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The Role of Corruption on Deforestation in Amazon Forest: The Collateral Effects of Bribes and Fines in an Environment of weak Enforcement’s Institutions.

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Abstract

The environmental problems related with deforestation have been the main concern of the governments around the world. Due to the general concern, the main policy adopted by the government and advised by many economist is the use of external regulations, e.g., fines to control the problem. We use the game theory approach, to analyze the case of Brazil. Results show that, the inexistence of robust institutions may undermine the effectiveness of such policies. Our results show that the policies of external control just have effective outcomes, when the agency problem, between the government and the official, is solved, otherwise, the outcome may be more deforestation.


JEL: Q10, Q18, Q23.

1. Introduction

Deforestation is one of the main environmental problems in countries with great extensions of rainforest, like Thailand, Malaysia, Indonesia, Congo, Ghana and Brazil, etc. There is substantial research on various aspects of deforestation, and economic reasons stand out as primary causes of the problem. Third world countries are at the most risk of deforestation due to weak or non-existence of solids institutions (Contreras-Hermosilla, 2001).

Given the press importance of the matter, many countries, among them African ones, are trying to increase public awareness of the problem, mainly in rural areas (Nair e Komero, 2004). In Brazil, illegal deforestation of the Amazon rainforest is, currently, a debated and highly talked about issue in the national and international media.

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According to a study by Instituto Nacional de Pesquisa Espacial (INPE), the rate of deforestation decreased in the period 1988-2007. The main culprits of deforestation are cattle ranchers (60 – 70%), followed by squatters (30 - 40%). Timber extraction and civil engineering projects are responsible for fewer than 5% of total deforestation.

The economic aspect of the matter inspired endogenous policies that take into account the profit seeking behavior of the agents, as a way for minimizing illegal deforestation. One of such policies is soil management, which has been considered an effective way of minimizing deforestation.

When endogenous policies don’t shows results, the government chooses exogenous policies such as: delimitation of the allowed areas, applying fines and surveillance activities. The current policy defends the increasing of surveillances and heavier penalties to the landowners. The Brazilian Institute of Environment (IBAMA) has been as important instrument for the government is implementing the current policies.

The current federal administration plans to decrease deforestation by introducing more severe penalties and more strict surveillances. However, this policy doesn’t contemplate the possibility of corruption by the officials. According to Viana (1998) and Amacher (2006 b)), 80% of the timber extracted from the Amazon forest is illegal. This fact indicates that, beyond increased surveillance, corrupt practices must be dealt with, because corruption is possibly one important cause for such a high percentage of illegal deforestation.

There are substantial literatures on the economic causes of corruption. The subject is no longer ignored in the environmental economics field, and some research points to corruption as an important determinant of illegal deforestation. Amacher (2006 a, 2006 b) assesses the importance of taking corruption into account when fighting illegal deforestation.

Some international studies on deforestation (Pelligrini (2007), Wibowo and Byron (1999), Palo (2002), Amacher (2006), etc, warns about corrupt practices in forest management and suggest harsher policies (heavier fines, more severe punishment for those who organize corruption schemes (i.e., landowners)), as a way of curtailing illegal deforestation. However, the information asymmetry that results of weak institutions stimulates opportunists behavior (Nair e Kowero, 2004). The existence of collusion undermines the effectiveness of government policies, i.e., in the presence of information asymmetry, corrupt practices cannot be stopped just by imposing harsher punishment for corruption.


4 Existence of information asymmetry and the resulting corrupt practices persuaded some researchers that heavier penalties and closer surveillance are the most effective policies. In this paper game theory is used to show that heavier penalties not necessarily decrease the rate of deforestation. On the contrary, it is shown that, due to information asymmetry, these harsher policies could lead to increased deforestation.
Research in Brazil on deforestation is concerned mainly with dealing with squatters and ranchers and with improving soil management techniques\(^5\). Information asymmetry almost always breeds corruption and leads to results different from the ones intended. So, a policy of closer surveillance and harsher punishment to squatters and ranchers may not result in less deforestation, because surveillance and dispensing fines are not directly controlled by the central government (i.e., the high rank officials), but by low rank, low salaries officials. So, assuming the existence of information asymmetry between government and low rank officials appears an agency problem. In such a situation, fraud is a possible equilibrium outcome, leading to illegal deforestation.

This paper puts into question the partial results of the policy of increased surveillance and heavier penalties for squatters, ranchers, lumber producers and others involved in activities that lead to illegal deforestation. The central point of this paper, (a point neglected in other papers), is the possibility of collusion between the landowner and the IBAMA official. This collusion, besides eliminating the effects of penalties on the landowners also guarantees that, under certain conditions, the penalties for corrupt officials (i.e., the ones with inspection duties) may not result in less illegal deforestation. This possibility is contrary to the mainstream international research on corruption. Imposing penalties is a necessary but not sufficient condition to eliminate collusion. The central result of this paper is that, when there is information asymmetry or weak enforcement’s institutions, heavier penalties for the landowner may result in more illegal deforestation.

Beyond this introduction, the present paper is structured as follow: in the next section we introduced some relationship between corruption and the forest sector. In the third section we analyzed how game theory can be used to interpret the problem of corruption in the forest sector. In the fourth section we present some simulations about the model, and finally we present the conclusion in the fifth section.

2. Corruption and the Forest Sector

The link between corruption and the Forest sector is not a new issue, international researchers claim that the government has to incorporate such elements in any policy adopted, e.g., see Damania (2002); Pellegrini and Gerlagh (2006); Amacher (2006); Transparency International (2002), (2007).

Despite knowing that corruption has an influence on the forest sector, the way in which corruption and deforestation are co-related still little known, (Transparency International, 2007). The existence of corruption can undermine all policies i.e., external policies, to avoid the illegal logging, Damania (2002)\(^6\).

Pellegrini et al., (2006b), through a cross-section approach, found that between democracy and corruption, the latter is the most important variable to control Forest damages. Moreover, democracy doesn’t have statistic influence on the environmental control.

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\(^5\) These matters are relevant in fighting illegal deforestation. Nevertheless, this paper intends to show that corruption is an issue that cannot be neglected.

\(^6\) The problem of corruption in the forest sector is also responsible for a great tax evasion. The Liberian government loose each year many millions of dollars due this kind of problem (Transparency International (2007).
Welsch (2004) analyzed the influence of corruption and Per capita GDP on the pollution levels. He found that there is a monotonic positive relationship between pollution and corruption, and a negative influence of the Per capita GDP on pollution.

There is an international consensus that corruption has an important role in illegal logging. However, this reality has not been given much attention by Brazilian researches and government. There are many works putting great effort into analyzing empirical questions, while theoretical questions are disregarded. The announced policies by the government only strike those directly related with illegal logging, i.e., farmers, etc. there are no internal mechanisms-designed to avoid the Agency problem. Thus, given the private interest of the involved agents, the outcome of any policy may be totally different. The inexistence of an internal mechanism of surveillance, allows the presence of an environment of collusion and corruption. At this point, it seems important to analyze such peculiarities of illegal deforestation. In this context, game theory seems to be a powerful tool to model these interactions and incentives.

The influence of corruption on environment policies (in a theoretical framework) has been given less attention, and within this group, deforestation is the less investigated, e.g., Polinsky (2001), Mookherjee and Png (1995), Svenson and Fredicksson (2003) analyzed the problem of ex-ante collusion in the pollution. However, our work differs in many aspect from their work, namely: first – for different sector in the economy, the corruption may have different rationality and consequences, Kolstad and Soreide (2009), so the role of the corruption in the forest sector is somehow different from other sector – our work focus in the phenomenon of deforestation; second – we used game theory to model the collusion game between the Ibama’s official and the landowner, so the model is applied for the Brazilian reality, and finally third – we showed that, due the weak enforcement institutions-related with environment issues, heavier fines would imply in more illegal deforestation.

Our paper introduces several new contributions about how corruption may influence illegal deforestation levels in Brazil. The use of the game theory is not a new one, but its application, for the case of Brazil, is. The present paper intends to fill some theoretical gaps left by previous studies, thus, we intend to make a zoom in about the illegal deforestation in Amazon forest (focusing in the so called indirect causes of deforestation –weak institutions in this case). For this purpose, we present a game-theoretical model of corruption and incentives. The paper also analyses the influences of external policies, used by the Brazilian government. We use many environmental scenarios to analyze the direct and indirect ways that corruption may influence the effectiveness of the government policies.

3. Game Theoretical models and Illegal Deforestation

The game theory is widely used in many fields: Economics, Sociology, Politics, etc. In the field of economics, there are a lot of applications in many areas: Microeconomics, International Trade, Macroeconomics, Experimental Economy, etc. there are also many works that apply the game theory to corruption issues, see: Suzann (2006), etc. However, we didn’t find any formal work that, theoretically, link corruption and illegal deforestation.

7 Sevenson and Fredrickson (2003) have a more general approach. They analyzed the influences of political instability, corruption and environment policy.

8 All agents in this paper are risk-neutral.
Mookherjee and Png (1995) analyzed, theoretically, the effect of collusion “ex-ante corruption” on the level of pollution. Contreras (2006) analyzed empirically the relationship between both, corruption and illegal logging, and he found a positive relationship.

Corruption and illegal deforestation are only cited in an informal way, see Viana (1974) and Amacher (2006a) (2006b). Thus, this paper may represent the first attempt to model the relationship between corruption and illegal deforestation, especially in the Brazilian case. In the following section we introduce a simple model to show the interdependence of the variables. First of all, we distinguish three elements, players, of our game, namely: the entrepreneur (landowner), the Government Official (IBAMA one), and the incorruptible official (the Government). The latter is responsible for establishing the role of the game: the salary schemes, the Environmental laws, and consequently the fines and limits, i.e., he is responsible for the external incentives. For the present purpose, the government doesn’t enter directly into the game, it just announces the role of the relationship. Inside the incentive environment created by the Government, the two former players, Official and the entrepreneur, behave as way to maximize their gain. These actors represent, in a good sense, the actual relationship between the individuals related with the deforestation in Amazon forest.

The entrepreneur has the possibility to stay in the law, i.e., to use just the limited areas, or not. The Official has the job of investigating the entrepreneur, if he finds any irregularity, he can report the illicit act, to his superior, and thus, charges the fines. In this case the entrepreneur will be forced by law to pay any kind of penalties, i.e., monetary fines. However, the official can chose to be corrupt, in this case, he wouldn’t inform the superior about the environment crime.

These are the frameworks that, in a good sense, we face these days in Brazilian structure. As we will see in the following section, the effectiveness of the policies actually used by the government depends on the assumptions about this relationship.

3.1. The Static Game Models with Perfect Information

In the model, there are three players: the landowner, the government official and the government. A proportion \( \Upsilon \) of the number of officials is composed of corrupt individuals. In order to formalize the model, the behaviors of a representative landowner, a representative corrupt official and the government are analyzed. The main objective is to highlight how information asymmetry affects deforestation.

Let \( \bar{T} \) be the size of the forest which belongs to the representative landowner, where \( t' \) is the lower bound and \( t' \) the upper bound. The landowner is allowed to clear the forest up to the limit \( t_m \), which is a number between the lower and upper bounds. If the landowner surpasses the upper limit, he receives a fine \( (\delta) \). Surveillance is not done directly by the government, but by a hired official, i.e., the official from

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9 Note that there is an important role played by the land movement in Brazil. Their role on the illegal deforestation is well treated in Muller (2007), (2009). The author, also make a good analyses about the influence of land reform in the level of deforestation.

10 Using different type of penalties, like prison instead of fines, can lead to different outcome, for an example see Polinsky (2001).

11 Only the official belonging to this group has their behavior modeled.
Ibama. After the area is inspected, the hired official reports to the government possible occurrences of illegal deforestation. At the end of the period, the official earns a salary \( w \), not contingent on his reports\(^{12}\). The landowner can choose whether to clear the forest up to the allowed limit or to go beyond the limit and risk being fined. That is, there are two states of nature: when the landowner clears more forest than he is allowed to \( t' > t_m \) and when the landowner respects the limit \( t' \leq t_m \). The real state of nature is not known by the government, because the official may decide not to report illegal deforestation\(^{13}\). If all officials are honest \((\Upsilon = 0)\), then the reports received by the government precisely inform them whether or not the landowner cleared more forest than he was allowed to. If the honesty of officials is questionable, the government then just has a probability distribution over the real state of nature.

The actual relationship between the three players can be exposed in the following way: The landowner, \( L \), can choose to illegally clear the forest, \( ID \), or not \( NID \). The landowner may be inspected, \( I \), (or not \( NI \)) by the official, \( F \), with probability \( \zeta \). If an investigation takes place, the official finds out whether illegal deforestation occurred, \( t' > t_m \), or not, \( t' \leq t_m \). The government, \( G \), receives the report, but doesn’t know, for sure, the actual state of nature. It just has a probability distribution of the real state of nature. The probability that the state of nature is that illegal deforestation took place is \( \chi \).

Given the relationship involving the three players, it is possible to ascertain the effects of the collusion between the landowner and the corrupt official\(^{14}\) on the illegal deforestation.

**Type of Equilibriums in the simultaneous game**

In the game between landowner and official, let the compact set \( s_i = \{s_1, s_2\} \), be the actions space for each player. There is a pay-off function for each player, suitable for the strategy adopted in response to the one adopted by the other player. For clearer explanation, the game played is a simultaneous one, with perfect/complete information. The strategies set for each player, are:

\[
s_i = \begin{cases} s_1 = \text{collude} \\ s_2 = \text{not collude} \end{cases}
\]

We follow the same approach of Mendes (2009), thus, the landowner’s profit, \( \pi(p, \nu) \) is a function of the prices level \( p \) and of output \( \nu \).\(^{15}\) Sales depend directly on

\(^{12}\) The salary of the official is not contingent on the government’s revenue from fines collected from the landowners.

\(^{13}\) We assume that the official has the means to appraise the real state of nature when inspecting a landowner’s lot.

\(^{14}\) This paper considers “ex-post” collusion. That is, which occurs after the illicit action is known. But there is also “ex-ante” collusion, in which collusion is considered bearing in mind the probability of being caught practicing the illicit action. For example in, “ex-ante” collusion see: Mookherjee and Png (1995).

\(^{15}\) For example, the landowner who engages in logging has a profit that is a function of the price of the cubic meter and the quantity of timber extracted from the forest. For the sake of simplicity, production costs (capital and labor) are considered as zero.
the deforested area $t$, where $t \in \{t_{i}, t_{m}\}$ and $v = \lambda(t)$. It is assumed that: $\lambda > 0 \land \lambda_{m} = 0$. In the special case that the coefficient equals the unity, the landowner’s profit is $\pi(p, t)$. The official’s pay-off is given by the salary $w$ earned in the end of the game.

To make feasible the game, is necessary to analyze the case of illegal deforestation, that is, when $t > t_{m}$. When illegal deforestation takes place, the landowner can allure the official by proposing collusion. The official may agree to collude or not. If the official accepts, he has a pay-off given by $w + \Delta w(t > t_{m})$, (Case D below) where $\Delta w(t > t_{m})$ represents the bribe paid by the landowner. The landowner’s pay-off, in this case, is given by $\pi(p, t) + \Delta \pi(p, t > t_{m}) - \varepsilon - \lambda$ (Case A below) where $\Delta \pi(p, t > t_{m})$ represents the earnings from clearing the forest beyond the allowed area, $\varepsilon$ represents the fine due to the official, $\Delta \pi(p, t > t_{m}) \in \mathbb{R}^{+}$ and $\varepsilon \in \mathbb{R}^{+}$, is easy to see that $\Delta w(.) = \varepsilon$ and finally $\lambda$ represents the transaction cost of the bribe. However, if the official choose to collude but the landowner not, his pay-off will be just his salary (Case C below), in this case the pay-off for the landowner would be $\pi(p, t) + \Delta \pi(p, t > t_{m}) - \delta$ (Case B below) where $\delta$ is the fine imposed, to the landowner, by the government, $0 < \varepsilon \leq \Delta \pi(p, t > t_{m}) < \delta$, $\delta \in \mathbb{R}^{+} \leq \infty$. Note: we follow Mendes (2009) and suppose that: $\delta = x + \varepsilon$, where $x$ represent the part of fine (not paid) kept by the landowner, and $\varepsilon$ represent the bribe paid for the official. In the event of illegal deforestation and the official is not willing to take the bribe, his pay-off depends of the strategies of the landowner: if the landowner decided to collude, he can receive $w + \alpha$ (Case C’ Below) where $w$ represent the salary and $\alpha$ represent external or internal incentives received by the official, in this case the landowner would receive $\pi(p, t) + \Delta \pi(p, t > t_{m}) - \delta$ (case B below). However, if the landowner doesn’t collude he (the official) receives just $w - i + \theta$ (case C’ below) where $i$ represent the net cost of effort, and $\theta$ represent the internal gains due the decision for not colluding, i.e., moral issues (see Carrillo (2000), he uses the same approach in a different modeling) in this case the landowner would receive $\pi(p, t) + \Delta \pi(p, t > t_{m}) - \delta - \kappa$ where $\kappa$ represent the landowner social cost for the media national communication on the matter (case B’).

The following chart shows the normal representation of the game.

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16 When there was not illegal deforestation, landowner and official have no reason to collude. So the situation of interest is the players behavior in the case of illegal deforestation.

17 Any of the two players can propose collusion. That is, once the official finds out about the illicit act, he may offer a collusion agreement to the landowner.

18 Mendes (2009) supposes, for simplicity, that the part $x$ is included the gains for illegal deforestation, $\Delta \pi(.)$.

19 In the present model we suppose that when the landowner is available for colluding, and the official is not, the latter can receive an internal or external benefit for his behavior. The internal gain represents his moral well-being for not got in a corrupt process. The external incentives can represent promotion in his job.

20 Is a fact that when IBAMA official found illegal deforestation related with any enterprise (landowner), there are, usually, media communication about matter. These national communications impose a moral cost to the enterprise. In our model this cost are presented by $k$. Thus, there is a difference in this case with the one when the landowner opted to collude (Case B), in the latter, the landowner opted to collude and we suppose that in such case the landowner cannot be exposed to the media, thus he is just fined directly.
The game in its normal form is:

<table>
<thead>
<tr>
<th>Official</th>
<th>Collude (p)</th>
<th>Not collude (1-p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collude (q)</td>
<td>D, A</td>
<td>C, B</td>
</tr>
<tr>
<td>Not collude (1-q)</td>
<td>C’, B</td>
<td>C’, B’</td>
</tr>
</tbody>
</table>

Where:

$$A = \pi(p, t) + \Delta\pi(p, t > t_m) - \varepsilon - \lambda$$

$$B = \pi(p, t) + \Delta\pi(p, t > t_m) - \delta$$

$$C = w$$

$$C'' = w + \alpha$$

$$D = w + \Delta w(t > t_m)$$

$$B' = \pi(p, t) + \Delta\pi(p, t > t_m) - \delta - \kappa$$

$$C' = w - i + \theta$$

The analysis of the strategies shows that there is a dominant strategy to both players. That is, the equilibrium is reached through dominant strategies (pure equilibrium). To reach this equilibrium, some assumption was used: $\Delta w(.) > \alpha, i > \theta; \delta < \varepsilon + \lambda; \delta > \varepsilon$.

**Typology of the Equilibrium: Mixed Strategies Equilibrium**

Without imposing several limitations on the parameters to ensure the pure equilibrium, we can use the mixed strategies equilibrium to analyze several important issues. The engagement of the individuals in the collusion process, demands several worries about the behavior of the other player, i.e., nobody has the conviction about the strategy that the other player will adopt. So, the best way to analyze such kind of situation is to analyze the *mixed strategies*. In such way, the new static form is presented in the following way (see the picture above):

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21 The components of the pay-offs represented in the game are: the right side represent the official pay-off and the left side represent the landowner pay-off.

22 These assumptions aim to guarantee equilibrium in dominant strategies. Thus, when we analyze the *mixed strategies equilibrium*, some of this assumption might be relaxed. Is easy to show that, if: $\Delta w(.) \geq \alpha$ we would have two Nash equilibriums.
Where \( p \) represent the probability that the Official will opt to collude, in the same sense, \( q \) represent the probability that the Landowner will collude. Given the structure we can define a \( p=p^* \) such that the Official is indifferent between the both choices, or \( q=q^* \) such that the landowner is indifferent between both choices. To calculate such probabilities we can analyze, in each case, the expected gain, from each player.

The case of pure strategies equilibrium is just a particular case (degenerate one) of mixed equilibrium. To analyze the relationship between the two agents we must introduce the expected gain from each strategy.

**The Problem for the Official**

The expected gain for the colluding or not, for the official, depends of the strategies adopted by the landowner. The expected gain for colluding is:

\[
(w+\Delta w(.))q + w(1-q) \rightarrow E[C]
\]

And for not colluding, is:

\[
(w+\alpha)q + (w-i+\theta)(1-q) \rightarrow E[NC]
\]

The official is indifferent between colluding or not if \( E[C] = E[NC] \)

Solving the official problem we find that, the probability of collusion from the landowner point of view, that makes the official indifferent between the two choices is:

\[
q^* = \frac{i-\theta}{[(i+\alpha)-\Delta w(.)+\theta]}
\]

Note that, as a probability we must have: \( q^* \in (0,1) \) thus, we must have: \((i-\theta) > (\Delta w(.)-\alpha)\).

**The Problem for the landowner**

The expected gain for the colluding or not, for the landowner, depends of the strategies adopted by the official. The expected gain for colluding is:

\[
(\pi(.)+\Delta \pi(.)-\lambda)p + (\pi(.)+\Delta \pi(.)-\delta)(1-p) \rightarrow E[C]
\]

And for not colluding, is:

\[\text{This condition just guarantees that the value of } p \text{ is non negative. Thus, the complementary condition for this case would be: } q < 1. \] The complementary condition in this case would be: \( i-\theta \leq [(i+\alpha)-\Delta w(.)+\theta] \), that is: \( \Delta w(.) \leq \alpha \)
\[(\pi(.) + \Delta \pi(.) - \delta) p + (\pi(.) + \Delta \pi(.) - \delta - \kappa)(1 - p) \rightarrow E[NC]\] (4)

The official is indifferent between colluding or not if \(E[C] = E[NC]\)

Solving the landowner problem we find that, the probability of collusion from the official point of view, that makes the landowner indifferent, is \(^{24}\):

\[p^* = \frac{\kappa}{(\varepsilon + \kappa + \lambda) - \delta} \]

According with the results, we can see that the condition for existence of equilibrium in this relationship, we must have the following conditions satisfied:

For the Official:

\[
\begin{pmatrix}
i - \theta \\
\frac{\alpha - \Delta w(.)}{(i + \alpha) - (\Delta w(.) + \theta)}
\end{pmatrix}, \begin{pmatrix}
\frac{\kappa}{(\varepsilon + \kappa + \lambda) - \delta} \\
\frac{(\varepsilon + \lambda) - \delta}{(\varepsilon + \kappa + \lambda) - \delta}
\end{pmatrix}
\]

And

\[
\begin{pmatrix}
\kappa \\
\frac{(\varepsilon + \lambda) - \delta}{(\varepsilon + \kappa + \lambda) - \delta}
\end{pmatrix}
\]

For the landowner.

Given the set of probabilities, the landowner and the official are indifferent if these probabilities are considered. Thus, we can use the static comparative to analyze the effect of some policies in the probabilities kept by each player.

**Mixed Strategies Equilibrium and “ex-post” collusion: effects on illegal deforestation**

To analyze the effect of the policies adopted by the government, for the case of mixed strategies equilibrium, we can use the static comparative. On the earlier section, we obtained the following probabilities: The probabilities that the landowner will collude, is given by:

\[q^* = \frac{i - \theta}{(i + \alpha) - (\Delta w(.) + \theta)}\]

The probably that official will collude, is given by:

\[p^* = \frac{\kappa}{(\varepsilon + \kappa + \lambda) - \delta} \]

Given the endogenous probabilities in equilibrium, we will use some calculus to derive some non-trivial propositions from our model:

\(^{24}\) Given that \(\kappa < 1\), the complementary condition would will be: \((\varepsilon + \lambda) > \delta\)
Proposition -1: An increase of bribe increases the probability that the landowner will opt to collude.

Proof:

\[
\frac{\partial q^*}{\partial \Delta w(.)} = \frac{i - \theta}{\left[(i + \alpha) - (\Delta w(.) + \theta)\right]^2} > 0
\]

That is, the increase of bribe increase the incentive for the landowner to opt to collude, because he knows that more illegal gain are available for the official, and thus, the former will have more incentive for corrupt behavior. Thus, illegal deforestation will be worthy, from the landowner point of view.

Proposition-2: Increasing internal incentives will decrease the probability that the landowner will be corrupt.

Proof: From Differential calculus we know that:

\[
\frac{\partial q^*}{\partial \alpha} = \frac{\theta - i}{\left[(i + \alpha) - (\Delta w(.) + \theta)\right]^2} < 0
\]

More internal incentives, e.g., promotion, can be an important tool to avoid the problem of illegal deforestation. As we can see, the partial derivates indicate that more incentives will reduce the probability of the landowner to collude, that is, he knows that when more internal incentives is available for the official, more unlikely the latter will be available for corrupt behavior, thus the expected cost from illegal deforestation (from the landowner point of view), will be higher. Thus, this kind of policies cannot be neglected by the government.

We can also analyze the effect of the penalties, \(\delta\), (those announced by IBAMA or directly from the Ministry for the Environment) when the principal (Brazilian Government through the IBAMA) doesn’t have an internal process of auditing about the reports delivered by the officials from IBAMA.

Proposition 3: The increase of the penalties from those, directly responsible for illegal deforestation, i.e., \(\delta\), in the environment of corruption, will increase the incentives for corruption behavior.

Proof\textsuperscript{25}:

we have:

\textsuperscript{25} We would have the same results if we supposed that: \(\Delta w(.) = \tau \delta\).
The present results show the dramatic situation about the effectiveness of the policies adopted by the Brazilian Government. The increase of fines, in an environment of weak institutions, may worsen the situation of illegal deforestation. This results is, somehow, intuitive, because if the enforcement institutions are weak, the increase of fines will just, ceteris paribus, increase the bargaining power of the official, therefore in this environment, more fines will increase the monetary gains from corruption: more bargaining power for the official means that he will receive a bigger share of the “cake” or fines than the landowner – from the landowner point of view, the increase of penalties means that he could pay more penalties if the official caught him, therefore he (landowner) will be available to pay the bribe to the official - his motivation to pay the bribes increases as increase his share in penalty.

Based on the regulation theory, the Brazilian Government has applied higher fines to avoid the problem. However, the static comparative shows that more penalties increase the landowner probability in colluding. Thus, the regulation theory has not been adequately adopted by the government, and the economist has forgotten how the incentives between the all three-parties are important for the outcome of such policies.

We can also use the static comparative to analyze the effect some variables on the probability of collusion from the official point of view.

In the mixed equilibrium, the probability that the official will be collude is given by:

$$p^* = \frac{\kappa}{[\epsilon + \kappa + \lambda - \delta]}$$

The interesting question, is how the official will behave when changes the parameters of the policies used by the government. The results show that (see figure-2 for numerical simulation):

$$\frac{\partial p^*}{\partial \delta} = \frac{(1 - \tau)k}{[(\epsilon + \kappa + \lambda - \delta)^2]} > 0$$

Where $\tau$ is the defined through the following relationship: $\epsilon = \tau \delta$

The results show that the policy of more penalties will increase the incentive of the official to collude, because more penalties mean more bribes paid by the landowner. This results show that the increasing penalties can make more profitable the corrupt behavior. We can easily obtain such relationship when we analyze the influence of the bribe paid and probability of colluding. As we stressed earlier, $\delta = \epsilon + x$, that is
\[ \varepsilon = f(\delta) \text{ and so, } \delta = f^{-1}(\varepsilon), \text{ really speaking we get } \delta = \mu \varepsilon, \text{ where } \mu \in (1, \mathbb{R} \setminus \{1\} < \infty) \]

so we have (do not forget that \( \varepsilon = \Delta w(.) )^{26}.\

\[ p^* = \frac{k}{(\varepsilon + \kappa + \lambda) - \delta^{-1}(\varepsilon)} \]

Such that:

\[ \frac{\partial p^*}{\partial \varepsilon} = \frac{-\kappa(1-\mu)}{(1-\mu)\varepsilon + \kappa + \lambda} > 0 \]

Or

\[ \frac{\partial p^*}{\partial \Delta w(.)} = \frac{-\kappa(1-\mu)}{(1-\mu)\Delta w(.) + \kappa + \lambda} > 0 \]

Thus, the probability to collude increases as increase the bribe paid. We use this approach and we make endogenous the determination of the bribe paid – ceteris paribus a increase of the fine just modifies the bargaining power of the game. This result, again, shows that the policies adopted by the governments may back-fire the \textit{ex-ante} expected outcome.

**Equilibrium Strategies and the Influences of Surveillance by the Government:**

**Mixed Equilibrium**

The surveillance used by the government to avoid the problems of corrupt behavior, can be an important tool to prevent corrupt behavior. We can use the same approach to analyze the effect of such policy, when the agents are indifferent between the both strategies.

\[ (w + \Delta w(.))(1 - \beta) + (w + \Delta w(.) - F) \beta)q + w(1-q) \rightarrow E[C] \]

\[ (w + \alpha)q + (w - i + \theta)(1-q) \rightarrow E[NC] \]

The only modification is the introduction, for the case that the official opts to collude, of the term \( F \) that represents the fines for corrupt behavior, and the term \( \beta \), that represent the probability that the official/Landowner will be investigated. Solving for the indifference level we obtain the following outcome:

\[ q^* = \frac{i - \theta}{(i + \alpha + \beta F) - (\Delta w(.) + \theta)} \]

For the landowner the problem will be:

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26 Note, that for the function: \( \varepsilon = f(\delta) \) we may have several relationship, i.e., \( \frac{\partial \varepsilon}{\partial \delta} \geq 0 \), which depends of the bargaining power. For a survey about these cases see Mendes (2009).
\[
\left( (\pi(.) + \Delta \pi(.) - \epsilon - \phi - \lambda) \beta + (\pi(.) + \Delta \pi(.) - \epsilon - \lambda)(1 - \beta) \right) p + (\pi(.) + \Delta \pi(.) - \delta)(1 - p) \rightarrow E[C]
\]

(7)

When he opts to collude, and:

\[
(\pi(.) + \Delta \pi(.) - \delta) p + (\pi(.) + \Delta \pi(.) - \delta - \kappa)(1 - p) \rightarrow E[NC]
\]

(8)

Otherwise.

The indifferent condition implies that the two expected gain will be the same. Solving for this condition we find that:

\[
p^* = \frac{k}{(k + \epsilon + \lambda + \phi \beta) - \delta}
\]

Where \( \phi \) represent the fine paid by the landowner when the official is investigated. Note that we suppose that when the surveillance is done by the government, he discover the real state of nature. In this case he will penalize both i.e., the official and the landowner, i.e., in this case the landowner receive two penalizations.

With these two results, we can analyze the static comparative when changes the parameters of the government policies, namely: \( \beta, \phi \). (see figure-1 for numerical simulation)

\[
\frac{\partial q^*}{\partial \beta} = \frac{-F(i - \theta)}{\left( (i + \alpha + \beta F) - (\Delta w(.) + \theta) \right)^2} < 0
\]

\[
\frac{\partial q^*}{\partial F} = \frac{-\beta(i - \theta)}{\left( (i + \alpha + F \beta) - (\Delta w(.) + \theta) \right)^2} < 0
\]

The results show that, there is a positive effect of the policy of surveillance in the probability that the landowner will be available to collude. More surveillance will increase the expected loss for engaging in the illegal activity, and this new environment will lower the incentives for colluding (from the landowner point of view).

The condition of indifference from landowner implies that:

\[
p^* = \frac{k}{(k + \epsilon + \phi \beta + \lambda) - \delta}
\]

Thus:

\[
\frac{\partial p^*}{\partial \phi} = \frac{-k \beta}{\left( (k + \epsilon + \phi \beta + \lambda) - \delta \right)^2} < 0
\]

The probability that the official will commit fraud depends on the fines paid by the landowner, when he is engaged in the corrupt dealing. Increasing the latter, we will have a decrease of the first. This result means that the policy of surveillance can be an
important tool to avoid the problem. Using the same approach, we can see the influence of the probability of surveillance. Results show that:

$$\lim_{\beta \to 0} p^* = \inf \left[ p^* \right] \in (0,1)$$

That is:

$$\frac{\partial p^*}{\partial \beta} = \frac{-k\phi}{\left(k + \epsilon + \phi\beta + \lambda\right)^2} < 0$$

Thus, the policy of surveillance and fines can an important tool to avoid the problem of illegal deforestation. However, as expressed in Greezy and Rustichini (1998), the fines can be adopted as price from both players. So, more fines from engaging in illegal behavior will be incorporated in the pay-off of the agents. Thus, the effectiveness of such policies can be mined if we have a wealth effect bigger than the price or substitution effect.

The Substitution Effect and the Crowding out effect (Wealth Effect)

The important issue to answer is the effect of both policies, i.e., fines from engaging in illegal deforestation, surveillance and fines from engaging in corrupt behavior. A naive analysis would defend that these policies, jointly, could mitigate the problem of illegal deforestation. Using simple calculus and the previous results we can demonstrate that the results are not so trivial. Ceteris paribus, we can define the probability of the official to collude as:

$$p = f(\phi\beta, \delta)$$

Thus, using the derivate approximation, we find that:

$$\Delta p = \frac{\partial f((\phi\beta), \delta)}{\partial (\phi\beta)} \Delta \phi\beta + \frac{\partial f((\phi\beta), \delta)}{\partial \delta} \Delta \delta$$

If, $$\Delta \delta = (\delta - \delta_{(i)}) > 0$$

The index $$i$$ represents the period that the fine is applied.

We can define the first part as a substitution effect and the second part as a wealth effect or crowding out effect (see figure-3 for numerical simulation).

The substitution effect represents the change in the official behavior due the existence of internal surveillance in IBAMA. Thus, more surveillance or more fines (for corrupt behavior) represents more expected cost. This substitution effect increases the

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27 Where $$\inf$$ represent the lower value.
cost of a corrupt behavior (from the official point of view). The first effect would attract fewer
officials for corrupt behavior, therefore would imply in less illegal deforestation.

However, the policies adopted by the government uses the fines, \( \delta \), and as we showed earlier, in
presence of such policies, the landowner can offer a bribe to the official, i.e., by increasing the fines, the
government will allow more available bribes in the bargaining game between official and landowner,
and consequently, in this framework, the official is more likely to have an corrupt behavior, i.e.,
\( \Delta w(.) = \epsilon = \frac{1}{\mu} \delta \)

Thus, increasing the fines would increase the will to be corrupt, from the official point of view.
We call this result crowding out effect or wealth effect. Given the assumption of weak institution,
the increase of fines just increases the share of the fine divided between the landowner and the corrupt
official, in other words, the increase of fines increase the rent of both player. Note that the dividing
procedure of the fines depends of the bargaining power within the players. Thus, if we suppose that
the amount of profit of the landowner is constant, we expect that the increase of fines increases
the bargaining power of of official, i.e., he receives a bigger share of the illegal activity (in terms of
the amount of fine that the landowner would be obliged to pay the government). If the profit of the
landowner is not constant, the increase of fines may be followed by an increase or decrease of the
official bargaining power\(^{28}\).

This effect can undermine all the policies adopted by the government. The net
out effect of the policies depends of the weight of each effect, i.e., the crowding out
effect (negative effect) and the substitution effect (positive effect)\(^{29}\).

The interesting outcome, in this framework is that decreasing the penalties and
increasing the expected cost for corrupt behavior, would decrease the incentive for
colluding behavior. Using derivate approximation we find that:

\[
\Delta p = \frac{\partial f(\phi, \delta)}{\partial \phi} \Delta \phi + \frac{\partial f(\phi, \delta)}{\partial \delta} \Delta \delta
\]

If \( \Delta \delta = (\delta_i - \delta_{i+1}) < 0 \)

In this case, both, the substitution and crowding out effect have negative signal,
meaning that the incentive to collude is lower, reducing the effect of corruption on
illegal deforestation.

Using the same approach we can test the separate effect of surveillance, penalty,
and the bribe amount.

\[ p = f(\phi, \epsilon, \beta) \]

Thus,

\(^{28}\) In the present paper we define bargaining power as a percentage of the amount received over the total
amount generated by the illicit activity.

\(^{29}\) Positive effect means that the illegal deforestation is reduced by that effect, otherwise is negative effect.
Δp = \frac{∂f(φ,ε,β)}{∂φ} Δφ + \frac{∂f(φ,ε,β)}{∂ε} Δε + \frac{∂f(φ,ε,β)}{∂β} Δβ

Again, we cannot see the net out effects of such policies because they have different signal. In the present case, the middle part this is the wealth effect, and the two others represents, jointly, the substitution effect.

The situation investigated in this paper shows that the interactions between players may create an incentive to perpetrate frauds, thus rendering ineffective government policies directed on fighting illegal deforestation. Thus, a new regulatory framework must be implemented in order to dissuade officials and landowner from colluding. In the following sector presents some numerical simulations to summarize, in the first place, the influence of auditing policies in the probability of colluding from both players and the second, place the effects of wealth and substitution effects discussed above.

4. Simulation: Effects of the Policies

We analyzed three type of simulation related first, with the influences of probability of the IBAMA official being audited, second, the influences of penalty in the probability of corruption of the official, and finally third we made a three dimensional simulation, analyzing the influences of , both, probability of auditing and penalty.

For our first simulation we use the following values:

\begin{align*}
  i &= 100 \\
  α &= 80 \\
  θ &= 70 \\
  Δw(.) &= 70 \\
  μ &= 2 \\
  k &= 20 \\
  λ &= 100 \\
  θ &= 100 \\
  F &= 500 \\
  ϕ &= 200
\end{align*}

30 In the case of simulation we can use real values (estimated one) to fulfill the model - in this case we would call this procedure of calibration. However when the values of some parameters are difficult to find or don’t exist, we can use the values according with the restrictions of the models, we call this procedure of numerical simulation. Our simulation is included in the second type of simulation, given the difficulty to find robust data on such parameters and the restrictions of the model used.
Following the second analysis we assume that:

\[ i + \alpha - \theta + \beta F = 320, \text{ where } \beta = 0.5 \quad k + \lambda + \phi \beta = 250 \quad \mu = 2 \]

Our last simulation, we analyzed the effects of both effects, namely probability of being audited and the effects of the penalty, in the incentives of the official to be corrupted. We used the following values:

\[ k = 120 \quad \phi = 200 \quad \mu = 2 \quad \lambda = 100 \]
Using our values of the parameters, the results above shows that the, as increases the penalty, from 0 to 200 the incentives to be corrupt, at the official point of view increases too. However, for the same probability of being audited the decrease of penalties decreases the incentive to collude. As we have analyzed earlier, when there is no penalties, combined with higher level of auditing (probability of being audited), there is no expected gain to official, in this case, is incentive to be corrupted measured as the probability for colluding reach the lower level, as we can see in the figure above.

5. Conclusion

The agency problem within the government and the IBAMA official has been widely neglected by theorist and analysts. Such relationship may play an important role in the success or not of the government’s policies.

Even thought, many cases of corruption of IBAMA official has been denounced in the media, we didn’t find any work on the matter. Thus, this is one of the first papers, in the Brazilian literatures, that focus in the problem of corruption as a leader variable for illegal deforestation.

Using a theoretical approach, static game, we analyzed how the actual relationship between the IBAMA official and the government, can play an important role. Due the static approach, our model have some limitation on capturing the dynamic relationship between the landowner and the official, however, it fulfills, perfectly, the aims of the paper, that is, it highlights perfectly how the problem of corruption, due the lack of good institutions, may backfire all the policies adopted by the government.

Generally speaking, our model suggests that the actual relationship between the official and the landowner may motivate the collusion strategy for both players. The gain is bigger when they collude than otherwise. In the present context, the external regulation policies adopted by the government is useless, that is, corruption may backfire all the effort from the government to avoid the problem of illegal deforestation.

The main result seems paradoxical when the government uses the policy of heavier fines. In the present context, more fines can induce more illegal deforestation.
5. References