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Gaoussou Diarra, Sébastien Marchand

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Gaoussou Diarra* and Sébastien Marchand†

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*Ph.D candidate in Development Economics and International Relations. Contact: Gaoussou.Diarra@u-clermont1.fr.
†Corresponding author: Ph.D candidate in Development Economics. Contact: Sebastien.Marchand@u-clermont1.fr, Tel: (+33)4 73 17 75 07, Fax: (+33)4 73 17 74 28.

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Abstract

This paper analyses the relationships between environmental compliance, corruption and environmental regulations in the case of forestry. Using a Principal-Agent model, we highlight interrelationships between firm's environmental non-compliance and corruption conditioned to the efficiency of the legal and regulatory framework. Moreover, we show that environmental compliance and judicial efficiency may be complementary or substitutable depending on the level of judicial efficiency to strengthen the forest stock. After having design a new indicator of environmental compliance, we test these predictions using cross section data for 59 developing countries. The empirical results support the predictions of the model. Judicial efficiency reduces corruption and environmental non compliance which are positively correlated and conditioned to judicial efficiency. We also find empirical evidences on the substitutability and complementarity of environmental compliance and judicial efficiency to preserve the forest stock.

Keywords: Corruption, Environmental compliance, Forest Stock, Political Economy, Governance.

JEL codes: D73, Q23.

"(S)ustainable development depends upon good governance, good governance depends upon the rule of law, and the rule of law depends upon effective compliance. None are sufficient alone, but together they form an indivisible force that is essential for survival and for sustainable development". Zaelke et al. (2005, p.29-30)

1 Introduction

Moving onto the path of sustainable development requires that human behavior change to address major environmental issues such as biodiversity loss and climate change. In this context, understanding factors of deforestation is relevant to improve sustainable environment for various reasons. For instance, the current global warming issue highlights the importance to reduce emissions from deforestation, forest degradations, and enhance forest carbon stocks in developing countries (REDD+) (Angelsen et al., 2009). Moreover the protection of biodiversity, particularly in pristine forested area, becomes a significant environmental issue in the current international development agenda. Thus, the depletion of forested areas in developing countries has drawn attention in order to improve sustainable development.

To respond to these issues, governance systems have to become more effective as it describes the available way to shape human actions towards its common goals as sustainable development. In this system, institutions, conceived as "rules of the game" (North, 1994) provide practices and guide economic, political and social human interactions. As noticed by (Zaelke et al., 2005, p.38), "all forces that can influence human behavior are potential tools of governance". In this context, good governance depends on rule of law which refers to a set of rules applied fairly, efficiently and predictably by independent institutions in a framework of public-private interaction process. Thus, a set of social norms comprising, rule of law, anti-corruption, and accountability have been put forward to enhance governance. In this context, compliance is a substantial element of good governance. Compliance with the law is related to the respect and the enforcement of legal system. As a result, compliance may be treated as an indivisible part of rule of law: rule of law cannot have meaning without compliance. The growing focus on compliance seems to be important to enhance the success of efforts to strengthen rule of law, which in turn will improve the achievement of efforts to promote good governance, and thereby allow the society to reach sustainable development. Indeed, in most studies on governance, emphasis is put on the supply side of reforms. The importance of taking into account the demand side of good governance reforms imply to be aware of factors driving stakeholder's compliance (Young,

1979; Odugbemi and Jacobson, 2008; McNeil and Malena, 2010).

This paper aims at bridging this gap by analyzing relationships between governance infrastructures and patterns of keys stakeholders' compliance with regulatory policies, notably in environmental field such as deforestation. The importance of compliance is nowhere more important than in the field of environment and sustainable development. For instance, in a poor legal and judicial system, in which non-compliance and corruption become pervasive and law are not enforced, the respect for the rule of law is lessened, environmental degradation is more likely to occur, and progresses towards sustainable development are weakened. In this context, improvements of governance infrastructures and more particularly norms enforcement and compliance have been widely recognized.

Thus, factors underlying actors' compliance concerned with regulatory policies allow to understand corruption phenomenon and functioning of governance infrastructures. Moreover, the literature on regulatory compliance has focused on whether a firm complies with existing regulations, and on effects of enforcement on a firm's compliance behavior (Magat and Viscusi, 1990; Deily and Gray, 1991; Laplante and Rilstone, 1996). Nonetheless, in these studies the role of bribery and other political economy aspects of enforcement and compliance were under-investigated. While compliance with regulations was treated in terms of compliance versus non-compliance (Deily and Gray, 1991), compliance level (Laplante and Rilstone, 1996) or duration of non-compliance episodes (Nadeau, 1997), studies on corruption have been focused on analysis of factors dealing with selection and incentives of actors taking policy decisions in a State with some interests on bureaucratic or political institutions structures. Besides, some evidences are also found about over-compliance of firms in manufacturing sector. Then, many firms are likely to comply with environmental regulations even when these regulations are weak or non-existent, well known as the Harrington paradox (Harrington, 1988).

Analyzing sustainability of governance reforms implies to know why is there too few demand for good governance in some economies, or to understand the persistence of some bad institutions such as those self-sustaining corruption. For instance, bureaucratic corruption can be attributed to a lack of sufficient political will while political corruption can be attributed to lack of adequate political competition. As good governance reforms are gradual processes and necessitate investment in legal and administrative infrastructures, political instability is likely to create an environment under which corruption becomes more pervasive and tends to persist (Damania et al., 2004; Mishra, 2006). Therefore, governments will be constrained in its abilities to enforce compliance with chosen policies while being vulnerable to lobbying activities. Hence, corruption is conceived along different

dimensions which are interlinked: grand versus petty corruption. Grand corruption which involves higher decision-levels in a country, is conceptually quite different from petty corruption. It includes cases when politicians or high-ranking civil servants manipulate a country's management or regulation of infrastructure industries to gain exclusive benefits (Knack, 2006; Kenny and Soreide, 2008). A main contrast between petty and grand corruption is related to monitoring mechanisms, which can be far better organized when petty corruption is the main issue. With grand corruption, elected politicians are often directly or indirectly controlling supposed monitoring mechanisms, including media as well as judicial system.

In this perspective, the fundamental rationale for giving special attention to corrupt actions in forestry highlights how these actions undermine the government's apparatus. This is critical in a sector such as forestry that generates many social and environmental impacts that call for a strong and clean intervention from State. If government is corrupt, there is little hope that illegal operations by other actors in the economy will ever be controlled (Contreras-Hermosilla, 2000). Anti-corruption policies limited to forestry are unlikely to work in countries with high corruption levels, which require systemic institutional changes. Corruption may matter for deforestation through design and implementation of land use plans. Indeed, grand corruption is likely to influence land use planning because decisions are made at high levels of government and large sums of money (or political support) are required to manipulate involved people. Petty corruption is likely to occur when local officials allow illegal encroachment on forest areas (Angelsen et al., 2009). Strategy for combating forest crime rests on an assessment of governance situation of the country, the streamlining of policy framework, and the focus on operational activities around a prevention, detection and suppression framework. However, since forestry does not operate in complete isolation from other sectors, enhancing compliance with forest law will depend on actions by judiciary and law enforcement agencies (FAO, 2005). Hence, this article examines interrelationships between governance, environmental compliance and forest cover in developing countries.

Positioned on the same lineage as Damania et al. (2004) but without being primarily interested by the channel of political instability as the way through which corruption may affect environmental compliance, we develop a theoretical model that explains how (i) petty corruption and environmental compliance interact belong to the extent of governance infrastructure and (ii) environmental compliance and governance infrastructure interact to reduce environmental damages as loss of forest stock. More precisely, a two-stage model is adopted where a profit-maximizing representative harvester selects

the optimal amount of harvested land to be cleared given the available technology in forestry. In the second step, the logging firm is inspected by a bureaucrat (inspector) and she might be willing to bribe this inspector in case of non-compliance. Firm-inspector interactions are shaped by judicial efficiency and authorized harvest quota previously set. Indeed, the first step presents a model of policy-maker corruption, following Grossman and Helpman (1994). Policy maker designs the forest policy *i.e* the maximum harvest. The logger acts as a lobby so that policy-maker maximizes a weighted sum of social welfare and received bribes.

We have drawn some positions predicting the relationships between firm's environmental compliance, petty corruption, governance infrastructures and environmental outcomes. Proposition 1 states that firm's environmental non-compliance and petty corruption are positively correlated (firm-inspector relation) and conditioned to the efficiency of the legal and regulatory framework. This proposition relies on two results concerning the negative effect of judicial efficiency and the positive effect of a less stringent harvest quota on both environmental compliance and petty corruption. Proposition 2 states that environmental compliance is a substitute of low judicial efficiency or a complement of high judicial efficiency to strengthen forest stock.

Empirical estimations, using cross section data for 59 developing countries, are supporting main theoretical predictions. First, we find that (i) environmental compliance and corruption are positively correlated but conditioned to judicial efficiency and (ii) that judicial efficiency lessens both corruption and compliance. Second, we find empirical evidences on the substitutability and complementarity of environmental compliance and judicial efficiency to preserve the forest stock.

The paper is organized as follows. Section 2 presents a political economy model. Section 3 provides econometrical evidence in support of the predictions of the model. Section 4 concludes and discusses policy implications.

2 The Baseline Model

A three-tier hierarchy agency model is used: firm-harvester/inspector/government (Tirole, 1986)[1]. We assume that all parties are risk neutral. The representative harvester has right to cut timber in a given public forested land (like a concession). The harvester decides the volume to harvest knowing that an inspector will monitor his production.

[1] An audit agency takes place in the game but only to monitor inspector's reported harvest production. Hence, the audit agency does not take part into the equilibrium process.

We first define the time sequence of actions and specify our model. Then, firm-inspector interactions are studied to determine harvesting and reporting decisions as well as optimal bribe. Finally, policy decisions are investigated.

2.1 Time Sequences of Decision

The model is a sequential finite-period stage game. The timing of events is given below:

- At date t = 0, the harvester determine its political contributions offered to the incumbent government. The level of these contributions is linked to the forest policy.
- At date t = 1, the incumbent government selects the forest policy to maximize his pay-off.
- At date t = 2, the harvester determines his harvest and reported effort.
- At date t = 3, the inspector controls firm's production and an optimal level of bribe is determined with a probability to be discover depending on the level of judicial efficiency i.e the quality of the audit agency.

A backward induction process is used for the resolution of the game. Hence the forest and legal policy is given for the harvester and inspector in the second stage.

2.2 Firm-Inspector Interaction

The policy-maker designs a forest policy in order to reduce deforestation, to preserve biodiversity or to implement a durable forestry management. This policy consists to set the maximum harvest effort, $\overline{e}$ required i.e a harvest quota. We assume that the harvester tends to produce more than the quota and to set $e > \overline{e}$ implying a positive level of non-compliance $v = (e - \overline{e})$. Given that harvest production results in environmental damages, the government has to control harvest effort and imposes a bureaucrat (for instance an inspector) who monitors the firm. Moreover, the harvester has a private information on his harvest production so that the principal has to use an inspector to monitor firm's reported information.

However, the harvester may propose a bribe B to inspector in the case of non compliance. This corrupt behaviour is defined as *petty* corruption because it occurs between the firm and inspector[2]. Then, the harvester's bribe incites inspector to declare that the quota is respected. In the model,

[2]In contrast, corruption occurring between the harvester and incumbent government is considered as *grand* corruption.

inspection is not probabilized because we suppose that the harvester is alone which makes obvious the inspection. In other words, given that the inspector is risk-neutral, he could accept or refuse the bribe if the amount of this contribution is not enough to optimize his pay-off. If the inspector accepts bribe, he reports harvest effort $e \leq \overline{e}$. Moreover, we assume that the inspector receives from the regulator (government) a fixed wage (w) and a variable wage (R). This last component of inspector's remuneration, R, is considered as a reward for reporting the true harvester's effort. Then, R depends positively on the level of non compliance (v, $\partial R/\partial v > 0$) but as public resources are scarce, R should not increase indefinitely with v ($\frac{\partial^2 R}{\partial v^2} > 0$). This award is a positive incentive used as a regulatory tool by the incumbent government to persuade the inspector to comply with his original purpose i.e to report the true harvest production.

However, knowing that the inspector could be bribed by harvester, the regulator implements an audit of the harvest effort. The audit uncovers the true harvest effort with a probability $\lambda \in (0, 1)$. Therefore, the level of λ could be an indicator of the efficiency of auditing process as noticed by Damania et al. (2004). If $e > \overline{e}$, a fine f(v) is imposed to the harvester (f^H) and inspector (f^I). Thus, the fine for corruption is increasing and convex in non-compliance $f(v)(\frac{\partial f}{\partial v} > 0; \frac{\partial^2 f}{\partial v^2} > 0)$. Hence, the harvest effort will depend on the forest policy ($\overline{e}$) and the efficiency of the audit (λ), built for penalties in the case of non compliance. Thus, harvest effort will be $e = e(\overline{e}, \lambda)$ in the *cheat/bribe* strategy and $e^S = e(\overline{e}, \lambda)$ in the *safe* strategy (where $e^S = \overline{e}$).

Let $H(e)$ be the net harvest function of the harvester from its harvest effort, with the land-holding cost and timber prices integrated. We assume that this logger is price taker given that he trades on international market. The net harvest function depends on the logging effort (which is the logger's choice variable), and takes the form $H(e)$, with standard properties: $H_e > 0, H_{ee} < 0$. The net harvest function is $H(\overline{e})$ in the safe case and $H(e)$ in the cheat strategy. Consequently, the strategies and their related pay-off are given in the following table 1.

Table 1: Strategies pay-off

Strategy	Harvester	Inspector
Safe	$H(\overline{e})$	$w + R(v)$
Cheat	$H(e) - [B + \lambda f^H(v)]$	$w + B - \lambda[f^I(v) + R(v)]$
Net	$\Psi^H(e, \overline{e})$ $= H(e) - [B + \lambda f^H(v)] - H(\overline{e})$	$\Psi^I(e, \overline{e})$ $= w + B - \lambda[f^I(v) + R(v)] - w - R(v)$ $= B - (1 + \lambda)R(v) - \lambda f^I(v)$

Following Damania et al. (2004) and Wilson and Damania (2005), we begin by determining the optimal level of bribe and effort intensity. The process of this game can be divided in two stages. First, the logger sets the effort level to maximize the joint pay-off ($\Psi^J \equiv \Psi^H + \Psi^I$). Then, the inspector and logger share the surplus through a Nash equilibrium process.

Therefore, taking the policy parameters as given $(\overline{e}, \lambda, f_v^H, f_v^I, R(v))$, the harvest effort is chosen to maximize the joint net pay-offs of the logger and the inspector.

$$\max_e \Psi^J \equiv \Psi^H + \Psi^I = [H(e) - [B + \lambda f^H(v)] - H(e^s)] + [B - (1 + \lambda)R(v) - \lambda f^I(v)] \tag{1}$$

The first order condition is:

$$\Psi_e^J = H_e - \lambda f_e^H - \lambda f_e^I = 0 \tag{2}$$

The logger's optimal harvest effort $e^*(\overline{e}, \lambda, f_v^H, f_v^I, R(v))$ is implicitly given by equation 2. In equilibrium, this equation (2) specifies that the actual effort is set such that the marginal revenue from production equals the marginal expected penalty.

The equilibrium bribe is determined by a Nash bargain between the harvester and bureaucrat. In this process, both parties share equally the benefit of the bribe strategy (non compliance) i.e they have the same bargaining power. To be successful, the bargaining has to respect the reservation values of the bureaucrat and logger. By the harvester's net pay off (table 1, col.1), the bribe is paid by the firm i.e the bribe strategy is dominant if $B < H(e) - H(e^S) - \lambda f^H(v) \equiv \overline{B}$. By the inspector's net pay off (table 1, col.2), the inspector accepts the bribe if $B > (1 + \lambda)R(v) + \lambda f^I(v) \equiv \underline{B}$. Therefore, the optimal bribe is determined by the following Nash bargain

$$\max_B (\Psi^H \Psi^I) \tag{3}$$

The first order condition is

$$\partial(\Psi^H \Psi^I)/\partial B = [H(e) - H(e^S) + (1-\lambda)R(v) - \lambda(f^H - f^I) - 2B] = 0 \tag{4}$$

Hence, the optimal bribe is

$$B^* = 1/2[H(e) - H(e^S) + (1-\lambda)R(v) - \lambda(f^H - f^I)] \tag{5}$$

The optimal bribe resulting of this process has to lie between $[\underline{B}, \overline{B}]$ so that the global benefit of the *bribe* strategy is higher than the global loss of this strategy.

Having defined the firm-inspector equilibrium of the model ($e^*(\overline{e}, \lambda)$ and $B^*(\overline{e}, \lambda)$), we now turn to analyse the comparative static properties of the equilibrium to examine interrelationships between forest policy ($\overline{e}$), judicial efficiency (λ), petty corruption (B^*) and non-compliance ($v = e^* - \overline{e}$).

First, to ensure that higher fines (f) reduces the optimal level of bribe (B^*), the term $f^H - f^I$ must be positive. This assumption implies that the fine paid by the recipient (inspector) is lower than that paid by the bribe giver (Damania et al., 2004; Delacote, 2008). The intuition is as follows: if the regulator punishes more severely the bribe-taker than the bribe-giver, the inspector would incite the harvester to increase the bribe to compensate for the inspector's expected fine. Hence, as suggested by Mookherjee and Png (1995, p.151), "one way to reduce the bribe is to raise the penalty [...] on the bribe-giver (factory), while reducing the penalty [...] on the bribe-taker (inspector)".

Second, the bribe raises if the inspector's emoluments (rewards, R) increase (Mookherjee and Png, 1995). Intuitively, the opportunity cost of cheating for the inspector raises, so the inspector demands and receives a bigger bribe. The idea leans on the inspector's weight in negotiations which increases with the level of rewards received. The inspector could ask a more important bribe to compensate rewards knowing that the probability of detection of the cheat is very low.

Result 1 *The harvest quota ($\overline{e}$) increases the effective harvest effort (e^*) but decreases the level of non compliance as well as the level of bribe payments (B^*) (see proof A.1.1).*

Firstly, the intuition for the positive effect of harvest quota on effective harvest effort is as follows: higher will be the harvest quota (increase of $\overline{e}$), lower will be the fine paid by the logger for a given harvest effort, higher will be the over harvest production. Put differently, a less stringent harvest quota reduces the extent of the potential fine because of the decrease of the extent of non compliance.

Moreover, the marginal effect of the quota on harvest production is less than one implying that the increase of harvest production is less important than the raise of the harvest quota (see proof A.1.1). Thereby the level of non compliance decreases with a rise of harvest quota. Secondly, a less stringent harvest quota (an increase of $\overline{e}$) reduces the level of bribe payments. The intuition is as follows: an over indulgent harvest quota decreases the probability and the extent of non compliance which implying a diminution of potential corrupt activities and so bribe payments.

Result 2 *Judicial efficiency (λ) decreases the effective harvest effort (and so non compliance for a given level of harvest quota) and bribe payments (see proof A.1.2).*

Firstly, an increase of the judicial efficiency reduces the harvest production and so the level of non compliance. The intuition is as follows. An improvement of the audit agency (increase of λ) increases the probability for the logger to pay a fine for a given harvest effort and so reduces his incentive to over harvest i.e to non comply. Put differently, a more efficient audit agency strengthens the extent of the potential fine. Secondly, an increase of the judicial efficiency leads to a decrease of the level of bribe payments. The intuition is as follows: knowing that the probability of the detection and sanctions of the cheat raised, the expected fine paid by the firm increases the cost of the cheat strategy implying that the harvester prefers to not bribe the inspector. More precisely, the firm knows that his non compliance behaviour will likely be detected with or without bribe, as judicial efficiency is high, and so will prefer to spare the amount of bribe. Thus, in a country with efficient judicial institutions, this leads to reduce opportunities of petty corruption.

From the marginal effects of the harvest quota and judicial efficiency, we have the proposition 1.

Proposition 1 *The covariance of non compliance and petty corruption is positive (see proof A.1.3) conditioned to judicial efficiency.*

2.3 Policy Determination

We now turn to the political process after having described the harvester-inspector interactions process. Remind that we proceed backward so that the political process, which determines the forest policy takes place before harvester-bureaucrat outcomes. The incumbent government has to draw the policy but the logger act as a lobby. Consequently, the threshold level of harvest quota ($\overline{e}$) is influenced by the harvester's lobbying.

Following Grossman and Helpman (1994), the incumbent government i receives political contributions S defined as grand corruption from the logger. We assume that the firm's political contributions depend on its level of non compliance, hence $S(v)$ with $S_v > 0$. In fact, a non compliant firm could have a trade off between the cost to bribe the incumbent government or the cost to bribe the inspector in the following stage. However, we assume that an optimal strategy for the firm would be to try to influence the government to have a well set harvest quota.

Thus, the government derives utility from political contributions and also from the welfare of voters (W). The incumbent government draws the level of forest policy in order to maximise its pay-off considering S as given. Consequently, the current utility of the policy-maker is a weighted sum of S and W:

$$U = (1-\alpha)\beta S(v) + \alpha W(H(e), e)$$

Where β measures the degree of environmental compliance in the economy. More compliance increases the weight of corruption in the government's utility because the rent seeking government is more incited to deal with a compliant firm than with a non compliant one. α measures the weight of social welfare in government's utility. Social welfare represents the sum of utility of all agents in the economy in a given period. It is decreasing in the harvest effort ($W_e < 0$; $W_{ee} < 0$) which is associated to environmental damages (biodiversity losses,...) and increasing in the total harvested volumes ($W_H > 0$; $W_{HH} < 0$).

Following Grossman and Helpman (1994) and Dixit et al. (1997), the equilibrium in a common agency model maximises the joint surplus of all parties. From lemma 2 of Bernheim and Whinston (1986), the forest policy ($\overline{e}$) has to satisfy two necessary conditions, which are

$$CI: \quad \overline{e}^* \in \arg\max U \tag{6a}$$

$$CII: \quad \overline{e}^* \in \arg\max \Pi + U \tag{6b}$$

The expected profit Π of the logger is

$$\Pi = H(e) - B - \lambda f^H(v) - S(v)$$

Condition 6a states that the incumbent government determines the forest policy to maximize its own welfare (U), given the offered political contribution schedules (S). Condition 6b denotes that the equilibrium of the forest policy maximizes the joint welfare of harvester and government.

The optimal forest policy ($\overline{e}^*$) maximizes (i) CI (equation 6a) and (ii) CII (equation 6b). Thereby, the first order conditions satisfy

$$(1-\alpha)\beta S_v + \alpha W_H H_e + \alpha W_e = 0$$

$$\alpha W_H H_e + \alpha W_e + H_e - \lambda f_v^H - \alpha\beta S_v = 0$$

Thus, $\overline{e}^*$ is implicitly given by:

$$H_e + \frac{\alpha}{\beta(1-\alpha)} W_H H_e + \frac{\alpha}{\beta(1-\alpha)} W_e - \lambda f_v^H = 0 \tag{7}$$

Having defined the political equilibrium of the model, we now turn to analyse the comparative static properties of the equilibrium to examine interrelationships between forest policy ($\overline{e}$), judicial efficiency (λ) and environmental non-compliance (β).

Result 3 *An increase of judicial efficiency (λ) reduces the forest quota i.e the forest policy becomes more stringent. (see proof A.2.1).*

This result implies that an improvement of judicial efficiency is a condition to weaken environmental damages. In fact, a more efficient audit agency suggests that the costs associated to the bribe strategy increase implying less petty corruption and finally less opportunity to non comply with the forest policy. Thereby, the principal, here the government, could implement a more stringent forest policy to reduce environmental damages because he knows that the logger will be less incited to not comply with the forest policy. Thus, judicial efficiency allows to promote sustainable environmental policies.

Result 4 *Conditioned to the level of judicial efficiency, an increase of compliance (a rise of β) tends to reduce the harvest quota i.e the forest policy becomes more stringent (see proof A.2.2).*

These results implies that in countries with low judicial efficiency, an improvement of environmental compliance allows to reduce environmental damages as deforestation i.e forest quota. Moreover, in

high judicial efficiency country, the effect of environmental compliance decreases harvest quota only if fines paid by firm are nil. Moreover given that judicial efficiency is high, firm has to be compliant to not pay fine (because the probability to be detected increases with judicial efficiency). Given that we have the following proposition concerning the effect of both environmental compliance and judicial efficiency on forest stock.

Proposition 2 *Environmental compliance is a substitute of low judicial efficiency or a complement of high judicial efficiency in order to reduce harvest quota (see proof A.2.3).*

Thereby, environmental compliance is a good substitute of weak governance infrastructure or a good complement of strong governance infrastructure to reduce environmental damages.

3 Econometric Framework

3.1 Econometric Approach and Data

3.1.1 Econometric Specification

The theoretical model has highlighted interrelationships between environmental compliance, petty corruption, governance infrastructures (here judicial efficiency) and environmental damages (here losses of forest stock). The econometric approach consists in testing whether: (i) environmental non compliance and petty corruption are positively correlated and conditioned to judicial efficiency (Proposition 1) which lessens both petty corruption and environmental compliance (Result 2) (ii) environmental compliance and judicial efficiency are complementary or substitutable to preserve the forest stock (Proposition 2).

To test our model, a cross-country data is used with a three equation econometric model of petty corruption (equation 8), environmental non compliance (equations 9) and forest stock (equation 10).

Petty Corruption Equation To test the proposition 1, results 1 and 2, we run the following regression:

$$Corruption_i = \partial_0 + \partial_1 Compliance + \partial_2 Forest_i + \partial_3 Judicial_i + \sum_k \partial_k W_i + \upsilon_i \quad (8)$$

where $Corruption_i$ is the inverse of the level of corruption in the country i, $Compliance_i$ is the degree of environmental compliance, $Forest_i$ is the level of forest stock and $Judicial_i$ is the quality of the legal framework. W_i are control variables, ∂_k are coefficients vector to estimate and υ_i is the error term.

Proposition 1 states that ∂_1 should be positive and significant without judicial efficiency as control variable. Result 1 states that ∂_2 should be positive and Result 2 states that ∂_3 should be positive.

Following the literature, we divide factors of corruption (W_i) into four main categories: (i) economic factors, (ii) political and legal determinants, (iii) social structure and (iv) geographical features.

First, on economic factors, *Log GDP per capita* is introduced to control for development process which lessens the level of corruption . The presence of potential rents is often associated to corruption (Tanzi, 1998). A variable of *Trade* openness is used because it is assumed to reduce corruption by depressing the presence of potential rents (Ades and Tella, 1999).

Second, on legal factors, Treisman (2000) and Damania et al. (2004) argue that democratic regime lessens corruption. Thus, a *Democracy* variable, measuring the extent to which there is a societal consensus supporting democratic principles, are introduced. Legal origins of the law and regulations are introduced to control for differences between major family of law (*Legal origins dummy*). La Porta et al. (1999) show that English common law countries have less-corrupt societies than French civil law ones often characterized by an important government ownership and regulation which are associated with many adverse impacts on markets such as corruption. In our sample, countries are of fourth different legal origins, namely English, French and Socialist.

Third, we include *Latitude* because temperate zones with healthier climate and more agricultural productivity could develop their economic activities and their institutions and so lessens the potential opportunity of corruption (La Porta et al., 1999).

Environmental Compliance To test the proposition 1, results 1 and 2, we run the following regression:

$$Compliance_i = \beta_0 + \beta_1 Corruption + \beta_2 Forest_i + \beta_3 Judicial_i + \sum_k \beta_k W_i + \upsilon_i \tag{9}$$

where $Compliance_i$ is the degree of environmental compliance in the country i, $Corruption_i$ is the inverse of the level of corruption; $Forest_i$, the level of forest stock and $Judicial_i$, the quality of the

legal framework. W_i are control variables, β_k are coefficients vector to estimate and υ_i is the error term.

Proposition 1 states that β_1 should be positive and significant without judicial efficiency as control variable. Result 1 states that β_2 should be positive and Result 2 states that β_3 should be positive.

Among control variables, *Log GDP per capita* is used to control for structural differences as economic development progresses. To capture the extent of pollution damages which may influence the degree of compliance with environmental regulations, we use the percent of urban population in a country (*Urban*) and the *population density*. More pollution exposure is assumed to lead to greater political pressure for compliance i.e both variables have a positive sign (Damania et al., 2004). We introduce legal origins to capture institutional persistences and major differences in the legal system La Porta et al. (1999). In our sample, countries are of fourth different legal origins, namely English, French and Socialist. A *latitude* variable as well as region dummies are also used to control for non observed differences.

Forest Stock Equation To test proposition 2, we run the following regression:

$$Forest_i = \alpha_0 + \alpha_1 Compliance_i + \alpha_2 Judicial_i + \alpha_3 Compliance_i \times Judicial_i + \sum_k \alpha_k Z_i + \varepsilon_i \quad (10)$$

where $Forest_i$ is the growing forest stock in the country i, $Judicial_i$ is the quality of the legal framework, $Compliance_i$ is the level of environmental compliance, Z_i are control variables, α are coefficients vector to estimate and ε_i is the error term.

Proposition 2 states that both α_1 and α_2 should be positive[3]. The sign of β_3 is not stated by the model. A positive sign means that judicial efficiency could preserve forest stock despite the fact that environmental compliance is low whereas a negative sign means that judicial efficiency lessens forest stock in country with weak environmental compliance. Moreover, a negative effect suggests that there is a threshold effect because the coefficient (α_3) term and the additive term (α_2) have an opposite sign. The threshold effect is:

$$\frac{\delta Forest_i}{\delta Judicial_i} = \alpha 3 + \alpha 2 * EnvironmentalCompliance_i = 0 \Rightarrow EnvironmentalCompliance_i = -\frac{\alpha 3}{\alpha 2}$$

Among control variables, the literature on factors of deforestation (here the forest stock is the inverse of deforestation) is substantial. First, the path of deforestation is often associated positively with the

[3]The marginal effect of compliance on the forest growing stock is: $\frac{\delta growing}{\delta compliance} = \alpha 1 + \alpha 2 * PastJudicial$.

initial forest area (*Forest Lag*) for three main reasons: (i) the scarcity effect implies that the remained forested lands are more preserved; (ii) logging or forest conversion activities are more expensive when forest areas are low; (iii) the non-forested lands (in proportion to total area) are more available to other land uses such as agriculture, cattle ranching, tree plantations or urbanization when forested lands are important.

Second, the Environmental Kuznets Curve (EKC) approach states that the level of environmental degradation, measured by environmental indicators as deforestation, is linked to economic development (Bhattarai and Hammig, 2001; Culas, 2007). This relation implies a non linear effect of economic growth on deforestation (*GDP per capita* and *GDP per capita squared*): the marginal income effect is positive for low income countries and become negative for high income economies.

Third, demographical effects and more particularly population pressures are associated with more deforestation. The common explanation advanced is that population growth encourages the conversion of forest land to other uses (and almost agricultural uses) by increasing the need for arable land. The growth of Population (*Pop*) and the extent of rural population (*Rural*) are introduced to control for these pressures on forested land (Cropper and Griffiths, 1994).

Fourth, the relative price of timber (*Timber*) is introduced being an important determinant in the trade-off between the keeping forest option or the clearing one (Arcand et al., 2008).

Fifth, we introduce legal origins dummy to capture institutional differences due to different legal system (La Porta et al., 1999). A *latitude* variable as well as region dummies are used to control for non observed differences.

3.1.2 The Issue of Endogeneity

Our model states that corruption and environmental compliance are simultaneously determined implying a reverse causality bias. A naïve estimation of the parameters of the model may lead to biased estimates if the issue of endogeneity is not taken into account. To tackle this issue, a selection on observables in adding a large number of control variables or a selection on unobservables measuring all other time-invariant determinants could be implemented. However, the first approach does not allow to control for all the bias whereas the second could not be implemented in this paper using cross country data.

Thus, a third approach relies on the use of instrumental variables (IV) under three conditions. First, IV should be correlated with the supposed endogenous variable. Second, the error term in

the instrumentation equations has to be uncorrelated with the measurement error in the structural equations. Third, the IV should not be correlated with the dependent variable, except through the endogenous variables or through the effect on the other variables that have been already controlled for. Estimation are made with the 2SLS estimator.

In our model, corruption and compliance are assumed to be endogenous but we also assume that judicial efficiency could be endogenous. The choice of pertinent instruments for each one of the three endogenous variables relies on the literature. As in Damania et al. (2004), environmental compliance could be instrumented in the corruption equation by the level of *civic liberties* and the degree of *environmental education*. These two variables measure the extent of informal regulatory pressures in the society and positively influence environmental compliance. Moreover, concerning the forest stock equation, environmental compliance is instrumented by a variable measuring the *ethic* of firms in a given country and by the *environmental education* variable.

Concerning the instrumentation of corruption in the compliance equation, we use, as instruments, a political federation dummy and the effectiveness of legislature. Treisman (2000) shows that federalism is associated with more corruption because "the competition of different autonomous levels of government to extract bribes from the same economic actors [...] lead(s) to "overgrazing"" (Treisman, 2000, P.433). Legislature effectiveness should decrease corruption by increasing the use of constitutional mechanisms to make politicians and officials more accountable to citizens and so to be viewed as an external control on corruption (Serra, 2006).

Last, as instruments of judicial efficiency in the corruption equation, we use a variable of *constitutional changes* whereas in the compliance equation we also use a variable of *judicial independence*[4]. Basically, we assume that judicial efficiency is negatively influenced by the frequency of changes in the legal system (Damania et al., 2004) and positively by the degree of judicial independence (La Porta et al., 2004).

3.1.3 Dataset

We begin by a description of main interested variables: environmental compliance, corruption, judicial efficiency and forest stock. Table 4, page 30 summarizes descriptive statistics and Table 2, page 28 provides definitions and sources of variables used.

[4]In the corruption equation, *judicial independence* could explain corruption through other channel that judicial efficiency i.e to be endogeneous.

In the literature, we found no data on environmental compliance at country level. To challenge this issue, we build an index of environmental compliance from data of several reports provided by the World Economic Forum. Compliance is predicted values of the corporate ethic[5] of firms in a given country which has been regressed on (i) a variable measuring the burdensome for businesses to comply with governmental administrative requirements (averaged on the period 2007-2009) and on (ii) a variable related to the stringency of environmental regulation (averaged on the period 2007-2009) (see table 3, page 31 for more information on these data and table 5, page 31 for rankings of 15 worst and best countries in term of compliance, a higher value of this index implies a high compliance).

Concerning data on *petty* corruption, we also found no information on this topic. Thereby, the index provided by Transparency International (averaged on 2000-2007) is used and focuses on corruption in the public sector seen by business people, risk analysts and the general public (from 0 (highly corrupt) to 10 (highly clean), see table 5, page 31 for rankings of 15 worst and best countries in term of corruption, a higher value of this index implies a low corruption).

As a measure of judicial efficiency, the *Rule of Law* index developed by Kaufmann et al. (2008) "capturing perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence" is introduced (from -2.5 (low) to 2.5 (high), averaged on 2005-2008). This index could be reasonably expected to approach the degree to which laws are enforced.

To measure the forest stock, we use the Growing Forest Stock which is defined as the standing volume of the trees in a forest above a certain minimum size. Higher growing stock implies more standing biomass, which often translates to better forest conditions. The variable used measures the change between 2000 and 2005, in cubic meters per hectare and comes from Environmental Performance Index (EPI) provided by Yale University.

3.2 Econometric Results

3.2.1 Interrelationships between Corruption and Compliance

The first proposition of our model states that environmental compliance and petty corruption are positively correlated and conditioned to the level of judicial efficiency. Moreover, result 2 states that

[5]Corporate ethic is the ethical behavior in interactions with public officials, politicians, and other enterprises of firms in a given country. Data are averaged on the period 2007-2009.

judicial efficiency lessens corruption as well as environmental non compliance. Also, in the theoretical model, these results are also controlled by the level of harvest quota. To take into account this effect, we introduce the forest stock variable.

In consequence, compliance and corruption are simultaneously determined and so endogenous. To deal with this issue, we use excluded instrumental variables.

Table 7 displays estimation results from OLS and IV regression of both corruption and compliance equation. Moreover, the use of compliance creates a potential generated regressor bias which could truncate the estimate of standard errors downward and make an inefficient estimation (Pagan, 1984). To deal with this issue, standard errors of the compliance variable are bootstrapped (250 replications) in the corruption equation (Wooldridge, 2002).

We find in all regressions that environmental non compliance and corruption are positively correlated as predicted in the model (proposition 1). However, this effect is conditioned by the quality of judicial system[6]. In fact, in both OLS and 2SLS regression, the casual effect of compliance on corruption or corruption on compliance becomes non significant when judicial efficiency is introduced as control variable. Result 2 of the model is also confirmed by the econometrical results. A strong judicial framework increases environmental compliance (col.6 and col.8) as well as undermines corruption (col.2 and col.4). This supports our prediction that strengthening the legal framework reduces opportunities for non compliance as well as corruption and rent-seeking activities. Hence, this result highlights the importance of legal infrastructure to understand the interrelationships between non-compliance and corruption. Judicial efficiency is a condition to enhance the appropriation of sustainable reforms by population but also to impede the extent of corruption.

Turning to the control variable effects in the corruption equation, we find that an important forest stock is associated to low corruption. This result supports our prediction which states that less stringent harvest quota strengthens corruption (result 1). Consistent with the literature, the presence of democracy (Democracy Dummy) appears to significantly weaken corruption but only when judicial efficiency is not taken into account contrary to Damania et al. (2004). Also, Log GDP has significant effects in all specification, whereas Openness, legal origins and latitude are insignificant at conventional levels.

Turning to the control variable effects in the compliance equation, we do not find support of our

[6]Remind that a high value of the corruption variable implies a low level of corruption and a high value of the compliance variable represent a high level of compliance.

prediction concerning the positive effect of a more stringent harvest quota on compliance. Indeed, the effect of forest stock is negative and insignificant in all specifications. Consistent with the literature, an increase of environmental concerns in people education allow to strengthen the environmental compliance. Among the other control variables, *Urban* and *Population Density* have the negative expected effects but not robust in all specifications and civil liberties are significant only in specification with judicial efficiency as control variable. Also, Log GDP has only a significant effect in the last column but negative whereas legal origins and latitude are insignificant at conventional levels.

Finally, for completeness Table 8 reports the first stage regressions.

[Table 7 around here]

3.2.2 Forest Stock Equation

The proposition 2 of the model states that environmental compliance is a substitute for a low level of judicial efficiency or a complement for a high judicial efficiency in order to preserve forest stock.

The table 9 display results related to proposition 2. As validity check, we use excluded instrumental variables for environmental compliance and judicial efficiency.

We find that environmental compliance could help to increase the forest stock. In both specification, compliance has a positive effect which is only significant in the 2SLS specification. Moreover, this effect is increased by the quality of legal infrastructure. The interaction term ($Compliance * JudicialEff.$) is positive and significant (in the 2SLS specification) suggesting that more judicial efficiency improves the POSITIVE effects of positive environmental compliance on forest stock.

However, the additive coefficient of judicial efficiency is negative suggesting that a improvement of the legal system could reduce forest stock but only in a society with a low environmental compliance. This result highlights that good governance reforms provided by politics has to be appropriated by demand side to become efficient. Moreover, there is a threshold effect because the coefficient term and the additive term of judicial efficiency have an opposite sign. From column 6, the threshold level of environmental compliance that ensures the marginal impact of judicial efficiency on forest stock stands at 4.84[7]. Also, 95 percent of the countries have levels consistent with an overall negative effect of judicial efficiency on forest stock. This result suggests that the low level of environmental compliance in developing countries could explain why good governance reforms as judicial efficiency may be become non efficient.

[7]Environmental compliance ranges from 2.57 to 5.25 with a mean at 3.80.

Among control variables, only socialist law and latitude have a positive and significant effect. Finally, for completeness Table F.2 reports the first stage regressions.

[Table 9 around here]

4 Concluding Remarks

This paper has provided explanations on interrelationships between environmental compliance, corruption and the effectiveness of regulatory institutions in the specific case of forestry in developing countries.

Using a principal-agent model, we highlight two propositions: (i) firm's environmental non compliance and petty corruption are positively correlated (firm-inspector relation) and conditioned to the efficiency of the legal and regulatory framework which lessens both petty corruption and environmental non compliance; (ii) environmental compliance is a substitute of low judicial efficiency or a complement of high judicial efficiency to strengthen forest stock.

Empirical estimations, using cross section data for 59 developing countries, are supporting main theoretical predictions. First, concerning Proposition 1, we find that (i) environmental compliance and corruption are positively correlated but conditioned to judicial efficiency; (ii) judicial efficiency lessens both corruption and compliance. Second, Proposition 2 is empirically validated. Environmental compliance help to preserve the forest stock but this effect is strengthened by the legal system. In countries where legal system is efficient to monitor economic activities and challenge disputes, environmental compliance is a good complement to legal infrastructure to avoid environmental damages. However, in countries where legal system is too weak to prevent environmental losses, environmental compliance could be a good substitute. Also, in country where environmental compliance is low, an improvement of the legal system could raise losses of the forest stock.

This paper brings a new explanation to understand the weak sustainability of good governance reforms in the environmental field and call for more consideration of the appropriation of institutional reforms (compliance) by main stakeholders to move towards sustainable change.

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A Proof of propositions

A.1 Proposition 1

A.1.1 Proof of the marginal effect of harvest quota

Proof.

1. The harvest quota $\overline{e}$ increases the effective harvest effort (e^*)

$$e^*_{\overline{e}} = \frac{-\lambda(f^H_{vv} + f^I_{vv})}{H_{ee} - \lambda(f^H_{vv} + f^I_{vv})} > 0 \tag{11}$$

but decreases non compliance ($v = e^* - \overline{e}$) given that

$$e^*_{\overline{e}} =< 1 \tag{12}$$

2. The harvest quota $\overline{e}$ decreases the effective bribe payments. (B^*).

$$B^*_{\overline{e}} = 1/2[-H_{\overline{e}} + (1-\lambda)R_{vv} - \lambda(f^H_{vv} - f^I_{vv})] < 0 \tag{13}$$

■

A.1.2 Proof of the marginal effect of judicial efficiency

Proof.

1. Judicial efficiency (λ) decreases the effective harvest effort (e^*) and so non compliance ($v = e^* - \overline{e}$, for a given harvest quota, $\overline{e}$).

$$e^*_{\lambda} = \frac{f^H_v + f^I_v}{H_{ee} - \lambda(f^H_{vv} + f^I_{vv})} < 0 \tag{14}$$

2. Judicial efficiency (λ) decreases the effective bribe payments (B^*).

$$B^*_{\lambda} = 1/2[-R(v) - (f^H(v) - f^I(v))] < 0 \tag{15}$$

■

A.1.3 Proof of Proposition 1

Proof. Given that a marginal increase of harvest quota lessens both non compliance and petty corruption and given that a marginal increase of judicial efficiency decreases also both non compliance and petty corruption, then the covariance of non compliance and petty corruption is positive.

Marginal Effect	Sign
$v^*_{\overline{e}}$	negative
v^*_{λ}	negative
$B^*_{\overline{e}}$	negative
B^*_{λ}	negative

■

A.2 Results 1 to 3 and Proposition 2

A.2.1 Result 3

Proof.

$$\overline{e}^*_{\lambda} = \underbrace{\frac{\overbrace{f^H_v}^{>0}}{H_{ee} + \frac{\alpha}{\beta - \alpha\beta}\left(W_H H_{ee} + W_{ee}\right) - \lambda f^H_{vv}}}_{<0} < 0 \tag{16}$$

The sign of the numerator f^H_v is positive and the sign of the denominator is negative ($H_{ee} < 0$, $W_H > 0$ and $H_{ee} < 0$, $W_{ee} < 0$, f^H_{vv}). Thereby the sign of the marginal effect of λ on $\overline{e}^*$ is unambiguously negative. ■

A.2.2 Result 4

Proof.

$$\overline{e}^*_{\beta} = \underbrace{\frac{\overbrace{-\left(\frac{\alpha}{(1-\alpha)\beta^2}\right)\left[W_H H_e + W_e\right]}^{?}}{H_{ee} + \frac{\alpha}{\beta - \alpha\beta}\left(W_H H_{ee} + W_{ee}\right) - \lambda f^H_{vv}}}_{<0} \tag{17}$$

The sign of the denominator is negative because $H_{ee} < 0$, $W_H > 0$ and $H_{ee} < 0$, $W_{ee} < 0$, $f^H_{vv} > 0$. Thereby, the sign of the marginal effect of β on $\overline{e}^*$ depends on the sign of the numerator which depends

on the sign of $W_H H_e + W_e$ given that the sign of $\frac{\beta-\alpha\beta+\alpha}{(\beta-\alpha\beta)^2}$ is positive. However, $W_H H_e$ is positive and W_e negative, the sign of $W_H H_e + W_e$ is ambiguous.

From equation 7, we have $1 + \frac{\alpha}{\beta-\alpha\beta} > \frac{\alpha}{\beta-\alpha\beta}$ so that $W_H H_e$ must be lower to $-W_e + \lambda f_v^H$ or $W_H H_e + W_e < \lambda f_v^H$ and so the sign of $W_H H_e + W_e$ depends on λf_v^H.

If λ tends to zero so $W_H H_e + W_e < 0$ and the sign of $\overline{e}_\beta^*$ is negative (the numerator is positive).

If λ tends to 1, the sign of $W_H H_e + W_e$ depends on the level of f_v^H. In the case where the firm is compliant, f_v^H will be nil and the sign of $W_H H_e + W_e$ will be negative as well as the sign of $\overline{e}_\beta^*$.

■

A.2.3 Proposition 2

Proof. Given that from result 3, the effect of non compliance β on $\overline{e}^*$ is conditioned to the level of judicial efficiency λ and that from result 4 the effect of judicial efficiency λ on $\overline{e}^*$ is negative, thus we have the proposition 2. ■

B List of countries

List of Developing Countries				
Central and South America				
Argentina	Bolivia	Brazil	Chile	Colombia
Costa Rica	Dominican Republic	Ecuador	Guatemala	Guyana
Honduras	Mexico	Nicaragua	Panama	Paraguay
Peru	Suriname	Uruguay	Venezuela	
Africa				
Algeria	Botswana	Burkina Faso	Cameroon	Ivory Coast
Ethiopia	Ghana	Kenya	Madagascar	Malawi
Mali	Morocco	Mozambique	Namibia	Nigeria
Senegal	South Africa	Tanzania	Tunisia	Uganda
Zambia	Zimbabwe			
Asia				
Azerbaijan	Bangladesh	Cambodia	China	India
Indonesia	Kazakhstan	Kyrgyz Republic	Korea, Rep.	Malaysia
Mongolia	Pakistan	Philippines	Saudi Arabia	Sri Lanka
Thailand	Turkey	Vietnam		

C Data Sources

Table 2: Data Descriptions and Sources

Code	Variables and Definition	Source
Dependent variables		
Corruption	Corruption index scaled 0-10 with a lower score associated with more corruption (2000-2007).	TI
Compliance	Created variable from data provided by World Economic Forum (WEF) (see table 3).	WEF
Deforest	Growing stock change between 2000 and 2005, in cubic meters per hectare.	EPI, Yale
Explanatory variables	**Corruption Equation**	
Trade	Trade Openness (percent of GDP) (2005-2007).	WDI
Democracy	An aggregate variable of democracy: Political Rights and Civil Liberties of Freedom House and the Polity2 variable of the PolityIV project (from 0 (least democratic) and 10 (most democratic), 2005).	The Quality of Government Dataset
Federalism	Countries classified as federations in 1995.	Treisman (2007)
Legislat. Effectiv.	The Effectiveness of Legislature ((0) No Legislature to (3) Effective).	Arthur S.Banks, CNTS-Data Archive
	Compliance Equation	
Environ. Education	The extent of environmental concerns for basic, secondary and tertiary education as well as for research and development (from 1 (low) to 10 (high), 2006).	Bertelsmann Transformation Index
Civic Liberties	Freedoms of expression and belief, associational and organizational rights, rule of law, and personal autonomy without interference from the state (1: most free to 7:least free, 2005).	Freedom House
Urban	Urban population (percent of pop. tot) (2005-2008).	WDI
Population Density	Population density (people per sq. km of land area) (2005-2008).	WDI
Ethic	Corporate ethics (1 = among the worst in the world; 7 = among the best in the world).	GCR, WEF (see table 3)
	Deforestation Equation	
Forest Lag	Initial Forest Areas: Log forested areas in 2000.	FAO
GDP	Log GDP per capita, ppp (2005-2007).	WDI
Pop. Growth	Annual population growth rate (percent) (2005-2007).	WDI
Rural	Rural population (percent of pop. tot) (2005-2007).	WDI
Timber	The relative price of timber (2002-2005).	FAO
	Common Variables	
Judicial efficiency	Rule of Law index scaled 0-6 with a lower score associated with less rule of law (2005-2008).	WGI
GDP	Log GDP per capita, ppp (2005-2008)	WDI
Latitude	Measure of distance from the equator i.e latitude (0 to 1, 0 is the equator).	(La Porta et al., 1999)
Legalor	Legal origins on law and regulation with common, French civil law and Socialist law.	(La Porta et al., 1999, 2007)
	Instrumental Variables for Judicial Efficiency	
Constitutional Changes	The number of basic alterations in a state's constitutional structure.	Arthur S.Banks, CNTS-Data Archive
Political Particip.	The right of the people to freely organize in political parties, to make politic. choices (0: worst; 16: best).	Freedom House
Judicial independence	Judiciary is independent from political influences (0 (low) to 10 (high).	Fraser Institute

Table 3: Data used to create the index of compliance

Variables and Definition	**Sources**
Corporate Ethics How would you compare the corporate ethics (ethical behavior in interactions with public officials, politicians, and other enterprises) of firms in your country with those of other countries in the world? (1 = among the worst in the world; 7 = among the best in the world) (2008-2009) weighted average	GCR, WEF
Burdensome to comply How burdensome is it for businesses in your country to comply with governmental administrative requirements (e.g., permits, regulations, reporting)? (1 = extremely burdensome; 7 = not burdensome at all) (2008-2009) weighted average	GCR,WEF
Stringency of Environmental Regulation How stringent is your country's environmental regulation? (1 = lax compared with most countries, among the world's most stringent) (2007-2008)	T-T, WEF
Sources: GCR: Global Competitiveness Report, World Economic Forum (WEF) T-T: Tourism and Trade Report, World Economic Forum (WEF)	

D Descriptive Statistics

Table 4: Summary Statistics

Variable	**Mean**	**(Std. Dev.)**	**Min.**	**Max.**	**♯ of Countries**
Envir. compliance	3.82	(0.61)	2.57	5.25	64
Corruption	3.18	(1.1)	1.77	7.13	64
Forest stock	0.98	(0.09)	0.65	1.23	64
Judicial efficiency	-0.45	(0.6)	-1.69	1.21	64
Log Gdp per capita	7.04	(0.81)	5.22	8.34	61
Trade (of GDP)	80.79	(37)	26.33	207.67	61
Democracy	6.42	(2.54)	0.42	10	63
Civil liberties	3.43	(1.31)	1	6	64
Urban population	49.99	(22.12)	12.5	92.3	64
Population density	108.65	(176.68)	1.67	1202.92	64
Environ. education	4.64	(1.45)	2	9	62
Log lag forest	9.15	(1.33)	6.76	13.1	64
Gdp^2	50.18	(11.35)	27.25	69.59	61
Rural	51.14	(21.53)	7.33	87.33	61
Pop. growth	1.61	(0.88)	-1	3	61
Timber	1.14	(0.28)	0.6	1.99	55
English Common Law	0.31	(0.47)	0	1	64
French Civil law	0.53	(0.5)	0	1	64
Socialist/Communist Laws	0.13	(0.33)	0	1	64
Latitude of capital	0.21	(0.14)	0.01	0.53	63
Asia	0.33	(0.47)	0	1	64
America	0.3	(0.46)	0	1	64

E Ranking: Compliance and Corruption

Table 5: Compliance Ranking: 15 worst and best countries

Envirn. Compliance				Corruption			
15 worst countries		**15 best countries**		**15 worst countries**		**15 best countries**	
Countries	Score	**Countries**	Score	**Countries**	Score	**Countries**	Score
Ivory Coast	2.57	Malaysia	5.25	Chad	1.78	Chile	7.13
Mongolia	2.65	Tunisia	5.12	Bangladesh	1.95	Uruguay	6.48
Chad	2.66	Costa Rica	4.89	Ivory Coast	2.03	Botswana	5.68
Suriname	2.93	Korea, Rep.	4.76	Cambodia	2.05	Korea, Rep.	5.2
Bangladesh	2.96	Chile	4.73	Kyrgyz Republic	2.1	Malaysia	5.08
Argentina	3.09	Namibia	4.65	Venezuela	2.13	South Africa	4.78
Algeria	3.12	Uruguay	4.61	Kenya	2.13	Costa Rica	4.6
Bolivia	3.12	Georgia	4.56	Azerbaijan	2.15	Tunisia	4.53
Kyrgyz Republic	3.13	Saudi Arabia	4.45	Zimbabwe	2.23	Namibia	4.35
Venezuela, RB	3.19	Azerbaijan	4.42	Ecuador	2.23	Turkey	4.00
Zimbabwe	3.19	South Africa	4.39	Nigeria	2.25	Peru	3.48
Cameroon	3.22	Thailand	4.36	Cameroon	2.3	Brazil	3.5
Nepal	3.23	Honduras	4.32	Pakistan	2.3	Thailand	3.55
Vietnam	3.27	Botswana	4.31	Indonesia	2.38	Ghana	3.6
Ecuador	3.29	Sri Lanka	4.30	Kazakhstan	2.38	Colombia	3.88

Authors' calculations.

F Econometric results

F.1 Interrelationships between Corruption and Environmental Compliance

Table 7: Interrelationships between Corruption and Environmental Compliance

Dep. Variable:	Corruption				Compliance			
	OLS Regression		IV Regression		OLS Regression		IV Regression	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Envir. Compliance	0.702***	0.071	1.355***	-.070				
	(0.174)	(0.124)	(0.395)	(0.316)				
Corruption					0.386***	0.027	0.405*	-.674
					(0.088)	(0.134)	(0.21)	(0.503)
Judicial Efficiency		1.395***		1.321***		0.901***		2.793***
		(0.23)		(0.4)		(0.3)		(0.898)
Forest Stock	4.148***	1.555	3.324**	2.111*	-1.073	-1.332	-1.175	-2.165
	(1.561)	(1.337)	(1.591)	(1.249)	(1.066)	(0.943)	(1.533)	(1.484)
Log Gdp per capita	0.484***	0.208*	0.242	0.255*	0.046	-.103	0.038	-.438**
	(0.144)	(0.119)	(0.187)	(0.135)	(0.13)	(0.125)	(0.149)	(0.196)
Trade (of GDP)	0.00009	-.0004	-.0007	0.0007				
	(0.002)	(0.002)	(0.003)	(0.002)				
Democracy	0.147***	0.006	0.11*	0.023				
	(0.043)	(0.035)	(0.059)	(0.038)				
Civic Liberties					0.083	0.199**	0.09	0.463***
					(0.088)	(0.094)	(0.107)	(0.137)
Urban population					-.011**	-.005	-.011***	0.008
					(0.005)	(0.006)	(0.004)	(0.008)
Population density					-.0003	-.0006**	-.0003	-.001**
					(0.0004)	(0.0002)	(0.0004)	(0.0005)
Environ. Edcuation					0.162**	0.149**	0.16**	0.115*
					(0.074)	(0.06)	(0.068)	(0.069)
French Civil law	-.022	-.081	0.15	-.193	-.038	-.152	-.033	-.377
	(0.196)	(0.148)	(0.25)	(0.135)	(0.161)	(0.137)	(0.154)	(0.234)
Latitude of capital	0.948	0.729	1.431	0.584	-.505	-.221	-.504	0.378
	(0.998)	(0.785)	(1.063)	(0.751)	(0.677)	(0.668)	(0.597)	(0.812)
Asia	-.297	-.450***	-.230	-.457***	0.041	-.064	0.042	-.280
	(0.211)	(0.173)	(0.241)	(0.162)	(0.23)	(0.199)	(0.2)	(0.227)
America	-.648**	0.093	-.350	0.075	0.2	0.497**	0.214	1.159***
	(0.256)	(0.239)	(0.323)	(0.265)	(0.227)	(0.209)	(0.23)	(0.346)
Constant	-7.755***	0.593	-7.740***	0.149	2.867***	5.094***	2.944**	9.987***
	(1.614)	(1.692)	(1.484)	(2.108)	(1.040)	(1.237)	(1.303)	(2.130)
Obs.	59	59	58	58	58	58	58	57
Adjusted R2	0.678	0.831	0.569	0.828	0.462	0.54	0.462	0.126
F-stat	10.295	17.002	9.044	20.629	7.16	10.939	6.936	5.733
Compliance instrum. equation F-stat			3.851	5.95				
Judicial Eff. instrum. equation F-stat				20.295				8.454
Corruption instrum. equation F-stat							7.532	20.943
Hansen P-Value			0.055	0.219			0.07	0.605

Robust standard errors. *** p<0.01, ** p<0.05, * p<0.1. The omitted continent is Africa and the omitted legal origins is common law.

Table 8: Instrumentation equation for environmental compliance and judicial efficiency

	Corruption Equation			Compliance Equation		
Depend Variable	Compliance	Compliance	Judicial Eff.	Corruption	Corruption	Judicial Eff.
Col. Table 7	col.3	col.4	col.4	col.7	col.8	col.8
	(1)	(2)	(3)	(4)	(5)	(6)
Excluded Instruments						
Civic Liberties	-.228	-.231*	-.462***			
	(0.141)	(0.139)	(0.078)			
Environ. Education	0.191**	0.193**	0.061			
	(0.09)	(0.085)	(0.048)			
Constitutional change		-.731**	-.435**		0.332	-.235
		(0.297)	(0.179)		(0.408)	(0.216)
Judicial Independence					0.311***	0.158***
					(0.063)	(0.033)
Federalism				-.441	-.342	-.121
				(0.279)	(0.229)	(0.123)
Legislature Effectiveness				0.352*	0.169	0.026
				(0.203)	(0.179)	(0.098)
Included Instruments						
Forest Stock	0.556	0.519	2.203***	4.937***	3.333***	1.510**
	(1.046)	(1.053)	(0.645)	(1.815)	(1.222)	(0.641)
Log Gdp per capita	0.148	0.104	0.226***	0.518***	0.063	0.114
	(0.125)	(0.134)	(0.067)	(0.193)	(0.216)	(0.092)
Trade (of GDP)	0.002	0.002	0.001			
	(0.002)	(0.002)	(0.001)			
Democracy	-.100	-.120	-.124***			
	(0.084)	(0.085)	(0.038)			
Civic Liberties				-.289***	-.156**	-.160***
				(0.1)	(0.077)	(0.042)
Urban population				0.006	0.015**	-.001
				(0.008)	(0.007)	(0.003)
Population Density				-.0008**	-.0008*	-.0001
				(0.0004)	(0.0004)	(0.0002)
Environ. Education				0.06	0.075	0.056
	(0.09)	(0.085)	(0.048)	(0.084)	(0.084)	(0.04)
French Civil law	-.174	-.253*	-.058	-.397*	-.024	0.121
	(0.16)	(0.151)	(0.107)	(0.23)	(0.234)	(0.103)
Latitude of capital	-.712	-.485	-.304	-.300	-.041	-.125
	(0.79)	(0.803)	(0.416)	(0.88)	(0.739)	(0.413)
Asia	-.087	-.023	0.21*	0.063	-.0002	0.184
	(0.193)	(0.205)	(0.114)	(0.302)	(0.325)	(0.144)
America	-.216	-.132	-.559***	-.786***	-.159	-.237
	(0.235)	(0.247)	(0.122)	(0.263)	(0.32)	(0.152)
Constant	3.020**	3.480**	-1.916***	-4.705***	-2.333*	-3.020***
	(1.492)	(1.473)	(0.718)	(1.486)	(1.212)	(0.684)
Obs.	58	58	58	58	57	57
Excluded instrument F-stat	4.32	4.54	17.19	3.11	7.25	8.88

Robust standard errors. *** p<0.01, ** p<0.05, * p<0.1.
The omitted continent is Africa and the omitted legal origins is common law.

F.2 Forest Stock Results

Table 9: Environmental Compliance, Judicial Efficiency and Forest Stock

Dep. Variable: Growing Stock of Forest	OLS Regression			IV Regression		
	(1)	(2)	(3)	(4)	(5)	(6)
Envir. Compliance	0.02	0.006	0.02	0.048*	0.154**	0.078**
	(0.017)	(0.021)	(0.021)	(0.028)	(0.071)	(0.036)
Envir. Compliance*Judicial Eff.			0.047**			0.052**
			(0.023)			(0.023)
Judicial Efficiency		0.025	-.152*		-.123*	-.252**
		(0.022)	(0.087)		(0.072)	(0.102)
Log Lag Forest	-.0001	0.0006	-.0002	0.001	-.0006	-.002
	(0.008)	(0.008)	(0.008)	(0.007)	(0.01)	(0.008)
Log Gdp per capita	-.013	-.020	0.125	-.096	-.101	0.046
	(0.197)	(0.189)	(0.204)	(0.174)	(0.27)	(0.211)
Log Gdp per capita squared	0.003	0.003	-.007	0.008	0.01	-.0006
	(0.014)	(0.014)	(0.015)	(0.012)	(0.02)	(0.015)
Rural	0.0005	0.0005	0.0006	-.00002	-.0003	0.0004
	(0.0008)	(0.0008)	(0.0007)	(0.0007)	(0.001)	(0.0007)
Pop. Growth	-.015	-.013	-.013	-.002	-.005	-.004
	(0.02)	(0.021)	(0.02)	(0.019)	(0.021)	(0.018)
Timber	-.007	-.014	-.003	-.018	0.016	0.008
	(0.037)	(0.037)	(0.035)	(0.035)	(0.055)	(0.037)
French Civil law	0.016	0.015	0.01	0.03	0.039	0.02
	(0.041)	(0.041)	(0.041)	(0.032)	(0.042)	(0.035)
Socialist/Communist Laws	0.118**	0.113**	0.114**	0.135***	0.169**	0.138**
	(0.052)	(0.05)	(0.051)	(0.051)	(0.086)	(0.058)
Latitude of capital	0.153	0.146	0.152	0.205*	0.297*	0.24*
	(0.131)	(0.129)	(0.123)	(0.122)	(0.163)	(0.13)
America	-.019	-.012	0.002	-.028	-.056	-.026
	(0.039)	(0.041)	(0.042)	(0.036)	(0.046)	(0.03)
Asia	-.076**	-.076**	-.074**	-.065**	-.061*	-.064**
	(0.037)	(0.037)	(0.036)	(0.029)	(0.034)	(0.03)
Constant	0.808	0.917	0.343	1.017*	0.501	0.284
	(0.676)	(0.668)	(0.726)	(0.592)	(0.951)	(0.7)
Obs.	52	52	52	50	50	50
Adjusted R2	0.182	0.176	0.221	0.18	-.363	0.148
F-stat	3.525	3.097	3.219	3.317	1.212	2.694
Compliance instrum. equation F-stat				4.852	7.096	19.551
Compliance*Judicial Eff. instrum. equation F-stat						116.61
Judicial Eff. instrum. equation F-stat					12.529	12.398
Hansen P-Value				0.035	0.217	0.343

Robust standard errors. *** p<0.01, ** p<0.05, * p<0.1. Africa (omitted) common law (omitted).

	Forest Stock Equation				
Depend Variable	Compliance	Compliance	Judicial Efficiency	Compliance	Judicial Efficiency
Col. Table 9	col.4	col.5	col.5	col.6	col.6
	(1)	(2)	(3)	(4)	(5)
Excluded Instruments					
Environ. Education	0.289***	0.278***	0.161***	1.870***	1.076*
	(0.092)	(0.083)	(0.058)	(0.592)	(0.551)
Civic Liberties	-.016	-.206*	-.372***	0.842**	0.425
	(0.092)	(0.123)	(0.115)	(0.353)	(0.369)
Constitutional change		-1.090***	-.421**	-4.615	1.371
		(0.317)	(0.181)	(3.175)	(2.805)
Pol. Participation		-.079**	-.060*	0.462***	0.277**
		(0.036)	(0.032)	(0.137)	(0.139)
Environ. Education*Pol. Participation				-.100***	-.054*
				(0.03)	(0.028)
Environ. Education*Civic Liberties				-.175*	-.115
				(0.09)	(0.086)
Environ. Education*Const. Change				-.600*	-.230
				(0.325)	(0.353)
Civic Liberties*Const. Change				0.369	-.536
				(0.602)	(0.539)
Civic Liberties*Pol. Participation				-.037*	-.029
				(0.021)	(0.018)
Const. Change*Pol. Participation				0.696***	0.232
				(0.206)	(0.204)
Included Instruments					
Log Lag Forest	-.067	-.043	-.028	-.012	-.0007
	(0.065)	(0.058)	(0.035)	(0.054)	(0.038)
Log Gdp per capita	-.594	-1.356	-.951	-2.009	-1.975
	(1.863)	(1.611)	(1.404)	(2.237)	(1.883)
Log GDP per capita squared	0.053	0.102	0.085	0.139	0.152
	(0.136)	(0.119)	(0.101)	(0.158)	(0.131)
Rural	0.006	0.009	0.004	0.01	0.008
	(0.007)	(0.007)	(0.005)	(0.007)	(0.005)
Pop. Growth	0.06	0.04	-.042	0.095	-.027
	(0.126)	(0.117)	(0.095)	(0.107)	(0.106)
Timber	-.243	-.249	-.219	-.530	-.331
	(0.343)	(0.305)	(0.242)	(0.396)	(0.357)
French Civil law	0.016	-.110	0.135	0.01	0.203
	(0.265)	(0.209)	(0.166)	(0.245)	(0.189)
Socialist/Communist Laws	-.081	-.669*	0.032	-1.119**	-.311
	(0.418)	(0.388)	(0.208)	(0.482)	(0.405)
Latitude of capital	-.162	0.239	0.508	0.732	0.804
	(0.779)	(0.714)	(0.528)	(0.68)	(0.591)
America	-.108	0.148	-.525***	0.232	-.438**
	(0.288)	(0.273)	(0.179)	(0.299)	(0.221)
Asia	0.014	0.274	0.183	0.426*	0.279
	(0.232)	(0.209)	(0.172)	(0.218)	(0.179)
Constant	4.605	8.647*	3.402	3.249	1.644
	(6.111)	(5.247)	(4.855)	(7.786)	(6.685)
Obs.	50	50	50	50	50
Adjusted R2	0.342	0.455	0.68	0.593	0.705
Excluded instrument F-stat	9.49	12.34	12.69	14.06	6.52

Robust standard errors. *** p<0.01, ** p<0.05, * p<0.1.
The omitted continent is Africa and the omitted legal origins is common law.