The Determinants of Compliance on Environmental Tax:
The Insights of Theoretical and Experimental Approaches Motivated by the Case of Indonesia

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Abstract

This study is intended to provide the clue regarding the determinants of compliance with environmental tax under imperfect monitoring and the presence of bribery, motivated by the case of Indonesia. The study is expected to contribute on environmental policy and tax compliance literatures, particularly by examining the impact of financial reward under the presence of bribery, aside of others conventional compliance instruments such as tax rate, audit, and sanction. In addition to financial reward, this study also incorporates the bribe explicitly as a determinant of compliance. The study employs theoretical and experimental approaches. While theoretical analysis find that the compliance will decrease with tax rate and increase with audit, sanction, financial reward, and the bribe rate; the experiment findings indicate that the impact of each determinant are vary according to the existence of bribery. Despite the difference, both approaches show that the bribery indeed hampers the compliance on environmental tax. The bribery encourages the polluting firms to aggressively evade the environmental tax as the tax rate increase and curbs the positive impact of financial reward in enhancing the compliance.

Keywords: Environmental Tax, Compliance, Theoretical Approach, Laboratory Experiment

1. INTRODUCTION

The necessity of environmental policies is motivated by the market failure, especially from the problem of externality and public goods. Most of environmental components (clean air, water, temperature, climate, etc) are by nature the public goods. The externality arises when the actions of one economic agent affect the utility of other agents in the uncompensated way. In the absence of regulations, the social cost will exceed the private cost and the public goods will be over-exploited. The primary objective of environmental policies is to restrict the damage on environment, by maintaining the situation under which the economic agents are liable to the full implication of its actions (Crew and Parker, 2006).

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In the case of Indonesia, the cost of environmental degradation has been highlighted in the Country Environmental Analysis by World Bank (2009). According to the analysis, environmental degradation is projected to lead to significant health and other welfare costs. World Bank predicts that the environmental degradation cost will grow at the same annual growth rate. The efforts of the Indonesian government have not yet succeeded in reducing the rate of environmental damage and pollution carried by the industries. Thus, to prevent a further environmental degradation, the government has planned to implement the environmental taxes (Hasan and Puspitasari, 2008).

Abimanyu, the head of Fiscal Policy Office of Indonesia, explains that the main objective of environmental taxes is to abate the adverse impacts resulted from industrial process on environment (Kompas, 2008). The adoption of environmental tax is crucial considering the increasing level of production waste discharging into the river, land, and air in Indonesia. Abimanyu states that the implementation of environmental tax could be considered as the attempt to raise the responsibility of industries for polluting the environment. The role of environmental tax gains more recognition with the provision of the Act No 32/2009 on Environmental Management and Protection that provides the legal basis for the government to levy the tax for the environmental purpose.

However, the problem of environmental taxes evasion should be anticipated. Tax evasion is an illegal action designed to lessen tax liability, particularly by underreporting the tax objects. Underreporting refers to the activity of tax payers that intentionally file the tax liability less than the accurate amount. In the case of environmental taxes, evasion could be translated into underreporting the actual level of emission to reduce the tax payment.

The tax will obviously increase the cost for the firms. At the viewpoint of the firms, cost can be lessened by minimizing the tax compliance. Since monitoring mechanism to enforce the compliance is costly, compliance behavior of the firms is not fully observable to government. Martowardojo, the current Finance Minister of Indonesia, mentions that the compliance with the corporate tax is still low. There are only 3.6% out of 12.9 million registered corporations in Indonesia that compliantly submit the corporate tax files (Koran Jakarta, 2011).

The problem of taxation is complicated further by the presence of bribery practice in taxation office[2]. The survey of Transparency International Indonesia in 2010 places taxation office in the top list of corrupting governmental institution in Indonesia. Although the government has tried to introduce the reformation in taxation sector, including the increase in tax officials' remuneration and more strict internal monitoring mechanism within the taxation office, the practice of corruption cannot be completely eliminated.

Corruption has been considered in the existing environmental literature at macro level as one of the major sources of environmental damage. Corruption includes the engagement in bribery by the administering officials who execute the regulation, in

[2] Joulfaian (2009) investigates the impact of bribes to tax officials in determining the business compliance behavior. His empirical findings from 27 economies in transition indicate that the tax evasion grows when the bribes to tax official are ordinary.

which the bribe is provided by the polluters to avoid the consequence of environmental regulation (Wilson and Damania, 2005). The cross-countries comparative study of Desai (1998) indicates that violation on environmental policies could become stronger when corruption takes place. The study shows that corruption by the mid and low level of officials is endemic in industrializing countries, and the infringement on environmental regulation is widespread. Using panel data from a mix of developed and developing countries from 1982 to 1992, Damania et al. (2003) provides the evidence that corruption leads to poor policy formulation, management, and enforcement that could become serious problems for environmental sustainability. This finding is supported by the cross-countries study of Morse (2006), suggesting the presence of an adverse relationship between corruption and environmental sustainability.

The study of bribery in environmental perspective is important for the policy purpose, since the bribery could obstruct the intended effect of environmental policies and the significance of enforcement will be weakened when the officials engage in bribery. The decline in the policies effectiveness will bring more difficulty for the regulator to restrict environmental degrading activities. However, the problem of bribery is less-researched in the environmental literature at micro level, particularly concerning the compliance behavior of the regulated polluters.

This study is intended to provide the clue regarding the determinants of compliance with environmental tax under imperfect monitoring and the presence of bribery. The compliance with environmental tax in this study is depicted as the result of strategic interplay between Ministry of Finance (MoF) and polluting firms. The firms are obliged to report the emission and pay the tax accurately to MoF, which is represented by the tax officials. The officials, who are acting on behalf of MoF, should audit the accuracy of the report and execute the sanction if the report is understated. Due to imperfect monitoring problem, firms may deceive tax officials by underreporting the emission and thus evading the emission tax. The problem of compliance will be more complex when the tax officials betray the assignment of MoF by taking the bribe from the cheating firms instead of executing the sanction.

This study may help the government in which the system is afflicted with bribery, such as Indonesia, in finding the alternative instruments to aid the enforcement on the emission taxes compliance. Inspired by the case of Indonesia, this study may offer the insight for other developing countries that share the similar characteristic of institutional situation and taxation setting. The study employs theoretical and experimental approaches. Experimental approach may or may not confirm the finding of theoretical approach, and the difference between those results may be interesting to find.

The rest of the paper is ordered as follows. The next section following the introduction part will present the brief review of literature on similar issue. The following section will describe the framework of interaction between MoF and the polluting firms. The theoretical model is presented afterward, followed by the section on the design and the results of experiment. The last section will provide the conclusion.

2. LITERATURE REVIEW

As described by Polinsky and Shavell (2000), the literature on environmental regulation and enforcement follows from the studies on optimal penalties in the law and economics. The theoretical study of Harford (1978) is among the first research on the emission taxes compliance. Harford extend the seminal work of Becker (1968) on crime and punishment to examine the compliance behavior of the firm under imperfectly enforceable pollution taxes, assuming that the firm aims for expected profit maximization. He derives a conclusion from his theoretical study that the actual pollutant level of the firm is determined by the pollution tax rate, while the probability of detection and the severity of sanction only affect the reported pollutant but not the actual pollutant. Therefore, increasing the fine and intensity of audit will lead to a more tax compliance, but not to a lower level of pollution. Further interpretation of his theoretical results infers that increasing the tax rate will lessen the emitted pollutant. However, a higher tax rate will decrease the reported pollutant in a bigger scale, thus suggesting an increase in the tax evasion.

Bontem and Bourgeon (2005) examine the optimal environmental taxation and enforcement policy in the principal-agent problem setting. Their theoretical study models the setting with self-reporting system, where the abatement cost is unknown to the regulator and emission level can be detected through a costly audit. Their result points out that the optimal level of tax will be higher than Pigovian level because of the adverse-selection problem. The firms may hide the true level of emission to decrease the tax liability; therefore, the tax should cover the costly enforcement to prevent the tax evasion. The further result shows that the optimal auditing effort of the regulator's agency is inversely related to the tax paid by the firms and their pollution levels.

The study of Macho-Stadler and Perez-Castrillo (2006) also focuses on the optimal audit policy to ensure the compliance with environmental taxes. Their theoretical study on the impact of the audit policy on an individual firm finds that the audit has a deterrence impact on both the actual level of emission and the reported emission. This result is different with the theoretical finding of Harford (1978) that suggest the increase in audit increases the tax compliance but does not decrease the level of emission. The difference is due to different hypothesis of the audit policy. Macho-Stadler and Perez-Castrillo (2006) argue that when the auditor decides to distribute the auditing intensity in a population of firms, the auditor may allocate the limited resources in a method where the firms do not behave as assumed by Harford (1978). Their analysis also suggests that the firms will always evade the environmental taxes, unless the monitoring budget is very large.

The effectiveness of environmental policies is often hindered by corruption. The theoretical study of Damania (2002) extends the literature by examining the problem of pollution tax in a corrupt bureaucracy. The analysis reveals that spending resources to monitor the emissions is unproductive in the setting plagued with bribery, unless the severity of prosecution is increased adequately. According to his analysis, the optimal emission tax requires that the net marginal benefits from the instrument for pollution and corruption deterrence be equalized. This finding contradicts the Pigovian principle that emission tax should be equal to the marginal

damage from pollution. In a corrupt system, a higher tax provides a stronger incentive to underreport, which should be balanced by increasing the auditing. Therefore, the optimal solution requires the marginal benefit from taxation to be traded off against the marginal benefit from auditing. This result implies that the ability of the government to control the emission is strictly limited if the auditing is expensive. He also finds that the tax rate rises with the reported emission while the audit rate decreases with the reported emission.

The study of Wilson and Damania (2005) is among a few of the theoretical studies on the interplay between bribery and emission tax. Bribery may determine the level of compliance, since it reflects the payment by the regulated firms to the regulator's agency for avoiding the consequences of an environmental policy. Their study considers the setting in which the firm creates pollution and government as the regulator tries to control it by setting emission tax. Regulator delegates the task of observing the level of emission to the inspector. The tax liability paid by the firm is based on the reported emission assessed by the inspector. Since it is mutually beneficial to both of them, the inspector and the firm may engage in bribery and agree to underreport the actual emission level. The audit conducted by the regulator can reveal the true emission level with certain probability, and the penalty will be imposed on both the firm and the inspector. The results of their study suggest that under the presence of bribery, an increase in the emission tax rate induces a decline in the actual emission since higher taxes increase the cost of production and thus reduce the production and pollution levels. Nevertheless, a higher tax raises the payoff from tax evasion that leads to increasing level of non-compliance. The study also shows that a higher fine reduces the emission and non-compliance level.

Most of the theoretical literature on environmental policies and taxes focus on the role of auditing and fine to impose the compliance. The impact of financial reward on compliance with environmental policies has scarcely been investigated. Swierzbinski (1994) introduces the financial reward as an additional instrument of deterrence policies in environmental taxation. He examines the optimal environmental taxes when the abatement cost of polluting firms is unknown to the regulator and observing the actual emission is costly. The enforcement effort of the regulator is restricted with the limitation of available resources. His model allows the regulator to choose the reward for the compliant firms, apart from conventional deterrence instruments such as penalty and auditing.

The findings of his study suggest that the optimal scheme will be similar to a deposit-refund system. The system refers to the plan where the firms are charged with the environmental tax and the reward is given afterward following the auditing process for the compliant firms (whereas the cheating firms are inflicted with the penalty). Further results suggest that when the maximum possible fine for violation is lower than the maximum reward, the decision to decrease emissions is determined by the probability of monitoring. On the other hand, if the maximum available reward is lower than the maximum fine, compliance decision is mostly driven by the variation in the tax rate.

Despite the different objective, the environmental taxes could be considered similar to other taxes in the experimental studies. The first experimental research on tax

compliance by Friedland, Maital, and Rutenberg (1978) examine tax evasion behavior employing three explanatory variables: tax rate, audit frequency, and magnitude of fine. The experiment reveals a significant increase in probability and occurrence of tax evasion as the tax rate increase. They conclude that the tax rate is the most important determining factor of tax evasion. The experimental result also suggests that the compliance is stronger influenced by the magnitude of fine than by audit probabilities. The latter result is supported by Park and Hyun (2003) who find that the magnitude of fine affects the compliance stronger than the probability of audit. However, Friedland (1982) reports that audit intensity affects compliance more than the severity of fine.

Beck, Davis, and Jung (1991) investigate the effects of variations in determinant variables, including tax rate, penalty rate, and audit probability on reported taxable income. The results support their hypothesis that the taxpayers will increase their compliant behavior as the detection probability and penalty rate increase. However, different with the finding of Freidland, Maital, and Rutenberg (1978), the tax rate is not found to influence the compliance behavior of taxpayers. Insignificant effect of the tax rate is also found in an experiment by Baldry (1987) and a study by Porcano (1988), investigating the self-reported compliance behavior.

Alm, Jackson, and McKee (1992a) conduct the experiment with declared income as the dependent variable and independent variables employed in their experiment are income, tax rate, fine rate, audit rate, and a public good (for some sessions). The results show that higher tax rates significantly lessen the tax compliance. The fine is also found to deter the evasion, although the impact is virtually zero. Alm, Sanchez, and De Juan (1995) show that fines are only effective in combination with high audit frequency. Their experiment suggests that the interaction of both variables is more important than their separate effects.

A Meta Study by Blackwell (2007) based on twenty laboratory experimental studies examines the impacts of traditional economic determinants of tax compliance: the tax rate, the penalty rate, and the probability of audit. In addition, it also examines the effect of a public good "return" to taxes paid. The study finds strong evidence that increasing the penalty rate, audit probability, and marginal-percapita return to the public good positively affect the tax compliance, but finds no statistically significant effect of the tax rate on compliance.

The experiment of Bilotkach (2006) examines the issue of tax evasion by companies through underreporting activity. He develops the game in which a businessman can hide part of his profit and offer bribe to the official. The results reveal that once it becomes known that supervising officials agree to accept bribes, participants offer bribes more aggressively and the magnitude of underreporting increases.

Only a few experimental studies investigate the effect of rewards on tax compliance. The study of Alm, Jackson, and McKee (1992b) examines the effects of financial reward on compliance behavior with multiple periods experiment. Compared with a control condition, tax compliance is higher in the reward conditions. However, the authors point out that the increase in compliance is primarily achieved by extreme tax compliance behaviors: it is either fully complying or completely evading the tax obligation. Torgler (2003) conducts a one-shot experiment with professionals from

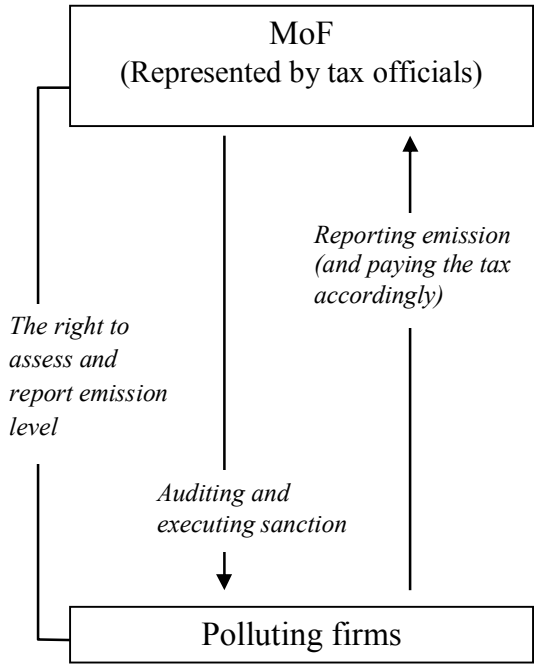
Costa Rica. Tax compliance in this experiment is higher when financial rewards are offered for a completely accurate income report. Bazart and Pickhardt (2009) conduct the experiments in which the rewards are given in the form of a lottery for audited and completely honest reports. The results show that the financial reward has a positive impact on compliance. However, Kastlunger et.al (2010) find from their experiment that providing the reward to the honest taxpayers does not generally increase the tax revenue. They propose that when the chance of reward for tax honesty is given, taxpayers seek one of the two goals: either they advance for the higher additional income from tax evasion, or they proceed toward obtaining the reward by complying with the tax.

Among the literatures on environmental taxes compliance (or even taxes compliance in genera), none analyzes the effect of financial reward and the bribery in combination. This study is expected to contribute on environmental taxes literatures by examining the role of financial reward on the compliance under the presence of bribery. Furthermore, this study also includes the bribe rate (the cost of bribe) as one of the compliance determinants under the presence of bribery, a variable that has not been considered in the literature of environmental compliance.

3. THE FRAMEWORK

Firms emit the pollutant as the result of their production process. To mitigate the problem of environmental damage, MoF levy an environmental tax on each unit of emissions. The tax is levied on the basis of reported emission level. In the self-assessment taxation system, MoF provides the polluting firms with the right to assess and report the emission level independently. The firms submit the report and pay the tax to the tax officials, who are acting as the agents of MoF. MoF delegates administrative authority to the officials for collecting the tax, conducting the audit and delivering the sanction (or the reward) to the rightful firms. The interaction of MoF, represented by the tax officials, and the polluting firms can be described in Figure 1.

Figure 1. Interaction of MoF and the polluting firms



The firm may cheat by reporting emission level below the actual level. To encourage the compliance of firm, MoF charges the cheating firms that submit incorrect emission level with a sanction. The sanction will be levied proportionally to the amount of evaded tax. To provide more incentive for firms to comply with environmental tax, MoF may provide a monetary reward to the compliant firms reporting the true level of emission. Monetary reward will be offered proportionally to the amount of the tax payment. Since the firms' true level of emission is unknown to MoF, sanction and reward can only be decided after the level of emission is examined trough an audit following the report submission. However, the costly audit cannot be directed to observe the emission level of all firms. Therefore, the firms can only be audited with certain probability.

In the presence of bribery, the officials may extract the bribe form cheating firm rather than execute the sanction. The amount of bribe is proportional to the amount of sanction, and determined by the officials who prepare to take the bribe. It is assumed that officials have a higher bargaining power than the cheating firms. The firms caught underreporting the emissions are required to accept the bribe rate set by officials; otherwise, they should pay the sanction.

4. THEORETICAL ANALYSIS

The objective of the theoretical analysis in this study is to investigate the optimal behavior of the firms regarding the compliance on environmental tax, responding to the determinant variables such as tax rate, sanction rate, probability of audit, financial reward rate, and bribe rate. The optimal responses are evaluated under three different settings. The first setting is calibrated for the clean taxation administration where bribery is completely prevented. The considered determinants

of compliance with the tax in the first setting are limited to tax rate, audit, and sanction. In the second setting, optimal behavior of the firms is observed under a situation where MoF provides a financial reward to the compliant firms as addition to conventional enforcement parameters such as audit and sanction. The third setting introduces the practice of bribery while the financial reward for compliance is available. As a consequence of bribery, the bribe rate (the cost of bribe) is incorporated among the determinants of compliance.

In the first setting, MoF relies on sanction and audit to deter noncompliance. Firm make a decision regarding optimal reported emission (*r*) given the emission tax rate (*t*), sanction rate for noncompliance (*s*), and audit probability ($\rho[a+r]$). The audit probability is the function of available budget allocated by the MOF on audit (*a*) and the reported emission (*r*), where $\rho'[a]>0$, $\rho''[a]>0$, $\rho'[r]<0$, and $\rho''[r]>0$. The profit from emitting the pollutant is expressed by $\pi[e]$, where *e* is the actual level of emission. It is assumed that one unit output linearly correlates with one unit of emission; therefore, *e* may reflect the level of output.

The payoff of the compliant firm that correctly reports the true level of emission from producing emission is given by $\psi_c^e = \pi - t.e$. The payoff is simply the difference between the profit of production that discharges emission and the emission tax payment. The payoff of the noncompliant firm that submit the reported emission (*r*) lower than actual emission (*e*) is defined by $\psi_c^r = \pi - \left(t.r + \rho.\left(s.t.\left(e-r\right)\right)\right)$. It is the profit of generating emission less the cost of tax payment and expected sanction from evading the tax. Obviously, if the firm decides to submit the correct emission report ψ_c^r will be equal to ψ_c^e.

The gain from underreporting emission and evading tax payment is

$$\psi_c = t.(e-r) - \rho.\left(s.t.\left(e-r\right)\right) \qquad (1)$$

Equation (1) is simply indicating the difference between the payoff of cheating and the payoff of compliance. The gain is the saved tax payment resulted from submitting the false emission report less the expected penalty for underpaying the tax. The noncompliant firm then decides the level of reported emission that maximizes the gain. The condition for optimal reported emission is given by FOC of equation (1).

$$\frac{\partial \psi_c}{\partial r} = -t + \rho.(s.t) - \frac{\partial \rho}{\partial r}.\left(s.t.\left(e-r\right)\right) = 0 \qquad (2)$$

Rewriting equation (2) in term of *r*, and adjusting for $\frac{\partial \rho}{\partial r} < 0$,

$$r = e - \left(\frac{t - \rho.(s.t)}{\frac{\partial \rho}{\partial r}.(s.t)} \right) \tag{3}$$

Equation (3) implies that reporting emission level accurately is an optimal decision if the marginal benefit of underreporting (tax rate) is equal to the marginal cost of underreporting (the expected sanction rate per one unit unreported emission). On the other hand, reporting the understated emission level is the optimal decision if that condition fails to obtain. The optimal unreported emission (*e*-*r*) is equal to the marginal gain of underreporting adjusted by the marginal expected sanction as the reported emission changes.

The impact of each enforcement instrument on optimal reported emission is demonstrated by comparative statics, deriving from of equation (2) using implicit differentiation. Adjusting for $\frac{\partial \rho}{\partial r} < 0$ and $\frac{\partial \rho}{\partial a} > 0$, all comparative statics are presented below.

$$\frac{\partial r}{\partial t} = -\frac{1 - \left(\rho.s + \frac{\partial \rho}{\partial r}.(s.(e-r)) \right)}{2.\frac{\partial \rho}{\partial r}.s.t + \frac{\partial^2 \rho}{\partial r}.(s.t.(e-r))} \tag{4}$$

$$\frac{\partial r}{\partial s} = \frac{\rho.t + \frac{\partial \rho}{\partial r}.(t.(e-r))}{2.\frac{\partial \rho}{\partial r}.s.t + \frac{\partial^2 \rho}{\partial r}.(s.t.(e-r))} \tag{5}$$

$$\frac{\partial r}{\partial \rho} = \frac{s.t}{2.\frac{\partial \rho}{\partial r}.s.t + \frac{\partial^2 \rho}{\partial r}.(s.t.(e-r))} \tag{6}$$

Comparative statics of tax rate impact on optimal reported emission in equation (4) shows that the optimal report is decreasing with the tax rate. The increase in a tax rate will reduce the optimal reported emission. The equation (4) also give a hint that the increase in tax rate may possibly induce the firm to report more, since the amount of sanction increases with the amount of unreported emission and the tax rate level. However, this can be attained only if the sanction is heavily severe and the probability of audit is exceptionally high. Equation (5) and (6) show that optimal reported emission increases with the sanction rate and the audit. A higher sanction rate for noncompliance and the more intensive audit will impose more pressure on firm to increase their reported income.

In the second setting, the firm may expect an additional income in the form of financial reward for reporting the true level of emission. The expected payoff to the compliant firm is defined by $\psi_c^e = \pi - t.e + \rho.(i.t.e)$. The payoff is the difference between the profit of generating emission and the cost of tax payment, plus the expected financial reward. Financial reward is conditional on the probability of audit since the reward is granted after the accuracy of the report is confirmed. The payoff to the noncompliant firm from generating emission is given by $\psi_c^r = \pi - \left(t.r + \rho.(s.t.(e-r)\right)$. The payoff is the profit less the underpaid tax payment and the expected cost from underreporting, consisted of the sanction and the loss of financial reward for compliance. The gain from underreporting emission is given by the following equation,

$$\psi_c = t.(e-r) - \rho.(s.t.(e-r)) + (i.t.e) \tag{7}$$

The gain is the saved tax payment resulted from submitting understating emission, less the expected sanction and the loss of financial reward for compliance. The condition for optimal reported emission that gives a maximum payoff to firm is given by First Order Condition (FOC) of equation (7).

$$\frac{\partial \psi_c}{\partial r} = -t + \rho.(s.t) - \frac{\partial \rho}{\partial r}.\left(s.t.\left(e-r\right) + (i.t.e)\right) = 0 \tag{8}$$

Adjusting for $\frac{\partial \rho}{\partial r} < 0$, equation (8) can be rewritten in term of *r*,

$$r = e - \left(\frac{t - \left(\rho.(s.t) + \frac{\partial \rho}{\partial r}.(i.t.e) \right)}{\frac{\partial \rho}{\partial r}.(s.t)} \right) \tag{9}$$

When the financial reward is provided, the optimal reported emission is higher than the previous situation without financial compensation, as formulated in equation (3). By introducing a financial reward, marginal cost of underreporting emission rises and leads to a reduction in marginal gain of evasion.

The impact of each determinant on the optimal reported emission is demonstrated by the following comparative statics, adjusting for $\frac{\partial \rho}{\partial r} < 0$,

$$\frac{\partial r}{\partial t} = -\frac{1 - \left(\rho.s + \frac{\partial \rho}{\partial r}.(s.(e-r) + (i.e)) \right)}{2.\frac{\partial \rho}{\partial r}.s.t + \frac{\partial^2 \rho}{\partial r^2}.(s.t.(e-r) + (i.t.e))} \tag{10}$$

$$\frac{\partial r}{\partial s} = \frac{\rho.t + \frac{\partial \rho}{\partial r}.(t.(e-r))}{2.\frac{\partial \rho}{\partial r}.s.t + \frac{\partial^2 \rho}{\partial r^2}.(s.t.(e-r) + (i.t.e))} \tag{11}$$

$$\frac{\partial r}{\partial \rho} = \frac{s.t}{2.\frac{\partial \rho}{\partial r}.s.t + \frac{\partial^2 \rho}{\partial r^2}.(s.t.(e-r) + (i.t.e))} \tag{12}$$

$$\frac{\partial r}{\partial i} = \frac{\frac{\partial \rho}{\partial r}.(t.e)}{2.\frac{\partial \rho}{\partial r}.s.t + \frac{\partial^2 \rho}{\partial r^2}.(s.t.(e-r) + (i.t.e))} \tag{13}$$

Comparative statics show that the optimal reported emission is decreasing with the tax rate and increasing with the audit, sanction rate, and financial reward rate. The comparison of the impact before and after the introduction of financial reward reveals that the negative impact of the tax rate on the reported emission is smaller when the financial reward is provided. Given that the audit intensity, sanction severity, and financial reward are significantly high, the possibility that the increase in the tax rate leads to higher reported emission is wider with the availability of financial reward. The impact of sanction rate and audit on reported emission are lower when the financial reward is offered. It shows that the insertion of financial reward crowds out the impact of other enforcement instruments.

The comparison of the sanction and financial reward impact on the reported emission yields ambiguous conclusion. The impact of financial reward will be higher than the impact of the sanction if the optimal reported emission as expresses in equation (9) is close to the actual level. However, the impact of the sanction is superior to financial reward if the optimal reported emission is much lower than the actual emission.

The provision of financial reward requires that the polluting firm report the accurate level of emission. Although the firm increases the emission report, the reward will not be granted if the requirement to state the full amount of emission is not met. Shifting from noncompliant to compliant behavior is less favorable to the firm if the expected gain from cheating is much higher than complying. Therefore, financial reward is only attractive and able to induce the firm to comply when the optimal level of reported emission is close to the actual level.

On the other hand, the intensity of sanction is defined by the degree of non-compliance; the gap between the reported and actual levels of emission. The sanction will be more sever if the size of underreported emission is higher. Sanction allows the polluting firm to adjust its behavior according to the tolerated level of expected loss. Firm may adapt to the severity of the sanction by manipulating the report. If the sanction is more severe as the sanction rate increases, firm may lower the expected loss by increasing the reported emission. However, it does not necessarily induce the firm to declare the real emission level.

The previous two settings model the optimal behavior of polluting firm when tax officials are law-abiding and prevented from corrupting behavior. The third setting observes the optimal behavior of the firm when the officials are willing to engage in bribery. The payoff of generating emission for the compliant firm is exactly similar with the payoff from the second setting, $\psi_c^e = \pi - t.e + \rho.(i.t.e)$. The payoff is the gain from generating emission and the expected financial reward for reporting the true level of emission, less the cost of the tax payment. The payoff for the noncompliant firm is given by $\psi_c^r = \pi - \left(t.r + \rho.(b.s.t.(e-r))\right)$, the profit of generating emission less the sum of the underpaid tax payment and the expected bribe. The gain from underreporting emission is given by the following equation,

$$\psi_c = t.(e-r) - \left(\rho.\left(b.s.t.(e-r) + (i.t.e)\right)\right)$$

(14)

The gain consists of the tax saving from underreporting emission less the expected cost of bribe and the loss of expected financial reward. FOC of equation (14) is

$$\frac{\partial \psi_c}{\partial r} = -t + \rho.(b.s.t) - \frac{\partial \rho}{\partial r}.\left(b.s.t.(e-r) + (i.t.e)\right) = 0$$

(15)

Optimal reported emission (*r*) can be obtained by re-writing equation (15) in term of *r*. Adjusting for $\frac{\partial \rho}{\partial r} < 0$, *r* is formulated as following,

$$r = e - \left(\frac{t - \left(\rho.(b.s.t) + \frac{\partial \rho}{\partial r}.(i.t.e) \right)}{\frac{\partial \rho}{\partial r}.(b.s.t)} \right)$$

(16)

Optimal reported emission is lower than the report when a financial reward is provided under the absence of bribery in equation (9). The introduction of bribery reduces the marginal cost of underreporting emission and increase the marginal gain from the evasion.

Adjusting for $\frac{\partial \rho}{\partial r} < 0$, the comparative statics derived from FOC in equation (15) are presented below.

$$\frac{\partial r}{\partial t} = -\frac{1 - \left(\rho.b.s + \frac{\partial \rho}{\partial r}.\left(b.s.(e-r) + (i.e)\right) \right)}{2.\frac{\partial \rho}{\partial r}.b.s.t + \frac{\partial^2 \rho}{\partial r^2}.\left(b.s.t.(e-r) + (i.t.e)\right)}$$

(17)

$$\frac{\partial r}{\partial s} = \frac{\rho.b.t + \frac{\partial \rho}{\partial r}.(b.t.(e-r))}{2.\frac{\partial \rho}{\partial r}.b.s.t + \frac{\partial^2 \rho}{\partial r^2}.(b.s.t.(e-r)+(i.t.e))} \tag{18}$$

$$\frac{\partial r}{\partial \rho} = \frac{s.t}{2.\frac{\partial \rho}{\partial r}.b.s.t + \frac{\partial^2 \rho}{\partial r^2}.(b.s.t.(e-r)+(i.t.e))} \tag{19}$$

$$\frac{\partial r}{\partial b} = \frac{\rho.s.t + \frac{\partial \rho}{\partial r}.(s.t.(e-r))}{2.\frac{\partial \rho}{\partial r}.b.s.t + \frac{\partial^2 \rho}{\partial r^2}.(b.s.t.(e-r)+(i.t.e))} \tag{20}$$

$$\frac{\partial r}{\partial i} = \frac{\frac{\partial \rho}{\partial r}.(b.t.e)}{2.\frac{\partial \rho}{\partial r}.b.s.t + \frac{\partial^2 \rho}{\partial r^2}.(b.s.t.(e-r)+(i.t.e))} \tag{21}$$

Optimal reported emission is decreasing with the tax rate and increasing with the audit, sanction rate, bribe rate, and financial reward rate. Similar to the pervious setting, the advantage of sanction and financial reward over each other is determined by the optimal size of underreported emission. The impact of financial reward will be superior to the sanction if the optimal reported emission is close to the actual level, otherwise, the sanction will have a greater impact.

Comparing the equation (18) and (20) trivially yields a deduction that the impact of bribe rate on the optimal report is higher than the impact of sanction rate. The bribe will curb the deterrence effect of the sanction. To the cheating firm, the actual punishment for underreporting is determined by the bribe rate set by the corrupting officials. Therefore, the firm will be more influenced by the bribe rate than the officially announced sanction rate.

Financial reward will have a greater impact on reported emission than a bribe only if the optimal reported emission is close to the actual emission and the bribe is very expensive. Bribing to evade the sanction is less appealing than the anticipation of financial reward when the amount of requested bribe is almost equal to the sanction. When the gap between the optimal report and the actual emission is narrow, shifting from underreporting behavior to presenting the accurate report will be less costly for a firm. However, reporting accurately will create a considerable loss of gain for the cheating firm if that gap is wide and the bribe is significantly less

than sanction. In this case, firm will be inclined to underreport the emission and anticipate the bribing.

Financial reward is less significant in inducing the firm to increase reported emission when the bribery is not restrained. Bribe is lessening the severity of a sanction; therefore, the cost for underreporting the emission is lower and thus the marginal gain of underreporting increases. It makes the financial reward is less attractive for the firm.

5. EXPERIMENTAL ANALYSIS

The objective of experimental analysis is to test a theoretical concept under laboratory setting, in order to generate reliable empirical results. Experimental study has three advantages. First, laboratory experiment enables to control the behavior of subjects in the way that is typically impossible in the field. It prevents external influencing factors, which may be exist in more complex field setting and restricts confounding external factors. Second, laboratory experiment allows manipulating systematically the circumstances and the corresponding behavior change and hence to address the issue of causality that is impossible in the field context. Third, testing alternatives institutional arrangement and policies in laboratory setting is obviously less costly than in the real life.

The experiment is conducted in Indonesia, to anticipate the compliance behavior of economic agent that may be different across countries. Torgler (2002) and Richardson (2008) state that the tax compliance differs across countries with different culture. Since the experiment is expected to calibrate the taxation situation in Indonesia, it is necessary to run the experiment in the same country.

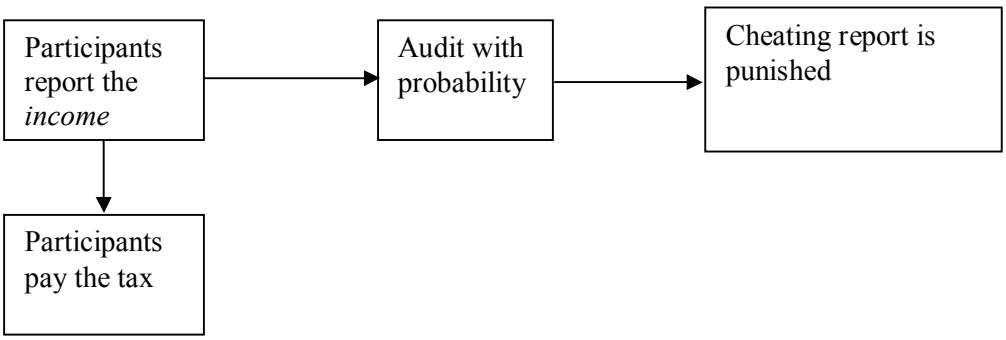
The experiment employs students as participant. The responses of students are not different with other subject under the same laboratory setting (Baldry, 1987), because the cognitive processes in the experiment are the same between subject pools (Alm, 1998). Students have been employed in previous experiments to investigate the firms' behavior. Fehr et al. (1993) in their experimental study on the existence of wage exchanges employs students to imitate the interaction between firms and workers. Other researches on wage contracts from Fehr and Gächter (2000), Fehr and Falk (1999, 2003), and Brandts and Charness (2004) also use students to assume the role of firms. Students are also recruited as the subjects in the experiments on firms behavior in the oligopolistic setting (Le Coq and Orzen, 2006; Morgen et al., 2006; and Orzen, 2007).

The design of an experiment should be simple enough to conduct, without losing the basic features of a real situation intended to be calibrated. Therefore, for the sake of simplicity, this experiment uses the assumption that the income received by pollutant emitting economic agents is linearly corresponding with the emission. Real and significant financial reward, where subjects are paid according to their success in decision making, is important in the experimental study. Therefore, the participants can earn and lose money by making decisions during experiment. Any earnings are given to the participants in cash at the end of the experiment.

Similar to the theoretical analysis, the experimental analysis observe the behavior of participants under three different treatments. The first treatment simulates the taxation condition when the reward for telling the truth is not implemented, and bribery is absent. Three parameters that affect behavior of tax compliance incorporated in this treatment are tax rate, probability of audit, and sanction rate. Participants receive income, and they have to pay the tax based on the voluntary reported income. Participants face the probability of audit, and the detected cheating-participants should pay the sanction on unpaid tax.

The choice variable in the first treatment that should be decided by participants is the reported income. The treatment variables, variables controlled by experimenter and changed over time (rounds) to see the response of participants' behavior, are tax rate, sanction rate, and probability of audit. Given the value of treatment variables, participants should make a decision regarding the amount of income to report.

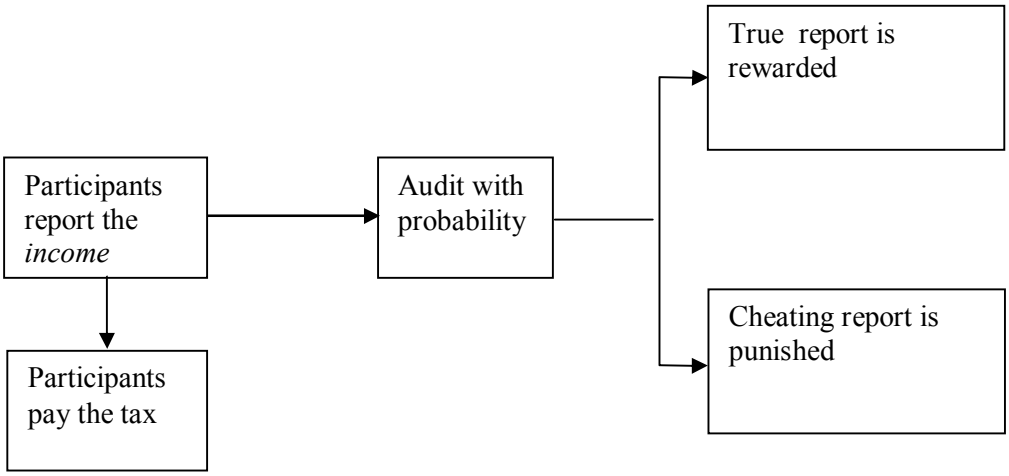
Figure 2. Sequence of actions in the first treatment



The sequence of actions in the first treatment is illustrated in Figure 2. First, participants decide the amount of received income that they are willing to report, given different values of treatment variables. After participants submit the reported income, their income will be deducted by the amount of tax proportional to their reported income. The report will be audited with certain probability. Participants who are found cheating (reporting the amount less than the received income) will be punished by subtracting further their income by the amount of sanction.

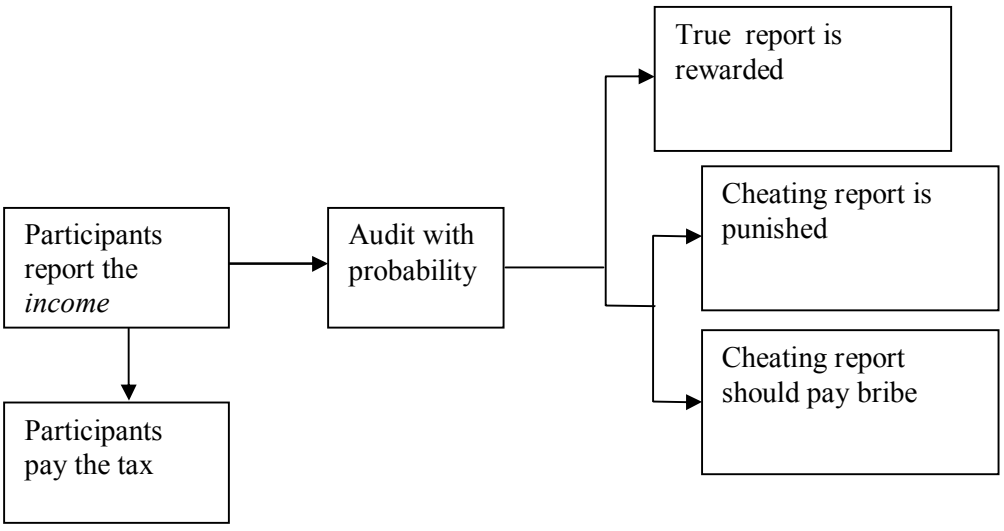
Financial reward as an additional determinant on compliance behavior is introduced in the second treatment. The second treatment represents the situation in the absence of bribery where the reward is given for reporting honestly, after the reports are checked. In this treatment, participants are not only punished for cheating, but they are also encouraged to report truthfully by providing them the financial reward to do so. The determinant parameters used in this treatment group are tax rate, probability of audit, sanction rate, and reward rate.

Figure 3. Sequence of actions in the second treatment



The third treatment calibrates the situation where the bribery practice is allowed, and the reward for fully reporting the received income is offered. Bribery is translated into the option for sanctioned participants in this experiment to choose between paying the penalty and paying bribe to avoid the sanction. Bribe rate is introduced in this treatment to indicate the price of bribe to be paid by the participants. Bribe is designed to be lower than the sanction, matching the real-life situation.

Figure 4. Sequence of actions in the third treatment



The sequence of actions is presented in Figure 4. In this treatment, participants are eligible to receive the reward or obliged to pay the cost of cheating (in term of sanction or bribing cost) after their report is checked. Choice variable that should be

decided by participants is reported income. Treatment variables are tax rate, sanction rate, bribe rate, reward rate, and probability of audit.

The game in all treatment groups consists of 24 rounds, in which the participants are given fixed income. They should make a decision repeatedly given the changing value of treatment variables. The values of treatment variables for all treatments are measured in percentage, ranging from low, moderately high, and very high. During the experiment, the value of treatment variables is randomly picked up so that different combination of determinant values occurs for each round in all treatments. The gap between each value is set distinctly wide so that the difference in percentages is noticeable to participants.

Before the experiment is conducted, the participants are asked to fill a simple questioner regarding risk attitude. The questionnaire consists of the questions assessing the perception of participants on the certain statement. The available choices are ordered using the Likert Scale. The questioner basically refers to the risk characteristic assessment using by financial investment companies.

To analyze the data of the experiments, standard econometric techniques are used. The reported incomes as the proxy of compliance are regressed on determinant variables using panel data regression. The repetition of games in each treatment provides the panel dataset, where the participants' decision responding to the changing values of determinant variables are observed over time. Panel data allows controlling variables that change over time but not across participants (treatment variables that are determined by experimenter); and variable which is different across participants but does not change over time (risk attitude of participants).

Random effect model is chosen to analyze the panel dataset occurred from the experiment. The argumentation behind the random effect model is that the variation across participants is assumed to be random and uncorrelated with the value of determinant variables included in the model. This assumption is justified since the value of determinant variables over time is selected randomly by experimenter, independent of the attribute of participants. Random effect is also preferable if the different across participants' characteristic (risk attitude) is assumed to influence their decision. The random effect model assumes that the error term of cross-sectional unit in the model is not correlated with the independent variables, therefore, allowing the time-invariant variables to be used as explanatory variables.

The first step in the analysis is determining whether the random effect approach is statistically preferable, or it is fixed effect approach that is more suitable. Hausman test is used to test whether the unique errors are correlated with the independent variables. Hausman test on the regression models revealed that the null hypothesis that the errors were uncorrelated was not rejected. Therefore, the random effect was more preferable than the alternative fixed effect model. The econometric results are presented in the table below.

Table 1. Determinants of reported income

Determinant of reported income	The first treatment (R^2: 0.18)	The second treatment (R^2: 0.17)	The third treatment (R^2: 0.15)
Tax rate	0.03 (0.47)	0.03 (0.47)	-0.15** (0.00)
Sanction rate	0.09* (0.03)	0.02 (0.67)	0.11** (0.01)
Financial reward rate	n.a	-0.04 (0.39)	0.07 (0.12)
Bribe rate	n.a	n.a	0.10* (0.03)
Audit probability	0.51** (0.00)	0.41** (0.00)	0.53** (0.00)
Risk	-0.02 (0.69)	0.00 (0.99)	-0.04 (0.40)

Note: * significant at 5% significance level
** significant at 1% significance level
The value in the bracket is P-value

The coefficients in the table represent the percentage of change in reported income as one unit change in the determinant variables. During all treatments, the risk characteristic of participants does not have a significant impact on their decision in deciding the amount of reported income, although the sign of the coefficient is correct. The signs of the risk coefficient show that the reported income will be lesser as the participants are more risk seeking.

In the first treatment, the determinant variables that significantly affect the reported income during the experiment are sanction rate and audit probability. Those variables are significant at 5% and 1% level of significance respectively. One unit change in sanction rate will increase the reported income by 9% of the actual income. Audit probability possesses a greater impact on reported income, where one unit change will lead to 51% increase in reported income. On the other hand, the tax rate is not affecting the decision of participants in reporting their income.

The only significant determinant in the second treatment is audit probability (significant at 1% significance level), where one unit change in probability of audit will increase the reported income by 41% of the received income. Other variables are not significantly affecting the decision of participants. Financial reward rate, the additional instrument to augment the compliance of the represented tax payers, is also insignificant.

The impact of the tax rate in the third treatment where the bribery practice is introduced into the experiment is significant at 1% level of significance. One unit increase in the tax rate will reduce the reported income 15% of actual income. Sanction rate and audit probability show the significant influence on the decision of participants in the third treatment. Both are significant at 1% significance level. One unit increase in the sanction rate lead to 11% increase in the third treatment, while one unit increase in audit probability raises the reported income by 53%.

Bribe rate, the additional determinant variable of compliance under the presence of bribery, also shows the significant impact on reported income at 5% level of significance in the third treatment. Following one unit increase in bribe rate, reported income in the third treatment increases by 10% of actual income.

The results indicate that probability of audit has the most important role in determining reported income of participants in all treatments. It is constantly significant at 1% significance level across all treatment groups. Sanction rate is also significant in all treatment groups, except in the second treatment where the financial reward is available. Tax rate, which does not have a statistically significant effect on reported income in the first and the second treatment, has a significantly negative impact on reported income when bribery is practiced in the third treatment. Bribe rate, as an addition to the conventional determinant of compliance, is significant under the presence of bribery.

Since the impact of financial reward is the main concern of this research, it is necessary to see whether the introduction of financial reward will make a different in the reported income. Therefore, financial reward was translated into the dummy variable consisting of binary values. Financial reward dummy was regressed on reported income, together with other controlled variables.

Table 2. Determinants of reported income with financial reward dummy

Determinant of reported income	Treatment without bribery (R^2: 0.21)	Treatment with bribery (R^2: 0.16)
Tax rate	0.02	-0.05*
	(0.33)	(0.05)
Sanction rate	0.07**	0.11**
	(0.00)	(0.00)
Bribe dummy	n.a	(Omitted)
Probability of audit	0.46**	0.51**
	(0.00)	(0.00)
Risk	-0.01	-0.03
	(0.79)	(0.38)
Reward dummy	0.22**	0.05
	(0.00)	(0.39)

Note: * significant at 5% significance level
** significant at 1% significance level
The value in the bracket is P-value

The results presented in Table 2. show that financial reward dummy is statistically significant in influencing the reported income when bribery is not practiced. The introduction of financial reward will increase the reported income under the absence of bribery by 22% of the received income. The significance of financial reward dummy might explain why financial reward rate does not affect the reported income in the second treatment. The main motivation that drives the participants to be more compliant is not the amount of financial reward, but the availability of the reward itself. Participants are more motivated by the presence of financial reward instead of the size of the reward. As long as the reward is provided, they will be

more compliant regardless of the amount of the reward. However, when the bribery practice is introduced, financial reward becomes insignificant. It indicates that the introduction of financial reward for compliance is only effective in affecting the reported income in the absence of bribery.

7. CONCLUSION AND POLICY RECOMMENDATION

While theoretical analysis find that the compliance will decrease with tax rate and increase with audit, sanction, financial reward, and the bribe rate; experiment findings indicate that the impact of each determinant are vary according to the existence of bribery. Under the presence of bribery, experiment shows that the tax rate is significantly reduce the compliance while it has no significant impact when the bribery is prevented.

Another different result between the two approaches is the finding regarding the impact of financial reward. Theoretical study indicates that the impact of financial reward on the compliance of polluting firms will be less than the impact of the sanction, in both the absence and the presence of bribery. On the other hand, experiment results show that the impact of financial reward is superior to the impact of the sanction if the bribery is fully prevented, while it is not able to significantly induce the compliance under the presence of bribery.

Theoretical study assumes that the firms will act optimally to maximize their profit; on the other hand, the experimental firms also act on ethical consideration aside of profit maximization behavior. Participants as the experiment firms who consider evading the obligation is ethically disapproving will be more encouraged to comply when the reward to do so is available. However, the presence of bribery creates a condition where the benefit of evasion is exceedingly more appealing than the benefit of compliance. In this situation, the economic motivation rules out the ethical consideration and the experimental firms will ignore the financial reward.

Despite the difference, both approaches show that the bribery indeed hampers the compliance on environmental tax. The bribery will make polluting firms to evade aggressively the environmental tax as the tax rate increase, and curb the positive impact of financial reward in enhancing the compliance.

Based on the findings of the theoretical and experimental studies, the proposed emission tax scheme under the presence of bribery and costly monitoring would be a combination of moderate tax rate, moderate financial reward for compliant firms, accompanied by a high sanction for evasion. Financial reward would be best to set at a moderate level since theoretical findings show that the impact of the reward on compliance is lower than the impact of the sanction, while experimental results suggest that what really significance is the presence of the reward regardless of the value.

Since the bribe also contributes a significant impact on compliance decision, the enforcement policies directed toward corrupting tax officials that eventually lead to the increase in the cost of bribe is recommended. For example, corrupting tax officials might be forced to increase the demanded bribe rate if MoF provides high

financial reward for tax officials who are able to discover the evasion and sets high penalty for corrupting tax officials.

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