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Profit Sharing as a Management Strategy for a State-owned Teak Plantation at High Risk for Illegal Logging

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ABSTRACT

Illegal logging is a serious threat to plantations in the tropics. Here, we study the roles of profit-sharing in plantation management strategy in a dynamic game model. The model assumes that the owner chooses the age of the trees to be harvested and the local people choose their level of monitoring effort to prevent illegal logging with surveillance. After the trees are removed, the owner hires local people to replant young trees. We derived recursive formulas for determining the value of a site with trees of age t, and solved them by iteration. Under the pressure of illegal logging, the owner may find it profitable to share harvesting profits with the local people to enhance their surveillance effort. A higher rate of natural disturbance shortens the mean tree age, leading the owner to invest more to suppress illegal logging by increasing the profit-sharing rate. A lower future discount rate leads to older trees being harvested and decreases the profit-sharing rate. If the cost of replanting is increased, the local people are reluctant to participate in surveillance activities, and the owner increases the profit-sharing rate to encourage their participation. We discuss the policy implications of these results.

1. Introduction

Illegal logging, which is illegal activities ranging from forest ecosystem and industries, and to timber and non-timber forest products, seriously threaten forests in the tropics. In some countries such as Cambodia, Indonesia, and Bolivia, the estimated illegally logged production may exceed 80% (Food and Agriculture Organization (FAO), 2005; European Forest Institute, 2005). At both state and community levels, illegal logging occurs widely and persistently (Corbridge and Kumar, 2002; Véron et al., 2006; The World Bank Group, 2006). Plantations occupy 7% of the forest area (FAO, 2010) and play an important role in providing industrial roundwood (Jurgensen et al., 2014). Indonesia is one of the top three teak timber producers in the world, along with India and Myanmar, mainly in the state-owned forests located in Java. Indonesian teak plantations suffered a high risk of illegal logging. Teak log production decreased dramatically by widespread illegal logging, after the collapse of the Soeharto regime (1968–1998) (Awang et al., 2006; Ministry of Forestry, Indonesia, 2002, 2008).

To tackle the problem of illegal logging, a new partnership program based on sharing harvest profit with the local community was proposed (Rosyadi et al., 2005). Profit sharing aims to suppress illegal logging by encouraging local community to join in the surveillance. The program was tested in several places and was shown to be effective in reducing damage by illegal logging (Fujiwara et al., 2012).

To understand the economic incentives underlying the community-involved forest management, we introduce a dynamic game between the landowner and the local people in the presence of an illegal logging risk. We regard the state forest company as the landowner (and the forest manager as the landowner's representative) and consider the local people, represented by an association, as a single player. We also assume that each managed teak plantation is composed of a very large number of sites and that the trees planted at each site belong to the same coeval cohort.

The purpose of the theoretical study in the current paper is to examine the idea that introducing profit-sharing mitigates the risk of illegal logging by making the local community more cooperative in the surveillance activity. We want to clarify the processes and elements that are needed for this idea to work. The model's structure was chosen to be the simplest possible one. The model was motivated by the case of Indonesian forests, in which profit-sharing seems to have successfully

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suppressed the risk of illegal logging. However, we did not intend to make the model provide a realistic description of the Indonesian forests.

A site can be cleared when (1) the forest manager decides to harvest the trees and sell the logs, (2) illegal logging takes place, or (3) a natural disturbance occurs. In deciding whether to harvest the trees, the forest manager considers the price of the timber (which increases with the age of the trees) and the risk of loss from illegal logging or a natural disturbance. Illegal logging refers to the invasion of the plantation by people or companies, who cut the trees and sell the timber illegally. The landowner hires rangers or guards to prevent illegal logging, but without the cooperation of the local people, the rangers may not be able to suppress it. The local people can help suppress illegal logging by reporting illegal logging activity when they observe it. We assume this reporting incurs no additional cost to them.

However, under some conditions, some local people may find it more profitable to allow illegal logging to take place, because after illegal logging (or a natural disturbance) occurs, the landowner needs to hire local people as workers and pay them wages to plant new trees. To reduce the labor cost, the landowner might let the workers use the land for agroforestry in lieu of wages, until the site becomes shaded by the growing trees. The community-based forest management scheme and game model is illustrated in Fig. 1.

Thus, to secure the collaboration of the local people, the state forest company may share the profit obtained by selling the harvested logs (profit-sharing). If the amount of profit-sharing is sufficient, the local people might find it more profitable to help prevent illegal logging than to overlook it. We use our dynamic game model to examine the conditions under which profit-sharing is beneficial to the owner and the optimal profit-sharing rate.

1.1. A Partnership Program for Community-based Forest Management in Indonesia

The Javanese State Forest Company (*Perum Perhutani*) has been the major producer of teak timber in Indonesia (Kollert and Cherubini, 2012). However, the teak log production by the state forest company has been dramatically decreased due to illegal logging. To deal with the illegal logging problem, the state forest company initiated a community-involved forest management scheme called PHBM (*Pengelolaan Sumberdaya Hutan Bersama Masyarakat*) in 2001. Fujiwara et al. (2012) pointed out two major features of PHBM policies that may enhance stewardship of the forest by the local people are [1] investing to solicit joint surveillance activities by the local people to suppress illegal logging by offering them a share of the profit from the timber harvest, and [2] implementation of an agroforestry system (called *tumpang sari*) that allows the local people to cultivate cash crops in the state forests while the planted trees are too small to shade the crops.

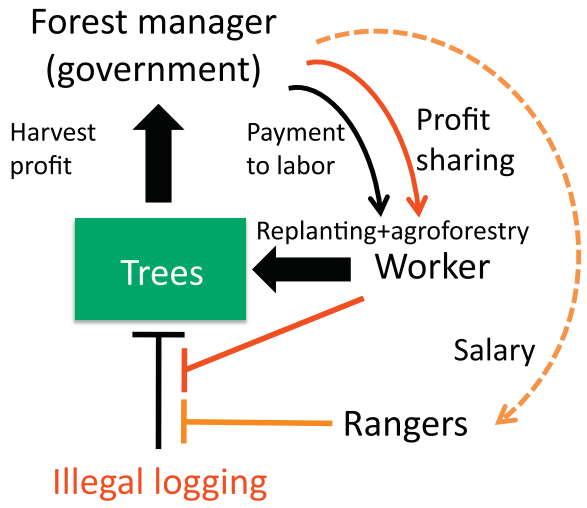

Fig. 1. The community-based forest management scheme (dynamic game model). The forest manager and the local people are the two main stakeholders. The forest manager hires rangers, who guard the forest. When a site is cleared, the manager hires local people to replant trees and perform maintenance work in the forest. In lieu of payment for their labor, the local people may be allowed to use the land for agriculture while the trees are still young (agroforestry). In addition, local people may receive some fraction of the profit when the trees are harvested in return for engaging in surveillance activities to help suppress illegal logging (profit sharing).

In plantation forests in Java, agroforestry system started around 1873 and became widely spread from 1895 (Peluso, 1992; Evans and Turnbull, 2004). For the first few years after planting young trees, farmers use the plantation land for cultivating crops, such as corn, peanuts, and cassava between planting tree rows until crown closure (Fujiwara et al., 2011). The new partnership program guarantees continued use of land for agroforestry, as well as sharing profit from harvest. The local community creates an association to represent local members who join PHBN. Fujiwara et al. (2012, 2015) argued that the local people should receive benefits, such as agroforestry and profit sharing privileges, for participation in PHBM to alleviate dissatisfaction that may discourage their cooperation with other stakeholders.

2. Model

We consider a forest plantation to be composed of a large number of sites, and at each site a coeval cohort of trees has been planted. Here, the age of the trees at a site implies the number of years since the most recent clearing. We assume that the owner has numerous sites of different tree ages, which allows smooth forest management that makes profits continuously. For simplicity, we assume no heterogeneity of the sites except for tree age.

Let p_0 be the price of the trees at a site with age 1 year and p_0t^3 be the price at a site with trees of age t, which represents the situation in which the value of matured trees is much higher than premature trees. This is a plausible assumption for teak forests, for which illegal logging is a serious problem. The payment c is made by the owner to workers (local people) for replanting labor just after a site is cleared. Let r be the future discount rate, and e^{-r} be the annual discounting factor that is called exponential discounter and widely accepted in economics (Samuelson, 1937; Strotz, 1955; Lucas, 1990). s is the probability that there will be no natural disturbance in a year; $(1 - s)$ is the probability a disturbance occurs in a year. L_t is the probability that illegal logging will occur at a site with trees of age t. L_t depends on the values of other parameters, as explained below.

2.1. Owner's Choice: Tree Age at Harvest

Let V_t be the value to the owner of a site with trees of age t at the beginning of a year. This value, which takes account of the current and future profits to the forest owner, is calculated with Eq. (1):

$$V_t = \max_{0\le\sigma_t\le 1}\left\{\begin{array}{c}\sigma_t[(1-\alpha)]p_0t^3 - c + e^{-r}V_0 \\ +(1-\sigma_t)[(1-s(1-L_t))(-c+e^{-r}V_0)]+s(1-L_t)e^{-r}Vt+1\end{array}\right\} \quad (1)$$

where is the probability that the owner chooses to cut trees with age t: $\sigma_t = 1$ indicates that the owner chooses to cut the trees, whereas$\sigma_t = 0$ indicates that the owner chooses not to cut the trees. When the owner chooses to cut the trees at a site, the logs are sold at price, which increases with tree age t. The owner may share the benefit derived from the harvest (i.e., the profit) with the local people, who receive fraction α of the profit. In addition, the owner must pay c for the labor of planting small trees at a newly cleared site. In the following year, the site value is V_0 with the trees at age 0. These terms are within square brackets and are all multiplied by σ_t.

Two terms are within the square brackets multiplied by $1 - \sigma_t$: the first term is, $1-s(1-L_t)$ which is the probability that the site will experience either a natural disturbance or illegal logging, multiplied by