## Title
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# Regulation and Moral Hazard in Forest Concessions in Brazil


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**Abstract**

Forests play a fundamental role in an ecosystem, they are capable of regulating the quality of air, the flow of water and the climate. In addition, they can hold vast amounts of carbon and serve as home to a wide range of biodiversity. In order to promote forest protection, avoiding degradation and disordered occupancy and, at the same time, to make sustainable management viable, forest concessions emerged. Therefore, this study aims to analyze the most important aspects of the formation of concessions in Brazil, under the scope of the asymmetric information theory. The idea is to describe and apply a model that takes into account the presence of uncertainty and the difficulties of monitoring. The results, applied to the National Forest of Jamari indicate that with a fine equal to the total value obtained from illegal extraction plus 20% requires a monitoring that establishes the probability of detecting illegal logging in 62%, in order to resolve the moral hazard problem.



Key Words: Forests; concessions; moral hazard

JEL Classification: C61. L51. Q23

1. Introduction

Forests play a key role within an ecosystem; they are able to regulate the quality of the air, the flow of water and climate. Moreover, they can hold high amounts of carbon which would be added to the greenhouse effect if discarded into the environment. Furthermore, it is habitat to a wide range of species of animals and plants.

According to Stenger and Normandin (2003), forests have the potential to be one of the most important reservoirs of biodiversity on earth. This feature extends even to regions where forests have been terribly affected by human activity, since in many cases you can still find high levels of genetic variation for both plants and animals.

However, according to the Global Forest Resources Assessment by FAO (2011), around 13 million hectares of forests were converted into other uses, including agriculture, or were lost due to natural causes each year between 2000 and 2010. There are innumerous organizations seeking for different alternatives to avoid the further shrinkage of forest area, among them is the adoption of concessions, which already has a long history in Central Africa and, for the last two decades have been gaining importance in South America, first with Bolivia and Peru and more recently in Brazil (KARSENTY et al., 2008).

Brazil is a among the top five countries in terms of forest area, accounting for 13% of the total amount globally, as well as being the country with the largest extension of tropical forest (FAO, 2012). However, the forest area is decreasing in Brazil, as it is shown by Figure 1.

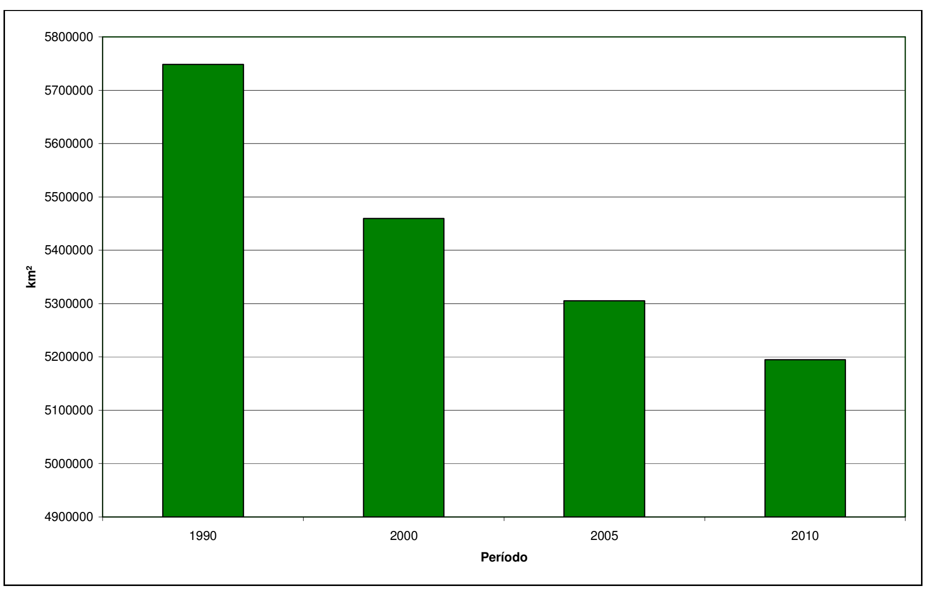


Figure 1. Area (km²) of Florests in Brazil.
Source: World Data Bank (2011).

According to the graphic above, the forest area in Brazil has been shrinking. In the initial period, the area regarded as forest was approximately 5.75 million km², whereas in the latter period, it was of 5.2 million km², resulting in a reduction of 9%.

When comparing the decades of 1990 and 2000, the deforested area in the first decade was 2.5 times higher, however, the rate of the deforestation is practically constant between the two periods, with a small reduction of only 0.2% in the latest decade. Still, it is noteworthy that in the last five years, the reduction of the forest area was of 109,720km² which accounts to a 2% decrease.

Also in the context of the Brazilian forests, it is important to highlight the area called Legal Amazon, which includes the Brazilian Amazon forest, constituting 49.3% of the total land area of Brazil (IBGE, 2012), where 93% of the public forests are located. This region shows a decrease in the deforestation rate, in 2010, it was 7000km²/year, a decline of about 6% comparing to 2009 (PRODES/INPE, 2012).

However, according to Pereira et al. (2011) there are estimates which points to an increase in the demand for forest products, such as energy, paper, solid wood and its derivatives. Also, the adoption of policies by the Brazilian government that spurs infrastructure and construction, such as the Programa de Aceleração do Crescimento - PAC, increases the demand for timber and warms the domestic timber market.

In order to promote the conservation of the Brazilian forest patrimony, the law n° 11.284 of 2006 was created. It refers to the public management of forests and establishes, in the structure of the Ministry of Environment, the Serviço Florestal Brasileiro[1] – SFB, and creates the National Fund for Forest Development. Together with the general law of bidding, n° 8.666/93, they create the legal foundations that enable forest concession in Brazil. The aim of these laws is to prevent the degradation and devastation of forests by irregular occupation and agricultural activities, while enabling the sustainable management of the same, increasing the income and improving the quality of life of local households (SFB, 2012).

One of the instruments created by this law, regarding the management of public forests, is the Annual Plan for Forest Concession - PAOF, which organizes and designs the sustainable forest production through concessions of public forests for the exploitation of timber resources, nontimber sub products and services (PAOF, 2012). Currently, PAOF has 4.4 million acres of federal public forests eligible for concession, distributed in ten national forests located in three Brazilian states, Acre, Rondônia and Pará.

The regulation of the process of forest concessions in Brazil is, according to the Serviço Florestal Brasileiro (2012), through bidding, in order to grant the exploitation of the forest area to firms that demonstrate the ability to practice and manage autonomously, sustainable forest management within a specified period of up to 40 years.

Thus, by 2010 there were two national forests under concession, one on the state of Pará and the other in Rondônia, summing for a total of 114.800 hectares. The first case of a forest concession in Brazil was in the Jamari National Forest, located in Rondônia, which had 96.000 of its 220.000 hectares allocated to concession. It is due to this relevance that we explore this case when applying the model described in this article.

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[1] In English: Brazilian Forest Service.

Within this context, there is a need for the government to control extractive activities, collect the royalties and monitor and restrict illegal logging for the forest under concession so it will achieve the established criteria for environmental sustainability and generate income for local households. Thus, this study examines the existence of the problem of information asymmetry between the government and the concessionaire under the assumption that there may be divergence of interests as to the best way to explore the forest.

The origin of this potential problem is the fact that the concessionaire is better informed of its actions than the State. Thus, the government, in its role as a regulator, incurs in monitoring costs that, by nature, are not perfect, so we have what is called the problem of agency under regulation, best explored in the subsequent sections.

The aim of this study is to adapt a model for the control of logging in concessions considering the presence of uncertainty and difficulties in monitoring, its application is demonstrated in the Jamari National Forest concession case. The proposed model was developed taking into account the benefits and risks of this type of contract from the perspective of information asymmetry theory.

This article is structured as follows. First, an analysis of the strengths and risks of forests concessions is discussed. Then, the proposed theoretical framework is described, including its application. The paper finishes with concluding remarks and final considerations.

## 2. Forest Concessions, benefits and risks

The concession of public forests can be defined as a contract between the owner of the forest, the State and the licensee, a private firm, which allows the exploration of timber, including some by-products, and services. This exploitation of the forest area is subject to the adoption of sustainable management activities, such as wildlife conservation, forest restoration, among others (KARSENTY, 2007).

There are many reasons for a government not to manage forests by themselves and, consider the option of concessions. Amongst them, as reported by Gray (2002), is the lack of capacity, capital or experience to explore the forest optimally, as well as lack of enforcement power in order to control deforestation and protect it from disordered occupation.

In this sense, the adoption of concessions comes as a solution to the problems of uncertainty on land property because if property rights are not strictly applied, clearing forests might become an investment for the farmer, which uses this as a strategy for the recognition of the right to the land (ANGELSEN, 1998). Thus, establishing concessions in areas where these problems are more likely to occur becomes a way to avoid this situation, especially because the grant is subject to sustainable management by the concessionaire.

Furthermore, according Karsenty et al. (2008) this link between the concession and the sustainable management implies less risk than when compared to individual forest owners, who have incentives to leave the sustainable management and to convert their land into more profitable uses when relative prices become favorable for this purpose. Also according to the authors, the land owners are usually more numerous than the concessionaires, making them more difficult to monitor and increasing the probability of overexploitation of the land in spite of possible financial sanctions imposed by the State. In the case of concessions, the very possibility of canceling the contract represents a significant risk, which prevents this type of behavior, resulting in an additional guarantee to the government that wants to prevent their forests from being converted into agriculture.

The risks associated with forest concessions are linked to what Buosquet and Fayard (2001) refer to as transfer of responsibility, i.e., the risk is switched from the regulatory authority to the company, since the company must be responsible for managing the area under concession and obtain revenues through the sale of the timber it harvests.

In this manner, a major issue that can emerge is that the revenue under sustainable forest management may not be high enough to provide an incentive to maintain such management viable over time. In other words, the internal rate of return may not be enough to cover the opportunity costs when compared to any other activity over a similar time period (VAN DIKJ; SAVENIJE, 2009). In the specific case of Brazil, Seroa da Motta, Young and Ferraz (1998) present some estimates of the rate of return of sustainable logging in the Amazon Region that are below 1%, which tends to make it more profitable to use illegal timber.

Thus, by this view, the State should seek funding for sustainable forest management as to generate the adequate living conditions for forest owners. That is, it should encourage investments to make this type of management more competitive compared to alternative uses, such as unsustainable management, agriculture, mining and pastoral activity.

Specifically for the Brazilian case, Marry and Amacher (2005) indicate three major risks associated with the system of forest concessions. First, the authors suggest that the government may have incentives to extend the areas under concessions in order to increase its revenue collection. Second, they suggest that high offers in the bidding process may encourage concessionaires to overexploit forests, due to the need to cover their costs. The idea is that because concessionaires have to pay a fixed rate over what they harvest, increasing the volume explored decreases the weight of additional units. Besides that, a high bid in the bidding process may raise the economic frontier of the concession, which is the geographical point[2] that, if exceeded, will cause the forest to generate lower returns than normal profit.

Finally, Marry and Amacher (2005) point out to the possibility of concessionaires to supply wood at lower prices when compared to private owned forests, which together with the possibility of an increase in the supply due to land clearing for new concessions, may result in the exit of timber harvesters that operate in the margin. Among these producers, the authors highlight those that undergo high costs due to sustainable management. Thus, the final outcome of this situation would be the polarization of the timber industry, where in one side would be the major firms

[2] See Hyde et. al (1991) for a theoretical discussion.

operating in major concessions and in the other, smaller producers, which are more likely to sell timber informally and are less likely to take the environmental precautions.

## 3. Regulation and the agency problem

The foundation for the design of any type of concession lays in the theory of incentives. The idea for the specific case of forests is that as the sustainable management of them requires a very high expertise and investments by the State, it eventually designates this task to a company through concessions. Thus, by the regulatory instruments imposed by the contract, we fall into the Principal-Agent theory, also called Agency theory.

This theory is widely used to model economic relationships involving risk sharing and incentives. Specifically, Jensen and Meckling (1976) define this theory as the one that deals with the relationship between agents in a contract where one party, called the Principal, has some power over the behavior of the other party, the Agent, which takes a private action that affects directly the final outcome, i.e., this action has an impact on the utility of both, agent and principal. Therefore, an important economic issue is how to characterize a contract between two parties so that it will generate enough incentive as to the agent act in accordance with what the Principal desires and with optimal effort.

The literature on Principal-Agent relationship is the basis for the analysis of the regulation problem, where the regulatory agency, which is, in this case, the government, must decide how to apply its regulatory mechanisms. Many cases in the literature involve regulation in order to prevent an environmental damage[3], such as over fishing or a polluting company. The reason for this, according to Shavell (1979), is that whenever there are risk transfers, so that the agent becomes fully responsible, the relationship between the agent and the principal can be used in a context where the contract will depend only on the final result.

To this effect, the adoption of the Principal-Agent approach for incentive regulation can be defined, according to Church and Ware (2000), as the government intervention that seeks to change situations of market failure, through the control of price, quantity, quality, among other mechanisms.

Accordingly, using the framework created by Sappington (1994), where the Principal - in this case the State - is necessary so as to hire an Agent with specific skills and knowledge to perform a given task. The main concern of this approach lies in how the agent can be motivated to perform this given job exerting effort, in a scenario where his actions are not observable, so as to maximize the welfare of the Principal.

That is, we analyze the theory of incentive regulation as a tool to solve the problem of moral hazard, which are situations where the agent's behavior is not verifiable by a variable in the Principal-Agent relationship, and thus, it can not be included in the terms of the contract. As a consequence of this, the Principal needs to spend resources on monitoring the actions of the Agent, which results in loss of efficiency in their relationship (MACHO-STRADLER; PEREZ-CASTRILLO, 1995).

[3] See Cohen (1987), Jensen e Vestergaard (2002) e Segerson (1986).

Despite these expenditures, generally, it is impossible to have an action that can be fully observed even because the cost of doing it makes it prohibitively expensive (HOLMSTROM, 1979). In other words, the regulator wants the Agent to have a specific behavior, but can't effectively intervene in all the operations of the company, the main reason is that the firm has better information about its actions than the regulatory agency.

In this regard, the regulatory instruments are used to align the interests of agents and principals, through the control of quality of products and services, or even by allowing for the internalization of externalities, compelling farmers to bear the total production costs rather than passing them on to third parties or to society. Thus, the optimal contract is determined by the tradeoff between two conflicting objectives, efficiency, in terms of optimal allocation of risk among participants, and the incentives of the agent.

Basically, according to Seroa Ferraz da Motta (1998), there are two types of mechanisms that the government could use to generate the incentives necessary for the adoption of sustainable management in forests. One could impose methods of command and control or use economic instruments. In the case of the control approach, the regulator would set the maximum amount of wood that could be extracted from the concession area for a period of time. The approach of economic instruments to control the amount of timber can be applied in the form of royalties and taxes on income, associated with the extraction of resources. Thusly, Amacher, Koskela and Ollikainen (2004) suggest that the adoption of a fine is the optimal way to avoid the problem of illegal logging in the existence of externalities.

4. Analytical Model and the Incentive Scheme

Based on the review above, the following model is an adaptation of the one developed by Amacher, Koskela and Ollikainen (2004) for the design of optimal control under different types of fees on the extraction of timber. Therefore, we consider a concessionaire that receives a permit to explore a particular forest area. Suppose the company is entitled to exploit an amount per year. Nonetheless, the government imposes a fee for this right that focuses on the volume of timber harvested, denoted by *k*. Thus, if the concessionaire acts in accordance with the contract, and extracts the exact amount allowed in the concession, the annual profit that she will get will be equal to:

$$\pi_t = q\overline{Q}(1-k) - c(\overline{Q}) \qquad t = 1,\ldots,T$$

Where $c(\overline{Q})$ is a convex cost function, that is, $c'(\overline{Q}) > 0$ and $c''(\overline{Q}) > 0$, and $q$ corresponds to the harvested wood price. If the profit of the concessionaire is positive in $\overline{Q}$, i.e., if $q(1-k) - c'(\overline{Q}) > 0$, then there will be incentives for illegal logging. Given that the concessions are not perfectly observed by the government we will incur in the moral hazard problem.

Let $X$ be the illegal harvested quantity, which will be defined in terms of the excessive exploitation, i.e., it can be described by the difference between the actual harvesting, Q, and the amount allowed, $\overline{Q}$, so that $X \equiv (Q - \overline{Q})$. Furthermore, let

$p(\leq 1)$ be the probability of the illegal logging get detected by the government, in a way that the size o $p$ would be linked to the manner and frequency of the auditing, that is, with the probability of being caught by the government monitoring. In summary, $p$ is considered as a measure of the intensity at which the government exerts monitoring and detects illegal activities.

For this purpose, we will consider a fine which penalizes the concessionaire's unreported income from illegal logging. Thus, the concessionaire's profits would depend on whether the illegal extraction is detected or not. Consequently, if the firm is not detected while making excessive harvesting, its profits will be defined as:

$$Y_t = \left[qQ_t - kq\overline{Q} - c(\overline{Q}) - c(Q_t)\right] \qquad t = 1,\ldots,T$$

However, should the monitoring be carried out by the government detects the excess of logging, profits must include a fine. Therefore, the expression for the net gains from the firm under such an occurrence is defined by:

$$Z_t = \left[Y_t - fqX_t\right] \qquad t = 1,\ldots,T$$

In this model, it is assumed that the concessionaire is risk neutral. This is a very reasonable assumption, given that in a concession model of this type, the licensee assumes the entire risk of the operation. Thus, it seeks to optimize the discounted present value of its current and future earnings during the period of grant, in such a way to solve the following problem:

$$\underset{Q}{Max} = \rho^t \sum_{t=1}^{T} \pi_t = \rho^t \sum_{t=1}^{T} (qQ_t - c(Q_t) - kq\overline{Q} - pqfX_t) \qquad t = 1,\ldots,T$$

This condition shows that the optimal amount of extraction is defined by the equality between marginal revenue ($q$) and the expected marginal cost, which consists in the cost of harvesting plus the expected value of the fine. In this sense, it is possible to show that illegal logging depends on exogenous parameters, such as:

$$X_t = X_t\left(\underset{+}{q}, \underset{-}{p}, \underset{-}{f}, \underset{0}{k}\right) \qquad t = 1,\ldots,T$$

The effects of $q, f, p$ on illegal extraction is that the higher the price, the higher illegal exploitation will be, whereas a higher probability of detection and a larger amount of the fine will reduce the excessive extraction.

4.1 The case of National Forest of Jamari

After describing the model, we apply it to the case of the first forest concession in Brazil, the granting of the Jamari National Forest, located in Rondônia. According to the SFB (2012), the forest has an overall area of approximately 220.000 hectares, of which 96.000 were allocated for the grant. The concession area was divided into three forest management units, which were intended for bidding. For the specific case of this article, only the third FMU will be considered. It covers a total 46.000 hectares and was won by the company Amata S/A.

The method used to solve the problem of the firm according to the model proposed was dynamic programming in discrete time. As such, it has been considered that in each moment of time the agent observes the state of an economic system and makes his decision. He also receives a reward for it, which will depend both on the state of the system and the action taken. The agent seeks a sequence of actions that maximizes the present value of its current and future rewards over a certain time horizon, discounted each period by a certain factor.

In the specific case of this article, we considered that each year the licensee observes the state of its forest concession, determined by the amount of cubic meters of wood available, and decides how much of timber it will extract, i.e., makes his decision. In the model proposed, the state variable evolves deterministically according to the agent's action and the growth of the forest.

In this regard, the data used for this estimation were the closest from the real concession as possible. First, according to the technical feasibility study performed by the company provided by SFB (2012), only 56% of the total area of the grant, i.e., about 26 thousand hectares were considered manageable by the firm. This area was estimated to have a total of 1.18 million cubic meters of timber volume.

Still, according to the winning proposal of the concession[4], the management criteria is structured to reach the maximum extraction capacity of the forest, namely, the one that still allows for the regeneration of the same - around 21.5 m³/ha per cutting cycle - which is estimated to be 25 years. Therefore, it is assumed that the annual forest growth is 0.86 m³/ha. Thus, taking into account the manageable area, the estimated annual growth is of around 22.6 cubic meters.

Moreover, the economic feasibility study of the concession provided by the SFB (2012), states that the average cost of logging is R$ 55.00 m³. In addition, the concession contract stipulates that the amount paid to the government per cubic meter of wood harvested is R$34.00.

In order to determine the average selling price of the wood, we used the classification of species into subgroups, such as the one used by the Brazilian Forest Service, then we used the market value of each type of tree as described in Pereira et al. (2011). The classification made by the SFB, subdivides the species of trees into four groups, assigning the total area of each. The intent of the SFB is to use this classification in order to obtain the minimum value that a proposal must have to enter the bidding process. Thus, when considering the area of each group and the identification of the corresponding market value of the existing species[5] in these different groups, it was possible to obtain a weighted average and so, an approximate price.

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[4] Documents available in SFB (2012).

[5] The common name of the species (in Portuguese) in the Jamari Forest and that had their price analyzed by Pereira et al. (2011) were: Abiu, Angelim-amargoso, Angelim-pedra, Breu, Cedro, Copaíba, Cumaru, Cupiúba, Faveira, Itaúba, Jatobá, Louro, Maçaranduba, Marupá, Muiracatiara, Pequiá, Roxinho, Sucupira e Tauari.

Through this procedure, we estimated the value of R$ 208.71 for the price, ($q$) of sales per cubic meter of wood extracted by the concessionaire. Given the values of cost and selling price, the parameter $k$, which is the fee charged by the government for the right of exploitation, was estimated at 0.16, obtained by the ratio of the amount that the company has to pay to the government for the extraction and the final selling price. Finally, it was considered a discount factor of future flows of timber of 0.95.

Furthermore, it was stipulated a fine equal to the total value obtained by illegal extraction increased by 20% if the concessionaire is caught by the regulator. It was considered that the legal limit of annual extraction ($\overline{Q}$), i.e., the one that maintains the forest preserved, as being equal to the estimated growth of same, that is, 22.6 cubic meters. Still, we imposed some physical constraints to the harvester, so that he is only able to extract twice the maximum allowed, which is equivalent to an extraction of 45.2 cubic meters per year.

So, we attempted to simulate the behavior of the agent, varying the probability of being caught by the government while extracting above the quantity allowed. The results can be seen in the following graphs.

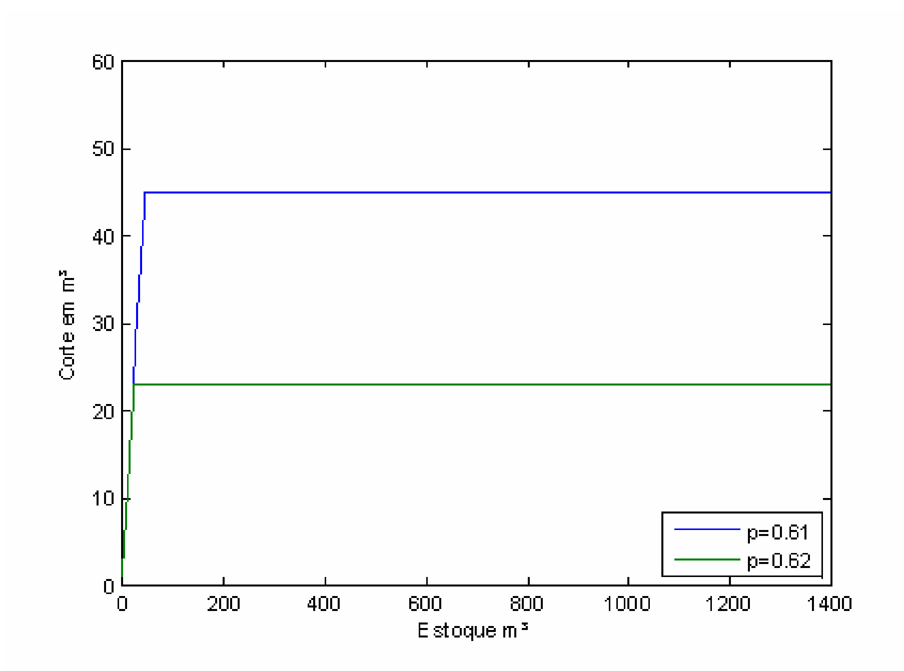


Figure 2. Wood harvesting by the concessionaire while varying monitoring probability.

In this sense, it was found that when the probability of being caught exploring beyond the capacity of the forest is 0.62, the concessionaire will act so as to not overexploit the forest, extracting the maximum allowed of 22.6 cubic meters per year. On the other hand, we find that when the probability of being detected performing illegal logging is 0.61, the company has incentives to engage in a moral hazard behavior, exploring as much as their physical constraint allows, i.e., 45.2 cubic meters per year.

Thus, according to the results, it is clear that whenever the probability of getting caught is greater than or equal to 0.62 the agent has sufficient incentives to act in accordance with the interests of the Principal. However, when this probability is less than or equal to 0.61, the concessionaire has an incentive to extract more timber than the amount allowed, and so it will operate at the full capacity of its physical constraint. That happens because for any value less than 0.62, the marginal cost of harvesting the maximum capacity will remain lower than the marginal revenue. Given the levels of the probability of being caught, we can observe the evolution of the stock of wood in cubic meters of the forest in each of these cases in Figure 3.

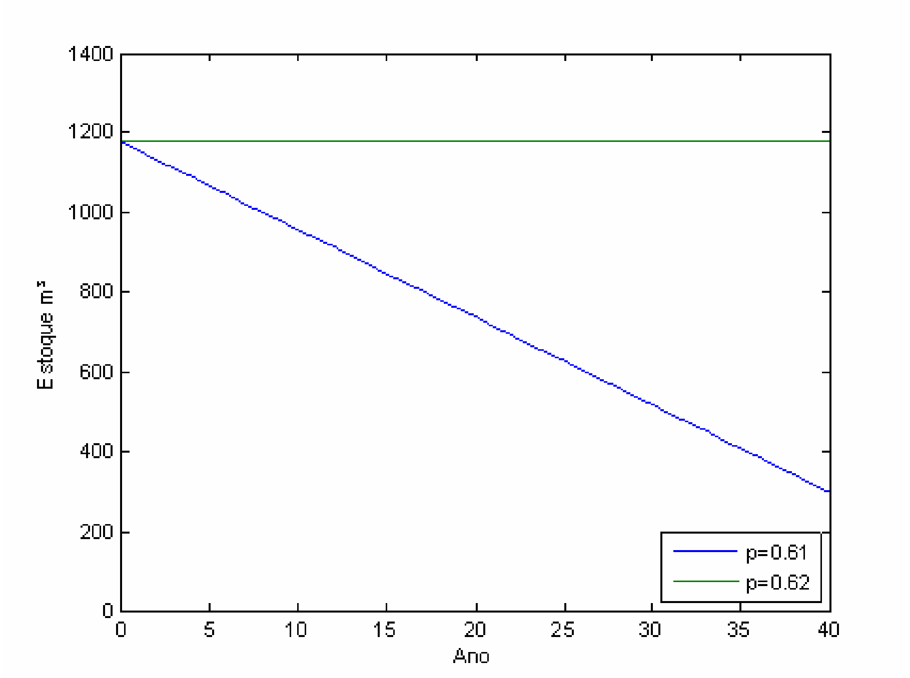


Figure 3. Wood stock evolution (m³) of the forest.

As it can be observed, with p = 0.62 the stock throughout the grant period does not change from the original amount. That happens because the agent has the right incentive to act in the best interest of the principal. So, he harvests the forest at the same amount of its growth rate. On the other hand, if p = 0.61, the stock of wood in the forest is reduced dramatically over the concession period. This happens because it is advantageous for the concessionaire to explore above the quantity allowed, characterizing the moral hazard problem.

We would then be incurring in the problem of information asymmetry because of a rational response given by the agent in the economy, which seeks to maximize his net earnings. Thus, the necessity of the adoption of more effective policies to exert monitoring and punishment that are able to align the interests of the regulator with the concessionaire's becomes clear.

Therefore, for the specific case of the Jamari's concession, and considering a fine that equals to the total value obtained by illegal extraction increased by 20%, a monitoring that results in the probability of detecting illegal activities at least in 62% are sufficient to avoid the problem of moral hazard.

## 5. Concluding Remarks

This study aimed to analyze the most relevant aspects of forests concessions in Brazil, taking into account the benefits and risks from the perspective of the information asymmetry theory. The idea was to conduct a literature review in order to provide the foundations of the model proposed. Due to the presence of uncertainty, difficulty in monitoring and economic incentives that may lead to the overexploitation of the forest by the concessionaire, we propose a model that considers the existence of moral hazard under forest concessions contracts.

The application of the model to the case of the Jamari National Forest, indicates that in a scenario that applies a fine that is equal to the total value obtained from the illegal extraction, increased by 20%, and with a monitoring that results in the probability of detection of 62% or more, the interests of the agent and principal are aligned. It is noteworthy that any probability that stands below this threshold will result in a moral hazard behavior, which leads to the overexploitation of the forest and in the usage of the full physical capacity of the harvester.

Thus, this article contributes to the literature that supports the necessity to make a careful analysis of the institutions that regulate forest concessions. Poorly defined property rights, lack of monitoring and punishment by credible institutions and regulators are often not able to solve problems they are intended to solve. Therefore, the main conclusion of this paper is that there is a need for an active effort by the government in order to control and inhibit moral hazard behavior.

In terms of future research, we suggest the further exploration of the regulation problem. This can be done by considering the government's role, i.e., the costs incurred by the State to exercise the level of monitoring consistent with the elimination of the moral hazard problem. The government would constitute the maximization problem by optimizing the social welfare, given the costs of monitoring the concessionaire. Consequently, the model would be more robust and consistent with the reality.

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