic with respect to the supervision efforts.

JEL classification: C73, D73, D83, H83

Keywords: Social Transformation, Group Reputation, Reputation Matching, Corruption

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‡We are grateful to David K. Levine, Masaki Aoyagi and seminar participants at UCLA, Singapore Management University, International Conference on Trust and Norms, 2011 North American Summer Meeting of the Econometric Society, 2013 China Meeting of the Econometric Society, 24th International Conference on Game Theory at Stony Brook University, and 7th FINT Workshop on Trust Within and Between Organizations for helpful feedback. The usual disclaimer applies.

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. Holmstrom (1999) investigates the dynamic incentive problem – an agent has the strongest incentive to work hard to reveal her managerial ability in the beginning. 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 certain type to achieve highest possible utility. Hörner (2002) introduces competition to keep high efforts sustainable.

However, players in complex societies often have to interact with strangers whose individual reputations cannot be easily acquired. Unlike in small communities where one can rather easily acquire another's individual reputation, they often have to infer their counterparts' characteristics from the latter's group reputation to simplify decision making. Cornell and Welch (1996) develop a model on "screening discrimination" based solely on "unfamiliarity," which makes it more difficult to make accurate assessments. Fang (2001) shows that by allowing a firm to give preferential treatment to workers based on some "cultural activity," a society can partially overcome the informational free-riding problem. The critique on this statistical discrimination theory is that it is a static theory, which discusses little about reputation formation and its persistence. Diamond (1989) constructs a dynamic reputation 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. However, the focus is still on reputation formation of the individual agents.

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 her peers and argues that their past behaviors affect the player's record of performance. Both papers focus on individual reputation and do not clarify the difference between individual reputation and group reputation. A major problem is that for a large group, its group reputation can hardly be dramatically affected by the behaviors of a small number of group members. Even worse, some group reputations may be false stereotypes that have little to do with actual individual reputations.

We define one's group reputation as others' beliefs on the characteristics of one's affiliated group. In small communities, others usually acquire such beliefs partially through first-hand information about a substantial number of group members. In complex societies, however, a group's reputation quite often disseminate among people who have never been at the presence of any member of the group. It's not uncommon that a player's individual reputation in a complex society is derived from her group reputation by adding individual signals. Based on this definition, we construct a model of group reputation formation and evolution, illustrated by a case in corruption, to answer the following two questions: how does the transformation from community to society affect reputation matching? What are the policy implications for regime change of reputation matching? We show that the regime change from acquaintance matching in small communities to anonymous matching in complex societies tends to cause rampant corruption. The effectiveness of an anti-corruption policy is non-monotonic with respect to the supervision efforts, which have to reach some long-term minimum level to reverse high corruption. To be effective, anti-corruption measures have to be taken on both lines of bribe taking and duty dereliction.

Our model is related to the literature of cooperation among strangers, which studies the repeated games with random matching of anonymous agents (e.g., Kandori 1992; Healy 2007; Camera and Casari 2009). Their theoretical models and experimental designs focus on imperfect public monitoring and the agents' own private monitoring. While in our model, we introduce external monitoring by a benevolent government who regulates against corruption.

Our model is also related to the literature of evolutionary game theory. Since the seminal paper by Maynard Smith and Price (1973), evolutionary dynamics of population games has been well studied in the area of evolutionary biology. However, evolutionary dynamics in human societies rely on much more complicated microfoundations than the genetically-determined strategies (Sandholm 2010). We characterize the equilibrium and study the evolutionary dynamics in such an environment of rational decision makers.

The rest of the paper is organized as follows. Section 2 describes the structure of the model. Section 3 studies how the change of reputation matching matters during the social transformation from community to society and presents our main results. Section 4 investigates the policy implications for regime change of reputation matching. Some comparative statics are discussed in section 5. Section 6 concludes.

2 The Model

2.1 Basic Conceptions

Bardhan's (1997) definition of corruption is applied as "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.” We focus on two types of corruptive behaviors, bribe acceptance and duty dereliction, of civil servants.

Suppose 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 examine and approve projects of the private agents by certain criteria, such as road test for a driver's license. The civil servants are categorized into two types: “bad” or “opportunist.” The bad type always accepts bribes or intentionally places obstacles during the tests if there is no bribe.[1] The opportunist type will weigh the advantages and disadvantages to decide whether or not to accept bribes, or if there is no bribe whether or not to place obstacles during the tests .

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.[2]
>
> Group G_k's **group reputation** to do X with respect to P_j is the belief of P_j on the distribution of behavioral types of players $A_s \in G_k$, 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 the same as the group reputation because P_j does not have additional individual signals on these players.

We consider two different regimes of reputation matching and the change between two regimes. Under **anonymous matching**, a potential briber does not know the true type of her matching civil servant and therefore will decide whether or not to offer a bribe according to the group reputation of the civil servants. Whereas under **acquaintance matching**, a potential briber knows the true type of her matching civil servant and therefore will decide whether or not to offer a bribe according to the private reputation of the civil servant. The transformation from community to society, as suggested by Tönnies (2001) and Cook and Hardin (2001), contributes greatly for decision making during the regime change between two types of matching.

[1] Bertrand, Djankov, Hanna, and Mullainathan (2007) provide the evidence of bureaucrats arbitrarily failing driver's licence test takers for rent-seeking in India.

[2] 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.

2.2 Stage Game

Time is discrete, indexed by t, and the horizon is infinite. At the beginning of each period, there is a continuum of mass 1 civil servants, who are assigned to examine the projects for some private agents. Each participating private agent decides whether or not to offer a bribe to the civil servant who is randomly assigned. Then it is the civil servant's turn to make a choice. There are two different scenarios depending on the choice of the private agent: if there is a bribe, the civil servant will decide to either reject or accept the bribe; if there is no bribe, the civil servant will decide to either implement a fair test or intentionally place obstacles during the test. Thus, there are two types of corruptive behaviors for the civil servants: bribe acceptance and duty dereliction.

Let (α, β) represent the fixed amount of ***supervision effort*** level of the government against these two types of corruptive behaviors, where α and $\beta \in [0, 1]$. I.e., if there is a mass of Γ_t civil servants accepting bribes in period t, then the probability for each of them to be detected $p_{\alpha,t} = \min\{\alpha/\Gamma_t, 1\}$.[3] Similarly, if there is a mass of Φ_t civil servants placing obstacles during the tests in period t, then the probability for each of them to be detected $p_{\beta,t} = \min\{\beta/\Phi_t, 1\}$.[4]

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. The action set of the private agents is $A_1 = \{B(ribe), N(ot\ \ bribe)\}$. Civil servants, of "opportunist" type or "bad" type denoted as type "O" and "B" respectively, are long lived with common discount factor $\delta \in (0, 1)$.

The bad type "B" always accepts a bribe and implements a fair test if there is any bribe or places obstacles during the test if there is no bribe. For the "opportunist" type "O," if there is a bribe, she will implement a fair test and weigh the benefits from the bribe and the jeopardy of being caught by the government to decide whether or not to accept the bribe. If there is no bribe, she will also implement a fair test. She has no incentive to place obstacles at her own risk of being caught.[5] Therefore, the action set for the "opportunist" type "O" civil servants $A_2 = \{A(ccept), R(eject)\}$.

Now we turn to the stage game payoffs, which are described in figure 1. At the beginning of each period, each civil servant will be randomly assigned to examine the project for a participating private agent. The private agent will choose to either bribe

[3] 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.

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

[5] With a continuum of agents, the action of a single civil servant cannot affect the proportion of the bad type in the society as a whole. In addition, as civil servants face generations of short-run private agents and are randomly assigned for the tests at the beginning of each period, the dominant strategy for the "opportunist" type "O" civil servants is to implement fair test regardless of bribe offering.

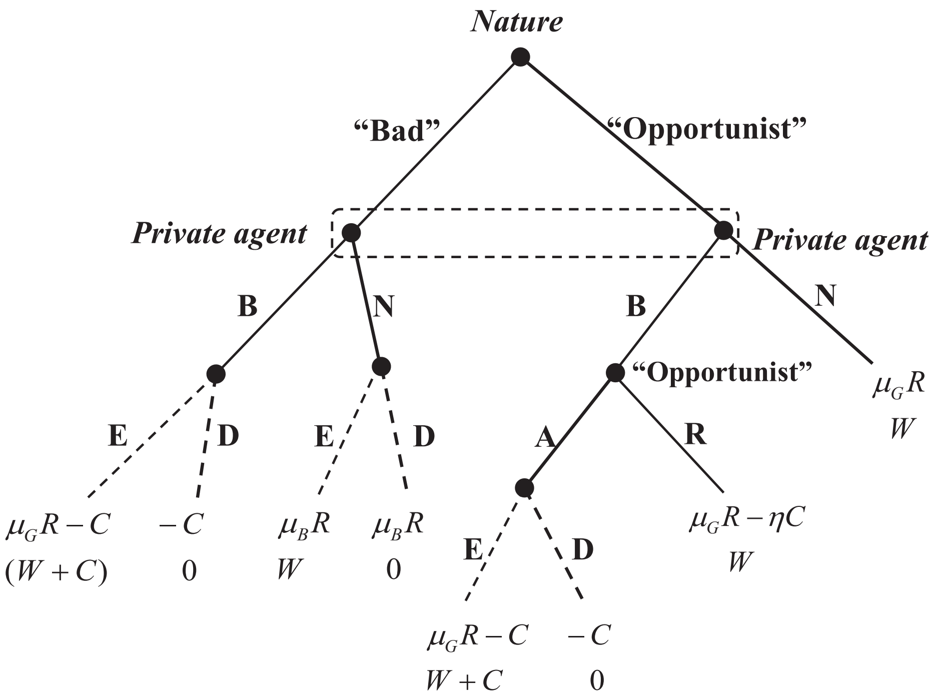

Figure 1: Stage Game Payoffs

(**B**) or not bribe (**N**).

Then, it is the turn for the civil servants. For a type "B" civil servant, if there is a bribe, depending on whether the bribing behavior is escaping scot-free (**E**) or detected (**D**) by the government, the corresponding payoffs for the private agent and the civil servant are: $(\mu_G R - C, W + C)$ if escaping scot-free; $(-C, 0)$ if detected. Here, μ_G is the probability of the project being approved under a fair test. R is the benefit from an approved project. The benefit from a failed project is normalized to zero. C is the amount of bribe. W is the periodical wage of the civil servant.

If there is no bribe, she will place obstacles during the test. Depending on whether such duty dereliction is escaping scot-free (**E**) or detected (**D**) by the government, the corresponding payoffs for the private agent and the civil servant are: $(\mu_B R, W)$ if escaping scot-free; $(\mu_B R, 0)$ if detected. Here, μ_B is the probability of the project being approved under an unfair test, in which the civil servant place obstacles.

In contrast, for a type "O" civil servant, if there is a bribe, she will weigh the advantages and disadvantages to choose accepting or rejecting. If she accepts the bribe, depending on escaping scot-free (**E**) or being detected (**D**), the corresponding payoffs for the private agent and the civil servant are: $(\mu_G R - C, W + C)$ if escaping scot-free; $(-C, 0)$ if detected. If she rejects, the corresponding payoffs are: $(\mu_G R - \eta C, W)$, where $\eta \in (0, 1)$ is the share of loss on a rejected bribe. If there is no bribe, the corresponding payoffs for the private agent and the civil servant are: $(\mu_G R, W)$.

2.3 Dynamic Game

Consider the game in period t. Let x_t represent the mass of type "B" in the population of civil servants at the beginning of period t. The remaining $1-x_t$ is the mass of type "O". Thus, $\{x_t\}$ represents the state of the economy in period t, which is common knowledge. The expected payoffs of the private agents and the civil servants in period t are denoted by $g_{i,t}(a_1, a_2|\theta, x_t)$ for $i = 1, 2$, where $a_i \in A_i$ and $\theta \in \{\theta_B, \theta_O\}$. Based on the stage game payoffs in section 2.2, for various combination of (a_1, a_2), the expected payoffs $(g_{1,t}(a_1, a_2|\theta, x_t), g_{2,t}(a_1, a_2|\theta, x_t))$ are listed in the following table.

Table 1: Expected Payoffs of the Private Agents and the Civil Servants in Period t

(a_1, a_2)	$\theta = \theta_B$	$\theta = \theta_O$
(B, A)	$((1-p_{\alpha,t})\mu_G R - C, (1-p_{\alpha,t})(W+C))$	$((1-p_{\alpha,t})\mu_G R - C, (1-p_{\alpha,t})(W+C))$
(B, R)		$(\mu_G R - \eta C, W)$
(N, A)	$(\mu_B R, (1-p_{\beta,t})W)$	$(\mu_G R, W)$
(N, R)		

Here, $p_{\alpha,t}$ and $p_{\beta,t}$ are functions of x_t. As defined earlier, $p_{\alpha,t} = \min\{\alpha/\Gamma_t, 1\}$, where Γ_t is the mass of civil servants accepting bribe in period t; $p_{\beta,t} = \min\{\beta/\Phi_t, 1\}$, where Φ_t is the mass of civil servants placing obstacles during the tests in period t. Clearly, only a type "B" civil servant places obstacles if there is no bribe. Thus, $\Phi_t = x_t$, which implies $p_{\beta,t} = \min\{\beta/x_t, 1\}$. In contrast, if there are bribes, type "O" civil servants may accept, in addition to the type "B". Therefore, depending on the choice of type "O", there are two scenarios. If type "O" accepts, $\Gamma_t = 1$ and $p_{\alpha,t} = \alpha$; if not, $\Gamma_t = x_t$ and $p_{\alpha,t} = \min\{\alpha/x_t, 1\}$.[6]

For the long-lived civil servants, we need to consider the continuation payoff in addition to the stage payoff. Assume the civil servants alive in date t remain in the economy in date $t+1$ with probability $\lambda \in (0, 1)$. 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 "O": $(f, 1-f)$. Hence, the size of the civil servants remains constant mass of 1. Further, at the beginning of each period, every civil servant will be assigned exactly one test. In each period the mass of private agents chosen by the government to get their projects tested equals the mass of the civil servants, which equals to one.

[6]For simplicity, we consider the symmetric equilibrium, in which all "opportunist" type "O" civil servants choose the same action in any given period.

Our solution concept is Markov Perfect Equilibrium. Consider the game at an arbitrary period with state x.[7] The (Markov) strategy of the private agent is $\sigma_1 : [0,1] \to \{B, N\}$, while the strategy of the "opportunist" type "O" civil servant is $\sigma_2 : [0,1] \to \{A, R\}$. The "opportunist" type "O" civil servant's intertemporal value function $V : [0,1] \to \mathbf{R}$ is written as:

$$V(x) = \begin{cases} \max\Big\{g_2(B, A|\theta_O, x) + \delta\lambda(1-p_\alpha)V(x'), \\ \qquad\qquad\qquad g_2(B, R|\theta_O, x) + \delta\lambda V(x'')\Big\} & \text{if } \sigma_1(x) = B, \\ g_2(N, a_2|\theta_O, x) + \delta\lambda V(x''') & \text{if } \sigma_1(x) = N. \end{cases} \tag{1}$$

where x' is the state variable after the acceptance of bribes, x'' is the state variable after the denial of bribes, and x''' is the state variable after no bribe.

Here, the equilibrium belief of the private agents on the masses of corruptive behaviors, bribe acceptance and duty dereliction, is the ***group reputation*** of the civil servants. Specifically, denote P_{A_1} as the belief of the private agents about the mass of bribe acceptance if there are bribes; denote P_{A_2} as the belief of the private agents about the mass of obstacle placing during the tests if there is no bribe. Given state x, the group reputation (P_{A_1}, P_{A_2}) is listed in the following table, depending on the equilibrium strategy profile (σ_1, σ_2).

Table 2: Group Reputation of the Civil Servants

(σ_1, σ_2)	(P_{A_1}, P_{A_2})
(B, A)	$(1, x)$
(B, R)	(x, x)
(N, A)	$(1, x)$
(N, R)	(x, x)

2.4 State Transition

Now, we turn to characterize the evolution of the state variable x. There are three cases, depending on the strategy profile of the private agents and the "opportunist" type "O" civil servants: (σ_1, σ_2).

Case 1: $(\sigma_1, \sigma_2) = (B, A)$

In this case, $p_\alpha = \alpha$. The state of transition from x to x' is as follows.

$$\begin{aligned} x' &= \lambda(1-p_\alpha)x + [(1-\lambda) + \lambda p_\alpha]f \\ &= \lambda(1-\alpha)x + [(1-\lambda) + \lambda\alpha]f \end{aligned} \tag{2}$$

[7] Here, we drop the subscript t.

Case 2: $(\sigma_1, \sigma_2) = (B, R)$

In this case, $p_\alpha = \min\{\alpha/x, 1\}$. The state of transition from x to x'' is as follows.

$$x'' = \lambda(1 - p_\alpha)x + [(1 - \lambda) + \lambda p_\alpha x]f$$
$$= \begin{cases} \lambda x - \lambda\alpha + (1 - \lambda + \lambda\alpha)f & \text{if } x > \alpha \\ (1 - \lambda + \lambda x)f & \text{if } x \leq \alpha \end{cases} \tag{3}$$

Case 3: $(\sigma_1, \sigma_2) = (N, A)$ or (N, R)

In this case, $p_\alpha = \min\{\beta/x, 1\}$. The state of transition from x to x''' is as follows.

$$x''' = \lambda(1 - p_\beta)x + [(1 - \lambda) + \lambda p_\beta x]f$$
$$= \begin{cases} \lambda x - \lambda\beta + (1 - \lambda + \lambda\beta)f & \text{if } x > \beta \\ (1 - \lambda + \lambda x)f & \text{if } x \leq \beta \end{cases} \tag{4}$$

3 Social Transformation

Now, we turn to analyze how the change of reputation matching matters during the social transformation from community to society. First, we start with anonymous matching, where a potential briber does not know the true type of her matching civil servant and therefore will decide whether or not to offer a bribe according to the group reputation of the civil servants. Then, we move on to acquaintance matching, where a potential briber knows the true type of her matching civil servant and therefore will decide whether or not to offer a bribe according to the private reputation of the civil servant. Finally, we show that the regime change from acquaintance matching in small communities to anonymous matching in complex societies tends to cause rampant corruption.

3.1 Anonymous Matching

Consider anonymous matching, in which a private agent does not know the true type of her matching civil servant. From the intertemporal value function of the "opportunist" type "O" civil servant in equation 1, we have the following lemma, which says that $V(x)$ increases in x and is bounded below and above.

Lemma 1 *$V(x)$ increases in x and $V_L \leq V(x) \leq V_H$, where $V_L = \frac{1}{1-\delta\lambda}W$ and $V_H = \frac{(1-\alpha)}{1-(1-\alpha)\delta\lambda}(W + C)$.*

Obviously, if x increases, $V(x)$ is non-decreasing, as the "opportunist" type "O" civil servants can always copy the previous strategy adopted in the case with lower

x and gain. Simply because now with more bad type "B", the probability of being detected by the government is going down. In addition, regardless of the choices by others, civil servants can guarantee the payoff of V_L by always rejecting bribes if there are any, where

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

Further, the upper bound of the payoff of the civil servants V_H is achieved if private agents offer bribes and all civil servants accept and these are sustained, where

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

3.1.1 Equilibrium Characterization

Now, we move on to characterize the symmetric Markov Perfect Equilibrium. From stage game payoff of the private agents in table 1 and the intertemporal value function of the "opportunist" type "O" civil servant in equation 1, the following lemma shows the existence of a symmetric Markov Perfect Equilibrium.

Lemma 2 *There exists a symmetric Markov Perfect Equilibrium, in which the strategy profile (σ_1, σ_2) at any given period with the state variable x is as follows.*

(i) *For $\alpha < \alpha_A$,*

$$(\sigma_1, \sigma_2) = \begin{cases} (B, A) & \text{if } x > x^* \\ (N, A) & \text{if } x \leq x^* \end{cases}$$

(ii) *For $\alpha \geq \alpha_A$,*

$$(\sigma_1, \sigma_2) = \begin{cases} (B, R) & \text{if } x > x^{**} \\ (N, R) & \text{if } x \leq x^{**} \end{cases}$$

where $\alpha_A = \frac{1}{1+\frac{W}{C(1-\delta\lambda)}}$, $x^* = \frac{C+\alpha\mu_G R}{(\mu_G-\mu_B)R}$, $x^{**} = \frac{\eta C+\alpha\mu_G R}{(\mu_G-\mu_B)R-(1-\eta)C}$. Note, $x^* > x^{**}$.

Proof. See the Appendix. ■

Intuitively, from lemma 1, $V(x)$ is bounded below by V_L and above by V_H. It is easy to see that if $\alpha < \frac{1}{1+\frac{W}{C(1-\delta\lambda)}} = \alpha_A$, $V_H > V_L$; if $\alpha \geq \alpha_A$, $V_H \leq V_L$. Consider the symmetric equilibrium. With a continuum of agents, the action of a single civil servant cannot affect the proportion of the bad type in the society as a whole. In the case of $\alpha < \alpha_A$, all "opportunist" type "O" civil servants accept bribes if there are any. Simply because $V_H > V_L$ and $p_\alpha = \alpha$ is the minimum value of p_α, so that accepting a bribe if there is any is the best for anyone to do. Back to the private agent's problem at the beginning of the period, as all "opportunist" type "O" civil servants accept bribes if there are any, $p_\alpha = \alpha$. From the stage game payoff of the private agents in table 1, to induce private agents not to offer bribes, $x \leq \frac{C+\alpha\mu_G R}{(\mu_G-\mu_B)R} = x^*$.

In contrast, in the case of $\alpha \geq \alpha_A$, all "opportunist" type "O" civil servants reject bribes if there is any. Simply because $V_H \leq V_L$, so that rejecting a bribe if there is any is the best for anyone to get the guaranteed payoff. Back to the private agent's problem at the beginning of the period, as all "opportunist" type "O" civil servants reject bribes if there are any, $p_\alpha = \min\{\alpha/x, 1\}$. From the stage game payoff of the private agents in table 1, to induce private agents not to offer bribes, $x \leq \frac{\eta C+\alpha\mu_G R}{(\mu_G-\mu_B)R-(1-\eta)C} = x^{**}$.

Further, we have $x^* > x^{**}$. The reasoning is that if α is small so that "opportunist" type "O" civil servants accept bribes if there is any, private agents are less willing to offer bribes. Only if the proportion of bad type "B" in the population is sufficiently large, will they offer bribes.

3.1.2 Evolutionary Dynamics

After characterizing the equilibrium, the natural extension is to analyze the evolutionary dynamics in the long run. There are four possible steady states, depending on the strategy profile of the private agents and the "opportunist" type "O" civil servants: (σ_1, σ_2).

High Corruption Steady State (HCSS): $(\sigma_1, \sigma_2) = (B, A)$

From equation 2, we can derive a steady state, in which the private agents always offer bribes and the type "O" civil servants accept bribes. The corresponding proportion of "bad" type "B" civil servant is

$$f_H = f$$

We designate such state as High Corruption Steady State (HCSS).

Low Corruption Steady State I (LCSS-I): $(\sigma_1, \sigma_2) = (B, R)$

From equation 3, we can derive a steady state, in which the private agents always offer bribes and the type "O" civil servants reject bribes. The corresponding proportion of "bad" type "B" civil servant is

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

where $\underline{f} = \frac{(1-\lambda)f}{1-\lambda f}$. Note, $f_I \geq \underline{f}$. We designate such state as Low Corruption Steady State I (LCSS-I).

Low Corruption Steady State II (LCSS-II): $(\sigma_1, \sigma_2) = (N, A)$

From equation 4, we can derive a steady state, in which the private agents do not offer any bribe and the type "O" civil servants would accept a bribe if there were any. The corresponding proportion of "bad" type "B" civil servant is

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

Note, $f_{II} \geq \underline{f}$. We designate such state as Low Corruption Steady State II (LCSS-II).

Low Corruption Steady State III (LCSS-III): $(\sigma_1, \sigma_2) = (N, R)$

From equation 4, we can derive one more steady state, in which the private agents do not offer any bribe and the type "O" civil servants would not accept a bribe if there were any. As there is no bribe from the private agents, the proportion of "bad" type "B" civil servant is the same as the proportion in the LCSS-II, f_{II}. We designate such state as Low Corruption Steady State III (LCSS-III).

Figure 2 illustrates the proportion of "bad" type "B" civil servants at these four steady states as functions of α, given the value of β. Similarly, we may draw the

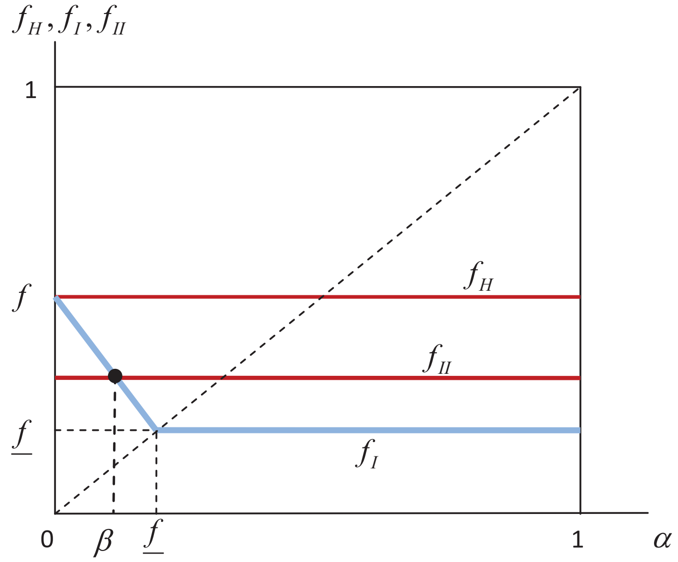

Figure 2: The Proportion of "Bad" Type "B" Civil Servant at the Steady States

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.

Lemma 3 **HCSS** *is feasible if* $\alpha < \alpha_H$*;*

LCSS-I *is feasible if* $\alpha_I > \alpha \geq \alpha_A$*;*

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

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

where

$$\alpha_H = \min\left\{\frac{f(\mu_G - \mu_B)R - C}{\mu_G R}, \alpha_A\right\}$$

$$\alpha_I = \min\left\{\frac{f[(\mu_G - \mu_B)R - (1-\eta)C] - \eta C}{\mu_G R + \frac{\lambda(1-f)}{1-\lambda}[(\mu_G - \mu_B)R - (1-\eta)C]}, \underline{f}\right\}$$

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

$$\alpha_{III} = \begin{cases} \max\left\{\dfrac{\frac{(1-\lambda)f - \lambda\beta(1-f)}{1-\lambda}[(\mu_G - \mu_B)R - (1-\eta)C] - \eta C}{\mu_G R}, \alpha_A\right\} & \text{if } \beta < \underline{f} \\ \max\left\{\dfrac{\underline{f}[(\mu_G - \mu_B)R - (1-\eta)C] - \eta C}{\mu_G R}, \alpha_A\right\} & \text{if } \beta \geq \underline{f} \end{cases}$$

Proof. See the Appendix. ■

Figure 3 sketches out space partition of the states when $\alpha_H < \alpha_A$. Figure 4 sketches out the state space partition when $\alpha_H = \alpha_A$. There are some more minor variations of state space partitions depending on the values of parameters. But the basic shapes are as described in figures 3 and 4. Generally speaking, if the governmental supervision effort level against the corruptive behavior of bribe acceptance α is low, HCSS is feasible; if α is high, LCSS-III is feasible; if α is in the middle, LCSS-I or LCSS-II may be feasible.

In the long run, the economy at any arbitrary state x_t may evolve into some steady state. The following lemma shows that when α is small, x_t will converge to f_H or f_I, or oscillate around x^*; when α is large, x_t will converge to f_I or f_{II}, or oscillate around x^{**}.

Lemma 4 *Suppose in period t the economy is at some state* x_t*. There are two scenarios for the transition of state in the long run.*

(i) *If* $\alpha < \alpha_A$*,* x_t *will converge to* f_H *or* f_{II}*, or oscillate around* x^**. In particular, if* $\alpha < \min\{\alpha_{II}, \alpha_H\}$*,* x_t *will converge to* f_H*. If* $\max\{\alpha_{II}, \alpha_H\} \leq \alpha < \alpha_A$*,* x_t *will converge to* f_{II}*. If* $\alpha_{II} \leq \alpha < \alpha_H$*, there are two subcases: if* $x_t > x^*$*, it will converge to* f_H*; if* $x_t \leq x^*$*, it will converge to* f_{II}*. If* $\alpha_H \leq \alpha < \min\{\alpha_{II}, \alpha_A\}$*,* x_t *will oscillate around* x^**.*

(ii) *If* $\alpha \geq \alpha_A$*,* x_t *will converge to* f_I *or* f_{II}*, or oscillate around* x^{**}*. In particular, if* $\alpha \geq \alpha_{III}$*,* x_t *will converge to* f_{II}*. If* $\alpha_I > \alpha \geq \alpha_A$*,* x_t *will converge to* f_I*. If* $\alpha_{III} > \alpha \geq \max\{\alpha_A, \alpha_I\}$*,* x_t *will oscillate around* x^{**}*.*

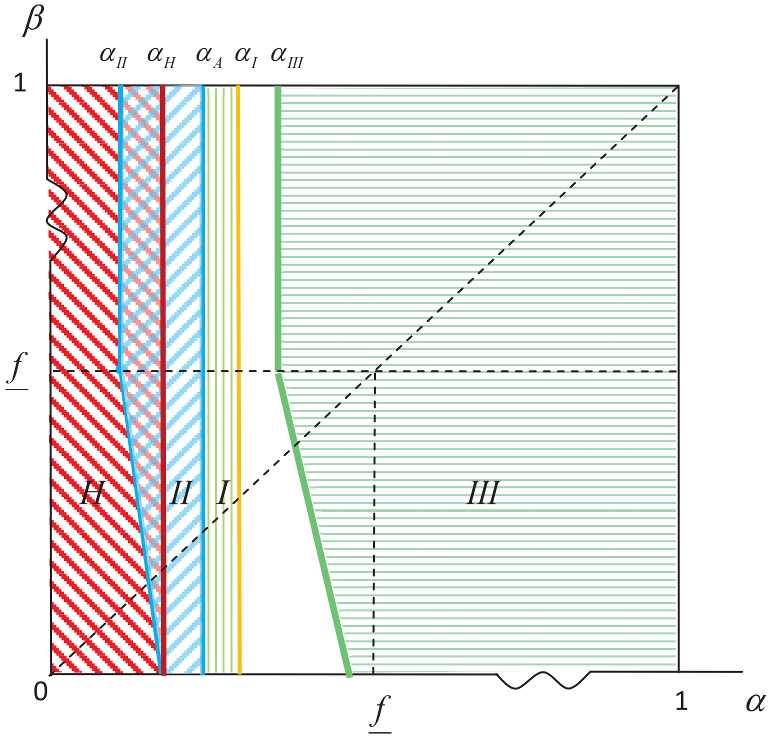

Figure 3: The State Space Partition: $\alpha_H < \alpha_A$

Proof. See the Appendix. ■

3.2 Acquaintance Matching

Consider acquaintance matching, in which a private agent knows the true type of her matching civil servant.[8] From stage game payoffs of the private agents in table 1, if a civil servant is the "opportunist" type "O", the best response for the private agent is to "not bribe," as the "opportunist" type "O" civil servant will always implement a fair test. In this case, the "opportunist" type "O" civil servant is passive and there is no loss of bribe. The following lemma shows the existence of a symmetric Markov Perfect Equilibrium.

Lemma 5 *There exists a symmetric Markov Perfect Equilibrium, in which the strategy σ_1 at any given period with the state variable x is as follows.*

$$\sigma_1 = \begin{cases} B & \text{if } x > \widetilde{x}^* \\ N & \text{if } x \leq \widetilde{x}^* \end{cases}$$

where $\widetilde{x}^* = \frac{\alpha\mu_G R}{(\mu_G - \mu_B)R - C}$. *Note,* $x^* > x^{**} > \widetilde{x}^*$.

[8]Still, the government does not know the true type of a civil servant.

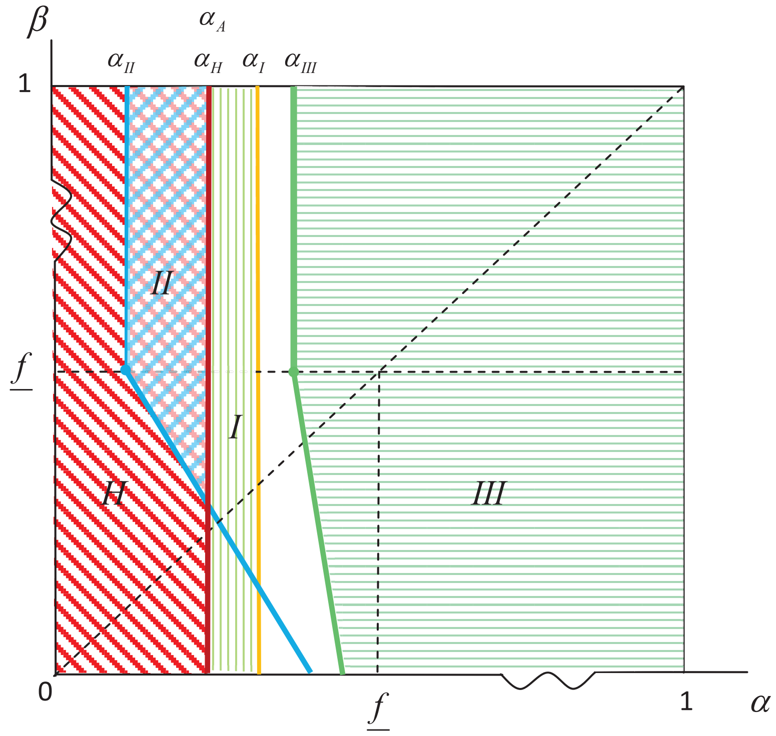

Figure 4: The State Space Partition: $\alpha_H = \alpha_A$

Proof. See the Appendix. ■

3.2.1 Evolutionary Dynamics

After characterizing the equilibrium, we move on to analyze the evolutionary dynamics in the long run. There are two possible steady states, depending on the strategy of the private agents: σ_1.

Low Corruption Steady State I′ (LCSS-I′): $\sigma_1 = B$

From equation 3, we can derive a steady state, in which the private agents offer bribes to the type "B" civil servants. The corresponding proportion of "bad" type "B" civil servant is the same as the proportion in the LCSS-I, f_I. We designate such state as Low Corruption Steady State I′ (LCSS-I′).

Low Corruption Steady State II′ (LCSS-II′): $\sigma_1 = N$

From equation 4, we can derive a steady state, in which the private agents do not offer any bribe to the type "B" civil servants. The corresponding proportion of "bad" type "B" civil servant is the same as the proportion in the LCSS-II, f_{II}. We designate such state as Low Corruption Steady State II′ (LCSS-II′).

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

Lemma 6 **LCSS-I′** *is feasible if* $\alpha < \alpha_I'$*;*

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

where

$$\alpha_I' = \min\left\{\frac{f[(\mu_G - \mu_B)R - C]}{\mu_G R + \frac{\lambda(1-f)}{1-\lambda}[(\mu_G - \mu_B)R - C]}, \underline{f}\right\}$$

$$\alpha_{II} = \begin{cases} \dfrac{\frac{(1-\lambda)f - \lambda\beta(1-f)}{1-\lambda}[(\mu_G - \mu_B)R - C]}{\mu_G R} & \text{if } \beta < \underline{f} \\ \dfrac{\underline{f}[(\mu_G - \mu_B)R - C]}{\mu_G R} & \text{if } \beta \geq \underline{f} \end{cases}$$

Proof. See the Appendix. ■

Figure 5 sketches out the state space partition. Generally speaking, if the govern-

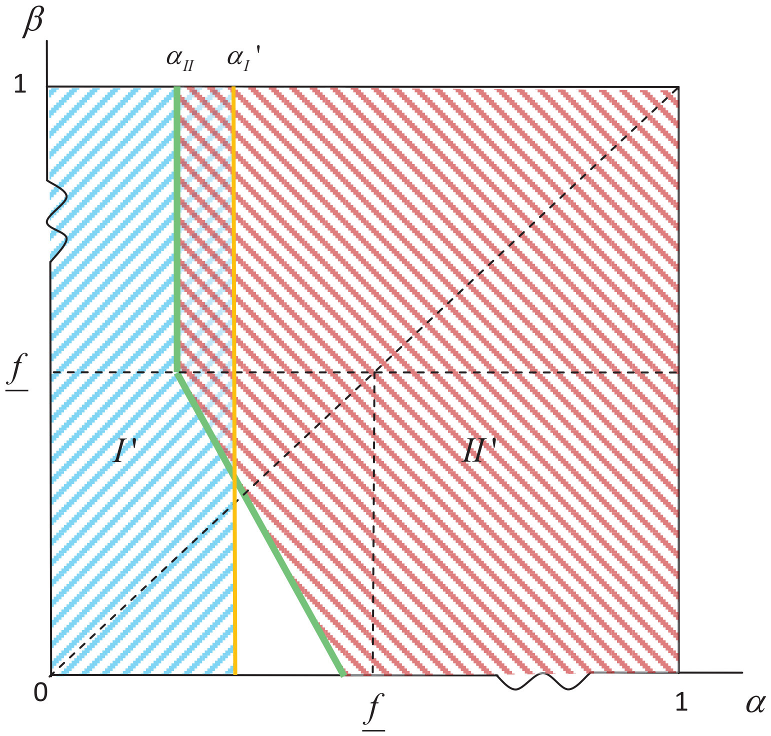

Figure 5: The State Space Partition: Acquaintance Matching

mental supervision effort level against bribe acceptance α is low, LCSS-I′ is feasible; if α is high, LCSS-II′ is feasible.

In the long run, the economy at any arbitrary state x_t may evolve into some steady state. The following lemma shows that when α is small, x_t will converge to f_I; when α is large, x_t will converge to f_{II}; when α is in the middle, x_t will converge to f_I or f_{II}, or oscillate around $\widetilde{x}^*$.

Lemma 7 *Suppose in period t the economy is at some state x_t. x_t will converge to f_I or f_{II}, or oscillate around $\widetilde{x}^*$. In particular, if $\alpha < \min\{\alpha'_I, \alpha_{II}\}$, x_t will converge to f_I. If $\alpha \geq \max\{\alpha'_I, \alpha_{II}\}$, x_t will converge to f_{II}. If $\alpha'_I > \alpha \geq \alpha_{II}$, there are two subcases: if $x_t > \widetilde{x}^*$, it will converge to f_I; if $x_t \leq \widetilde{x}^*$, it will converge to f_{II}. If $\alpha_{II} > \alpha \geq \alpha'_I$, x_t will oscillate around $\widetilde{x}^*$.*

Proof. See the Appendix. ■

3.3 Acquaintance Matching to Anonymous Matching – the Rampancy of Corruption

Consider the regime change from acquaintance matching to anonymous matching. The transformation from community to society, as in Tönnies (2001) and Cook and Hardin (2001), may change the way of interaction among individuals. In particular, originally a private agent knows the true type of her matching civil servant. Now with the enlarged group, the true type of the matching civil servant is unknown and the decision to bribe or not to bribe will be made according to the current group reputation of the civil servants.

The following proposition shows that the regime change from acquaintance matching in small communities to anonymous matching in complex societies tends to cause rampant corruption, if the governmental supervision effort level against the corruptive behavior of bribe acceptance α is small.

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

Intuitively, under acquaintance matching, by lemma 7, x_t will converge to f_I or f_{II}, or oscillate around $\widetilde{x}^*$. Suppose there is a regime change from acquaintance matching to anonymous matching at the beginning of period t. By lemma 4, x_t will converge to f_H, if $\alpha < \min\{\alpha_{II}, \alpha_H\}$. Therefore, there will be a rampancy of corruption.

4 Anti-Corruption

The regime change of reputation matching has significant policy implications. From lemma 4 and 7, we know in the long run the state variable will converge to either

f_H, f_I or f_{II}, or oscillate around x^*, x^{**} or $\widetilde{x}^*$. Accordingly, we define the levels of corruption as follows.

> The economy in some period t is at the **high level of corruption** if $x_\tau = f_H$ for all $\tau \geq t$.
>
> The economy in some period t is at the **mid-level of corruption** if x_τ oscillates around x^* for all $\tau \geq t$.
>
> The economy in some period t is at the **low level of corruption** if $x_\tau = f_I$ or f_{II}, or oscillates around x^{**} or $\widetilde{x}^*$ for all $\tau \geq t$.

Suppose currently the economy is at the high level or mid-level of corruption. The government introduces some anti-corruption policy, i.e., adjusting the level of supervision effort $\{\alpha, \beta\}$, aiming to lead to the low level of corruption. There are two types of anti-corruption policy. The first is permanent, in which the government exerts a new level of supervision effort $\{\alpha^*, \beta^*\}$ staring from the current period and it lasts forever. The second is transitional, one-time policy, in which the government exerts a new level of supervision effort $\{\alpha_t, \beta_t\}$ in the current period t. And it only lasts one period. After period t, the supervision effort goes back to the original level. Now, we turn to discuss the two types of anti-corruption policy for the high level and mid-level corruption respectively.

4.1 Permanent Anti-Corruption Policy

The following proposition shows that to reverse the high or mid-level of corruption, for the permanent anti-corruption policy, α^* must exceed some minimum level, which is a decreasing function of β^*.

Proposition 2 *Suppose in period t the economy is at the high or mid-level corruption. 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. To reverse the high or mid-level of corruption, α^* must be greater than or equal to* $\max\{\alpha_H, \min\{\alpha_{II}, \alpha_A\}\}$*, which is a decreasing function of β^*.*

Intuitively, by lemma 4, if $\alpha \geq \alpha_A$, x_t will converge to f_I or f_{II}, or oscillate around x^{**}. In addition, in the case of $\alpha < \alpha_A$, if $\max\{\alpha_{II}, \alpha_H\} \leq \alpha < \alpha_A$, x_t will converge to f_{II}. Combining these, as long as $\alpha^* \geq \max\{\alpha_H, \min\{\alpha_{II}, \alpha_A\}\}$, x_t will evolve to the low level of corruption. In addition, as α_{II} decreases in β and both α_H and α_A are independent of β, $\max\{\alpha_H, \min\{\alpha_{II}, \alpha_A\}\}$ decreases in β.

In addition, by lemma 4, the effectiveness of the permanent anti-corruption policy is not monotonic with respect to $\{\alpha^*, \beta^*\}$, as described in the following proposition.

Proposition 3 *The effectiveness of a permanent anti-corruption policy is not monotonic with respect to $\{\alpha^*, \beta^*\}$. In particular, we have the following scenarios.*

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

(ii) *If $\alpha_I > \alpha^* \geq \alpha_A$, x_t will converge to f_I, which is a decreasing function of α^*. In this case, β^* is irrelevant.*

(iii) *If $\alpha_{III} > \alpha^* \geq \max\{\alpha_A, \alpha_I\}$, x_t will oscillate around x^{**}.*

(iv) *If $\alpha^* \geq \alpha_{III}$, x_t will converge to f_{II}, which is a decreasing function of β^*. In this case, increasing α^* further does not help.*

In particular, as α^* reaches the minimum threshold, we could end up with some lower level corruption, which is a decreasing function of β^*. But further increasing of α^* may not help till to some point before which the level of corruption is a decreasing function of α^*. Thereafter, if α^* increases further, the level of corruption could be even higher. Finally, if α^* is sufficiently large, to increase α^* becomes futile and the level of corruption depends on β^*. In this sense, anti-corruption measures have to be taken on both lines of bribe taking and duty dereliction.

Moreover, from proposition 3, it is easy to see that it is no use to set the supervision effort greater than some upper limit.

Corollary 1 *$\alpha^* \leq \alpha_{III}$ and $\beta^* \leq \underline{f}$.*

4.2 One Time Anti-Corruption Policy

If the government adopts a one time anti-corruption policy, the following proposition says that most likely it will only have temporary effects. Once the supervision effort goes back to its original level, the corruption level will converge back to f_H or oscillate around x^* from lemma 4. Only under some special circumstance, a one time anti-corruption policy can overturn the high level of corruption.

Proposition 4 *Suppose in period t the economy is at the high or mid-level of corruption The government introduces a one time anti-corruption policy, i.e., exerting a new level of supervision effort $\{\alpha_t, \beta_t\}$ in the current period t. And it only lasts one period. After period t, the supervision effort goes back to the original level. There are two scenarios as follows.*

(i) *If $\alpha < \min\{\alpha_{II}, \alpha_H\}$ or $\alpha_H \leq \alpha < \min\{\alpha_{II}, \alpha_A\}$, there is no one time anti-corruption policy to effectively reverse the high or mid-level of corruption.*

(ii) *If $\alpha_{II} \leq \alpha < \alpha_H$ and $\frac{f-x^*}{\lambda(1-f)} \leq f$, then the one time anti-corruption policy will overturn the high level corruption, as long as $\alpha_t \geq \max\{\alpha_A, \frac{f-x^*}{\lambda(1-f)}\}$.*

Proof. See the Appendix. ■

5 Discussion

In this section, we discuss the comparative statics of the discount factor δ and the survival rate λ. By lemmas 3 and 6, we have the following proposition: if the civil servants are more impatient, i.e. δ and λ decrease, the economy is more likely to end up with the high level of corruption. Even if the economy stays in the low level of corruption, the corresponding degree of corruption is higher. Further, by proposition 2, the corresponding threshold for permanent anti-corruption policy also shifts up.

Proposition 5 ***(i)*** *$\underline{f}$, f_I, f_{II} decrease in λ. In particular, as $\lambda \to 0$, $\underline{f}$, f_I, $f_{II} \to f$; as $\lambda \to 1$, $\underline{f}$, f_I, $f_{II} \to 0$.*

(ii) *α_A, α_H, α_I, α_{II}, α_{III}, α_I' decrease in δ and λ. In particular, as $\delta\lambda \to 1$, α_A, α_H, α_I, α_{II}, α_{III}, $\alpha_I' \to 0$.*

(iii) *α^*, β^* decrease in δ and λ. In particular, as $\delta\lambda \to 1$, α^*, $\beta^* \to 0$.*

6 Conclusion

This paper presents a model of group reputation formation and evolution, illustrated by a corruption case, in the context of social transformation. A player's group reputation is defined as others' beliefs on the characteristics of her affiliated group. We characterize the symmetric Markov Perfect Equilibrium of the model and analyze the evolutionary dynamics of the equilibrium in the long-run for both anonymous reputation matching and acquaintance reputation matching.

We show that the regime change from acquaintance matching in small communities to anonymous matching in complex societies tends to cause rampant corruption. This supports the idea that the transformation from community to society may change the way of interaction among individuals (Tönnies 2001; Cook and Hardin 2001).

Finally, we show that the effectiveness of an anti-corruption policy is non-monotonic with respect to the supervision efforts, which have to reach some long-term minimum level to reverse high corruption. To be effective, anti-corruption measures have to be taken on both lines of bribe acceptance and duty dereliction.

Appendix

Proof of Lemma 2

Suppose we are currently at some period with state x. By backward induction, consider the "opportunist" type "O" civil servant's problem: to reject or accept a bribe if there is any. Consider the symmetric equilibrium, either all "opportunist" type "O" civil servants reject bribes if there are any or all accept. From lemma 1, $V_L \leq V(x) \leq V_H$, where $V_L = \frac{1}{1-\delta\lambda}W$ and $V_H = \frac{(1-\alpha)}{1-(1-\alpha)\delta\lambda}(W+C)$. It is easy to see that if $\alpha < \frac{1}{1+\frac{W}{C(1-\delta\lambda)}} = \alpha_A$, $V_H > V_L$; if $\alpha \geq \alpha_A$, $V_H \leq V_L$. Let us discuss these two scenarios one by one.

(i) $\alpha < \alpha_A$

Suppose currently all "opportunist" type "O" civil servants accept bribes if there are any, in which $p_\alpha = \alpha$. Let us check if there is incentive to deviate. With a continuum of agents, the action of a single civil servant cannot affect the proportion of the bad type in the society as a whole. By the one-shot deviation principle, there is no incentive for any individual "opportunist" type "O" civil servant to deviate unilaterally, as long as $(1-\alpha)[(W+C)] \leq W$, which implies $\alpha \leq \frac{1}{1+\frac{W}{C}}$. Since $\alpha_A = \frac{1}{1+\frac{W}{C(1-\delta\lambda)}} < \frac{1}{1+\frac{W}{C}}$, this condition is satisfied. As for the coalition deviation, again there is no incentive for the "opportunist" type "O" civil servants to deviate. Simply because $V_H > V_L$ and $p_\alpha = \alpha$ is the minimum value of p_α, so that accepting a bribe if there is any is the best for anyone to do.

Back to the private agent's problem at the beginning of the period, as all "opportunist" type "O" civil servants accept bribes if there are any, $p_\alpha = \alpha$. From stage game payoffs of private agents in table 1, to induce private agents not to offer bribes[9]

$$x\mu_B R + (1-x)\mu_G R \geq (1-\alpha)\mu_G R - C \tag{5}$$

which implies

$$x \leq \frac{C + \alpha\mu_G R}{(\mu_G - \mu_B)R} = x^*$$

(ii) $\alpha \geq \alpha_A$

Suppose currently all "opportunist" type "O" civil servants reject bribes if there are any, in which $p_\alpha = \min\{\alpha/x, 1\}$. Let us check if there is incentive to deviate. Again, with a continuum of agents, the action of a single civil servant cannot affect the proportion of the bad type in the society as a whole. By the one-shot deviation principle, there is no incentive for any individual "opportunist" type "O" civil servant to deviate unilaterally, as long as $(1-p_\alpha)[(W+C)+\delta\lambda\frac{W}{1-\delta\lambda}] \leq \frac{W}{1-\delta\lambda}$, which implies $p_\alpha \geq \alpha_A$. Depending on x, if $x \leq \alpha$,

[9] Again, we consider the symmetric equilibrium, either every or no private agent offers bribe. With a continuum of civil servants, the action of a single private agent cannot affect the proportion of the bad type in the society as a whole. Same logic, there is no gain from unilateral deviation. Obviously, if you are the only one offering a bribe, then for sure you will be caught. In addition, there is no gain from any coalition deviation.

$p_\alpha = 1$, which is greater than α_A. If $x > \alpha$, $p_\alpha = \alpha/x$, which is greater than or equal to α_A as $\alpha \geq \alpha_A$. As for the coalition deviation, again there is no incentive for the "opportunist" type "O" civil servants to deviate. Simply because $V_H \leq V_L$, so that rejecting a bribe if there is any is the best for anyone to get the guaranteed payoff.

Back to the private agent's problem at the beginning of the period, as all "opportunist" type "O" civil servants reject bribes if there are any, $p_\alpha = \min\{\alpha/x, 1\}$. From stage game payoffs of private agents in table 1, to induce private agents not to offer bribes

$$x\mu_B R + (1-x)\mu_G R \geq x[(1-p_\alpha)\mu_G R - C] + (1-x)[\mu_G R - \eta C] \tag{6}$$

If $x \leq \alpha$, $p_\alpha = 1$. The condition above becomes

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

which always holds.

If $x > \alpha$, $p_\alpha = \alpha/x$. The condition above becomes

$$x\mu_B R + (1-x)\mu_G R \geq x[(1-\alpha/x)\mu_G R - C] + (1-x)[\mu_G R - \eta C]$$

which implies

$$x \leq \frac{\eta C + \alpha\mu_G R}{(\mu_G - \mu_B)R - (1-\eta)C} = x^{**}$$

Note, $x^{**} > \alpha$. Combining the two cases above, if $x \leq x^{**}$, a private agent will not offer a bribe at the beginning of the period.

Further, from the no bribe condition in 5 and 6, as $x \to 1$, it becomes

$$\mu_B R \geq (1-\alpha)\mu_G R - C$$

That is to say, if the condition above is satisfied, the gain from "bribing" is definitely less than or equal to the cost and therefore the private agents will for sure have no incentive to offer a bribe, no matter how large x is. To exclude this degeneracy case, we assume $\mu_B R < (1-\alpha)\mu_G R - C$. Given this, it is easy to check that $x^* > x^{**}$. ■

Proof of Lemma 3

Feasible Conditions of HCSS:

At HCSS, $(\sigma_1, \sigma_2) = (B, A)$. The corresponding proportion of "bad" type "B" civil servant is $f_H = f$. From lemma 2, if $\alpha < \alpha_A = \frac{1}{1+\frac{W}{C(1-\delta\lambda)}}$, an "opportunist" type "O" civil servant will accept a bribe if there is any. Back to the private agent's problem, to induce a private agent to offer a bribe,

$$f_H > \frac{C + \alpha\mu_G R}{(\mu_G - \mu_B)R} = x^*$$

These imply that if $\alpha < \alpha_H = \min\left\{\frac{f(\mu_G-\mu_B)R-C}{\mu_G R}, \alpha_A\right\}$, HCSS is feasible. Note that $\alpha_H \leq \alpha_A$.

Feasible Conditions of LCSS-I:

At LCSS-I, $(\sigma_1, \sigma_2) = (B, R)$. The corresponding proportion of "bad" type "B" civil servant is

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

From lemma 2, if $\alpha \geq \alpha_A = \frac{1}{1+\frac{W}{C(1-\delta\lambda)}}$, an "opportunist" type "O" civil servant will reject a bribe if there is any. Back to the private agent's problem, to induce a private agent to offer a bribe,

$$f_I > \frac{\eta C + \alpha\mu_G R}{(\mu_G - \mu_B)R - (1-\eta)C} = x^{**}$$

There are two subcases depending on the value of α.

If $\alpha \geq \underline{f}$, $f_I = \underline{f} \leq \alpha$. The condition above becomes

$$\underline{f} > \frac{\eta C + \alpha\mu_G R}{(\mu_G - \mu_B)R - (1-\eta)C}$$

which does not hold.

If $\alpha < \underline{f}$, $f_I = \frac{(1-\lambda)f-\lambda\alpha(1-f)}{1-\lambda} \geq \underline{f} > \alpha$. The condition above becomes

$$\frac{(1-\lambda)f - \lambda\alpha(1-f)}{1-\lambda} > \frac{\eta C + \alpha\mu_G R}{(\mu_G - \mu_B)R - (1-\eta)C}$$

which implies $\alpha < \frac{f[(\mu_G-\mu_B)R-(1-\eta)C]-\eta C}{\mu_G R + \frac{\lambda(1-f)}{1-\lambda}[(\mu_G-\mu_B)R-(1-\eta)C]}$.

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

$$\min\left\{\frac{f[(\mu_G - \mu_B)R - (1-\eta)C] - \eta C}{\mu_G R + \frac{\lambda(1-f)}{1-\lambda}[(\mu_G - \mu_B)R - (1-\eta)C]}, \underline{f}\right\} = \alpha_I > \alpha \geq \alpha_A = \frac{1}{1 + \frac{W}{C(1-\delta\lambda)}}$$

Feasible Conditions of LCSS-II:

At LCSS-II, $(\sigma_1, \sigma_2) = (N, A)$. The corresponding proportion of "bad" type "B" civil servant is

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

From lemma 2, if $\alpha < \alpha_A = \frac{1}{1+\frac{W}{C(1-\delta\lambda)}}$, an "opportunist" type "O" civil servant will accept a bribe if there is any. Back to the private agent's problem, to induce a private agent not to offer a bribe,

$$f_{II} \leq \frac{C + \alpha\mu_G R}{(\mu_G - \mu_B)R} = x^*$$

There are two subcases depending on the value of β.

If $\beta \geq \underline{f}$, $f_I = \underline{f}$. The condition above becomes

$$\underline{f} \leq \frac{C + \alpha\mu_G R}{(\mu_G - \mu_B)R} = x^*$$

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

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

$$\frac{(1-\lambda)f - \lambda\beta(1-f)}{1-\lambda} \leq \frac{C + \alpha\mu_G R}{(\mu_G - \mu_B)R}$$

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

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.

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

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

At LCSS-III, $(\sigma_1, \sigma_2) = (N, R)$. The corresponding proportion of "bad" type "B" civil servant is

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

From lemma 2, if $\alpha \geq \alpha_A = \frac{1}{1 + \frac{W}{C(1-\delta\lambda)}}$, an "opportunist" type "O" civil servant will reject a bribe if there is any. Back to the private agent's problem, to induce a private agent not to offer a bribe,

$$f_{II} \leq \frac{\eta C + \alpha\mu_G R}{(\mu_G - \mu_B)R - (1-\eta)C} = x^{**}$$

There are two subcases depending on the value of β.

If $\beta \geq \underline{f}$, $f_I = \underline{f}$. The condition above becomes

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

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

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

$$\frac{(1-\lambda)f - \lambda\beta(1-f)}{1-\lambda} \leq \frac{\eta C + \alpha\mu_G R}{(\mu_G - \mu_B)R - (1-\eta)C}$$

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

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-III as follows.

$$\alpha \geq \alpha_{III} = \begin{cases} \max\left\{\frac{\frac{(1-\lambda)f-\lambda\beta(1-f)}{1-\lambda}[(\mu_G-\mu_B)R-(1-\eta)C]-\eta C}{\mu_G R}, \alpha_A\right\} & \text{if } \beta < \underline{f} \\ \max\left\{\frac{\underline{f}[(\mu_G-\mu_B)R-(1-\eta)C]-\eta C}{\mu_G R}, \alpha_A\right\} & \text{if } \beta \geq \underline{f} \end{cases}$$

Note that $\alpha_A \leq \alpha_{III}$, $\alpha_I < \alpha_{III}$, and $\alpha_{II} < \alpha_{III}$. I.e., $\max\{\alpha_A, \alpha_I, \alpha_{II}\} \leq \alpha_{III}$. ■

Proof of Lemma 4

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

(i) $\alpha < \alpha_A$

In this case, all "opportunist" type "O" civil servants accept bribes if there are any. Further, if $x_t > x^*$, 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 equation 2. Since $\lambda(1-\alpha)$ is less than 1, $x_{t+1} < x_t$ if $x_t > f_H$; $x_{t+1} > x_t$ if $x_t < f_H$; $x_{t+1} = x_t = f_H$ if $x_t = f_H$. Thus, x_t will monotonically converge to f_H, if HCSS is feasible.

In contrast, if $x_t \leq x^*$, 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 equation 4. Same argument, since both λ and λf are less than 1, $x_{t+1} < x_t$ if $x_t > f_{II}$; $x_{t+1} > x_t$ if $x_t < f_{II}$; $x_{t+1} = x_t = f_{II}$ if $x_t = f_{II}$. Thus, x_t will monotonically converge to f_{II}, if LCSS-II is feasible.

Back to lemma 3, HCSS is feasible if $\alpha < \alpha_H$; LCSS-II is feasible if $\alpha_A > \alpha \geq \alpha_{II}$; and $\alpha_H \leq \alpha_A$. Therefore, if $\alpha < \min\{\alpha_{II}, \alpha_H\}$, only HCSS is feasible and x_t will converge to f_H.[10] If $\max\{\alpha_{II}, \alpha_H\} \leq \alpha < \alpha_A$, only LCSS-II is feasible and x_t will converge to f_{II}. If $\alpha_{II} \leq \alpha < \alpha_H$, both HCSS and LCSS-II are feasible. There are two subcases: if $x_t > x^*$, it will converge to f_H; if $x_t \leq x^*$, it will converge to f_{II}. If $\alpha_H \leq \alpha < \min\{\alpha_{II}, \alpha_A\}$, neither HCSS nor LCSS-II is feasible and x_t will oscillate around x^*.

(i) $\alpha \geq \alpha_A$

In this case, all "opportunist" type "O" civil servants reject bribes if there are any. Further, if $x_t > x^{**}$, 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 equation 3. Since both λ and λf are less than 1, $x_{t+1} < x_t$ if $x_t > f_I$; $x_{t+1} > x_t$ if $x_t < f_I$; $x_{t+1} = x_t = f_I$ if $x_t = f_I$. Thus, x_t will monotonically converge to f_I, if LCSS-I is feasible.

In contrast, if $x_t \leq x^{**}$, 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 equation

[10] x_t may not directly converge to f_H. If $x_t \leq x^*$, it will converge to f_{II} following equation 4. Since LCSS-II is not feasible in this case, $f_{II} > x^*$, once at some τ, $x_\tau > x^*$, it will be back to the track of converging to f_H directly following equation 2. Similar argument apply to the cases follow.

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

Back to lemma 3, LCSS-I is feasible if $\alpha_I > \alpha \geq \alpha_A$; LCSS-III is feasible if $\alpha \geq \alpha_{III}$. In addition, $\alpha_A \leq \alpha_{III}$ and $\alpha_I < \alpha_{III}$. Therefore, we have three disjoint areas: if $\alpha \geq \alpha_{III}$, only LCSS-III is feasible and x_t will converge to f_{II}; if $\alpha_I > \alpha \geq \alpha_A$, only LCSS-I is feasible and x_t will converge to f_I; if $\alpha_{III} > \alpha \geq \max\{\alpha_A, \alpha_I\}$, neither LCSS-I nor LCSS-III is feasible and x_t will oscillate around x^{**}. ■

Proof of Lemma 5

Suppose in period t the economy is at some state x_t. Under acquaintance matching, a private agent knows the true type of her matching civil servant. From stage game payoffs of private agents in table 1, if the matching civil servant is the "opportunist" type "O", the best response for the private agent is to "not bribe," as a type "O" civil servant will always implement a fair test. In this case, type "O" civil servants are passive and there is no loss of bribe.

In contrast, if the matching civil servant is the bad type "B", the private agent will not offer a bribe whenever

$$\mu_B R \geq (1 - p_\alpha)\mu_G R - C \tag{7}$$

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

If $x \leq \alpha$, $p_\alpha = 1$. The condition above becomes

$$\mu_B R \geq (1 - 1)\mu_G R - C$$

which always holds.

If $x > \alpha$, $p_\alpha = \alpha/x$. The condition above becomes

$$\mu_B R \geq (1 - \frac{\alpha}{x})\mu_G R - C$$

which implies

$$x \leq \frac{\alpha \mu_G R}{(\mu_G - \mu_B)R - C} = \widetilde{x}^*$$

Note, $\widetilde{x}^* > \alpha$. Combining the two cases above, if $x \leq \widetilde{x}^*$, a private agent will not offer a bribe to the bad type "B" civil servant at the beginning of the period. Note, $x^* > x^{**} > \widetilde{x}^*$. ■

Proof of Lemma 6

Feasible Conditions of LCSS-I′:

At LCSS-I$'$, the private agents offer bribes to the bad type "B" civil servants. By equation 3, we can derive the proportion of "bad" type "B" civil servant at LCSS-I$'$, which is the same as the proportion in the LCSS-I, f_I.

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

Back to inequality 7, to induce a private agent to offer a bribe to the bad type "B" civil servant, the following condition must hold.

$$\mu_B R < (1-p_\alpha)\mu_G R - C \tag{8}$$

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

At LCSS-I$'$,

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

There are two subcases depending on the value of α.

If $\alpha \geq \underline{f}$, $f_I = \underline{f} \leq \alpha$ and $p_\alpha = 1$. The condition in (8) becomes

$$\mu_B R < (1-1)\mu_G R - C$$

which does not hold.

If $\alpha < \underline{f}$, $f_I = \frac{(1-\lambda)f-\lambda\alpha(1-f)}{1-\lambda} \geq \underline{f} > \alpha$ and $p_\alpha = \alpha/f_I$. The condition in (8) becomes

$$\mu_B R < (1-\frac{\alpha}{f_I})\mu_G R - C$$

Thus, we have

$$f_I > \frac{\alpha\mu_G R}{(\mu_G-\mu_B)R - C}$$

which implies $\alpha < \frac{f[(\mu_G-\mu_B)R-C]}{\mu_G R+\frac{\lambda(1-f)}{1-\lambda}[(\mu_G-\mu_B)R-C]}$.

Combining these two subcases, we have the feasible condition of LCSS-I$'$ as follows.

$$\alpha < \alpha_I' = \min\left\{\frac{f[(\mu_G-\mu_B)R-C]}{\mu_G R+\frac{\lambda(1-f)}{1-\lambda}[(\mu_G-\mu_B)R-C]}, \underline{f}\right\}$$

Note that $\alpha_I' \geq \alpha_I$.

Feasible Conditions of LCSS-II$'$:

At LCSS-II$'$, the private agents do not offer bribes to the bad type "B" civil servants. By equation 4, we can derive the proportion of "bad" type "B" civil servant at LCSS-II$'$, which is the same as the proportion in the LCSS-II, f_{II}.

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

Back to inequality 7, to induce a private agent not to offer a bribe, the following condition must hold.

$$\mu_B R \geq (1 - p_\alpha)\mu_G R - C \tag{9}$$

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

At LCSS-II$'$,

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

There are four subcases depending on the value of α and β.

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

If $\beta \geq \underline{f}$, $f_{II} = \underline{f}$. Further, if $\alpha \geq f_{II} = \underline{f}$, $p_\alpha = 1$. The condition in (9) becomes

$$\mu_B R \geq (1 - 1)\mu_G R - C$$

which always holds.

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

If $\beta < \underline{f}$, $f_{II} = \frac{(1-\lambda)f - \lambda\beta(1-f)}{1-\lambda}$. Further, if $\alpha \geq f_{II} = \frac{(1-\lambda)f - \lambda\beta(1-f)}{1-\lambda}$, $p_\alpha = 1$. The condition in (9) becomes

$$\mu_B R \geq (1 - 1)\mu_G R - C$$

which always holds.

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

If $\beta \geq \underline{f}$, $f_{II} = \underline{f}$. Further, if $\alpha < f_{II} = \underline{f}$, $p_\alpha = \alpha/f_{II} = \alpha/\underline{f}$. The condition in (9) becomes

$$\mu_B R \geq (1 - \frac{\alpha}{\underline{f}})\mu_G R - C$$

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

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

If $\beta < \underline{f}$, $f_{II} = \frac{(1-\lambda)f - \lambda\beta(1-f)}{1-\lambda}$. Further, if $\alpha < f_{II} = \frac{(1-\lambda)f - \lambda\beta(1-f)}{1-\lambda}$, $p_\alpha = \alpha/f_{II}$. The two conditions in (9) become

$$\mu_B R \geq (1 - \frac{\alpha}{f_{II}})\mu_G R - C$$

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

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-II$'$ as follows.

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

■

Proof of Lemma 7

Following lemma 5, if $x_t > \widetilde{x}^*$, a private agent will offer a bribe to the bad type "B" civil servant at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equation 3. Since both λ and λf are less than 1, $x_{t+1} < x_t$ if $x_t > f_I$; $x_{t+1} > x_t$ if $x_t < f_I$; $x_{t+1} = x_t = f_I$ if $x_t = f_I$. Thus, x_t will monotonically converge to f_I, if LCSS-I$'$ is feasible.

If $x_t \leq \widetilde{x}^*$, a private agent will not offer a bribe to the bad type "B" civil servant at the beginning of period t. The transition of the state of the economy from period t to period $t+1$ follows equation 4. Same argument, since both λ and λf are less than 1, $x_{t+1} < x_t$ if $x_t > f_{II}$; $x_{t+1} > x_t$ if $x_t < f_{II}$; $x_{t+1} = x_t = f_{II}$ if $x_t = f_{II}$. Thus, x_t will monotonically converge to f_{II}, if LCSS-II$'$ is feasible.

Back to lemma 6, LCSS-I$'$ is feasible if $\alpha < \alpha'_I$; LCSS-II$'$ is feasible if $\alpha \geq \alpha_{II}$. Therefore, if $\alpha < \min\{\alpha'_I, \alpha_{II}\}$, only LCSS-I$'$ is feasible and x_t will converge to f_I. If $\alpha \geq \max\{\alpha'_I, \alpha_{II}\}$, only LCSS-II$'$ is feasible and x_t will converge to f_{II}. If $\alpha'_I > \alpha \geq \alpha_{II}$, both LCSS-I$'$ and LCSS-II$'$ are feasible. There are two subcases: if $x_t > \widetilde{x}^*$, it will converge to f_I; if $x_t \leq \widetilde{x}^*$, it will converge to f_{II}. If $\alpha_{II} > \alpha \geq \alpha'_I$, neither LCSS-I$'$ nor LCSS-II$'$ is feasible and x_t will oscillate around $\widetilde{x}^*$. ■

Proof of Proposition 4

If the economy in period t is currently at the high level of corruption, by the feasible condition in lemma 3, $\alpha < \alpha_H$. There are two scenarios: $\alpha < \min\{\alpha_{II}, \alpha_H\}$ or $\alpha_{II} \leq \alpha < \alpha_H$. For the first scenario, $\alpha < \min\{\alpha_{II}, \alpha_H\}$, by lemma 4, the state variable will converge to f_H once the supervision effort goes back to the original level. Therefore, there is no one time anti-corruption policy to effectively reverse the high level of corruption in this case.

For the second scenario, $\alpha_{II} \leq \alpha < \alpha_H$, by lemma 4, once the supervision effort goes back to the original level, there are two subcases depending on the value of x_{t+1}: if $x_{t+1} > x^*$, it will converge to f_H; if $x_{t+1} \leq x^*$, it will converge to f_{II}. Therefore, to reverse the high level of corruption, for the one time anti-corruption policy, we need to set $\{\alpha_t, \beta_t\}$ in period t, such that $x_{t+1} \leq x^*$.

Let's see the state transition from x_t to x_{t+1} given $\{\alpha_t, \beta_t\}$. By lemma 2, for $\alpha_t < \alpha_A$, given $x_t = f_H > x^*$, the equilibrium strategy profile in period t $(\sigma_1, \sigma_2) = (B, A)$ and the state of transition from x_t to x_{t+1} follows equation 2, which yields $x_{t+1} = f_H > x^*$. For $\alpha_t \geq \alpha_A$, given $x_t = f_H > x^{**}$, the equilibrium strategy profile in period t $(\sigma_1, \sigma_2) = (B, R)$ and the state of transition from x_t to x_{t+1} follow equation 3, which yields

$$\begin{aligned} x_{t+1} &= \lambda(1 - p_{\alpha,t})x_t + [(1-\lambda) + \lambda p_{\alpha,t} x_t]f \\ &= \begin{cases} \lambda x_t - \lambda \alpha_t + (1 - \lambda + \lambda \alpha_t)f & \text{if } x_t > \alpha_t \\ (1 - \lambda + \lambda x_t)f & \text{if } x_t \leq \alpha_t \end{cases} \end{aligned}$$

Given $x_t = f_H = f$,

$$x_{t+1} = \begin{cases} \lambda f - \lambda \alpha_t + (1 - \lambda + \lambda \alpha_t)f & \text{if } f > \alpha_t \\ (1 - \lambda + \lambda f)f & \text{if } f \leq \alpha_t \end{cases}$$

Therefore, to fulfill $x_{t+1} \leq x^*$, the equation above implies $\alpha_t \geq \frac{f-x^*}{\lambda(1-f)}$ for $\alpha_t \leq f$. In addition, $\alpha_t \geq \alpha_A$. Combining all these, if $\alpha_{II} \leq \alpha < \alpha_H$ and $\frac{f-x^*}{\lambda(1-f)} \leq f$, then the one time anti-corruption policy will overturn the high level of corruption, as long as $\alpha_t \geq \max\{\alpha_A, \frac{f-x^*}{\lambda(1-f)}\}$.

In addition, if the economy in period t is at the mid-level of corruption, by the feasible condition in lemma 4, $\alpha_H \leq \alpha < \min\{\alpha_{II}, \alpha_A\}$. Similar to the case of $\alpha < \min\{\alpha_{II}, \alpha_H\}$, by lemma 4, the state variable will oscillate around x^* once the supervision effort goes back to the original level. Therefore, there is no one time anti-corruption policy to effectively reverse the mid-level of corruption. ■

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