Corruption game of incomplete information

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Abstract

This paper investigates one well-known kind of corruption between the traffic officer and the driver in Vietnam by constructing a simple game-theoretic model of incomplete information. Various parameters are incorporated and studied in the model, including the fine (F), the bribe (B), the penalty (P), the complying cost (C), the reward (R) and the likelihood (λ) that the illegal action is discovered by the higher authority. The results are consistent with the standard observations of the corruption activities. Interestingly, the information available to the driver may significantly affect their decision in the sense that the player's different types may have different critical or threshold incentive values in the identical situation.

Key words: corruption, bribe, incomplete information

1. INTRODUCTION

In Vietnam, the problem of bribery and corruption, euphemistically known as the illegal cooperation between the traffic officer and driver, has received a lot of discussion from both the government and citizens. The driver sometimes makes a mistake by driving across a red light or by driving faster than the restricted speed, for example. Immediately, he is stopped by a yellow-uniformed traffic officer. The driver then will be asked to go to the post with his legal documents. According to regulation, the traffic officer has an obligation to explain to the driver the driving mistake and the level of seriousness as well as the amount of fine as stated in the Traffic Law. The officer keeps the driver's legal documents and writes a bill; then the driver signs the bill, and takes a copy to the Treasury, and makes payment there. After that, he comes

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back to the same police post where he was stopped and collects his license. However, since the driver has a lot of work to do, he tries to save his time as much as possible by a soft negotiation. In most cases, the *"50-50 solution"* is agreed upon. In other words, the driver discreetly gives the traffic officer an amount of money which is smaller than the regular fine, but sufficient for the officer to let the driver go immediately.

This phenomenon involves the interaction between two strategic players: the traffic officer and the driver. To understand the manner in which the traffic officer and the driver behave, we construct a simple game-theoretic model and explore its solutions. We then study how some parameters and the information structure may affect the incentives of the two players and change their decision. In this model, we employ many ideas from the model of Mishra (2006). Mishra (2006) considers a two-stage model, in which firms face the certain pollution standard. In the first stage, each firm decides either to comply or not to comply with this standard while the officer chooses whether to become "informed" or "uninformed". The informed officer is able to differentiate the polluting firms from the non-polluting firms upon inspection. In the second stage, the two players play the simple corrupt-bribing game. Our model yet is different in some significant aspects. First, Mishra's model has complete information while our model belongs to the incomplete information class. More specifically, in our model some driver may be unable to completely realize whether he actually violated the traffic law or the officer used their magic hand. Moreover, this inability of the driver is not perfectly observed by the officer. In other words, the officer only know that with some probability the driver does know themselves well when making decision in the bribe game. Consequently, we arrive at some different conclusion comparing to Misha.

The rest of this paper is organized as follows: Section 2 proposes the game-theoretic model. Section 3 solves the just-constructed game. Section 4 provides some discussion, and section 5 makes some conclusion.

2. THE MODEL

First, the driver is suddenly stopped by the traffic officer in the street. The traffic officer, having observed the driving action of the driver and known whether it violates the traffic law or not, announces the fine (F). Then the two players participate in the standard corruption game. The officer can choose either to be corrupt, denoted by (C) or be honest, denoted by (H) while the driver decides whether to bribe, denoted by (b) the officer or to comply with the law, denoted by (c). We assume that two players act simultaneously.

2.1. Information structure and beliefs

We shall consider the case that the information about the driver's problem is manipulated easily by the officer. That is, there are two types of the officer, denoted by (T) and (W). Type T only stops the actually violated drivers while type W might stop the innocent ones and wrongly announces the fine. The officer knows his type. The driver is assumed to belong to one of two types: informed (I) and uninformed (U). The informed driver knows the truth about the officer's announcement of the fine (F), whether it is invented and/or over-reported. On the other hand, the uninformed driver only knows that the officer is telling the truth with the probability $(0 < \varphi < 1)$. These assumptions capture the fact that many people may lack of the knowledge of the law, or/and the legal system is unclearly and inconsistently specified in many developing countries (Vietnam, for example). While knowing his own type, the officer is assumed to unable to perfectly distinguish between the informed driver and the uninformed driver when negotiating with the driver. He barely knows the probability, denoted by μ, that the driver belongs to the informed type.

2.2. Incentives

We shall consider two cases. First, if the driver actually violates the rules, and the officer correctly prosecutes the driver, then the payoffs to the players do not depend on the types of the driver. The officer may agree not to report the driver in exchange for a bribe (B). In this case, the driver avoids the fine (F) but must bear the cost of the bribe. With the probability $(0 < \lambda < 1)$ the corrupt or/and bribing actions are revealed to the appropriate authority. In this case, the officer is assumed to pay the penalty (P) while the bribe is taken by the Law, and the driver pays the fine (F). On the other hand, by acting honestly, the officer reports the driver and receives the reward (R). Meanwhile, the driver pays the fine.

If the driver completely follows the traffic instruction but the officer over-reports him, then the payoffs to the two players are dependent on the types of the driver. More specifically, the informed driver who decides not to bribe the officer may face the cost (C) of the compliance. This cost may be interpreted as the effort and time spending on debating with the officer about this problem. The uninformed type, however, may have to pay the over-reported fine (F) while the officer gains the reward (R). The value of the above quantities is assumed to be possible and as follow:

$$B < F,\ R < F,\ C < F,\ P < P^*$$

Based on the information structure and the players' beliefs, this game of incomplete information has totally four states whose names are denoted by two characters: The first is the officer's type, and the second is the driver's type. Let O(X, y) and D(X, y) be the payoffs to the traffic officer and the driver, respectively when the former uses the strategy "X", and the latter uses the strategy "y".

State 1: T-I

$$O_1(C,b) = \lambda(-P) + (1-\lambda)B \qquad D_1(C,b) = \left[\lambda(-F-B) + (1-\lambda)(F-B)\right]$$

$$O_1(C,c) = \lambda(-P) + (1-\lambda)R \qquad D_1(H,b) = -F-B$$

$$O_1(H,b) = O_1(H,c) = R \qquad D_1(C,c) = D_1(H,c) = -F$$

State 2: W-I

$$O_2(C,b) = \lambda(-P) + (1-\lambda)B \qquad D_2(C,b) = D_2(H,b) = -B$$

$$O_2(C,c) = \lambda(-P) + (1-\lambda).0 \qquad D_2(C,c) = D_2(H,c) = -C$$

$$O_2(H,b) = O_2(H,c) = 0$$

State 3: T-U

$$O_3(C,b) = \lambda(-P) + (1-\lambda)B \qquad D_3(C,b) = \left[\lambda(-F-B) + (1-\lambda)(F-B)\right]$$

$$O_3(C,c) = \lambda(-P) + (1-\lambda)R \qquad D_3(H,b) = -F-B$$

$$O_3(H,b) = O_3(H,c) = R \qquad D_3(H,c) = D_3(C,c) = -F$$

State 4: W-U

$$O_4(C,b) = \lambda(-P) + (1-\lambda)B \qquad D_4(C,b) = -B$$

$$O_4(C,c) = \lambda(-P) + (1-\lambda)R \qquad D_4(C,c) = -F$$

$$O_4(H,b) = O_4(H,c) = 0 \qquad D_4(H,b) = D_4(H,c) = 0$$

3. SOLUTIONS

Let α_1 and α_2 be the probabilities that the T officer and the W officer play C, respectively; β_1 and β_2 the probabilities that the informed driver plays *b* given that the officer's types are T and W, respectively; β_3 the probability that the uninformed driver plays *b*.

$$0 \le \alpha_1,\ \alpha_2,\ \beta_1,\ \beta_2,\ \beta_3 \le 1$$

We then construct the two players' best responses to the other's strategies given their types and their beliefs about the other player's types.

** The type T officer's best response*

The expected payoffs to the T officer from playing C and H respectively are:

$$U^T(C) = \mu[\beta_1 O_1(C,b) + (1-\beta_1)O_1(C,c)] + (1-\mu)[\beta_3 O_3(C,b) + (1-\beta_3)O_3(C,c)]$$

$$U^T(H) = \mu[\beta_1 O_1(H,b) + (1-\beta_1)O_1(H,c)] + (1-\mu)[\beta_3 O_3(H,b) + (1-\beta_3)O_3(H,c)]$$

Then

$$U^T(C) > U^T(H) \Leftrightarrow \beta_1 > \frac{\lambda(P+R)}{(1-\lambda)\mu(B-R)} - \frac{1-\mu}{\mu}\beta_3 \Rightarrow \alpha_1 = 1 \qquad (3.2.1)$$

$$U^T(C) < U^T(H) \Leftrightarrow \beta_1 < \frac{\lambda(P+R)}{(1-\lambda)\mu(B-R)} - \frac{1-\mu}{\mu}\beta_3 \Rightarrow \alpha_1 = 0 \qquad (3.2.2)$$

$$U^T(C) = U^T(H) \Leftrightarrow \beta_1 = \frac{\lambda(P+R)}{(1-\lambda)\mu(B-R)} - \frac{1-\mu}{\mu}\beta_3 \Rightarrow \alpha_1 \in [0,1] \qquad (3.2.3)$$

** The type W officer's best response*

The expected payoffs to the T officer from playing C and H:

$$U^W(C) = \mu[\beta_2 O_2(C,b) + (1-\beta_2)O_2(C,c)] + (1-\mu)[\beta_3 O_4(C,b) + (1-\beta_3)O_4(C,c)]$$

$$U^W(H) = \mu[\beta_2 O_2(H,b) + (1-\beta_2)O_2(H,c)] + (1-\mu)[\beta_3 O_4(H,b) + (1-\beta_3)O_4(H,c)]$$

Then:

$$U^W(C) > U^W(H) \Leftrightarrow \beta_3 > \frac{[\lambda P - (1-\lambda)(1-\mu)R] - (1-\lambda)\mu B\beta_2}{(1-\lambda)(1-\mu)(B-R)} \Rightarrow \alpha_2 = 1 \qquad (3.2.4)$$

$$U^W(C) < U^W(H) \Leftrightarrow \beta_3 < \frac{[\lambda P - (1-\lambda)(1-\mu)R] - (1-\lambda)\mu B\beta_2}{(1-\lambda)(1-\mu)(B-R)} \Rightarrow \alpha_2 = 0 \qquad (3.2.5)$$

$$U^W(C) = U^W(H) \Leftrightarrow \beta_3 = \frac{[\lambda P - (1-\lambda)(1-\mu)R] - (1-\lambda)\mu B\beta_2}{(1-\lambda)(1-\mu)(B-R)} \Rightarrow \alpha_2 \in [0,1] \qquad (3.2.6)$$

** The type I driver's best response to the type T officer*

The expected payoffs to the type I driver from playing b and c respectively are:

$$u_T^I(b) = \alpha_1 D_1(C,b) + (1-\alpha_1)D_1(H,b)$$

$$u_T^I(c) = \alpha_1 D_1(C,c) + (1-\alpha_1)D_1(H,c)$$

Then:

$$u_T^I(b) > u_T^I(c) \Leftrightarrow \alpha_1 > \frac{B}{2(1-\lambda)F} \Rightarrow \beta_1 = 1 \quad (3.2.7)$$

$$u_T^I(b) < u_T^I(c) \Leftrightarrow \alpha_1 < \frac{B}{2(1-\lambda)F} \Rightarrow \beta_1 = 0 \quad (3.2.8)$$

$$u_T^I(b) = u_T^I(c) \Leftrightarrow \alpha_1 = \frac{B}{2(1-\lambda)F} \Rightarrow \beta_1 \in [0,1] \qquad (3.2.9)$$

** The type I driver's best response to the type W officer*

The expected payoffs to the type I driver from playing b and c respectively are:

$$u_W^I(b) = \alpha_2 D_2(C,b) + (1-\alpha_2)D_2(H,b)$$

$$u_W^I(c) = \alpha_2 D_2(C,c) + (1-\alpha_1)D_2(H,c)$$

Then:

$$u_W^I(b) > u_W^I(c) \Leftrightarrow B < C \Rightarrow \beta_2 = 1 \quad (3.2.10)$$

$$u_W^I(b) < u_W^I(c) \Leftrightarrow B > C \Rightarrow \beta_2 = 0 \quad (3.2.11)$$

$$u_W^I(b) = u_W^I(c) \Leftrightarrow B = C \Rightarrow \beta_2 \in [0,1] \qquad (3.2.12)$$

** The type U driver's best response*

The expected payoffs to the U driver from playing b and c respectively are:

$$u^U(b) = \varphi[\alpha_1 D_3(C,b) + (1-\alpha_1)D_3(H,b)] + (1-\varphi)[\alpha_2 D_4(C,b) + (1-\alpha_2)D_4(H,b)]$$

$$u^U(c) = \varphi[\alpha_1 D_3(C,c) + (1-\alpha_1)D_3(H,c)] + (1-\varphi)[\alpha_2 D_4(C,c) + (1-\alpha_2)D_4(H,c)]$$

Then:

$$u^U(b) > u^U(c) \Leftrightarrow \alpha_2 > \frac{\varphi B - 2(1-\lambda)\varphi F\alpha_1}{(1-\varphi)(F-B)} \Rightarrow \beta_3 = 1 \qquad (3.2.13)$$

$$u^U(b) < u^U(c) \Leftrightarrow \alpha_2 < \frac{\varphi B - 2(1-\lambda)\varphi F\alpha_1}{(1-\varphi)(F-B)} \Rightarrow \beta_3 = 0 \qquad (3.2.14)$$

$$u^U(b) = u^U(c) \Leftrightarrow \alpha_2 = \frac{\varphi B - 2(1-\lambda)\varphi F\alpha_1}{(1-\varphi)(F-B)} \Rightarrow \beta_3 \in [0.1] \qquad (3.2.15)$$

Under the certain conditions, there exists a pure Bayesian-Nash equilibrium[2] in which the two players choose to cooperate (corrupt and bribe) no matter which type they might be. That is,

$$(\alpha_1*, \alpha_2*, \beta_1*, \beta_2*, \beta_3*) = (1,1,1,1,1)$$

Consider the following conditions:

(1) $(1-\lambda)B - \lambda P \geq R$

Given $(\beta_3* = 1)$, $\dfrac{\lambda(P+R)}{(1-\lambda)\mu(B-R)} - \dfrac{1-\mu}{\mu}\beta_3* \leq 1$, then from (3.2.1) and (3.2.3) one of the type T officer's best response to $(\beta_1*, \beta_3*) = (1,1)$ is to play C $(\alpha_1* = 1)$.

(2) $(1-\lambda)B - \lambda P \geq 0$

Given $(\beta_2* = 1)$, $\dfrac{[\lambda P - (1-\lambda)(1-\mu)R] - (1-\lambda)\mu B\beta_2*}{(1-\lambda)(1-\mu)(B-R)} \leq 1$, then from (3.2.4) and (3.2.6) one of the type W officer's best response to $(\beta_2*, \beta_3*) = (1,1)$ is to play C $(\alpha_2* = 1)$.

(3) $2(1-\lambda)F \geq B \Leftrightarrow \dfrac{B}{2(1-\lambda)F} \leq 1$

From (3.2.7) and (3.2.9) one of the type I driver's best response to $\alpha_1* = 1$ (when confronting the type T officer) is to play C $(\beta_1* = 1)$.

(4) $C \geq B$

From (3.2.10) and (3.2.12) one of the type I driver's best response to $\alpha_2* = 1$ (when confronting the type W officer) is to play C $(\beta_2* = 1)$.

(5) $(1-\lambda)\varphi F + (1-\lambda\varphi)F \geq B$

Given $(\alpha_1 = 1)$, $\dfrac{\varphi B - 2(1-\lambda)\varphi F\alpha_1}{(1-\varphi)(F-B)} \leq 1$, then from (3.2.1) and (3.2.3) one of the type U driver's best response to $(\alpha_1*, \alpha_2*) = (1,1)$ is to play C $(\beta_3* = 1)$.

The strategy profile $(\alpha_1*, \alpha_2*, \beta_1*, \beta_2*, \beta_3*) = (1,1,1,1,1)$ in which all types of the officer and all types of the driver choose to cooperate is a Baysian-Nash equilibrium when all five above conditions are satisfied.

4. DISCUSSION

[2] For simplicity, we ignore the other possible pure Baysian-Nash equilibriua and the mixed strategies Baysian-Nash equiliria and pay more attention in studying the contribution of the main parameters to the players' behaviors.

a) Condition (1) and (2)

The officer will choose to act corruptly if the expected gain from cooperating is higher than the reward for being honest. The value of the reward is equal to zero when the driver does not break the law. This expected gain is higher the higher the bribe and/or the lower the penalty (P) and/or the lower the probability of being caught.

Since R is assumed to greater than zero, one conclusion may be derived from comparing two conditions (1) and (2) is that the W officer is more tempting to play the corruption strategy than the T officer. The officer's behavior is yet independent of the driver's types. This result comes from the fact that the T officer's payoffs from being corrupt, given the driver choosing to bribe, is identical the W officer's.

b) Condition (3)

Rearrange the expression in this condition, one will obtain:

$$(1-\lambda)(F-B) \geq \lambda B - (1-\lambda)F$$

The term in the left-hand side is the expected gain from bribing the corrupt officer which is higher if the fine is more cumbersome and/or the bribe is lighter and/or the illegal action is less likely to be explored. The first term in the right-hand side is the expected gain of being compliant which is reversely higher when the bribe is bigger and/or the monitoring system works more effectively. The second term is the expected cost from fulfilling the duty. It is the increasing function of the fine (F) but the decreasing function of the being-caught probability. Intuitively, the informed driver is more willing to commit the criminal if the penalty of violating the traffic law is brutal while the feasible bribe is more reasonable and it is less likely that his action will be caught and punished by the appropriate authority.

c) Condition (4)

It is intuitively obvious that the informed driver will choose the 50-50 solution if it is even more costly for him to contend with the W officer than bribing him and moving on.

d) Condition (5)

Rearrange the expression in this condition, one will obtain:

$$(1-\lambda)\varphi(F-B) \geq [1-(1-\lambda)\varphi]B - (1-\lambda\varphi)F \qquad (*)$$

The interpretation of this condition is relatively similar to the case of the condition 3. Recall that the left-hand term is the expected gain from bribing the T officer while the left-hand side is the expected gain from choosing to pay the fine. There is yet the appearance of the new variable φ, the probability that the officer belongs to the type T. The term in the right-hand side of the inequality is the increasing function of φ. The characteristics of the left-hand side is more complicated and of course more interesting. Rearrange this term as the function of φ, we have:

$$G(\varphi) = [\lambda(F + B) - B]\varphi + (B - F)$$

There are three possible cases:

i) $\lambda(F + B) - B > 0$, then $G(\varphi)$ is an increasing function.

The cost of the bribing action when encountering the T officer i

s greater than the one when encountering the W officer, then the more likely the officer truly convicts the uninformed driver of his mistake, the higher the gain that the driver achieves by choosing not to bribe. In other words, it becomes more profitable for the driver to comply. In this case, both the left-hand and right-hand sides of the inequality (*) are the increasing function of φ. No matter what the driver does he is always better off given the higher probability that the officer works well.

ii) $\lambda(F + B) - B < 0$

In this case, it is more costly for the driver to comply when it is more likely that the officer is announcing the truth. The left-hand of the inequality is an increasing function while the right-hand side is a decreasing function. Then the uninformed driver is more willing to bribe the officer it is more likely that this officer is telling the truth.

iii) $\lambda(F + B) - B = 0$, then $G(\varphi) = (B - F)$

In this case, φ does not affect the well-being of the driver from abiding by the legal sanction. Since $G(\varphi) < 0$ while $(1-\lambda)\varphi(F - B) \geq 0$, the condition (5) is always satisfied no matter how large or small φ may be.

e) Comparison

By comparing the left-hand side of the conditions (3), (4) and (5), one will arrive at some interesting observations. Assume that $2(1-\lambda)F \geq C$. Then the informed driver is more likely to bribe the T officer than the W one in the sence that the informed driver will bribe the T officer if he has done so when confronting the W officer in the identical situation. The reverse statement may not be true. That is, in spite of bribing the T officer, the informed driver may refuse to bribe the W one in the identical situation.

If $\lambda \geq \frac{1}{2}$, then $(1-\lambda)\varphi F + (1-\lambda\varphi)F \geq 2(1-\lambda)F \geq C \geq B$, the uninformed driver is more likely to bribe the officer than the informed driver since the former's maximum bribing value is higher than the latter. If $\lambda \leq \frac{1}{2}$, then $2(1-\lambda)F \geq (1-\lambda)\varphi F + (1-\lambda\varphi)F \geq B$, the former is less likely to bribe than the latter when the latter actually made a mistake. If $\varphi = 1$ then the condition (5) becomes the condition (3).

5. CONCLUSION

By constructing a simple game theoretic model of asymmetric information between the traffic officer and the driver, we have obtained some insights about the corruption in Vietnam. First, there are possibly multiple Bayesian-Nash equilibria which may be derived from this game, including both pure and mixed strategies. For the purpose of simplification, we construct only one pure strategy equilibrium and spend more efforts on studying the effects of many various parameters and the information structure on the players' behaviors. These parameters include the fine (F), the bribe (B), the penalty (P), the complying cost (C), the reward (R) and the likelihood (λ) that the illegal action is discovered by the higher authority. The results are consistent with the standard observations of the corruption activities. Interestingly, the information available to the driver may significantly affect their decision in the sense that the player's different types may have different critical or threshold incentive values in the identical situation.

REFERENCES

Aidt, Toke S., 2003, Economic Analysis of Corruption: A Survey, *The Economic Journal, 113, 632-652*

Harrington, Joseph E., 2009, *Games, Strategies, and Decision Making*, New York, Worth Publishers.

Mishra, Ajit, 2006, Persistence of Corruption: Some theoretical Perspectives, *World Development, 34, 349-358*

Osborne, Martin J., 2004, *An Introduction to Game Theory*, New York, Oxford University Press.

Shleifer, Andrei & Vishny, Robert W., 1993, Corruption, *The quarterly Journal of Economics, 108, 599-617*

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